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A Review of the Conservation Status of Selected

Australian Non-Marine Invertebrates

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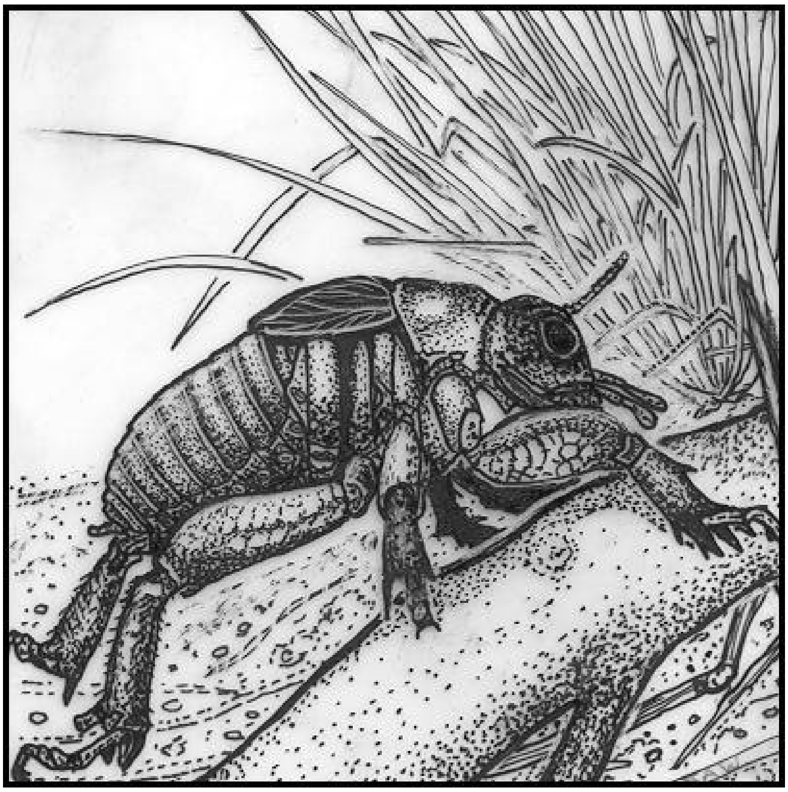

Contents

Summary

This Review represents the first attempt to objectively assess the conservation status of a selected suite of Australian non-marine invertebrates.

Australia is home to over 300,000 species of non-marine invertebrates of which over 80% are endemic; the majority of which are not formally described. Any attempt to provide a detailed and comprehensive overview of the conservation status of such a large and diverse group is obviously impractical.

The approach we have taken is to select a suite of 25 species that are representative of the diversity of our invertebrate fauna, their geographic distribution, different habitat requirements and associations and potential threats. THESE 25 SPECIES SHOULD NOT BE VIEWED AS PRIORITY TAXA IN ANY SENSE.

For each selected species we provide information on:

1. General taxonomic status of the species, including an illustration
2. Species survival status. This includes information of current listing under State or Commonwealth legislation, or on the 2000 *IUCN Red List of Threatened Species* (Hilton-Taylor 2000). Also included is the IUCN categorisation determined by application of the *Ramas RedList* software program (Akçakaya and Ferson 1999).
3. Species distribution – a map of current distribution is provided at the end of each synopsis overlaid with Conservation and Protected Areas shown in green.
4. Habitat details
5. Biological overview
6. Significance – details of the biological, ecological, and scientific significance of the species which have contributed to its inclusion in the plan
7. Threats
8. Conservation objectives
9. Conservation actions already initiated for the taxon
10. Conservation actions required for long-term conservation of the species. This section is subdivided into research and management needs.
11. A list of relevant experts who provided information

Each of the selected species has been objectively assessed against the 1994 IUCN Threatened Species Criteria using the software package *RAMAS RedList*®. As anticipated the majority of taxa were categorised as Critically Endangered with the remaining as Data Deficient. This latter category highlights many of the problems associated with assessment of invertebrate species, namely the lack of detailed and comprehensive biological, ecological and distribution data.

Effective invertebrate conservation cannot rely on the conventional single species approach adopted for the conservation of our vertebrates and plants. The focus needs to change to a more community and landscape scale approach with a primary emphasis on habitat conservation and threat abatement. However, for some faunal elements a single species emphasis may still have merit.

The aims of this Review are twofold. The first is to highlight that invertebrates are amenable to conventional assessment of their conservation status. Although such assessment might be more difficult than for better-known groups, such as vertebrates, there is nothing intrinsically different about them to prevent objective assessment. The second and perhaps more important aim is to draw attention to the conservation needs of the largest and most diverse component of Australia's biota. There is a general increase in awareness of the uniqueness and importance of Australia's invertebrates. This Review stresses that this fauna is just as worthy of conservation as our koalas, parrots and Wollemi Pine.

Acknowledgments

Many people have assisted in the preparation of this Review. In particular we wish to thank Sharyn Wragg for providing the wonderful illustrations used within each Species Synopsis. Dr John Vranjic (Environment Australia) is thanked for comments on a draft version of the Plan and for suggesting the inclusion of Tables 1 and 2. The following are thanked for advice and/or provision of data.

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1. Introduction

A very detailed and comprehensive overview of the conservation of Australian non-marine invertebrates has recently been published (Yen and Butcher 1997). This overview outlines the major issues facing the conservation of invertebrates in Australia, particularly in relation to the perceived and known threats. As such this Review will only provide a summary of these issues and the reader is referred to Yen and Butcher (1997) for more detail.

The importance and dominance of invertebrates as a component of biodiversity, and their role in ecosystem functioning is well documented, and for the most part equally well accepted and appreciated. It has been conservatively estimated that invertebrates comprise over 80% of the world's biodiversity, both in terms of the number of species and biomass. This overwhelming number of species is regarded as being the major impediment to effective invertebrate conservation in Australia and throughout the world. In Australia there are estimates of as many as 300,000 species of non-marine invertebrates, of which less than 100,000 are described (Yen and Butcher 1997). By comparison, Australia is home to approximately 16,000 species of higher plants and 5,000 species of vertebrates.

A further complication arises from a general lack of knowledge of our invertebrate fauna. Despite nearly 100,000 species being formally described, with the exception of a few charismatic groups, most notably the butterflies, these species have very little associated biological or ecological knowledge. Many described species are known from a limited number of specimens housed in museum collections. For the most part, knowledge of the distribution, habitat requirements, population sizes, life cycles and population biology are completely unknown. However, although the number of species and general lack of information are not helpful for effective conservation of our invertebrate fauna (New 1991), they should not be used as excuses to sit back and complain 'that its too hard'

Invertebrate conservation in Australia has been steadily gaining momentum over the last decade. Four biannual meetings have been held around the country specifically focussed on invertebrate biodiversity and conservation, of which the proceedings of three have been published (Ingram *et al*. 1994; Yen and New 1997; Ponder and Lunney 1999). In addition, the publication of the overview mentioned above, and a book by New (1995), has done much to raise the awareness and profile of invertebrates in the wider community.

This Review is designed to further this process, via a mechanism consistent with, and more formally tied to, current threatened species legislation and activities. Previously a number of documents (Key 1978; Hill and Michaelis 1988; Yen and Butcher 1997) have presented lists of invertebrate species of conservation concern. In addition, there have been some limited treatments of particular faunal components, e.g. crustaceans (Horwitz 1990), dragonflies (Hawking 1999) and freshwater molluscs (Ponder 1997). In the majority of these cases there has not been formal objective assessment of the species conservation status. This Review makes a first attempt at such assessment and hopefully provides a framework for future efforts.

2. Methods

2.1 Selection of taxa

Formally assessing the conservation status of even a small fraction of the 300,000 or more Australian species of non-marine invertebrates is a daunting, if not impractical task. This stems, not because there are so many species, but because we have very little relevant biological, ecological and distribution data for the vast majority of species. In addition, even in cases where such data are available, there are no comparable historic data on species ranges, numbers of populations or population sizes, on which to base the necessary comparisons.

The approach we have taken within this Review has been to select 25 species covering a range of taxonomic groups, habitat types and geographic distribution. Butterflies have not been included in this plan as a separate Action Plan for Australian Butterflies in currently under development. THESE 25 SPECIES SHOULD NOT BE VIEWED AS BEING PRIORITY TAXA IN ANY REAL SENSE. All of them, however, are in need of conservation protection. The idea of choosing the 25 most important, or at risk, taxa among a group of 300,000, even if we had complete information, is obviously nonsense. Rather, we view these taxa as being representative of larger taxonomic groupings (e.g. dragonflies in general), habitat type (e.g. grasslands), geographic range (e.g., alpine areas) or unique faunal elements (e.g. Remipedia) and potential threat (see Tables 1&2). Obviously a species-based approach to conservation of the invertebrate fauna is not practicable given the large numbers of taxa, thus it is more desirable to focus on these representative larger groupings. It is likely that future 'formal' invertebrate conservation efforts will be at group and landscape levels, rather than focused on single species.

Our choice of taxa was made after wide consultation with both professional and amateur invertebrate biologists. This was achieved by a number of mechanisms (see Figure 1). Initially we compiled a list of over 800 species for which any conservation concern had been expressed in the literature, or that were listed on any threatened species list, including the IUCN Red List. This list was put up on the CSIRO Entomology web site and widely advertised through broadcast e-mails to members of the Australian Entomological Society and participants in the 1997 Invertebrate Biodiversity and Conservation meeting held in Sydney. The web site asked people to check the list for accuracy, and make suggestions for additions and deletions. This site will be maintained in the future and regularly updated (http://www.ento.csiro.au/conservation/actionplan.html).

Secondly a presentation on the development of the Review was given at the 1999 meeting of the Australian Entomological Society. Finally, selected experts on certain taxa were approached for assistance. Using this approach we hoped to ensure that the coverage of taxa would be representative. The final list of 25 species was based on the responses, and does not represent any special preference of the authors. The only prerequisite for inclusion was that sufficient knowledge or data were available for the species to enable objective assessment of their conservation status. The decision to include taxa already listed on State or Commonwealth threatened species lists was made by Environment Australia.

Table 1. Taxonomy, distribution and status of selected taxa

SPECIES	FAMILY	COMMON NAME	DISTRIBUTION	LISTED	HABITAT TYPE	ENDANGERED COMMUNITY	PROTECTED IN RESERVE
Arthropoda – Arachnida *Idiosoma nigrum*	Ctenizidae	Shield-backed trapdoor spider	SW WA	Vulnerable (WA)	*Eucalyptus/Acacia* woodland	No	No
Arthropoda – Collembola ***Dinaphorura tooheyensis***	Onychiuridae	Toohey Forest Collembola	S QLD	Unlisted	*Eucalyptus planchoniana* woodland	National Estate	Yes
Arthropoda – Insecta ***Aulocopris matthewsi***	Scarabaeidae	Dung beetle	N QLD	Unlisted	Microphyll vine-fern thicket rainforest	No	Yes
Clarissa tasbates	Pergidae	Wingless sawfly	TAS	Unlisted	Subalpine *Eucalyptus* woodland	World Heritage Area	Yes
Cooloola spp.	Cooloolidae	Cooloola & sugarcane monsters	S QLD	Unlisted	Sugarcane fields; *Casuarina* forest	No	Part
Cooraboorama canberrae	Gryllacridae	Canberra raspy cricket	ACT	Unlisted	Temperate grassland	Yes	Part
Dirce aesiodora	Geometridae	Pencil pine moth	TAS	Vulnerable (TAS)	Montane rainforest with pencil pine	World Heritage Area	Yes
Edwardsina gigantea	Blephariceridae	Giant torrent midge	NSW, ACT	Endangered (IUCN)	Clear torrential mountain streams	No	Most
Hygrobia australasiae	Hygrobidae	Water beetle	QLD, NSW, VIC, SA, TAS	Unlisted	Still ponds	No	No
Lissotes latidens	Lucanidae	Broad-toothed stag beetle	TAS	Endangered (TAS)	Wet sclerophyll forest	No	Part
Nothomyrmecia macrops	Formicidae	Dinosaur ant	SA	Specially protected (WA), Critically Endangered (IUCN)	Old growth mallee	No	Part
Petalura spp.	Petaluridae	Giant dragonfly	NSW, QLD	Endangered (NSW)	Swamps and bogs	No	Most
Petasida ephippigera	Pyrgomorphidae	Leichardt's grasshopper	NT	Unlisted	Sandstone outcrops with *Pityrodia* and *Dampiera*	No	Yes
Phyllodes imperialis	Noctuidae	Pink underwing moth	S QLD	Unlisted	Primary lower montane rainforests	National Estate	Yes
Reikoperla darlingtoni	Gripopterygidae	Mt Donna Buang wingless stonefly	VIC	Threatened (VIC)	Streams within wet montane *Eucalyptus* forest	No	Yes

SPECIES	FAMILY	COMMON NAME	DISTRIBUTION	LISTED	HABITAT TYPE	ENDANGERED COMMUNITY	PROTECTED IN RESERVE
Synemon plana	Castniidae	Golden sun moth	ACT, NSW, VIC	Endangered (ACT) Endangered (NSW) Threatened (VIC)	Temperate grasslands and grassy woodlands	Yes	No
Taskiria otwayensis	Kokirridae	Caddis fly	VIC	Unlisted	*Eucalyptus* forest	No	Part
Tenogogonus australiensis	Gerridae	Water strider	N QLD	Unlisted	Streams with closed rainforest canopy	No	No
Xylocopa aeratus	Anthophoridae	Metallic green carpenter bee	SA, VIC, NSW	Unlisted	Open heathy forest with *Xanthorrhoea*	No	Part
Arthropoda – Malacostraca *Euastacus armatus*	Parastacidae	Murray crayfish	NSW, ACT, VIC, SA	Vulnerable (ACT) Protected (SA) Vulnerable (IUCN)	Cool rivers with soft banks	No	No
Arthropoda – Remipedia *Lasionectes exleyi*	Spekeonectidae	Remipede	WA	Vulnerable (WA) Vulnerable (CWLTH)	Caves and sinkholes	Yes	No
Annelida – Oligochaeta *Megascolides australis*	Megascolecidae	Giant Gippsland earthworm	VIC	Threatened (VIC) Vulnerable (CWLTH) Vulnerable (IUCN)	Moist soils under open forest	National Estate	Part
Mollusca – Gastropoda *Adclarkia dawsonensis*	Camaenidae	Boggomoss snail	S QLD	Unlisted	Brigalow boggomoss	No	No
Notopala sublineata	Viviparidae	River snail	NSW, VIC, SA	Unlisted	Sublittoral areas of rivers	No	No
Onychophora *Euperipatoides rowelli*	Peripatopsidae	Tallaganda velvet worm	NSW, ACT	Unlisted	Old logs in wet and dry sclerophyll forest	No	Part

Table 2. Representational status of the selected taxa

SPECIES	FAMILY	REPRESENTATIVE OF			
		TAXON	HABITAT	GROUP	THREAT
Arthropoda – Arachnida *Idiosoma nigrum*	Ctenizidae	Spiders & scorpions	Dry sclerophyll woodlands with sparse litter and heavy clay soils	Soil fauna; unique faunal elements; agricultural remnants	Habitat fragmentation; agriculture; feral animals
Arthropoda – Collembola ***Dinaphorura tooheyensis***	Onychiuridae	Springtails	*Eucalyptus* woodland	Soil and litter fauna	Urban development
Arthropoda – Insecta ***Aulocopris matthewsi***	Scarabaeidae	Dung beetles, scarabs	Tropical rainforest	Rainforest relict fauna	Habitat fragmentation
Clarissa tasbates	Pergidae	Sawflies	Cool temperate subalpine forest	Unique faunal elements	Habitat fragmentation; recreation; climate change
Cooloola spp.	Cooloolidae	Cooloolidae	*Casuarina* forest on sandy soils	Agricultural remnants; Unique faunal elements	Land clearing; agriculture; tourism
Cooraboorama canberrae	Gryllacridae	Crickets	Temperate grasslands	Grassland remnants	Habitat fragmentation; agriculture; urban expansion; invasive species
Dirce aesiodora	Geometridae	Archiearine moths	Montane rainforest	Unique faunal elements; rainforest relicts	Host plant loss; climate change; fire; disease
Edwardsina gigantea	Blephariceridae	Torrent midges	Fast flowing mountain streams	Stream fauna, unique faunal elements	Pollution; hydrological changes
Hygrobia australasiae	Hygrobidae	Water beetles	Still water bodies	Pond fauna	Eutrophication; wetland drainage/alteration
Lissotes latidens	Lucanidae	Flightless stag beetles	Wet sclerophyll forest	Soil and litter fauna	Habitat loss; clearing; forestry
Nothomyrmecia macrops	Formicidae	Ants	Old growth mallee	Faunal relicts;	Habitat fragmentation; human impact
Petalura spp.	Petaluirdae	Dragonflies	Swamps and bogs	Swamp fauna; unique faunal elements; faunal relicts	Swamp drainage; agriculture; changes in water quality
Petasida ephippigera	Pyrgomorphidae	Grasshoppers	Tropical heathland	Unique faunal elements	Fire; human impact; habitat fragmentation
Phyllodes imperialis	Noctuidae	Moths	Lower montane rainforest	Unique faunal elements; rainforest relicts	Habitat loss and fragmentation; host plant loss
Reikoperla darlingtoni	Gripopterygidae	Stoneflies	Montane wet *Eucalyptus* forest	Aquatic fauna, alpine forest remnants	Human impact; changes in water quality;
Synemon plana	Castniidae	Day flying moths	Temperate grassland and grassy woodland	Unique faunal elements; grassland fauna	Habitat fragmentation; agriculture; weed invasion
Taskiria otwayensis	Kokirridae	Caddis flies	Flowing streams	Forest relictual fauna	Forestry; pollution; changes in water quality

SPECIES	FAMILY	REPRESENTATIVE OF			
		TAXON	HABITAT	GROUP	THREAT
Tenogogonus australiensis	Gerridae	Water striders	Tropical rainforest streams	Rainforest remnants; stream fauna; unique faunal elements	Vegetation change; habitat fragmentation;
Xylocopa aeratus	Anthophoridae	Bees	Open forest	Pollinators	Habitat loss and destruction; fire; competition
Arthropoda – Malacostraca *Euastacus armatus*	Parastacidae	Freshwater crayfish	Streams	Aquatic fauna	Overexploitation; hydrological changes; pollution; disease; agriculture
Arthropoda – Remipedia *Lasionectes exleyi*	Spekeonectidae	Cave fauna	Caves and sinkholes	Unique faunal elements; cave fauna	Human impact
Annelida – Oligochaeta *Megascolides australis*	Megascolecidae	Earthworms	Moist soils under open forest	Unique faunal elements; soil fauna	Habitat fragmentation; clearing; agriculture; soil compaction
Mollusca – Gastropoda *Adclarkia dawsonensis*	Camaenidae	Terrestrial molluscs	Brigalow boggomosses	Moist relicts in arid environments; biodiversity 'hotspots'	Wetland drainage; land clearing
Notopala sublineata	Viviparidae	Aquatic snails	Freshwater streams	Unique faunal elements; freshwater fauna	Water regulation; hydrological changes;
Onychophora *Euperipatoides rowelli*	Peripatopsidae	Velvet worms	Sclerophyll forest	Log/litter fauna; unique faunal elements	Forestry; log removal; firewood collection; habitat fragmentation

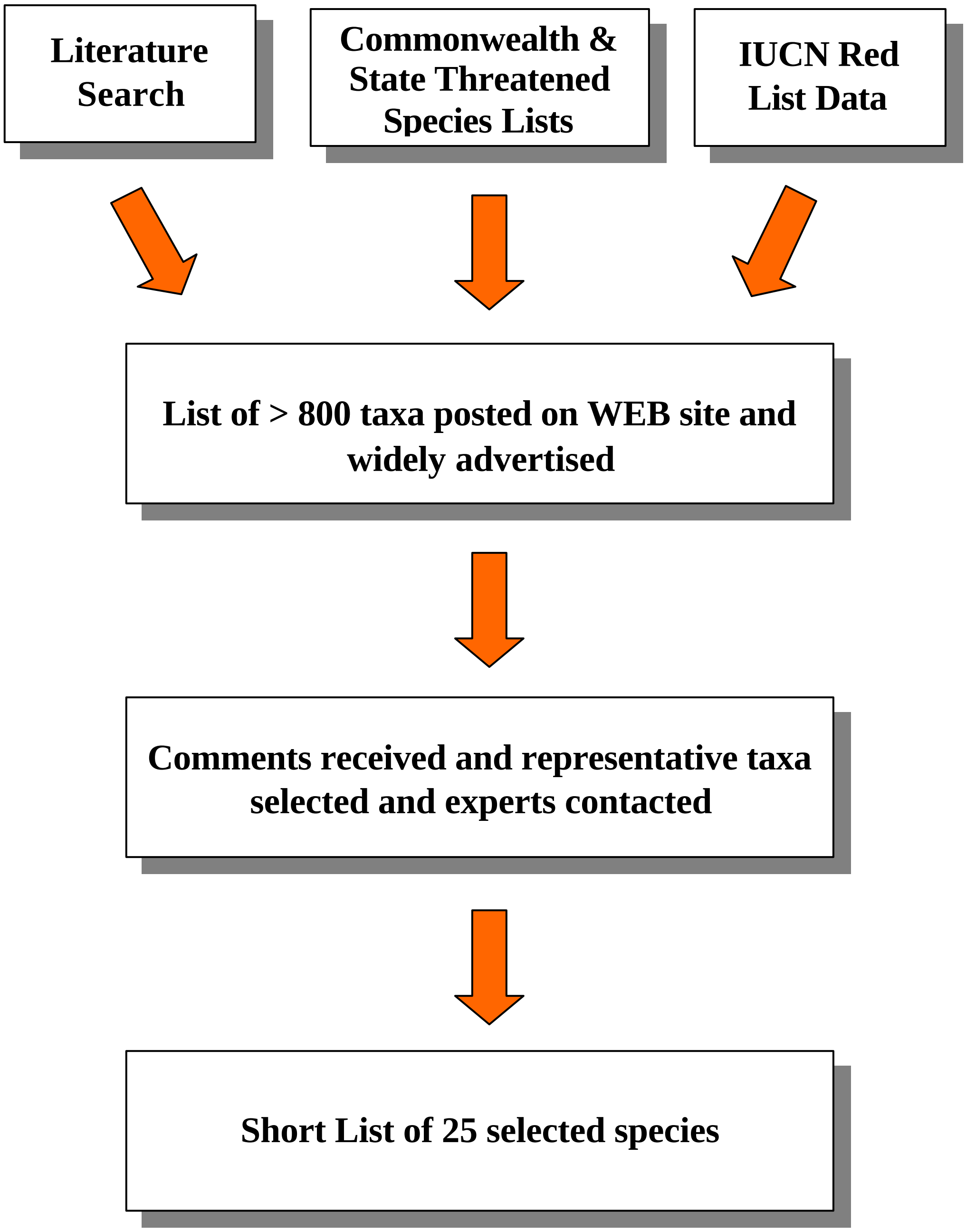

Figure 1. Diagram of methodology used to select species for inclusion in the Action Plan

2.2 IUCN assessment and categorisation

There has been much debate in Australia over the applicability of the 1994 IUCN Red List Criteria (IUCN 1996) for invertebrates (Hutchings and Ponder 1999). A workshop held in Sydney in 1997 to discuss these issues resolved that, while the IUCN criteria provided a useful and valuable framework for assessment of conservation status, some of the individual criteria were unsuitable, or inapplicable, for invertebrates, and for others the threshold needed to be adjusted (Hutchings and Ponder 1999). Much of the debate has surrounded the issue of population size. Accurate assessment of population size is difficult for many vertebrate species, but is even more so for the majority of invertebrates. Many species have different life stages present at different times and it is unclear at which stage population size should be calculated. The most serious problem is that most invertebrate species display large fluctuations from season to season and year to year, as is to be expected of most poikilotherms. Thus even if it was possible to accurately assess population size, it would be difficult to determine if any change in the number over time was due to natural variation or not, unless the populations was followed for a very long time. Workers on many small mammal populations that undergo similar population dynamics have also identified this problem. It should be noted that the IUCN criteria are currently under review (Isaac and Mace 1998).

However, although there are some limitations of the current IUCN criteria as applied to invertebrates, the advantage of the IUCN system is that the individual criteria are relatively independent, and it is possible to effectively apply other criteria, not based on population size, to many, if not all, invertebrate species, providing data are available. Estimates of numbers of populations are readily available or obtainable for many taxa, as are extent of occurrence and area of occupancy. IUCN criteria have been effectively applied for Australian dragonflies (Hawking 1999). The IUCN categorisation scheme has the advantage that it is internationally recognised and does provide some degree of objective standardisation across taxa and political boundaries.

Despite the debate within the invertebrate community over the applicability of IUCN criteria for categorisation, there have been very few attempts to actually apply the criteria to assess their usefulness. In this Review we have made such an attempt using the software application *Ramas RedList* (Akçakaya and Ferson 1999). This software works in much the same way as doing manual assessment. Data are gathered on distribution, biology, ecology, population numbers and sizes and their rates of change, and then used to make assessment against each criterion (IUCN 1996). In addition to being a lot faster, and perhaps more objective, this application has the advantage that it can incorporate any uncertainty in the data. For example it is possible to enter a range of values for most parameters, which might range form best to worst estimates. Another advantage is that this range does not have to be linear as the program uses fuzzy numbers within its algorithms. For example an estimate for the number of populations might be 10 (worst case), 40 (best case) and 25 (best guess); these are entered into the program as the fuzzy number 10,25,40. The program can also take into account the quality of the data, by the use of data qualifiers. Data based on actual observation or calculation are given greater weight than comparable data based on best guess or indirect methods. The output presents the IUCN category assigned, and where appropriate the range of 'possible' categories, for example Vulnerable-Endangered. It also outputs the influence of each criterion to the final assessment so that it is possible to determine the basis on which the categorisation was made. Outputs for all assessments of the 25 taxa within this Action Plan are available from the authors. Relevant experts on each taxon provided data for input into the program.

The results of the categorisation were as expected. Species were categorised either Critically Endangered or Data Deficient (see Table 3). Our choice of taxa was such that we assumed they were all of serious conservation concern. For some species however there were insufficient data to enable a formal assessment. An interesting result is that for many species a range of threat categories were suggested, in some cases ranging from Vulnerable through to Critically Endangered. This represents the uncertainty in the data in relation to estimated number of populations, population sizes and rates and extent of change. The identification of a range of possible threat categories and the contribution of each individual IUCN criterion in the determination is very useful as a conservation tool, as it allows the identification of which factors are most important in changing a species' conservation status. For example it might be identified that for a particular species the number of populations was the major factor contributing to the range of threat category and that population size was less important (in terms of its influence on categorisation). Such a result might suggest that conservation efforts could be concentrated on increasing the number of populations rather than the number of individuals within populations.

It needs to be stressed that there are some inherent biases in the IUCN criteria. For example if all known populations of a given species are severely fragmented (effectively small and isolated) it will be categorised as threatened regardless of the number of, or size, of populations. Under most circumstances this will be reasonable in a biological sense, but it highlights the need to take care when interpreting IUCN categories and to consider the actual criteria under which the categorisation has been determined.

In cases where a range of threat categories has been determined we have applied the Precautionary Principle and selected the more severe category as representing the conservation status of the species.

Table 3. IUCN categorisation of selected taxa based on *RAMAS RedList*

SPECIES	IUCN CATEGORY
Arthropoda – Arachnida *Idiosoma nigrum*	Data Deficient
Arthropoda – Collembola ***Dinaphorura tooheyensis***	Critically Endangered
Arthropoda – Insecta ***Aulocopris matthewsi***	Critically Endangered
Clarissa tasbates	Critically Endangered
Cooloola spp.	Data Deficient
Cooraboorama canberrae	Data Deficient
Dirce aesiodora	Critically Endangered
Edwardsina gigantea	Critically Endangered
Hygrobia australasiae	Data Deficient
Lissotes latidens	Critically Endangered
Nothomyrmecia macrops	Critically Endangered
Petalura spp.	Critically Endangered
Petasida ephippigera	Data Deficient
Phyllodes imperialis	Critically Endangered
Reikoperla darlingtoni	Critically Endangered
Synemon plana	Critically Endangered
Taskiria otwayensis	Data Deficient
Tenogogonus australiensis	Data Deficient
Xylocopa aeratus	Data Deficient
Arthropoda – Malacostraca *Euastacus armatus*	Data Deficient
Arthropoda – Remipedia *Lasionectes exleyi*	Critically Endangered
Annelida – Oligochaeta *Megascolides australis*	Critically Endangered
Mollusca – Gastropoda *Adclarkia dawsonensis*	Critically Endangered
Notopala sublineata	Critically Endangered
Onychophora *Euperipatoides rowelli*	Data Deficient

3. Conservation Status of Invertebrates

3.1 Threats

The major threats facing non-marine invertebrate species are similar to those faced by all freshwater and terrestrial species. Yen and Butcher (1997) provide an excellent detailed discussion of the threats impacting invertebrate species and only a summary of these are presented below.

Yen and Butcher (1997) listed 13 primary threatening processes impacting non-marine invertebrates:

1. Agriculture and clearing of native vegetation
2. Habitat fragmentation
3. Grazing and trampling
4. Inappropriate fire regimes
5. Forestry activities
6. Pollution
7. Pests and diseases
8. Alterations to aquatic ecosystems
9. Mineral extraction
10. Transport and recreation
11. Exotics and introduced taxa
12. Direct exploitation
13. Long term environmental changes

A number of these processes obviously overlap and there are interactions among them. Yen and Butcher (1997) found that all these processes have the potential to detrimentally impact invertebrate populations, as they do both vertebrate and plant populations. However, very little quantitative or qualitative research has been done which documents these impacts.

There has been considerable debate, particularly among the butterfly community, as to whether collection of specimens constitutes a threat to long-term species or population survival. Yen and Butcher (1997) argue that overcollecting should only be viewed as a threat when a population is already in decline due to other processes. In fact, the collection of specimens by amateurs and professionals has previously provided much-needed biological, ecological and distributional data for many species. This issue will be discussed in more detail in the Action Plan for Australian Butterflies.

3.2. Invertebrates currently recognised as threatened

There are currently 374 species of Australian invertebrates (predominantly freshwater and terrestrial molluscs) listed on the 2000 *IUCN Red List of Threatened Species* (Hilton-Taylor 2000) (see Appendix 2). This represents less than 0.5% of known taxa. By comparison over 20% of Australia's 282 species of mammal are listed as threatened, 14% of our amphibians and 6% of our birds. At the Commonwealth level there are only four invertebrates (a butterfly, two crustaceans and a worm) listed as threatened (vulnerable) under the *Environment Protection and Biodiversity Conservation Act* 1999, representing less than 0.005% of the known fauna. Within the States and Territories there are a total of over 1,000 animal species listed under their respective threatened species legislation, of which 97 are invertebrates (excluding butterflies) (see Appendix 1). Neither South Australia nor the Northern Territory have any invertebrates listed.

There may be a number of reasons for the under-representation of invertebrates in current listings. Firstly, with the exception of a few groups, taxonomic, biological and distribution data are not available for the vast majority of invertebrate taxa, and thus it is difficult to assess their conservation status. Groups for which information is available are not representative of their relative proportions of the invertebrate fauna in general, and represent their popularity among research workers and amateurs (e.g. butterflies). Secondly, the invertebrate fauna may simply receive less conservation attention and effort than vertebrates for a range of political and social reasons (the 'cute and cuddly' syndrome) and thus there is little interest in their conservation status. Thirdly, invertebrates may be less sensitive to perceived threatening processes than vertebrates. It is commonly argued that because of their small size invertebrates are able to maintain larger population sizes than vertebrates in a given patch area, and are thus less likely than vertebrates to suffer the demographic and genetic consequences of small population size. Finally, it is often perceived that by focussing conservation and protection attention on the larger vertebrates then smaller, less demanding components of the fauna, will be afforded protection by default (i.e., the umbrella species concept). In reality the reason for the general under-representation of invertebrates in threatened species lists is probably a combination of all these (and probably other) factors. Very little research on these issues has been undertaken either in Australia or globally.

The issue of listing species has been a topic of debate among conservation biologists for over two decades. It has been argued that listing, especially when associated with legislation, can be detrimental to overall species conservation in that it focuses too much on species level conservation, rather than threatening processes, and habitat or landscape level issues. In general there is NO debate that habitat conservation is the primary goal of all conservation efforts. Even species level Recovery Plans have conservation of species' habitat and threat abatement as their primary focus. However, a certain amount of species-level information is required when making management decisions about habitats and landscapes. Decisions made at these levels without such species-level information can be fraught with danger. For further discussion of this topic as it specifically applies to invertebrates the reader is referred to Yen and Butcher (1997) and references therein.

There is provision within the various State and Commonwealth endangered species legislation for the listing of threatened ecological communities. However, to date very few such communities have been listed, and almost all have been based on vegetation type (eg temperate grasslands, white box woodlands) rather than faunal components. Only a single faunal community (Butterfly Community No. 1) has been listed (Victorian *Flora and Fauna Guarantee Act*). The difficulty in listing ecological communities lies in the inherent problems of community definitions. Defining a community in sufficiently explicit detail to fulfil the legislative legal requirements for protection is problematic. However, it is obvious that such landscape-scale protection will be the most effective means of conserving large components of our invertebrate fauna in the future.

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4. Species Synopses

This section details information on the 25 taxa included in this Review. Each synopsis is structured to provide the following information.

1. General taxonomic status of the species, including an illustration
2. Species survival status – includes information of current listing under State or Commonwealth legislation, or on the 1996 *IUCN Red List of Threatened Species* (Hilton-Taylor 2000). Also included is the IUCN categorisation determined by application of the *Ramas RedList* software program (Akçakaya and Ferson 1999)
3. Species distribution – a map of current distribution is provided at the end of each synopsis overlaid with Conservation and Protected Areas.
4. Habitat details
5. Biological overview
6. Significance – details of the biological, ecological, and scientific significance of the species which have contributed to its inclusion in the plan
7. Threats
8. Conservation objectives
9. Conservation actions already initiated for the taxon
10. Conservation actions required for long-term conservation of the species. This section is subdivided into research and management needs.
11. A list of relevant experts
12. References

In preparing each synopsis we have attempted to maintain consistency throughout. However, there is some level of heterogeneity among them. For some species (e.g., *Euastacus armatus*) there is a considerable amount of information available on their biology, habitat requirements, distribution, threats and conservation/management requirements, whereas for others (e.g., *Tenogogonus australiensis*) this information is relatively scant. For these lesser-known species identification of threats and required conservation action was more difficult, and by necessity are relatively generic in nature. This heterogeneity is a true reflection of the state of current knowledge of our invertebrate fauna.

The preparation of each synopsis was undertaken in consultation with one or more relevant experts for the taxon under consideration. A final draft of each synopsis was checked for accuracy by at least one expert. Hence the information contained within each synopsis is based on up-to-date expert opinion.

Adclarkia dawsonensis	**Boggomoss Snail**

Phylum: Mollusca **Class:** Gastropoda **Order:** Eupulmonata
Family: Camaenidae
Scientific name: *Adclarkia dawsonensis*
Common names: Boggomoss Snail

1. Taxonomic status (including species and subgroups)

Adclarkia dawsonensis Stanisic, 1996.

'*Adclarkia*': for Adam Clark of Taroom; '*dawsonensis*': in reference to the Dawson Valley

This species, described in 1996, is the only member of the genus *Adclarkia* (Stanisic 1996).

2. Species survival status

Currently not listed under any State or Commonwealth legislation. One of the *Adclarkia* sites (Isla-Delusion) is under consideration for inclusion on the Register of the National Estate (J. Stanisic personal communication).

Adclarkia dawsonensis is not listed on the 2000 *IUCN Red List of Threatened Species.* Assessment of the IUCN categorisation for the species using the *Ramas RedList* software program (Akçakaya and Ferson 1999) indicated that it may be Critically Endangered.

3. Distribution

Two populations of *Adclarkia dawsonensis* are found in the Dawson Valley, northeast of Taroom, on the Dawson River, southeastern Queensland (Stanisic 1996).

4. Habitat

The Dawson Valley is found within the Brigalow Belt of eastern Queensland. Much of this area has been cleared for agriculture, but some of the Brigalow (*Acacia harpophylla*) still remains as dry open forests and woodland, with scattered pockets of semi-evergreen vine thickets dominated by the narrow-leaved bottle tree (*Brachychiton rupestre*) (Johnson 1984). The area is sub-humid, with a rainfall of 600–700mm annually (Stanisic 1996). This environment is far too harsh for many land snails, and they are dependent on oases of moist habitat found scattered within it (Bishop 1981).

Field surveys suggest that *A. dawsonensis* is confined to the alluvial flats and riparian environments between Taroom and Theodore. Much of the soil here is a well-drained brown/grey loam and clay derived from basalt. Most of this habitat has been cleared for farming and little original vegetation remains. On Mt Rose Station, northeast of Taroom, remnant alluvial habitat is associated with a series of unconnected boggomosses. A boggomoss is a small peat bog that is formed by water from underlying aquifers of the Great Artesian Basin being pushed to the surface through mound springs. *A. dawsonensis* survives on one of these. These moist habitats are dominated by water-tolerant species, such as Coolibah trees (*Eucalyptus coolibah*), sedges and ferns. These isolated fragments occur scattered throughout the landscape. However, the vegetation on each boggomoss is different (J. Stanisic personal communication). This type of environment produces a lot of litter and debris, within which the snails live (Stanisic 1996).

Closer to Theodore, *A. dawsonensis* is found in a small patch of riparian habitat in a stock and water reserve. Here the vegetation is dominated by forest red gum (*Eucalyptus teretecornis)*, palm trees *(Livistona* sp) and sandpaper fig (*Ficus* sp).

5. Biological overview

The shell of *A. dawsonensis* is light brown, becoming greenish-yellow towards the horn, with a white lip. Some specimens also exhibit a narrow red subsutural band and a small red circumumbilical patch. *A. dawsonensis* has a thin shell, with an average diameter of about 23 mm that is made up of 5 1/8 – 5 5/8 whorls. The helicoid shell is 15 mm high with a depressed spire (Stanisic 1996). The animal itself is light brown to white, with the amount of grey around the neck, on the sides of the foot and above the tail differing between specimens (Stanisic 1996). Refer to Stanisic (1996) for a more detailed description.

The life history, lifespan, growth rates and mode of reproduction are unknown for *A. dawsonensis*. Other camaenid snails are known to live for up to four years without food, so it may be long lived (Bishop 1981; Stanisic 1994; Ponder 1997a). It is assumed that, like many other snails, it feeds on decaying plant matter, bacteria and fungi (Bishop 1981). Population size and seasonal rates of change in abundance are unknown.

Stanisic (1996) suggests that *flooding in the past may have dispersed A. dawsonensis*. Following clearing, in the absence of the floodplains, dispersal of the species is limited to the opportunistic colonisation of drainage lines and boggomosses (Stanisic 1994; Ponder 1997b).

6. Significance

Non-marine molluscs comprise the largest number of recorded extinctions in Australia during the last 200 years (Ponder 1997b). Over 98% of non-marine molluscs found in Australia are believed to be endemic (Ponder 1997b). However, in Eastern Australia alone, it is estimated that 75% of land snails are still to be described (Stanisic 1999).

Snails are a vital part of the environment as they feed on dead and decaying plant material, thus assisting in keeping the habitat clean and free of diseases, and maintaining the balance of other decomposers. Land snails may also assist in identifying areas of climatic refugia for conservation, due to their specific moisture requirements (Stanisic 1994, 1999).

Snails in general are an important food source for birds, frogs, reptiles, and some insect larvae.

Biological information about *A. dawsonensis* and other land snails is very limited, yet it is believed that many species are being lost to extinction (Ponder 1997a,b; Queensland Museum 1999). As only 5% of Australia is suitable for many land snails, it is critical to protect the remaining suitably moist fragments (Ponder 1997b; Queensland Museum 1999).

As very little is known about these habitats, more information is vital to a full understanding of their importance as refugia for many moisture adapted organisms, and why the vegetation differs so greatly between sites. Further studies on the boggomoss habitats have already shown that these habitats are home to many invertebrates, including another land snail *Elsothera hewittorum* (Stanisic 1996; Queensland Museum 1999). Many of these patches of moist habitat may prove to be localised 'hotspots' of biodiversity, and may be vital to the conservation of many species, due to the presence of permanent water and the antiquity of the remnant biota (Stanisic 1996; Ponder 1997b; Queensland Museum 1999).

Fensham (1998) showed that the vegetation found in boggomosses form a complex and unique combination of plant species. Many high quality sites, where there is limited disruption by cattle and weed invasion, contain species listed on the Queensland Register of Rare or Threatened species. It is unknown how many boggomoss habitats are within conservation reserves and National Parks.

7. Threats

Over the last three decades six million hectares of Brigalow-dominated communities have been cleared, and this process is still continuing (Glazning 1995; Ponder 1997b; Queensland Museum 1999). Sattler and Webster (1984) indicated that only about 0.5% of the original Brigalow-associated communities still remained in Queensland in 1984. Little has been done since then to quantify the extent of clearance (Fensham *et al*. 1998). Approximately 2.2% of Brigalow-dominated habitats within the Brigalow Belt are reserved in protected areas (Young *et al*. 1999). Much of the remaining stands are found on freehold land and are threatened by development (Pulsford 1984; Fensham *et al*. 1998).

It is believed that such widespread habitat destruction makes these small pockets of boggomosses extremely vulnerable, either to deliberate destruction or habitat change, especially drying out, once the surrounding vegetation is removed.

The possibility of fire is also a major threat, as a fire may destroy the last remnants of moister habitat (Ponder 1997b; Queensland Museum 1999). Since these remnants are small, they are particularly vulnerable to the passage of hot fires, and the moisture will not serve as a sufficient impediment.

Current leasing arrangements also allow for use of the Isla-Delusion site as a stock reserve, with associated tree clearing and quarrying (J. Stanisic personal communication). Trampling by stock and feral animals may pose a problem, as they compact the soil and destroy the vegetation, thereby causing the habitat to dry out. This has already happened in some of the 50 remaining boggomoss sites (Stanisic 1996; Ponder 1997b; Queensland Museum 1999). The frailty of the shell of *A. dawsonensis* suggests that this species may be particularly sensitive to any habitat modification that exacerbates dryness. Indeed, the range may have already contracted due to this process (Stanisic 1996).

A proposal to dam the Dawson River would flood the boggomoss habitat and possibly alter the Isla-Delusion habitat through changes in river flows. This could possibly cause the extinction of the boggomoss snail (Queensland Museum 1999). A study undertaken by Fensham (1998) on the impact of the impoundment indicated that up to 58% of the boggomoss sites in the survey would be inundated.

8. Conservation objectives

- To further our knowledge of the distribution and biology of *A. dawsonensis* through surveys and associated research
- The populations so far discovered to be maintained at the current level or increased through habitat protection.

9. Conservation actions already initiated

- Scientists at the Queensland Museum recently documented the fauna of these boggomoss habitats. The information gathered is now being used to illustrate the importance of protecting these pockets because of their role as moist refugia in an otherwise dry environment (Queensland Museum 1999).
- Currently the Isla-Delusion site is under consideration by the Australian Heritage Commission for inclusion on the Register of the National Estate (J. Stanisic personal communication).

10. Conservation actions required

Research

- Investigation into the population biology, reproductive biology, population dynamics and behaviour of *Adclarkia* (Bishop 1981; Queensland Museum 1999).
- Investigation into the distribution, composition and importance of boggomoss habitats (Stanisic 1996; Queensland Museum 1999).

Management

- Due to the sparse nature of these relict habitats, very few are represented in the current system of National Parks. For a group such as molluscs, reserves that may be considered too small for other species may still be suitable (Sattler and Webster 1984b; Ponder 1997b; Queensland Museum 1999). Many non-marine molluscs have very small ranges therefore areas which have a concentration of narrow range endemics (hotspots) should have a high priority for conservation (Ponder 1997b).
- A Rural Conservation Strategy or a set of guidelines and incentives have also been suggested as a way of protecting pockets within the Brigalow Belt (Sattler and Webster 1984b; Queensland Museum 1999), and could be used to protect these boggomoss sites while educating local people about the importance of such fragments.
- The State Government could also alleviate the threat to *A. dawsonensis* by reviewing the proposed damming of the Dawson River. If the dam goes ahead, measures will need to be implemented to keep the impact on boggomoss communities to a minimum. This could involve the relocation of snails to a more suitable habitat (Queensland Museum 1999).

11. Relevant Experts/Data Providers

John Stanisic – Queensland Museum, Brisbane
Rod Fensham – Queensland Herbarium, Brisbane
Penny Greenslade – Australian National University, Canberra

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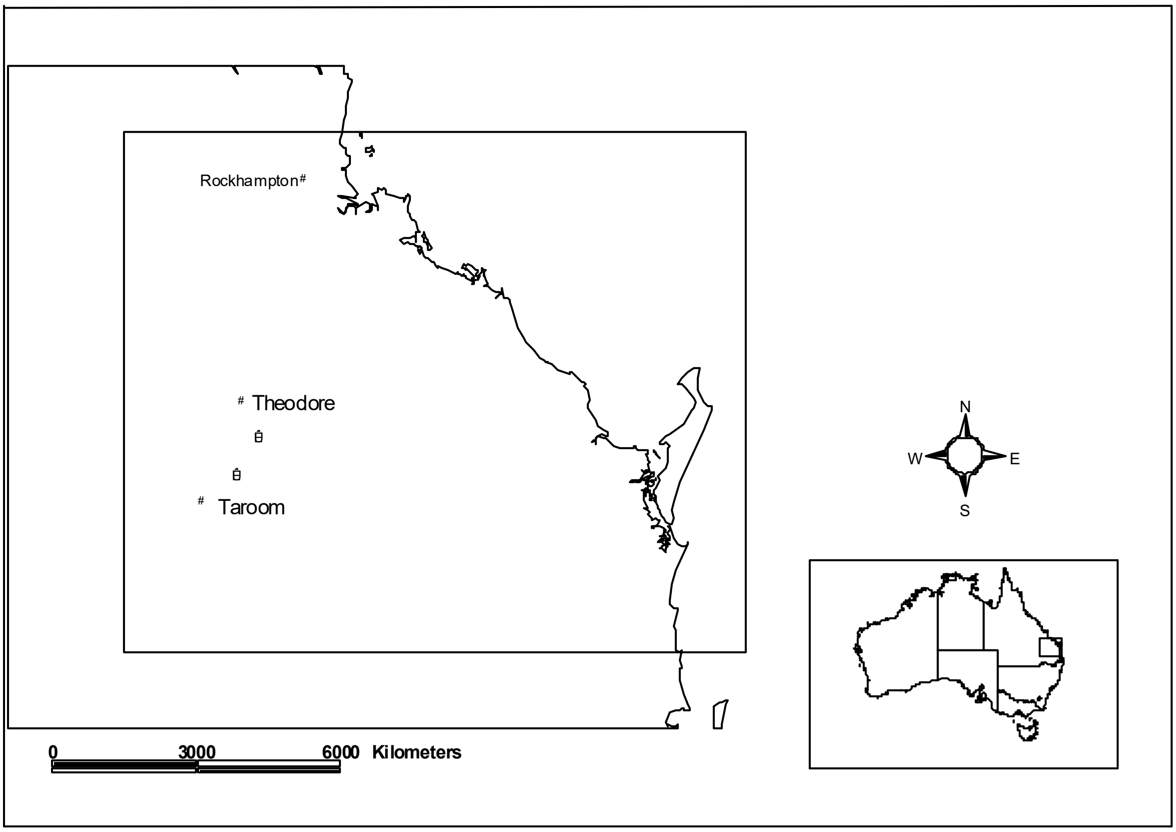
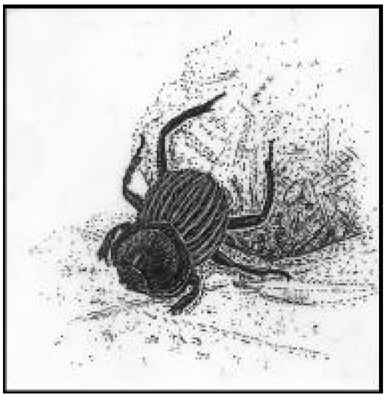


Distribution of *Adclarkia dawsonensis* (source: Stanisic 1996).

Aulacopris matthewsi Dung Beetle



Phylum: Arthropoda **Class:** Insecta **Order:** Coleoptera
Family: Scarabaeidae **Subfamily:** Scarabaeinae
Scientific name: *Aulacopris matthewsi*
Common names: Dung Beetle

1. Taxonomic status (including species and subgroups)

Aulacopris matthewsi Storey, 1986.

'*matthewsi*': named in honour of Dr E.G. Matthews, who worked on the taxonomy of the Australian Scarabaeinae (Storey 1986).

The genus *Aulacopris* consists of three species found in eastern Victoria, NSW, and the southeast Queensland coastal ranges (Storey 1986).

2. Species survival status

Currently not listed under any State or Commonwealth legislation.

Aulacopris matthewsi is not listed on the 2000 *IUCN Red List of Threatened Species*. Assessment of the IUCN categorisation for the species using the *Ramas RedList* software program (Akçakaya and Ferson 1999) indicated that it may be Critically Endangered.

3. Distribution

Aulacopris matthewsi is only found on the eastern ridges of Mt Sorrow, Cape Tribulation North Queensland.

4. Habitat

The vegetation at the site is a simple microphyll vine-fern thicket within continuous rainforest (Storey 1986).

5. Biological overview

Aulacopris matthewsi is approximately 8–11mm long, making it the smallest species in the genus (Storey 1986). What makes this dung beetle unusual is the huge sternal fossa and associated tubercle found in the majority of males (Storey 1986). Their function is unknown. The wings of *A. matthewsi* also are reduced. Although this flightlessness is common in Scarabaeini (close to 50% of Australian species), *A. matthewsi is* the first brachypterous *Aulacopris* species to be discovered (Matthews 1974; Storey 1986). For a more detailed description see Storey (1986).

The larvae of dung beetles live in burrows or chambers in the soil where they feed on provisions of dung supplied by the adult beetles. They have a humped appearance, which is characteristic of the group and reduced legs (Lawrence and Britton 1991).

Nothing is known of the growth or reproduction in *A. matthewsi* populations. It is suspected that, similar to other dung beetles, both adult and larval *A. matthewsi* feed on the scats of macropods and other native animals (Cassis and Weir 1992). Dung beetles are noted for their ability to roll balls of dung, and relocate them to a more suitable site to be used as food for the adult beetles, or are buried for the larvae to feed on. Eggs are laid within each ball, which is then consumed by the developing larvae. The adults also feed on dung (Matthews 1974; Cassis and Weir 1992). *A. matthewsi* pushes the ball by facing backwards and holding the ball with its middle and hind legs, while the front legs and the head are pushing against the ground. Some other dung beetle species pull the ball by standing in front of it and pulling it with the front legs (Matthews 1974; Storey 1986). Extensive trapping for dung beetles (*A. matthewsi* comes readily to dung baited traps) in the Cairns hinterland over the past 25 years has failed to locate any further populations.

Members of the Scarabaeine are able to locate both food and mates easily through smell receptors located on the antennae (R. Storey personal communication).

Currently there is very little known about *A. matthewsi*, thus no estimates of population size are available. However, although believed to be highly localised, it is relatively common at the sites where it has been found (Storey 1986).

6. Significance

Worldwide there are approximately 4,600 species of dung beetles in 220 genera (Cassis and Weir 1992). The other species in the genus *Aulacopris* occur in eastern Victoria, New South Wales, and the southeast Queensland coastal ranges (Matthews 1974).

Dung beetles are vital components of the nutrient cycle as they break down organic waste by feeding on it. Nearly all Scarabaeinae are coprophagous, many specialised on different types of dung, while others feed on decaying vegetable material (Matthews 1974). Dung beetles are also useful in biological control by reducing breeding sites for many pest species of flies (Lawrence and Britton 1991).

In Australia, many of the genera and species of dung beetles are endemic, suggesting that many areas may hold relict species due to environmental stability and restricted habitats over long periods of time. This refugia status has been linked to the inability to fly in many species, including *A. matthewsi*, which appears to have a highly restricted distribution. As the other members of the genus occur in southeast Australia the discovery of *A. matthewsi* is important (Matthews 1974; Storey 1986; Cassis and Weir 1992). In the wet tropics there are many other beetle species with similar relict distributions that are now restricted to mountain tops where once their distribution was far wider (R. Storey personal communication).

7. Threats

A. matthewsi, like most narrow-range endemic species is particularly susceptible to habitat fragmentation. Its being flightless and thus having limited dispersal ability intensify this.

A. matthewsi needs a reliable supply of dung all year (Storey 1986). With a greater supply of food available the chances of finding both food and a mate increase. However, if the dung supply was to be reduced this would become harder, which would have an overall negative effect on an already limited population (Matthews 1974).

8. Conservation objectives

To determine the distribution, ecological requirements and conservation status of *A. matthewsi* so as to help maintain the current populations.

9. Conservation actions already initiated

The sites where *A. matthewsi* has been found so far occur within Cape Tribulation National Park, and are, therefore protected (Storey 1986).

10. Conservation actions required

Research

- Surveys to determine the distribution and abundance of *A. matthewsi*
- Investigation into the life history, reproduction, and habitat requirements.

Management

- As there are currently no other perceived threats, any other future changes to the site need to be identified and monitored.

11. Relevant Experts/Data Providers

Ross Storey – Queensland Department of Primary Industries, Mareeba

12. References

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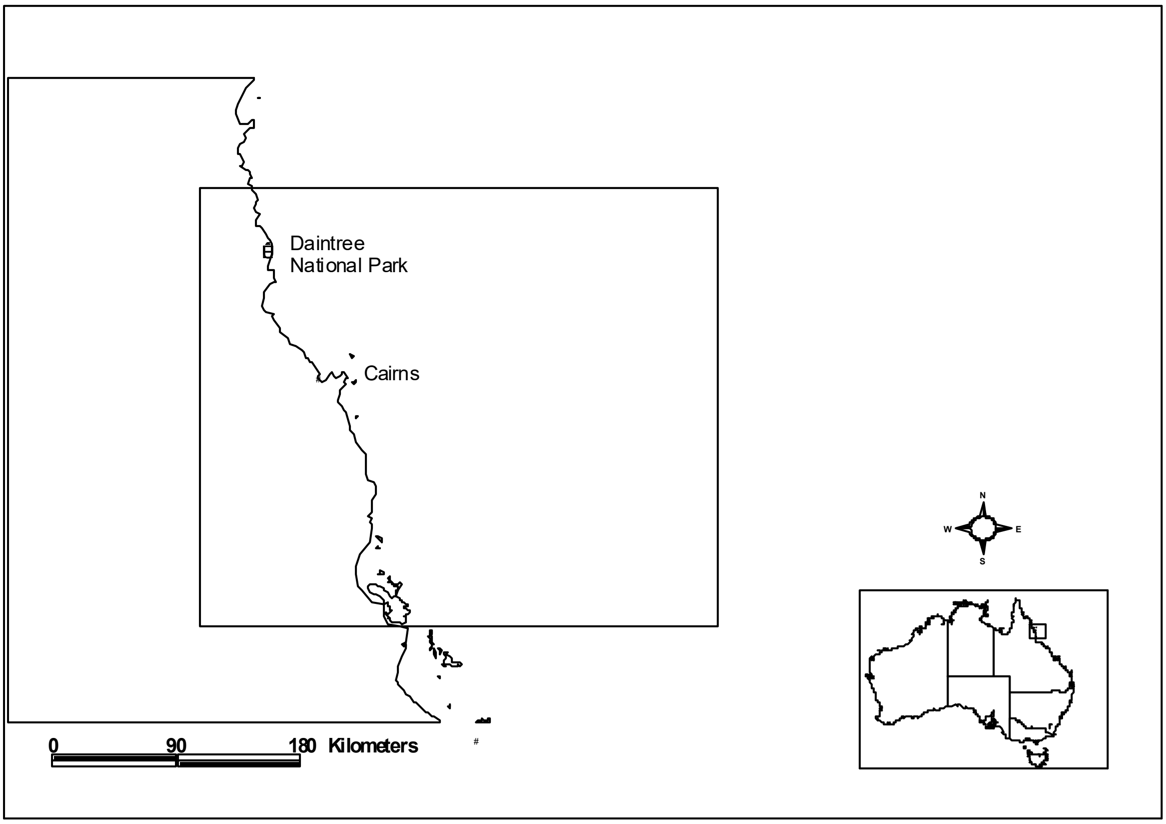
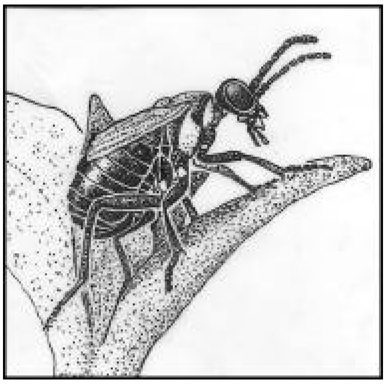


Distribution of *Aulocopris matthewsi* (Source: Storey 1986)

Clarissa tasbates Flightless Sawfly



Phylum: Arthropoda **Class:** Insecta **Order:** Hymenoptera
Family: Pergidae
Scientific name: *Clarissa tasbates*
Common names: Flightess Sawfly

1. Taxonomic status (including species and subgroups)

Clarissa tasbates Naumann, 1997.

'*tasbates*': means 'one that walks over Tasmania', referring to the flightless nature of the sawfly.

The Family *Pergidae* is found in Australia, South America and Papua New Guinea, as well as the Nearctic and Oriental Regions. The genus *Clarissa* is endemic to Australia and consists of 12 species (Naumann 1991, 1997).

2. Species survival status

Currently not listed under any State or Commonwealth legislation.

Clarissa tasbates is not listed on the 2000 *IUCN Red List of Threatened Species*. Assessment of the IUCN categorisation for the species using the *Ramas RedList* software program (Akçakaya and Ferson 1999) indicated that it may be Critically Endangered.

3. Distribution

Clarissa tasbates has only been found within 500 m of Pelion Hut, 860 m above sea level, a site 3 km south of Mt Oakleigh, western Tasmania (Naumann 1997).

4. Habitat

Pelion Hut is found in eucalypt woodland dominated by Alpine Ash (*Eucalyptus delegatensis)* and other subalpine species. The understorey is also made up of subalpine species such as tussock grass (*Poa labillardierei)* and heath and sedges (Naumann 1997, 1998).

The particular collection sites of *C. tasbates* have been in clearings where this habitat type is adjacent to temperate forest, as well as from swampy tussock areas of the woodlands. These sites are humid and sheltered from strong winds. Rainfall and humidity may be an important factor, as these sites are generally moist and cool, and snow is not uncommon, although temperatures can rise to 30^{o}C during mid-summer (Naumann 1997).

5. Biological overview

Sawflies differ form other wasps in that they lack the thin waist that is characteristic of most members of the order (Naumann 1991). The saw, after which the wasp is named, is actually a modified ovipositor which is designed to cut into plant matter so as to lay the eggs, and is an important characteristic in identifying different species of sawflies (Naumann 1997). They do not sting.

The females are approximately 5.6–6.3 mm long. Most of the body is non-metallic dark brown to black, except for the palps, which are a pale brown. Parts of the thorax are reddish-orange, and areas of the mouth are cream coloured. Antennae are present. The females are unique in that they are brachypterous, that is, possessing reduced wings, which are only ? – ½ the length of the abdomen, and tinged brown with brown venation. The males have two pairs of complete wings that are longer than their abdomen, and are similar to the females in colour and venation. The body of the male is approximately 4.7–6.2 mm long and is similar in colour and shape to the female except that the abdomen is slimmer and yellow/orange in colour. The lower legs are orange/brown. The larvae are longer than the adult and are predominantly black with the tubercles forming paler bands on the grainy body. Larvae that have recently undergone a moult are orange pink with dark brown bands. For a more detailed description see Naumann (1997).

Little is known of the biology or ecological requirements of *C. tasbates*. Sawflies are leaf eaters, and the larvae of *C. tasbates* are believed to feed on the dead leaves of tussock grass (*P. labillardierei)* and other herbs which grow in the grasslands (Naumann 1991, 1998).

As yet little is known about reproduction in *C. tasbates*. Surveys suggest that mating may occur in summer, as adults have only been caught in early and mid summer, while larvae have only been seen feeding in late summer. The species appears to pupate within the leaf litter where they form black oval cocoons, are camouflaged by webbing dead leaves around the outside of the cocoon (Naumann 1997, 1998).

Adult sawflies generally are active in the daytime, particularly on sunny mornings and evenings when the humidity is high and there is little wind. *C. tasbates* is different in that it is also active at night (Naumann 1997), and can be seen walking around on grass tussocks and the ground, sometimes in large numbers (Naumann 1997).

Due to their reduced wings the females are unable to fly, but it transpires that the males also are poor fliers. Despite their full wings males may only be able to fly a few meters from the ground (Naumann 1997).

As the species was discovered in 1996, nothing is known about the size or variability of the population.

6. Significance

Clarissa tasbates is a vital species to conserve because it represents the only known brachypterous species in the family Pergidae and is endemic to Tasmania (Naumann 1997, 1998).

Wasps, which are phytophagous, are important in ensuring that pollination occurs, and adult sawflies are no exception.

In turn, wasps provide food for a wide range of other organisms, such as other wasps, ants, nematodes, bugs, lacewings, spiders, frogs, reptiles, birds, and mammals (Naumann 1991).

7. Threats

Little is known about current or possible threats to *C. tasbates*.

As female *C. tasbates* are flightless, the species may be extremely vulnerable to predation and habitat fragmentation.

To date, all *C. tasbates* sites are within the Cradle Mountain/Lake St Claire National Park, (also part of a World Heritage Area), and thus are protected from many of the pressures that cause fragmentation of the habitat. However, the sites are located very near the Overland Walking Track and associated huts, so the impacts of human activity may be a potential threat. Although it does not appear to be threatening the population currently (Naumann 1997), any significant increase in the numbers of walkers may increase the risk of detrimental impacts.(Naumann 1998)

Clarissa tasbates, like many other alpine and subalpine species may be particularly susceptible to habitat and ecosystem changes associated with climate change, particularly increased temperatures and changes in rainfall.

8. Conservation objectives

To determine the distribution and conservation status of *C. tasbates*, and to determine the ecological requirements so as to help maintain the current population.

9. Conservation actions already initiated

As the species is found in a current World Heritage Area, the wasp's habitat is already protected from destruction, although any management or recreation activity in the area needs to consider the impact on the immediate environs and microhabitat.

10. Conservation actions required

Research

- Additional surveys to ascertain whether the species is more widespread. The microhabitat that the sawfly appears to prefer is not restricted to this location, so the species could occur over a much wider area than is currently known (Naumann 1997).
- Further research into the species' ecology and biology.

Management

- The species is already protected in the Cradle Mountain/Lake St Claire National Parks. However, the species needs to be considered when assessing the impacts that any management decisions and recreation activities may have on the habitat.
- A monitoring program needs to be implemented to identify any future threats.

11. Relevant Experts/Data Providers

Ian Naumann – Agriculture, Forestry and Fisheries Australia (AFFA), Canberra.

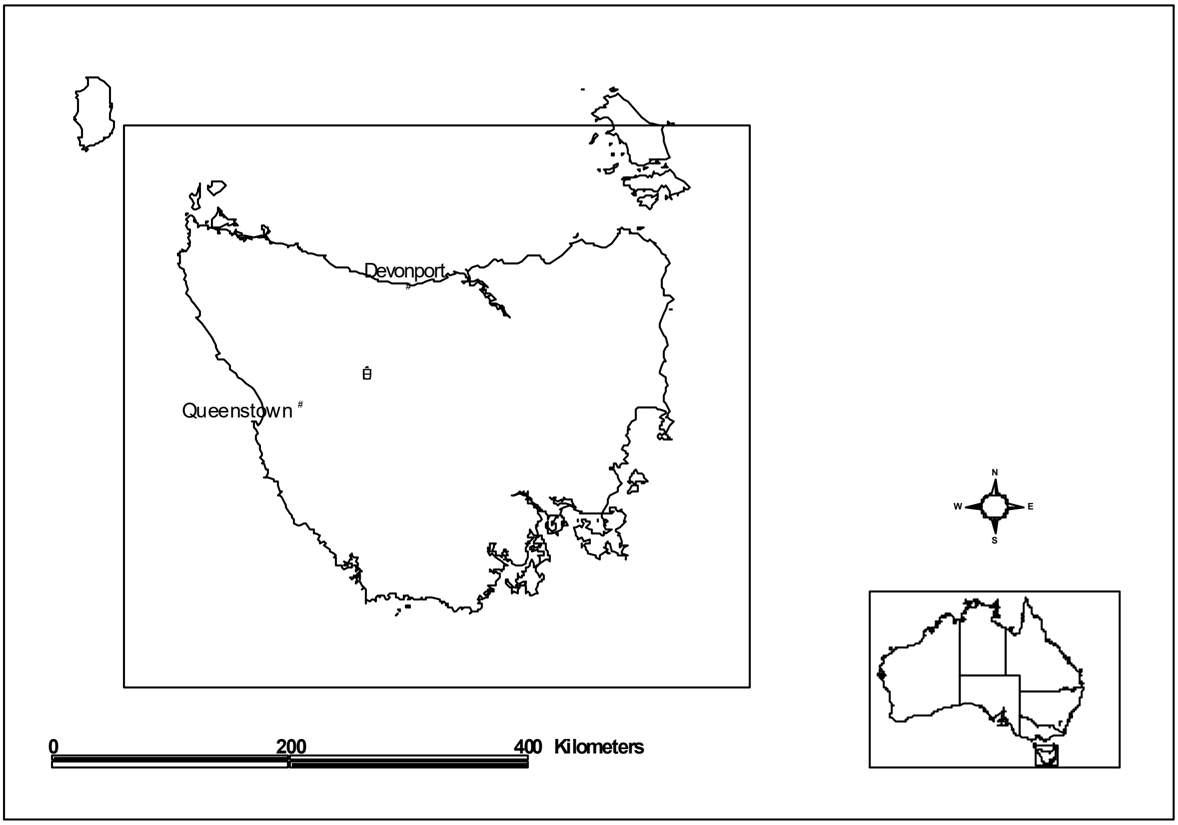
12. References

Akçakaya, H.R. and Ferson, S. 1999. *RAMAS® Red List: Threatened Species Classifications Under Uncertainty. Version 1.0*. Applied Biomathematics, Setauket, NY.

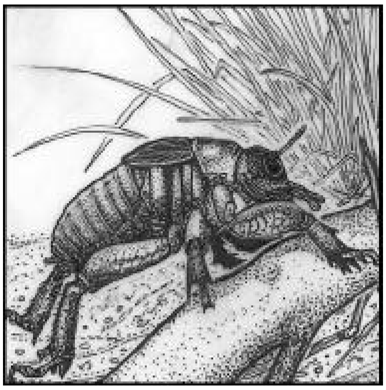
Naumann, I.D. 1991. Hymenoptera. In *The Insects of Australia*, (CSIRO ed.). pp. 916-1000. Melbourne University Press, Carlton.

Naumann, I.D. 1997. A remarkable, new Australian sawfly with brachypterous, nocturnal or crepuscular females (Hymenoptera: Symphyta: Pergidae). *Journal of Natural History* **31:** 1335-1346.

Naumann, I.D. 1998. Hymenoptera. In *Wilderness Ecosystems Baseline Studies (WEBS): Pelion Plains - Mt Ossa.Tasmanian Parks and Wildlife Service Report 98/2*, (Driessen, M.M., Comfort, M.D., Jackson, J., Balmer, J., Richardson, A.M.M., and McQuillan, P.B. eds.). pp. 93-101. Parks & Wildlife Service, Hobart.



Distribution of *Clarissa tasbates* (source: Naumann 1997).



Phylum: Arthropoda **Class:** Insecta **Order:** Orthoptera
Family: Cooloolidae
Scientific Name: *Cooloola* species
Common Name Cooloola monsters

1. Taxonomic status (including species and subgroups)

Cooloola ziljan Rentz, 1986
Cooloola propator Rentz 1980
Cooloola dingo Rentz 1986
Cooloola pearsoni Rentz 1999

'*Cooloola*': named after Cooloola National Park where it was found.

'*ziljan*': named in honour of Eric Zillmann, naturalist, and Raymond C. Jansen, farmer, who originally discovered the species (Rentz 1986).
'*propator*': means ' the first'.

'*dingo'*: named after the township of Dingo near the Blackdown Tablelands, Queensland.

'*pearsoni*': named after Steve Pearson, a ranger with Queensland National Parks and Wildlife Service who discovered *C. pearsoni* and *C. dingo*.

The Cooloolidae are an endemic family. The genus *Cooloola* contains only four species.

2. Species survival status

Currently not listed under any State or Commonwealth legislation.

None of the *Cooloola* species are listed on the 2000 *IUCN Red List of Threatened Species*. Assessment of the IUCN categorisation for *Cooloola ziljan* using the *Ramas RedList* software program (Akçakaya and Ferson 1999) indicated that it may be Data Deficient.

3. Distribution

Cooloola ziljan has been collected from canefields surrounding the town of Bundaberg, Queensland; *C. dingo* is found locally near the township of Dingo on the Blackdown Tablelands, while *C. propator* is found within Cooloola National Park and on Fraser Island. The fourth species *C. pearsoni,* described in 1999 (Rentz 1999), is found on South Percy Island, 85 km southeast of Mackay.

4. Habitat

C. ziljan has only been found in deep soils in the Bundaberg area where it has been collected at sites that have been ploughed every two years for sugarcane production. Rentz (1986) suggests that the animals may have been attracted to the fields in search of food or other resources from the remnant riverine vegetation that has been retained adjacent to the fields along the Burnett River.

All four *Cooloola* species occur in sandy soil (Rentz 1987); *C. ziljan* in land cultivated for sugar cane, *C. propator* under *Casuarina* stands along the banks of streams, *C. dingo* found near forest she-oak (*Casuarina torulosa*) along a creek bank in a tall mixed *Eucalyptus* forest, and *C. pearsoni* under stands of coastal Banksia (*Banksia integrifolia* var. *compar)* (Rentz 1986).

5. Biological overview

Members of the family Cooloolidae are large orthopterans, of which *C. ziljan* is the largest. They are similar to crickets in that they have very short antennae and highly modified legs and body (Rentz 1996). The knife-shaped lacinia (the apex of two laterally moving appendages on either side of the head behind the mandibles) is concave and so can be used for digging as well as predation (Rentz 1980, 1986, 1987).

Adult males have short forewings, while the females are wingless. Female *C. ziljan* are more robust than males (Rentz 1986). The female also has reduced tarsi and claws, superficial eyes and very short stocky legs. They generally have no pigmentation, as they rarely leave the soil (Rentz 1987, 1996). Males have longer legs than the females and are pigmented (Rentz 1987). Colouring of the adult *C. ziljan* is a tawny brown, similar to *C. propator*, with grey patches on parts of the body. The remainder of the body is black with a white 'shoulder' on the males (Rentz 1986). For a more detailed description of *C. ziljan* see Rentz (1986).

It is believed that members of the family are opportunistic and feed predominantly on insect larvae, such as scarab beetles and cicada nymphs (Rentz 1987). The foregut of specimens have been found to be extremely long, which may be an adaptation to long periods without food (Rentz 1980, 1986, 1987, 1996).

The animals appear to live underground for most of their life, with the males leaving the sand during heavy rain to search for a mate. Females may release a pheromone that is detected by the male (Rentz 1987). The males walk in a 'stomping' fashion while on the surface (Rentz 1980, 1986, 1987, 1996). They do not construct any sort of underground nest or burrow. All specimens collected have been within the top 45 cm of the soil profile (Rentz 1986, 1996).

Nymphs exude an unpleasant sticky substance when disturbed which is believed to be a glandular secretion, and may as a defence mechanism against predators (Rentz 1986).

Moisture within the habitat appears to be an important factor for survival, as *C. propator* and *C. dingo* are found along stream banks where they burrow deep into the soil presumably searching for moister areas (Rentz 1987). In hotter seasons they may dig deeper into the soil profile or move to moister areas of habitat (Rentz 1986).

Adult males of all species have been predominantly found in the months of September to December, just before the heavy monsoonal rains, while females of *C. ziljan* are found in April (Rentz 1986, 1987).

Little is known about the growth or reproduction of any of the *Cooloola* species, but they are believed to be slow growing, taking a year or more to reach adulthood. Adult females of *C. ziljan* may be longer lived than the males, as they are found later in the year after the males have dispersed (Rentz 1986, 1987).

Nothing is yet known of the size or dynamics of populations.

6. Significance

The discovery of *C. propator* in 1976 in Cooloola National Park marked the discovery of an entirely new family endemic to Australia (Rentz 1980).

7. Threats

The major threat to the members of the genus is habitat destruction, although the mechanisms vary among species.

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As *C. ziljan* occurs on a sugarcane farm it is at risk from the cultivation practises associated with growing cane. However, it appears to have survived cultivation for at least 50 years. The previous owner was concerned about the protection of the species but, since the discovery, the farm has been sold and the future of the species is uncertain (D. Rentz personal communication).

C. propator is found within two national parks, Cooloola National Park and Fraser Island National Park (which was listed as a World Heritage Area in 1992). Despite this it is still considered threatened due to the impact of over 300,000 visitors per year to Fraser Island alone (Sinclair 2000).

The threats to *C. dingo* and *C. pearsoni* are at present unknown.

8. Conservation objectives

To determine the ecological requirements, distribution and conservation status of *Cooloola* species so that current populations can be maintained or increased.

9. Conservation actions already initiated

- Taxonomic work has been undertaken on members of the family to determine its taxonomic status (Rentz 1980, 1986, 1999).
- The site where *C. ziljan* was first discovered has been nominated for listing on the Register of the National Estate (Australian Heritage Commission 2000).

10. Conservation actions required

Research.

- Further surveys are required to determine the current distribution of the species.
- Investigation into many aspects of the Cooloolidae, including the basic life history, reproduction, and habitat requirements.
- Investigation of the potential impacts of agricultural practices and increasing tourist visitation on distribution and abundance
- Determine soil types preferred by members of the Cooloolidae.

Management

- As the only site where *C. ziljan* has so far been found is a sugarcane field, it is important to reduce the impacts on the site from further detrimental influences until new sites have been found. The use of pesticides and cultivation of the known sites need to be avoided until more is understood of *C. ziljan*.
- Conservation reserves in the surrounding area that contain the identified preferred soil types need to be identified, or old sugarcane farms could be resumed for possible reserves.

11. Relevant Experts/Data Providers

David Rentz – CSIRO Entomology, Canberra

12. References

Akçakaya, H.R. and Ferson, S. 1999. *RAMAS® Red List: Threatened Species Classifications Under Uncertainty. Version 1.0*. Applied Biomathematics, Setauket, NY.

Australian Heritage Commission 2000. Nolans Pocket, Kolan South, QLD. http://www.erin.gov.au/cgi-bin/heritage/register/site.pl?101951.

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Rentz, D.C. 1987. Considerations in naming a family: The Orthoptera family Cooloolidae. In *Evolutionary Biology of Orthopteroid Insects*, (Baccetti, B. ed.). pp. 433-437. Ellis Horwood Limited, Chictester.

Rentz, D.C. 1996. *Grasshopper Country: The Abundant Orthopteroid Insects of Australia*. University of New South Wales Press, Kensington, NSW.

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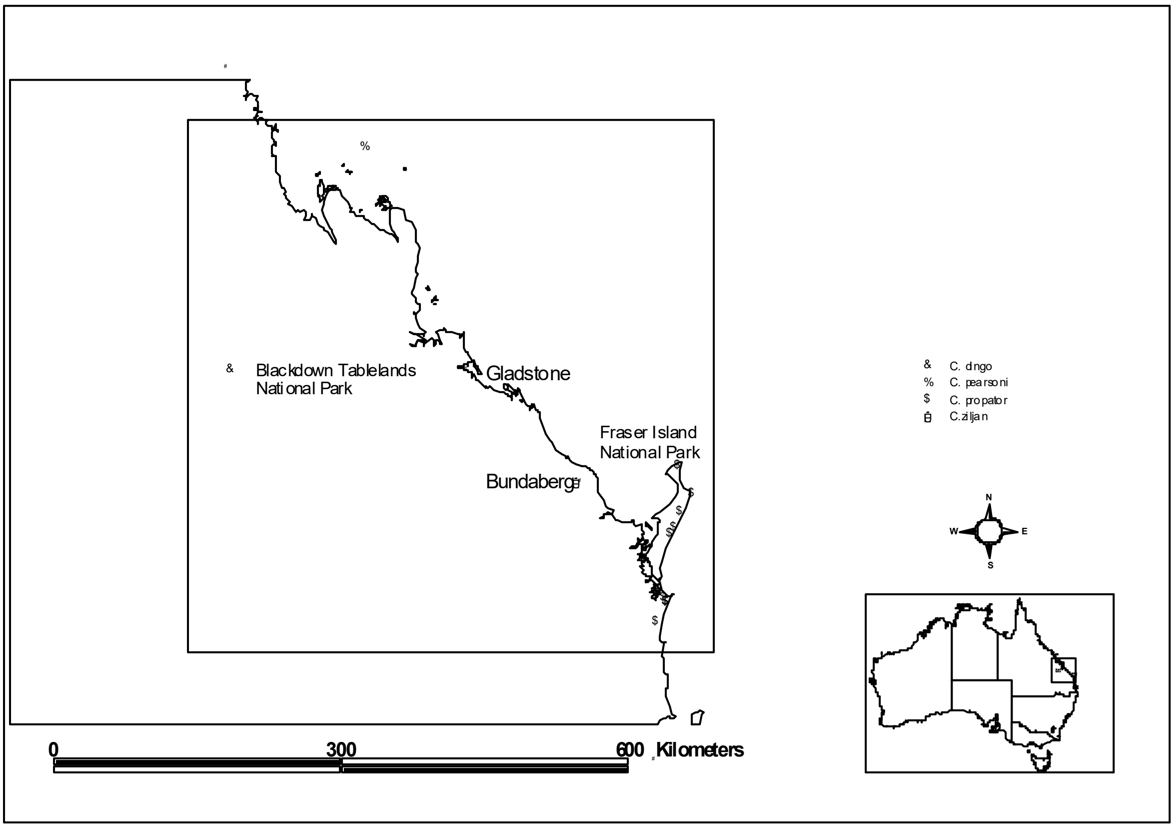
Sinclair, J. 2000. The Fatal Shore. *Habitat Australia* **February**.



Distribution of *Cooloola* species (source Rentz personal communication).

Cooraboorama canberrae Canberra Raspy Cricket

Phylum: Arthropoda **Class:** Insecta **Order:** Orthoptera
Family: Gryllacrididae
Scientific name: *Cooraboorama canberrae*
Common names: Canberra Raspy Cricket

1. Taxonomic status (including species and subgroups)

Cooraboorama canberrae Rentz & John, 1990

'*Cooraboorama*': an aboriginal word meaning 'monster', which is a reference to the size of the head (Rentz and John 1990).

'*canberrae*': named after Canberra, where the species is found.

Cooraboorama canberrae is the only member of the endemic genus *Cooraboorama* (Rentz 1996).

2. Species survival status

Currently not listed under State or Commonwealth legislation.

Cooraboorama canberrae is not listed on the 2000 *IUCN Red List of Threatened Species*. Assessment of the IUCN categorisation for the species using the *Ramas RedList* software program (Akçakaya and Ferson 1999) indicated that it may be Data Deficient.

3. Distribution

Cooraboorama canberrae has only been collected from within the ACT.

4. Habitat

Little is understood about this rarely encountered species. It is believed to be dependent on native grasslands and grassy woodlands of the Canberra region (Rentz 1996), although the type of grassland is at present unknown.

5. Biological overview

The stocky long legged appearance and the huge mandibles of this cricket give the creature a distinct and unusual appearance. It also has a large head, small tegmina and small wings, and is of a pale yellow brown colouration with a white venter. Females are distinguished by their long ovipositor (Rentz and John 1990). Rather than a row of pegs like other members of the family, *C. canberrae* has a stridulatory patch used to produce sound (Rentz and John 1990; Rentz 1996).

It is believed that *C. canberrae* is a nocturnal species, as are many Gryllacridids, because of its pale colouration and large eyes. Little is known of its growth, reproduction, or diet, although many members of the family are dependent on specific foods that differ between species (Rentz 1996).

Gryllacridids hide from daylight in burrows made from leaves, twigs, and other materials, which are held together by silk produced by a gland in the mouth. Species which dig burrows or roll themselves in leaves have long antennae which can be folded in a spiral, way over the body so that they are protected (Rentz and John 1990; Rentz 1996). *C. canberrae* digs perfectly vertical spherical burrows up to 60 cm deep.

6. Significance

The raspy crickets are a large well-known group, both in Australia (more than 120 species) and around the world (more than 600 species) (Rentz 1996).

Museum collections indicate that *C. canberrae* was once very common in the grasslands of the ACT, becoming less common as the urbanisation has encroached onto the remaining grasslands habitats. The status of *C. canberrae* is indicative of the general decline in temperate grassland habitats throughout southeastern Australia (Rentz and John 1990).

Recently it has been discovered that the endangered eastern lined earless dragon, Typanocryptis lineata pinguicolla, often uses disused burrows of C. canberrae.

7. Threats

As a native grassy woodland species, it is believed to be threatened primarily through urban development and consequent grassland habitat destruction in the ACT (Rentz 1996). Temperate native grasslands are the most threatened vegetation type in Australia. The majority of remaining patches are small, isolated and often subject to high levels of weed invasion. Grassland species with low vagility, such as *C. canberrae* are particularly susceptible to habitat fragmentation, deterioration and destruction. The species appears absent from previously known sites that are now altered due to urban development.

8. Conservation objectives

To determine the distribution, ecological requirements and conservation status of *Cooraboorama canberrae* so as to maintain the existing populations.

9. Conservation actions already initiated

- Some survey work has been undertaken to ascertain the distribution of *C. canberrae* in the ACT. A small number of extant populations have so far been found.
- Many grasslands in the ACT, particularly in north Canberra, are protected in grasslands reserves, or incorporated into other nature reserves. Museum records indicate the species has been collected from some reserves within the ACT, although it is not known whether the species is present at any of these sites.

10. Conservation actions required

Research

- Further survey work needs to ascertain the current distribution and number of extant populations.
- Investigation into aspects such as life history, reproduction, biology and habitat requirements

Management

- Ensure that populations of *C. canberrae* and their associated native grasslands occur within protected reserves or nature parks within the ACT.

11. Relevant Experts/Data Providers

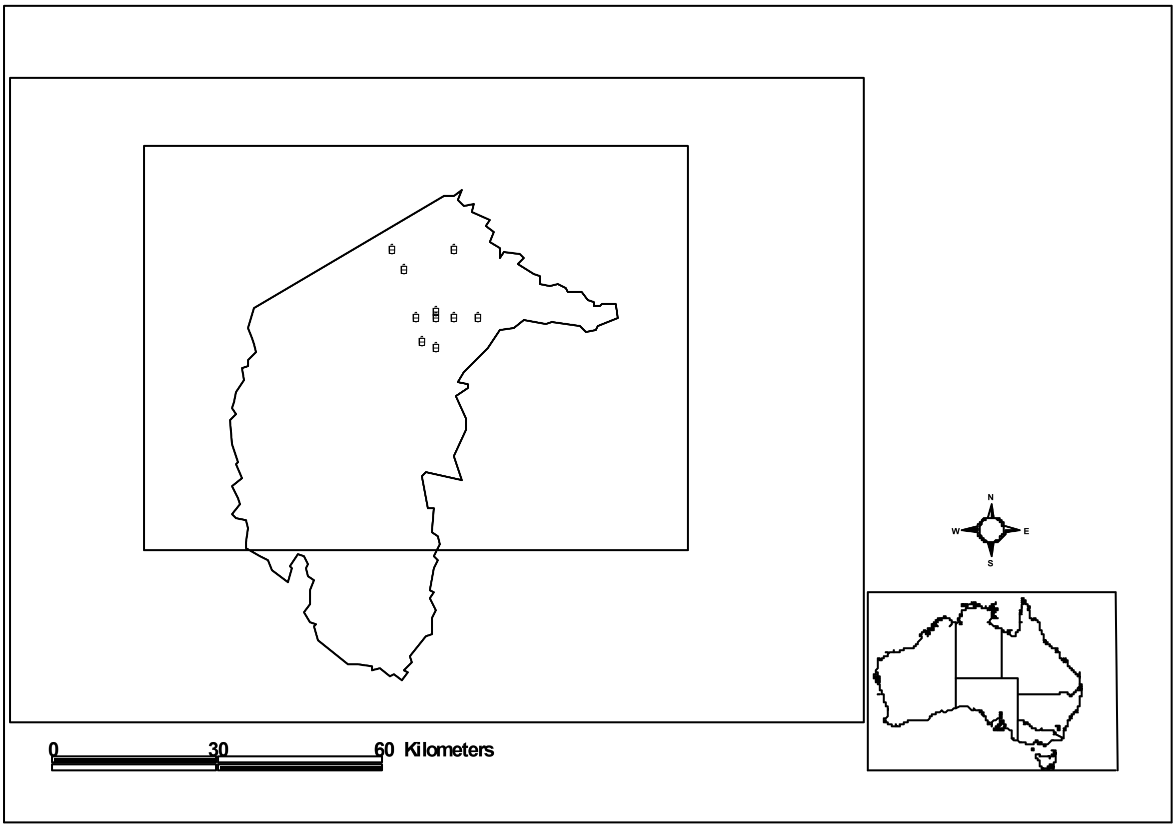
David Rentz – CSIRO Entomology, Canberra

12. References

Akçakaya, H.R. and Ferson, S. 1999. *RAMAS® Red List: Threatened Species Classifications Under Uncertainty. Version 1.0*. Applied Biomathematics, Setauket, NY.

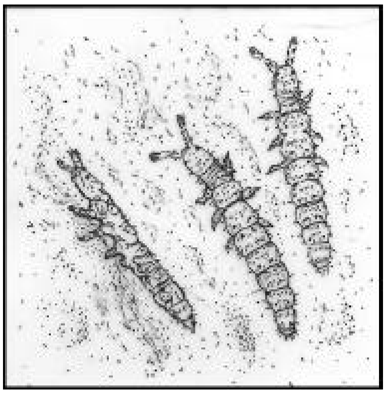
Rentz, D.C. 1996. *Grasshopper Country: The Abundant Orthopteroid Insects of Australia*. University of New South Wales Press, Kensington, NSW.

Rentz, D.C.F. and John, B. 1990. Studies in Australian Gryllacrididae: taxonomy, biology, ecology, and cytology. *Invertebrate Taxonomy* **3:** 1053-1210.



Distribution of *Cooraboorama canberrae* (Source: David Rentz, personal communication)

Dinaphorura tooheyensis Toohey Forest Collembola



Phylum: Athropoda **Class:** Collembola **Order:** Arthropleona
Family: Onychiuridae
Scientific name: *Dinaphorura tooheyensis*
Common names: Toohey Forest Collembola

1. Taxonomic status (including species and subgroups)

Dinaphorura tooheyensis Rodgers and Greenslade, 1996

'*tooheyensis*': reference to Toohey forest, where it was discovered.

There are four species of the genus *Dinaphorura* found in Australia, with another 10 found overseas in New Zealand, South America, New Caledonia and sub-Antarctic islands (Rodgers and Greenslade 1996).

2. Species survival status

Currently not listed under any State or Commonwealth legislation.

Dinaphorura tooheyensis is not listed on the 2000 *IUCN Red List of Threatened Species*. Assessment of the IUCN categorisation for the species using the *Ramas RedList* software program (Akçakaya and Ferson 1999) indicated that it may be Critically Endangered.

3. Distribution

Dinaphorura tooheyensis is only known from the Toohey Forest, in the Brisbane suburb of Nathan in southeast Queensland (Rodgers and Greenslade 1996).

4. Habitat

Toohey forest is an urban *Eucalyptus* open woodland forest reserve, of approximately 655 hectares (Australian Heritage Commission 2000). The vegetation is representative of sandstone vegetation which includes some uncommon species such as *E. planchoniana*, Bailey's stringybark (*E. baileyana*), and the rare Plunkett mallee (*E. curtisii*), as well as some unusual associations (Coutts and Dale 1987; Australian Heritage Commission 2000). Other tree species of note found in Toohey Forest include the broadleaved white mahogany (*E. umbra* ssp. *carnea*) and smudgee (*Angophora woodsiana*) (Australian Heritage Commission 2000). Many of these trees are found scattered sparsely throughout the forest presumably due to moisture variations in the soil (Coutts and Dale 1987).

The understorey predominantly comprises native grasses such as kangaroo grass (*Themeda triandra*) and shrubs (*Hibbertia stricta* and *Leptospermum attenuatum*) with grass trees (*Xanthorrhoea johnsonii)* (Australian Heritage Commission 2000).

The site also incorporates the headwaters of the Norman, Oxley and Bulimba creeks (Stock 1987).

D. tooheyensis is found in the moist shallow, red-yellow podzolic loamy soil of Toohey Forest in an area where Planchon's stringybark (*E. planchoniana*) woodland is the dominant vegetation type (Rodgers and Greenslade 1996; Australian Heritage Commission 2000).

5. Biological overview

Dinaphorura tooheyensis is a small (1.2mm) white wingless animal belonging to the Class Collembola. It has a soft body (covered in short hairs), three pairs of short legs and antennae (Rodgers and Greenslade 1996). Like all Collembola the mandibles are concealed, but those of *D. tooheyensis* are designed for chewing. A few other species of Collembola are fluid feeders (Greenslade 1991; Rodgers and Greenslade 1996). *D. tooheyensis* lacks a furcula (a forked structure on the underside of the animal), indicating that it is a soil dweller (Rodgers and Greenslade 1996).

Dinaphorura tooheyensis differs from other species in the genus as it only has a single spiniform process on abdominal segment VI instead of the usual five to seven (Rodgers and Greenslade 1996).

For a more detailed description of *D. tooheyensis* see Rodgers and Greenslade (1996).

Nothing is known as yet of the biology of *D. tooheyensis* (P. Greenslade personal communication), although generally, the life cycle of Collembola from egg to adult is approximately three to four weeks, and moult continuously throughout their lifetime (Hopkin 1997).

Typically within the Collembola, sperm is transferred from the male by depositing a spermatophore on the ground, which a female collects. The female will then lay eggs, maybe hundreds over the individual's lifetime (Hopkin 1997). Any sperm stored is lost when the individual moults. Some soil dwelling species are parthenogenetic, which means that reproduction does not require a fertilisation by a male. Reproductive instars may alternate with non-reproductive females (Greenslade 1991; Hopkin 1997).

Collembola generally feed on the fungi and micro-organisms living associated with plant roots, or that are responsible for breaking down organic matter, although some also feed on pollen or other Collembola (Greenslade 1991; Hopkin 1997).

Defence mechanisms used by Collembola include strategies such as mimicry, immobility, and the use of defensive secretions (Greenslade 1991).

Soil species tend to have an aggregated distribution. Rodgers & Greenslade (1996) estimate that *D. tooheyensis* may be common within its habitat, with a density of approximately 1,300 per square metre.

6. Significance

Dinaphorura tooheyensis is phylogenetically significant (Rodgers and Greenslade 1996). Its restriction to an urban environment makes it of conservation concern.

Collembola are a vital component of our soils as they are important in breaking down organic matter, increasing the soil fertility, and therefore ensuring that nutrients continue to cycle through the system. Their faeces also improve the structure and nutrient status of soils (Greenslade 1991; Hopkin 1997).

In turn, Collembola provide food for many species of invertebrates, some of which are adapted for catching the active animals. Higher vertebrates such as fish, frogs, lizards, marsupials and birds are also known to feed on Collembola (Greenslade 1991; Hopkin 1997).

The Toohey Forest itself provides refuge for other species in the urban area (Halliburton *et al*. 1987). This high diversity is possible due to the diversity of habitats within Toohey Forest. The forest also includes many species that are uncommon in the region, as well as many unusual vegetation associations, including shrubs more commonly found along the coastal lowlands coexisting with those from the subcoastal uplands (Coutts and Dale 1987). Toohey Forest harbours 400 species of flowering plants, 30 species of ferns, 136 birds, seven native mammals, 30 reptiles, 60 butterflies, 20 ants, 50 spiders and 10 amphibians (Halliburton *et al*. 1987; Toohey Forest Protection Society 2000).

A study undertaken by (Rodgers 1997) identified 25 species of Collembola in Toohey Forest (Australian Heritage Commission 2000). The Toohey Forest site also harbours a newly described species of mite *Xanthodasythyreus toohey* (Walter and Gerson 1998). This mite is the only representative of the family *Dasythyreidae* (Raphignathoidea), found in Australia, and it is only known from Toohey Forest (Walter and Gerson 1998).

7. Threats

The primary threat to *D. tooheyensis* is habitat destruction due to the extension of urban areas and university campus facilities (P. Greenslade personal communication). Soil compaction is a common impact from development.

The environmental integrity of Toohey Forest is at risk due to its proximity to the city of Brisbane, encroachment of weed species such as *Lantana* spp. and Camphor laurel (*Cinnamomum camphora*) and domestic animals (Toohey Forest Protection Society 2000). Some of the larger vertebrates such as wallabies, the brindled bandicoot and the echidna, appear to be low in numbers, whereas they were recorded as present in surveys undertaken in 1982–3. This is believed to be due to the isolated nature of the forest and the presence of foxes, cats, and domestic dogs from the neighbouring suburbs. The Cane Toad (*Bufo marinus*), which competes with the native species of frogs, is also present in the forest (Toohey Forest Protection Society 2000).

In the past there was an uncoordinated system of management of the Toohey Forest. Today approximately half is owned by the Brisbane City Council (2/3 of which is designated conservation area while the remaining 1/3 is for recreation purposes) and the rest is owned by Griffith University (H. Proctor personal communication). The establishment of the Toohey Forest Management Committee and the implementation of the Management Plan in 1994 has not prevented the threat of development and urban encroachment, with an additional six hectares of forest lost in 1999 to development of the Griffith University campus (Toohey Forest Protection Society 2000).

8. Conservation objectives

That populations so far discovered are maintained at the current level or greater through habitat protection and further surveys.

9. Conservation actions already initiated

- The importance of Toohey Forest has been highlighted by its listing on the Register of the National Estate (Australian Heritage Commission 2000), however, the site where *D. tooheyensis* is found is still threatened by the expansion of university buildings, widening of roads and the expansion of urban areas (H. Proctor personal communication).
- The Management Plan that was implemented in 1994 saw the employment of a ranger and the introduction of a Fire Management Plan and a Recreation Management Plan (Toohey Forest Protection Society 2000). The Management Plan included the establishment of a 'core' zone that would be protected against disturbance through the protection of 'buffer' zones that would be used for education and other sustainable uses. Other actions included the establishment of community groups to help protect the forest, and ensuring that corridors existed linking the forest to surrounding patches of bushland (Toohey Forest Protection Society 2000).

10. Conservation actions required

Research

- Further surveys to establish the current distribution of *D. tooheyensis*, and to establish whether there are any other invertebrate species present with restricted distributions (Rodgers and Greenslade 1996).

Management

- Development of the site should be avoided and the area left to regenerate naturally
- The park is subject to many activities which should be banned such as trail bikes, dumping of rubbish, fire, and uncontrolled vehicular access, to ensure the integrity of the forest. Developments such as powerlines and the south-east freeway also threaten the integrity of the forest and future such actions should be avoided (Halliburton *et al*. 1987; Australian Heritage Commission 2000).
- An education program focussing on the rich diversity of Toohey Forest may also assist in fostering greater respect for the site in the future (Halliburton *et al*. 1987).

11. Relevant Experts/Data Providers

Penny Greenslade – Australian National University, Canberra

Dave Walter – University of Queensland, Brisbane

Heather Proctor – Griffith University, Brisbane

12. References

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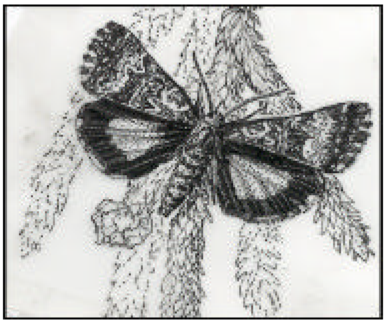
Distribution of *Dinaphorura tooheyensis* (source: Rodgers & Greenslade 1996).

Dirce aesiodora Pencil Pine Moth



Phylum: Arthropoda **Class:** Insecta **Order:** Lepidoptera
Family: Geometridae
Scientific name: *Dirce aesiodora*
Common names: Pencil Pine Moth

1. Taxonomic status (including species and subgroups)

Dirce aesiodora Turner, 1922.

'aesiodora': means 'a fortunate gift'.

The subfamily Archiearinae consists of 12 species worldwide, with six species (five described) endemic to Tasmania.

2. Species survival status

Listed as vulnerable under the *Tasmanian Threatened Species Protection Act 1995*.

Dirce aesiodora is not listed on the 2000 *IUCN Red List of Threatened Species.* Assessment of the IUCN categorisation for the species using the *Ramas RedList* software program (Akçakaya and Ferson 1999) indicated that it may be Critically Endangered.

3. Distribution

The subfamily Archiearinae is restricted to the high mountainous regions of Tasmania, the South American Andes, Britain, Northern Europe, Japan and North America, and thought to include 12 species. Of these, five, including *Acalyphes philorites, Dirce aesiodora* and *Dirce lunaris*, are found in Tasmania (Edwards and McQuillan 1998).

4. Habitat

These Tasmanian representatives are only found at altitudes between 960 m and 1,100m (Edwards and McQuillan 1998; Department of Environment and Land Management 1999). *D. aesiodora* is only found at sites of montane rainforests where the pencil pine (*Athrotaxis cupressoides*) is found (Driessen 1999), including sites at Cradle Mountain, Mt Doris, Lake Ada and Mt Field National Park (Department of Environment and Land Management 1999). Understorey consists of grasses, heath, shrubs or sphagnum (Bryant and Jackson 1999).

5. Biological overview

Dirce aesiodora is a small geometrid moth with a wingspan ranging from 26–30mm. The triangular forewing is black, mottled with grey and white, with a black central spot. The rounded hindwing, which is about the same size as the forewing, is black with an orange central patch and orange and black hairs. The underside of the hindwing is predominantly pale orange. Much of the insect's body is black, with white found on the face, palpi and the thorax (Turner 1922; McQuillan 1986; Common 1990).

The larvae of many geometrid moths are long and slender ('loopers'). Larvae of *Dirce* lack prolegs on the third, fourth, and fifth segments and have a projected lower jaw. They develop into heavily sclerotised pupae. Within the family eggs can be laid singly, or in groups, on the leaves of the larval food plant and are generally flattened and ovate with one end slightly wider than the other (Common 1990).

Of the five species known from Tasmania both *D. aesiodora* and *A. philorites* are known to feed on the pencil pine, *Athrotaxis cupressoides* (Taxodiaceae) while *D. lunaris* feeds on an

Epacris (Epacridaceae) (McQuillan and Edwards 1996; Edwards and McQuillan 1998).

Adults are known to be active on spring and summer days (Common 1990), predominantly in January (E.D. Edwards, personal communication; Driessen 1999). *D. aesiodora* flies only in bright sunlight during the warmest parts of the day, and are swift and very strong fliers (McQuillan 1986; Common 1990).

Males are territorial and will chase away other males during the breeding season. The larvae of *D. aesiodora* may stop growing over the coldest months, pupating in spring and emerging as an adult in the following summer (Bryant and Jackson 1999). Growth rates and life cycle duration are unknown (E.D. Edwards personal communication).

Many alpine species are covered with hairs which is thought to be an adaptation to the dampness and coldness of these environments (Turner 1922; McQuillan 1986). Other modifications to living in such harsh conditions include the darker colouration of sclerotised tissue and longer setae which to provide some insulation from the cold.

Population sizes and their rates of change are unknown for *D. aesiodora*.

6. Significance

As five of the twelve described species of Archiearinae known in the world occur only in Tasmania, this region represents a very significant centre of biodiversity of this group (E.D. Edwards personal communication).

The interest in the species lies in the antiquity of the subfamily (being one of the most primitive of the Geometridae and thought to be a relict from Gondwana) and in the relationship which *D. aesiodora* has with the pencil pine. However, since the discovery of the species in 1917 at Cradle Mountain not much has been learned of the species (Driessen 1999; Department of Environment and Land Management 1999).

Feeding by invertebrates may be very important to the structure of the community in alpine areas by maintaining pressure on certain species, a pressure that vertebrate herbivores may not be able to exert (McQuillan 1986). It is unknown what the result may be if that pressure were to be released, but we may find a reduction in species present, and an increase in weed species (McQuillan 1986).

The Tasmanian alpine regions are also important in themselves as they are home to many threatened species such as other members of the family, e.g., *Acalyphes philorites* and *Dirce lunaris*, as well as the wingless sawfly *Clarissa tasbates*, covered elsewhere in the Review (Edwards and McQuillan 1998).

These species illustrate the level of endemism found in the alpine areas of Tasmania (McQuillan 1986). Currently 20% of Tasmania is protected within World Heritage Areas, and so far there are 13 species of threatened invertebrates known to occur within these reserves. Seven of those species are not found outside the World Heritage Areas (Driessen 1999).

7. Threats

The main threat to *D. aesiodora* results from dependence on a single species for larval food – loss of the food plant would result in the extinction of the moth. Evidence also suggests that the pencil pine moth may require stands of pencil pines, rather than individual trees (Edwards and McQuillan 1998; Department of Environment and Land Management 1999).

Pencil pines currently occupy a highly restricted range, which may be undergoing further reduction as a result of global warming (Edwards and McQuillan 1998).

Alpine tree species are generally highly intolerant of fire and cannot recover after a fire. Approximately 40% of the stands of pencil pines in Tasmania have been destroyed by fire (Edwards and McQuillan 1998; Driessen 1999; Department of Environment and Land Management 1999; Bryant and Jackson 1999).

The introduction of diseases such as *Phytophthora* is also a serious threat. *Phytophthora* has recently been discovered for the first time on pencil pines in the Pine Lake region of the Central Plateau of Cradle Mountain. The pines attacked have not been able to recover from the disease, which has resulted in many losses and an area of 92,020ha being quarantined to avoid further spread (Driessen 1999; Department of Environment and Land Management 1999).

8. Conservation objectives

- To maintain the known populations at current population sizes.
- To find ways of ameliorating the pressures on the species, so as to increase the

population where possible, or to find more populations.

- To conserve the single host plant of *D. aesiodora* in stands of sufficient size.

9. Conservation actions already initiated

- The montane rainforest habitats that the species depends on are protected from many possible threats as they are within the World Heritage Area Reserves such as Mount Field (Department of Environment and Land Management 1999).
- The threat of fire had been reduced by the ban on open fires in the camping areas at Lake Ada and Mount Doris (Department of Environment and Land Management 1999). These sites are also noted in the Tasmanian World Heritage Areas Management Plan as highly sensitive to fire (Driessen 1999).
- An interim management plan for the dieback at Pine Lake has been produced to attempt to alleviate the problem associated with *Phytophthora*.

10. Conservation actions required

Research

- Improving the taxonomic knowledge of the species (Edwards and McQuillan 1998).
- Detailed surveys of the distribution of *D. aesiodora*. It is thought to be less than that of the food plant. This will provide baseline data to monitor the effects of global warming.
- Studies in the biology of the species so that its requirements and potential recovery rates are better understood.
- An understanding of the ecology and population dynamics of pencil pines, eg: what is their level of recruitment?

Management

- A program of tree planting to establish new stands of pencil pines is recommended. As pencil pines are slow growers such a program may need to be implemented soon.
- Need to ensure that vehicles and any equipment that may contact soil be cleaned before entering/leaving sites of pencil pines to reduce the risk of spreading the *Phytophthora* disease (Bryant and Jackson 1999).

11. Relevant Experts/Data Providers

Ted Edwards – CSIRO Entomology, Canberra
Peter McQuillan – University of Tasmania, Hobart
Mike Driessen – Tasmanian Parks & Wildlife Service, Hobart

12. References

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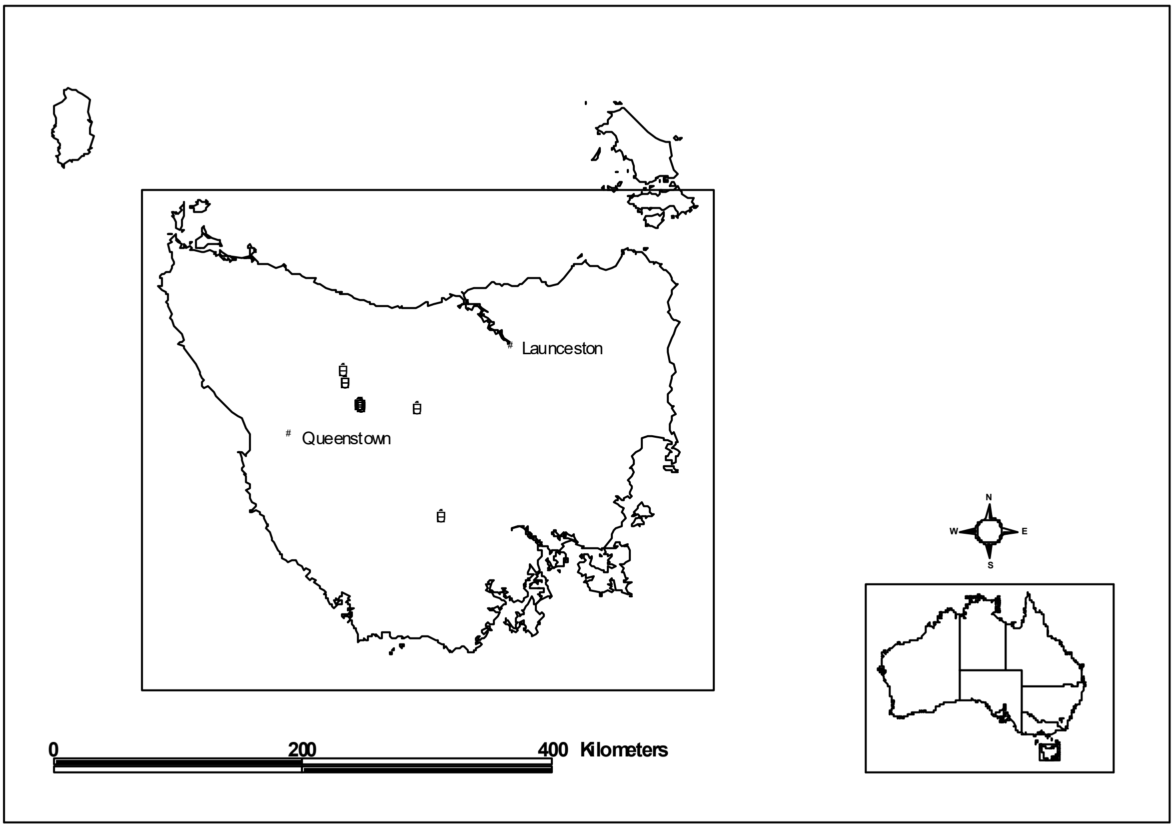
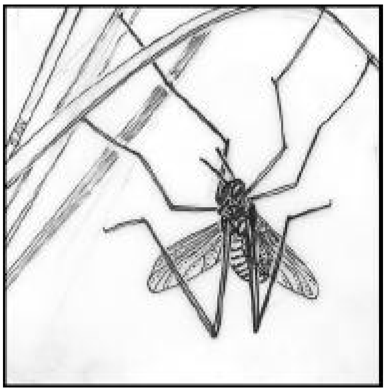


Distribution of *Dirce aesiodora* (source: Australian National Insect Collection)

Edwardsina gigantea Giant Torrent Midge



Phylum: Arthropoda **Class:** Insecta **Order:** Diptera
Family: Blephariceridae
Scientific name: *Edwardsina gigantea*
Common names: Giant Torrent Midge / net-veined midges

1. Taxonomic status (including species and subgroups)

Edwardsina (*Tonnoirina*) *gigantea* Zwick, 1977.

The genus *Edwardsina* (subfamily Edwardsininae) consists *of* approximately 20 species (all within the subgenus *Tonnoirina*) (Zwick 1981; Bugledich 1999). The family Blephariceridae is found in Australia, Madagascar and southern South America (Arens 1998).

2. Species survival status

Currently not listed under any State or Commonwealth legislation.

Edwardsina gigantea is listed as Endangered (EN B1+2c) on the 2000 *IUCN Red List of Threatened Species*. Assessment of the IUCN categorisation for the species using the *Ramas RedList* software program (Akçakaya and Ferson 1999) indicated that it may be Critically Endangered.

3. Distribution

Edwardsina gigantea has been found in Pipers Creek, Geehi River, Snowy River, Spencers Creek and the Thredbo River in Kosciusko National Park, NSW, and at the Cotter River, ACT (Bugledich 1999).

4. Habitat

Edwardsina gigantea appears to be restricted to fast flowing streams in mountainous areas. The substrate needs to be smooth rocks, which the larvae affix themselves to. The water needs to be fresh, clear and torrential, so that it is well aerated (Zwick 1981; Wells *et al*. 1984; Bugledich 1999).

5. Biological overview

Adult 'net veined midges' are slender flies with long legs. The wings have a large anal lobe and few main veins, which are replaced with a fine network of creases. *Edwardsina gigantea* is the largest member of the genus, reaching a wingspan of up to 12.5 mm in females (11.5 mm in males) (Zwick 1977, 1981; Wells *et al*. 1984; Bugledich 1999). Males have reduced mouthparts, while the females appear to have complete mandibles (Zwick 1981).

E. gigantea eggs are ovoid, covered with small circular knobs over the dorsal surface, which stick to rocks (Zwick 1977). The larvae of *E. gigantea* have not been identified. For a more detailed description of *E. gigantea* see Zwick (1977).

Generally, the larvae of the family Blephariceridae are less than 13 mm long and have a flattened body that consists of six lobes, each one with a ventral sucker, by which it attaches to rocks. As *E. gigantea* is a large species, the larvae may be larger than this (Zwick 1981; Bugledich 1999). Mouthparts of the larva are not obvious, but consist of three large teeth that are used for scraping algae off rocks. In younger larvae these are a brown/yellow, transparent colouring, which become darker and blunter as they age (Zwick 1977). Pupae are approximately 8.5 mm long, oval and ventrally flattened in shape and dark in colouration (Wells *et al*. 1984; Arens 1998). They also have prothoracic spiracles, which are hidden by special gills (Zwick 1981).

Adult females have mandibles and have been observed feeding on small insects (Zwick 1977, 1981; Bugledich 1999) whilst the males lack functional mandibles and presumably feed on nectar (Wells *et al*. 1984). Adults of Blephariceridae usually rest on, or under, rocks, or on vegetation, close to the water's edge (Zwick 1981; Bugledich 1999). When hanging from vegetation, they assume a characteristic position, holding on with the first pair of legs while the others hang freely (Zwick 1977).

The timing of the life cycle of members of *Edwardsina* depends on environmental constraints such as temperature and rainfall. Larvae of *E. gigantea* are believed to hatch in late summer or early autumn and go into pupation from September to early November, probably for about two to four weeks. The eggs of many *Edwardsina* species appear to spend an extended period in the egg stage. Adults emerge in summer and then mate (Zwick 1977; Zwick 1981; Arens 1998; Bugledich 1999). Eggs are laid in spring on bare stones which are protruding from the water, and may remain dormant for some time until conditions are suitable (Zwick 1977; Bugledich 1999).

It is very important that the habitat contains rocks which have been smoothed by water movement for the larvae and pupae to attach to, and that there is a moderate water flow, which is important for respiration (Zwick 1977). When the larvae are ready to pupate, factors such as water level and the orientation relative to the current are vital to the survival of the pupae, as they appear to be very sensitive to desiccation, and have been found fastened to rocks from 2–70 cm (when snow is melting) below the waters' surface (Zwick 1977).

The current population sizes or rates of change are unknown.

6. Significance

Torrent midges are restricted to cool mountainous areas with a high reliable rainfall and clear torrential streams, which on mainland Australia are confined to the Great Dividing Range. Although the family is widespread, many endemic species have evolved in these mountainous areas in isolation and under different climatic conditions, which gives them zoogeographic importance (Zwick 1977; Wells *et al*. 1984; Arens 1998).

Some invertebrates have been found to feed on the larvae of Blephariceridae, such as the larvae of some caddisflies (Hydrobiosinae) and midges (Chironomidae), as well as some nematodes (Zwick 1977).

7. Threats

As the species requires particular environmental constraints, it is very vulnerable to any environmental changes. Blephariceridae are very poor fliers, so there is a very limited opportunity for the species to disperse to new sites (Zwick 1981).

The most serious threats are pollution, the construction of dams and changes in hydrology, all of which are linked to the presence of the Snowy Mountain Hydroelectric and other water supply schemes. As the larvae and pupae are fully aquatic, pollution of the waterways, including raw sewage emissions, is a major threat. Other impacts such dam construction, changes in river flow, stream level, siltation, and change in temperature would have a devastating impact on *E. gigantea*. The pupae seem to be particularly sensitive to changes in water level, as they need to align themselves with the current before pupation occurs (Zwick 1977; Wells *et al*. 1984). The species is believed to have disappeared from much of the Snowy, Cotter and Geehi Rivers and possibly other sites. Currently it appears to persist in Spencers Creek and the Thredbo River, below the alpine village (Zwick 1977; Wells *et al*. 1984).

8. Conservation objectives

- To determine the distribution and conservation status of *Edwardsina gigantea*.
- To determine the ecological requirements so as to help maintain the current populations.

9. Conservation actions already initiated

- Many of the sites where *E. gigantea* is known to occur are within Kosciusko and Namadgi National Parks.

- Studies have been undertaken into the water quality of the Thredbo River so as to reduce harm done by further pollution (Wells *et al*. 1984).

10. Conservation actions required

Research

- Further surveys of streams in Kosciusko National Park are required to determine whether the species persists in regional streams and to determine whether there are any further populations
- Studies into the ecological and phenological requirements of *E. gigantea*.

Management

- Management of potential sources of water pollution, e.g. installation of sewerage treatment plants within the catchment.
- Active stream management to prevent siltation, altered water flows, impoundment, changes to substrate and prolonged changes in water levels.

11. Relevant Experts/Data Providers

Peter Cranston – University of California, Davis, USA

12. References

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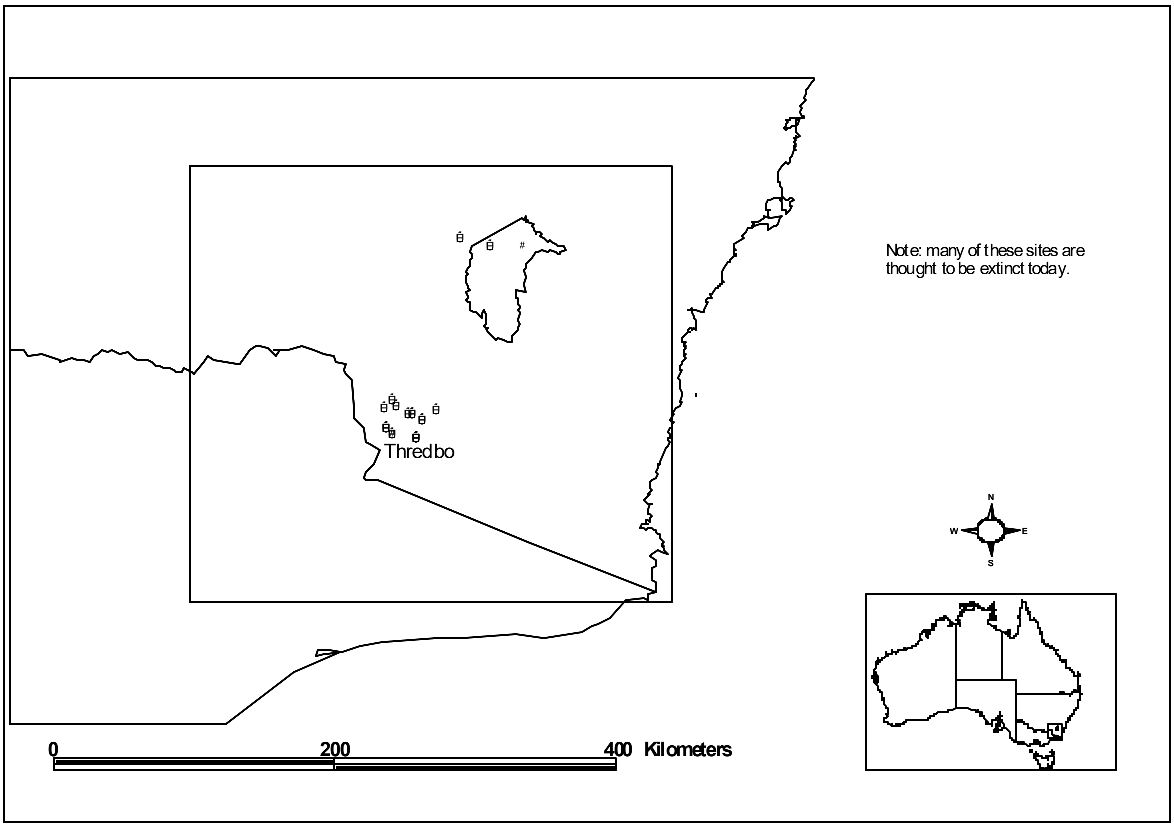
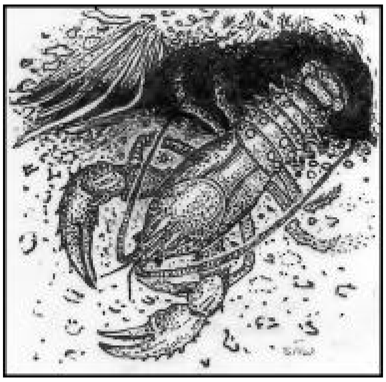


Distribution of *Edwardsina gigantea* (source: Zwick 1977)

Euastacus armatus — Murray Crayfish



Phylum: Arthropoda **Subphylum:** Crustacea **Class:** Malacostraca **Order:** Decapoda
Family: Parastacidae
Scientific name: *Euastacus armatus*
Common names: Murray River Crayfish, Murray Cray

1. Taxonomic status (including species and subgroups)

Euastacus armatus Von Martens, 1866.

The family Parastacidae contains all of the freshwater crayfish in the southern hemisphere (100 species in nine genera) which includes species found in Australia, New Guinea, New Zealand, Madagascar and South America (Horwitz 1990; Geddes 1990). Currently 36 species of the endemic genus *Euastacus* are known (Geddes *et al*. 1993).

2. Species survival status

Listed as Vulnerable in the ACT under Section 21 of the *Nature Conservation Act 1980*. Protected Invertebrate - schedule 1 of the *Nature Conservation Act 1980*, Gazette No. S85, 28 Aug 1991.

In NSW Murray Crayfish are currently not listed but may be protected under the *Fisheries Management Amendment Act 1997* in the long term.

Protected in South Australia under the *Fisheries Act 1982*.

Euastacus armatus is listed as Vulnerable (VU A1ade) on the 2000 *IUCN Red List of Threatened Species*. Assessment of the IUCN categorisation for the species using the *Ramas RedList* software program (Akçakaya and Ferson 1999) indicated that it may be Data Deficient.

3. Distribution

Euastacus armatus used to occupy a wide range of approximately 800 km including most of the Murray River and its tributaries (except the Darling River) flowing through NSW, Victoria and South Australia. It is also found in the Murrumbidgee and Cotter Rivers in the ACT. The most northerly recording was at Kandos, 160 km west of Newcastle (Morgan 1986).

This species of spiny crayfish is believed to have occupied the widest range of the family, as it ventured out of the cooler montane habitats, characteristic of spiny crays, into the warmer lower parts of the Murray Darling Basin (Morgan 1986). However the species is now thought to be rare below Mildura, and has suffered a major reduction across its range (Horwitz 1990; Lintermans and Rutzou 1991).

There have been recorded sightings of the species in a number of urban lakes and ponds in the ACT, but they are thought to be individuals that have been introduced (ACT Government 1999).

The species now appears to be rare in South Australia and within the Edwards, Wakool and Neimur rivers in NSW. Numbers appear to be greatly reduced in the remaining range (Geddes 1990).

4. Habitat

Euastacus armatus is found in both large and small streams ranging from pasture lands to sclerophyll forests, below altitudes of 700 m (Morgan 1986; Horwitz 1990; Hawking and Smith 1997) where there are cool (14°–19°C) flowing waters and soft banks into which they can dig burrows (Horwitz 1990; Hawking and Smith 1997; ACT Government 1999).

5. Biological overview

Euastacus armatus is the largest member of the genus, and second largest freshwater crayfish in the world (behind the Tasmanian Giant freshwater crayfish), with records of individuals up to 3 kg in weight (Lintermans and Rutzou 1991) and 50 cm in length (Horwitz 1990; Hawking and Smith 1997; ACT Government 1999).

Adults are identifiable by their large white claws and spiny abdomen, with spines that are orange or white in colour. The carapace and abdominal segments are generally dark green or brown, but may exhibit a blue tinge. In young individuals the claws may be a greenish yellow colour (Morgan 1986; Horwitz 1990; Ponder 1998; ACT Government 1999).

Murray crayfish are slow growing and individuals estimated at 20–50 years old suggests that they are long lived. Sexual maturity may not be reached until they are about 6–9 years old (Lintermans and Rutzou 1991; Maloney 1997; ACT Government 1999). Females breed only once a year near the end of Autumn, when they lay between 500–1,000 eggs, although fecundity is low (Morgan 1986; Lintermans and Rutzou 1991; Maloney 1997; ACT Government 1999; NSW Fisheries 1999). After the eggs are laid they remain under the tail of the female for up to six months until hatching in spring. Early instars remain under the tail for another four weeks and moult twice before leaving the female (Horwitz 1990; Maloney 1997; ACT Government 1999; NSW Fisheries 1999).

Murray crayfish are opportunistic feeders, feeding mostly on decaying vegetation but will also feed on dead fish (Horwitz 1990; Maloney 1997; ACT Government 1999). They are most active in the cooler part of the year from May to October when the temperature of the water is less than 20°C (Horwitz 1990; Maloney 1997; ACT Government 1999). Crayfish are burrowers, and where the riverbank is clay, as in the Murray and the lower Murrumbidgee Rivers, the Murray Crayfish will construct burrows. In other areas, where the banks are not conducive to digging, they will make use of the crevices between rocks on the riverbed (ACT Government 1999).

Nothing is known of the size of the current populations or their rates of change.

6. Significance

Euastacus, which is the second largest genus, is endemic to the eastern seaboard of Australia. In NSW there are more than 24 members of the genus (Morgan 1997) and in the ACT there are three (ACT Government 1999). Unlike the Murray Crayfish many of these species inhabit small ranges and so are naturally restricted (Horwitz 1990).

Crustacea may be useful ‘umbrella’ species, as they are easily identified and there is interest in their protection from recreational and commercial fishing groups. They are also found in many threatened ecosystems such as caves, moundsprings, alpine areas and rainforests (Horwitz 1990). As a freshwater species, any protection measures implemented for the Murray Crayfish may also assist other aquatic species which are considered threatened in the same habitat, such as the trout cod (*Maccullochella macquariensis*) Macquarie perch (*Macquaria australasica*) and the two-spined blackfish (*Gadopsis bispinosus*) (ACT Government 1999).

7. Threats

The main threat to the Murray Crayfish, as well as other crayfish species, (e.g., *E. bispinosus*, *Astocopsis gouldi*, *Cherax tenuimanus* and *C. quadricannatus*), is overfishing by recreational anglers. If too many larger individuals are removed the smaller non-reproductive individuals cannot replace the older crayfish, which will result in population declines (Horwitz 1990; Lintermans and Rutzou 1991; ACT Government 1999). Surveys suggest that the species was abundant throughout the Murray River until the 1950’s, after which the population appeared to suffer a dramatic decline. The status of the population after the 1960’s is unclear (Geddes 1990).

Habitat modification and changes to the river systems is another potential threat (Maloney 1997; ACT Government 1999). This modification is happening through a variety of means: siltation of the riverbed reducing shelter spots, loss of aquatic plants through turbidity, a decrease in oxygen, increased temperatures, an increase in weed species due to increased nitrogen, altered water temperature from industry and dams, and alteration in water flows from irrigation and weir construction (Horwitz 1990; Lintermans and Rutzou 1991; Maloney 1997; ACT Government 1999).

Many of these habitat modifications occur through inappropriate land uses, such as overgrazing and overclearing, forestry, and urban development causing siltation of the rivers. Siltation through urban development is thought to be the major impact in sections of the Murrumbidgee River in the ACT (ACT Government 1999).

Specific examples of adverse habitat modifications for *E. armatus* include:

- Cold water being released from dams such as the Hume, Dartmouth, the Tumut River storages, and Burrinjuck in summer, or when irrigation is required, causing *E. armatus* to breed for a greater part of the year. Whilst this could benefit population growth it also increases the pressure from fishing (Maloney 1997)
- The collapse of tailings dumps at the Captains Flat mine in 1938 and 1943 is believed to have resulted in high levels of zinc, copper and lead finding its way into the Molonglo River, which still cannot support fish for 15 km downstream of the mine (ACT Government 1999).
- Inappropriate agricultural practices in the 1850's along with the rabbit plagues of the 1920's may also have resulted in siltation by the removal of vegetation cover (ACT Government 1999)
- Increased salinity in rivers through inappropriate land uses may also be a significant factor in many areas of the lower Murray (Horwitz 1990; Maloney 1997)
- Introduced fish such as mosquitofish *(Gambusia holbrooki)*, carp (*Cyprinus carpio*), rainbow trout (*Onchorhynchus mykiss*) and brown trout (*Salmo trutta*) may be a threat to crayfish, through the introduction of diseases, competition for resources, habitat alteration or predation (Horwitz 1990; Lintermans 1998; ACT Government 1999)
- Introduction and the spread of diseases through uncontrolled trade of crayfish.

8. Conservation objectives

To ensure the long term survival of viable populations in the wild through coordinated management of the Murray Darling system.

9. Conservation actions already initiated

- Surveys have been undertaken in SA, Victoria, NSW and the ACT to determine the conservation status of Murray Crayfish. Recreational fisheries in NSW and Victoria were closed in the 1980's to allow research to be done into the life history, growth and habitat requirements (Lintermans and Rutzou 1991; Lintermans 1998). These fisheries have since been reopened with strict guidelines. NSW, Victoria, and the ACT have ongoing monitoring programs (Barker 1990; ACT Government 1999).
- Regulations in Victoria and NSW govern the way in which Murray Crayfish are caught with licences being required. Regulations include limiting gear to lift or hoop nets, which cannot cause platypus, tortoises, water rats, and other crayfish to drown, and limiting individuals to five nets in NSW and 5–10 in Victoria, depending on the location (Natural Resources and Environment 2000). There are also limits on the size and bags (10) of crays taken (Maloney 1997). In both NSW and Victoria the smallest cray that can be taken is one which has a carapace of 90 mm in length (Lintermans and Rutzou 1991); (Barker 1990).(Horwitz 1990; Lintermans and Rutzou 1991; ACT Parks & Conservation Service 1992; Maloney 1997; Lintermans 1998; ACT Government 1999)
- The taking of berried females (females with eggs) is illegal in NSW, Victoria and the ACT (Horwitz 1990; Lintermans and Rutzou 1991; ACT Parks & Conservation Service 1992; ACT Government 1999; NSW Fisheries 1999)
- In both NSW and Victoria some areas are closed to fishing (Horwitz 1990). In NSW rivers are also closed 400 m above and below many weirs (NSW Fisheries 1999).
- In the ACT *E. armatus* is listed as 'vulnerable' under the *Nature Conservation Act* 1980, which means that a permit is required to take individuals from a nature reserve. Since 1994 it is illegal to use drum nets and yabby traps in public waters. It is also illegal to sell Murray Crayfish in the ACT and NSW (Lintermans 1998; ACT Government 1999). In the ACT an Action

Plan has been written for the species (Lintermans 1998; ACT Government 1999).

- In South Australia Murray Crayfish are completely protected, as they are considered threatened after dramatic declines in the 1950's, and any trapping is illegal (Horwitz 1990; Lintermans and Rutzou 1991; Lintermans 1998).

10. Conservation actions required

Research

More research is required in the following areas:

- Effects of habitat modification on *E. armatus* populations.
- Effects of pesticides on aquatic ecosystems, as studies indicate that crustaceans are sensitive to heavy metals.
- Effects of eutrophication and salinity (Horwitz 1990).
- Biology and ecology of *E. armatus* eg: size at first breeding.
- Effects of introduced species.
- Seasonal use of microhabitats by *E. armatus*.
- Effect of land use practices (ACT Government 1999).
- Population size of *E. armatus* (Horwitz 1990).
- Possibility for reintroduction into sites in South Australia at sites downstream from weirs, as sites above them appear to be unsuitable for *E. armatus* (Geddes *et al*. 1993)
- Further surveys are required across some of the range.

Management

- A monitoring program needs to be set up in each State and Territory (ACT Government 1999).
- Legislation needs to be drafted so as to strengthen control over trade of crayfish between states (ACT Government 1999) and all States and Territories need to have similar regulations and fines for the protection of fisheries (Horwitz 1990).
- A national system or policy to control trade in introduced crayfish needs to be adopted by all of the appropriate States and Territories so as to reduce the spread of crayfish diseases.
- Better management is also required into the allocation of water from the Murray and other rivers for irrigators and environmental flows, which are essential for breeding (Maloney 1997).
- An education program is required to inform the public of the plight of *E. armatus* and the ways in which we can protect the species (Lintermans 1998).

Future management of *E. armatus* habitats need to include:

- Fencing of riverbanks so as to reduce bank erosion and allow natural revegetation (Maloney 1997).
- Balanced water harvesting so as to allow adequate environmental water flows (Maloney 1997).
- Better management at the state level of catchments.
- Employment of more fisheries inspectors may be useful in some areas where there has been greater pressure.
- Rehabilitation of many sites altered by siltation, erosion and habitat modification.

11. Relevant Experts/Data Providers

Mark Lintermans – ACT Parks and Conservation, Canberra
John Merrick – Macquarie University, Sydney

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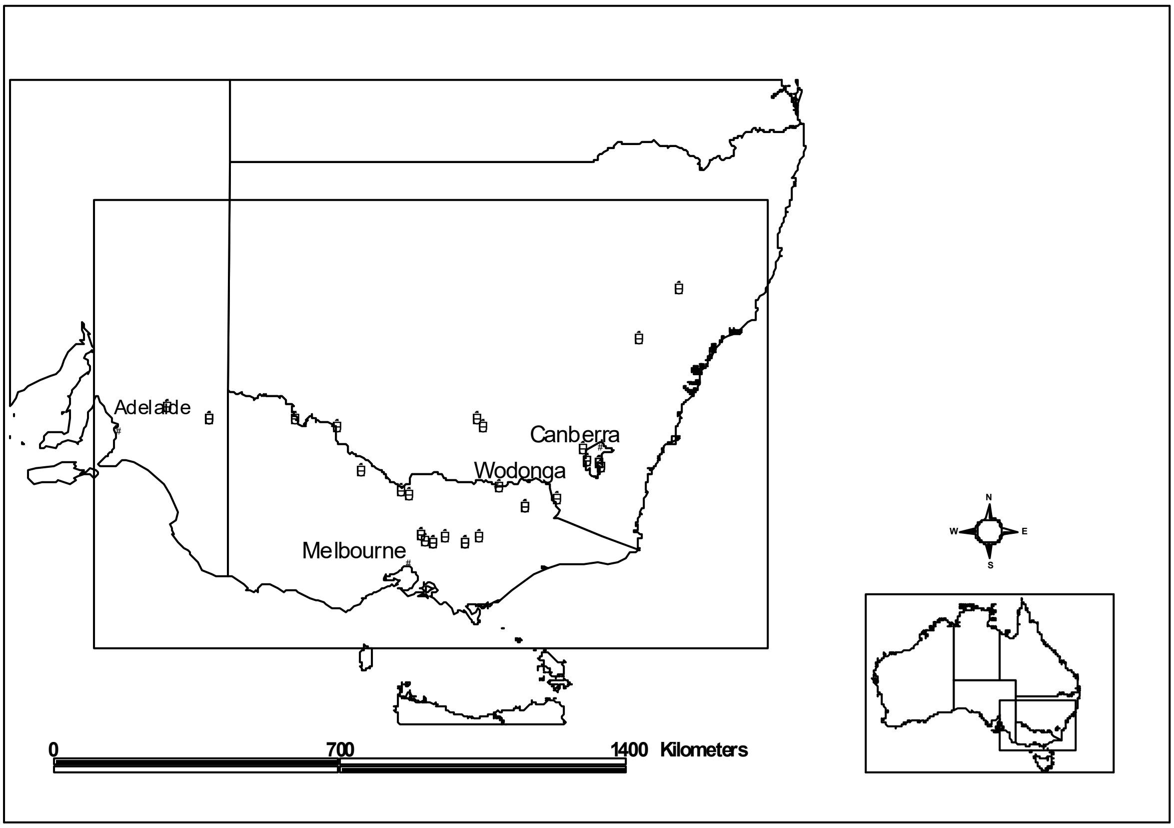
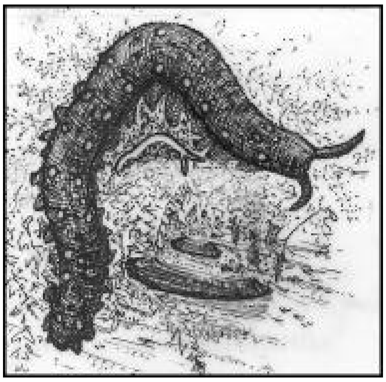


Distribution of *Euastacus armatus* (source: Morgan 1986)

Euperipatoides rowelli Tallaganda Velvet Worm



Phylum: Onychophora
Family: Peripatopsidae
Scientific name: *Euperipatoides rowelli*
Common names: Tallaganda Velvet worm

1. Taxonomic status (including species and subgroups)

Euperipatoides rowelli Reid, 1996

'*rowelli*': named in honour of Dr David Rowell who works on chromosome morphology of Onychophora (Reid 1996).

The phylum Onychophora contains only two families, the Peripatidae and the Peripatopsidae of which there are currently 140 species worldwide. In Australia 44 species are currently recognised, approximately 80% of the world's Peripatopsidae. The genus *Euperipatoides* is endemic to southeastern mainland Australia and currently contains three species (Reid 1996). Until 1996 *Euperipatoides rowelli* was believed to be a variant of *E. leuckartii* (Reid 1996).

2. Species survival status

Currently not listed under any State or Commonwealth legislation.

Euperopatoides rowelli is not listed on the 2000 *IUCN Red List of Threatened Species*. Assessment of the IUCN categorisation for the species using the *Ramas RedList* software program (Akçakaya and Ferson 1999) indicated that it may be Data Deficient.

3. Distribution

Euperipatoides rowelli is present from Black Mountain, ACT, to the southeast coast of NSW, with its major concentration located in Tallaganda State Forest, NSW (Reid 1996).

4. Habitat

Euperipatoides rowelli is found over a wide area that covers both dry sclerophyll and wet sclerophyll habitats (Reid 1996). Tallaganda State Forest includes both forest types. Species composition changes with aspect and altitude and includes species such as *Eucalyptus fastigata, E. obliqua*; *E. radiata, E. sieberi*; *E. pauciflora, E. stellulata*, *E. dalrympleana*, *E. viminalis*, *E. nitens*, and *E. rubida*. The understorey consists mainly of *Acacia* species and microphyll shrubs with *Poa*, *Dianella* and bracken fern, which may help in maintaining the moist conditions the animal requires (Barclay *et al*. 2000b).

The average daytime temperature at Tallaganda State Forest ranges from 7°–13°C in winter and 23°–29°C in summer, with average summer and autumn rainfall of 1,200mm per annum (Scott and Rowell 1991; Barclay *et al*. 2000b). Snow occasionally falls at altitudes over 1,000 metres, and coastal air drifting in can form into rain or fog (Barclay *et al*. 2000b).

Onychophorans are prone to desiccation, so they require moist surroundings, such as rotten logs and rotting forest litter (Reid 1996; Forest Practices Board 1998).

5. Biological overview

Onychophorans are caterpillar-like creatures, with females growing to about 16 mm long and males shorter at 13 mm, with two antennae, a soft segmented body with a pair of unjointed legs called 'lobopods' with two curved claws attached to each segment (15 segments in *E. rowelli*) (Forest Practices Board 1998; Barclay *et al.* 2000b).

Generally this species is of a blue velvety appearance with no distinct patterning (Reid 1996; Barclay *et al.* 2000b). The general appearance can be highly variable over the fragmented range (Reid 1996). Young *E. rowelli* are born white with a characteristic triangular pattern on the dorsal side, obtaining the blue of the adults later (Reid 1996). An identifying characteristic of *E. rowelli* is the presence of two distinct rows of bristles on the antennal rings. For a more detailed description of *E. rowelli* see Reid (1996).

Reproduction among onychophoran species ranges through ovipary (laying eggs, which is only found in Australian and New Zealand species) ovovivipary (producing eggs that hatch within the body), primitive vivipary (in the Peripatopsidae) and placental vivipary (Peripatidae) (Scott and Rowell 1991). *E. rowelli* is ovoviviparous (giving birth to live young) (Leishman and Eldridge 1990; Tait *et al.* 1990; Rowell *et al.* 1995; Barclay *et al.* 2000a,b).

Sperm transfer is unusual in some onychophorans, including *E. rowelli*, where the male places a spermatophore randomly on the body of the female, and sperm is absorbed through the body wall into the haemolymph and on to storage sites near the ovary (referred to as dermal-haemocoelic reproduction) (Curach and Sunnucks 1999; Sunnucks *et al.* 2000). Here the sperm remain until eggs are released, which then develop in the uterus for the next 30 weeks (Hardie 1975). The males of some Australian species possess head structures which are used in the transfer of sperm (Tait *et al.* 1990).

Molecular studies undertaken by Curach and Sunnucks (1999) indicate that *E. rowelli* employs some, as yet unknown, mechanism so as to compartmentalise sperm from different males, therefore increasing the genetic diversity of the offspring. Many uteri studied have been found to possess both developed and undeveloped embryos, resulting in batches of young produced up to six months apart without remating (Curach and Sunnucks 1999). Sperm held may remain viable for more than nine months (Sunnucks *et al.* 2000).

Young develop the blue colouring of the adults over time (75 days), which may signify sexual maturity, and continue growing by moulting for up to 18 months (Hardie 1975; Leishman and Eldridge 1990; Scott and Rowell 1991). Young can catch and eat prey immediately after birth (Leishman and Eldridge 1990).

Males are larger than females as juveniles, but this changes once they reach maturity. The reason for this is unknown, but it may suggest that females are longer lived than males, or that females grow more quickly. Most populations appear to be biased towards females, with the ratio being as high as 3:1 in favour of females, which may be due to males leaving to colonise new sites when they reach maturity (Scott and Rowell 1991). It is thought that the males initially disperse to find new sites, releasing a pheromone from the crural papillae which attracts females when they have located a suitable site (Barclay *et al.* 2000a; Barclay *et al.* 2000b).

Euperipatoides rowelli is an opportunistic feeder primarily feeding at night when there is more moisture in the air (Hardie 1975; Forest Practices Board 1998). Their diet consists mainly of termites (Scott and Rowell 1991), Collembola and other litter dwelling invertebrates. Onychophorans have an unusual way of feeding. The mouthparts consist of two sclerotised jaws and two small protruding oral papillae. The purpose of the latter is to cover potential prey with slime to disable it. The animal then cuts a hole in the body wall of the prey and sucks the liquids from it (Hardie 1975; Reid 1996).

As for all onychophorans, *E. rowelli* are slow moving creatures that are generally restricted to moist microhabitats, as they lack the cuticular covering over the tracheal openings along the side of the body. Despite this requirement, suitable moist microhabitats can be found in caves, dry woodlands, and grasslands (Tait *et al.* 1990; Barclay *et al.* 2000a,b). Some species found in drier regions have adapted to the lack of water by spending much of their time in small crevices between rocks, lying so that most of the tracheal openings are sealed. They can also pass into a state of torpor for up to three months at a time (Hardie 1975; Rowell *et al.* 1995). Dispersal occurs when conditions are suitable and the risk of desiccation is low.

Studies suggest that *E. rowelli* is specific in the log species it inhabits, with aspect, log length and density, amount of decay present and presence of termites being important factors (Barclay *et al.* 2000b). Before a log becomes suitable for *E. rowelli*, it needs to have been decaying on the forest floor for an estimated 45 years, so that the wood is very soft. If the heartwood is too soft the remaining structure will collapse, resulting in the loss of suitable habitat for the animal (Barclay *et al*. 2000b). It has also been suggested that the water content of the wood is of critical importance (Scott and Rowell 1991; Barclay *et al*. 2000a,b). The volume of the log may be an important factor in its suitability for colonisation, as there is considerable overlap in the moisture content of inhabited and uninhabited logs (Barclay *et al*. 2000b).

In Tallaganda State Forest termites are found in close association with many populations of *E. rowelli*. The presence of termites, as well as providing a food source, may also provide suitable habitat for the onychophorans by breaking down the tough woody tissues of the logs (Scott and Rowell 1991; Barclay *et al*. 2000b).

Little is currently understood about the population size or dynamics of *E. rowelli*, but the population in Tallaganda State Forest has been estimated to be over 1,000 per hectare on SE facing slopes (Barclay *et al*. 2000b).

6. Significance

The importance of the *Onychophora* lies in the unusual characteristics and phylogenetics of the phylum, which suggest that the onychophorans represent a 'missing link' in the evolution of arthropods (Hardie 1975; Leishman and Eldridge 1990; Scott and Rowell 1991). There is no doubt that the onychophorans are a very ancient phylum represented by fossils from the Burgess Shale, 540 million years old (Tait *et al*. 1990; Archer 1994).

Dispersal appears to be very low in the Peripatopsidae (Reid 1996), and many extant populations exhibit inbreeding pressures (Barclay *et al*. 2000a). The large number of species found in the ACT region may suggest that an overlap exists between newly evolved species from the north and the more prehistoric forms from the south (Reid 1996).

Wet forests such as the type that *E. rowelli* depends on are vulnerable to many threats due to the delicate balance of microhabitats and the presence of forestry operations. These habitats support many invertebrates, particularly those which depend on rotting wood (New 1995; Barclay *et al*. 2000a). *Euperipatoides rowelli* may prove useful as a 'flagship' taxon, that is a well-known species that can be used to protect habitat that may harbour other threatened species. Few studies have been undertaken on Australian onychophorans, making the work undertaken on *E. rowelli* vital in our understanding and conservation of a scientifically significant order. There are currently five genera of onychophorans known to be present in Tallaganda State Forest (Sunnucks *et al*. 2000).

As *E. rowelli* requires the logs of *Eucalyptus* species that break down rapidly, populations at any location are highly fragmented. This fragmentation has resulted in a high level of endemism, which makes the species highly vulnerable to any disruption of the environment (Reid 1996; Barclay *et al*. 2000a). This endemism has resulted in substantial genetic variations within species (Curach and Sunnucks 1999). Several distinct local forms of *E. rowelli* are identifiable within Tallaganda State Forest and its surrounds (Sunnucks and Wilson 1999). These differences encompass variations in reproduction, morphology and genetics (P. Sunnucks personal communication).

7. Threats

Euperipatoides rowelli is threatened by habitat destruction, primarily through forestry operations. Although logging has taken place in Tallaganda State Forest for over 100 years, until 1960 selective logging meant that many logs where left on the forest floor to decompose, providing habitat for *E. rowelli*, and other species dependent on these microhabitats. Recently the forest has been included in the Eden Woodchip Concession area, which means that fewer logs may be left on the forest floor. As current habitat logs become unsuitable there may be fewer available logs present in the future. This may not pose a threat for the next 80–100 years, but current logging practices may be an issue for many species of log dependent invertebrates (Scott and Rowell 1991; Barclay *et al*. 2000a; Barclay *et al*. 2000b). Removal of significant amounts of fallen timber for use as firewood, primarily by residents of the ACT, further reduces the amount of suitable habitat remaining on the forest floor.

Due to the high level of genetic variation found within a location, the clearance of small forest blocks may cause the extinction of cryptic species. This genetic variation may also make the species highly vulnerable to the negative impacts of genetic mixing (outbreeding depression) if geographically distinct taxa were to mix, due to translocation or changes in the habitat (P. Sunnucks personal communication).

8. Conservation objectives

To determine the distribution and conservation status of *E. rowelli* and to determine the ecological requirements so as to help in maintaining the current populations.

9. Conservation actions already initiated

Research has been undertaken into the distribution and population genetics of *E. rowelli*. Some research has been completed on the process of decomposition of trees in relation to the habitat requirements of *E. rowelli* and other log dwelling invertebrates, but this is not complete.

10. Conservation actions required

Research

- Whether the presence of termites facilitates the presence of *E. rowelli* populations (Barclay *et al.* 2000b).
- Dispersal and colonisation behaviour (Barclay *et al.* 2000a).
- What microclimates are exploited by *E. rowelli*.
- What effect do changes in the habitat have on populations and the impact of microclimate variations (Scott and Rowell 1991; Reid 1996).
- The predator/prey relationship and what effect any changes may have on either population (Reid 1996).
- Distribution of the species.
- What tree species are utilised most frequently and what factors are important in the decomposition process (Scott and Rowell 1991).
- The long-term effects of various logging practices (Reid 1996).
- Population biology of onychophorans in general, including issues such as sex ratio modulation, sexual dimorphism (Scott and Rowell 1991; Curach and Sunnucks 1999).
- The importance of the understorey in maintaining moisture (Barclay *et al.* 2000b).
- If colonisation always occurs once a tree has been felled, or if they are present before (Scott and Rowell 1991).
- A regional evaluation of the taxonomic status is required (New 1995).

Management.

- Ensure that some felled trees remain on the forest floor to ensure the availability of future habitat (Barclay *et al.* 2000b).
- Ensure that some of the habitat required by *E. rowelli* is protected in reserves.
- An education program is required to inform the public and land managers of the importance of protecting habitat that onychophorans and other species depend on.

11. Relevant Experts/Data Providers

Dave Rowell – Australian National University, Canberra
Paul Sunnucks – LaTrobe University, Melbourne
Noel Tait – Macquarie University, Sydney

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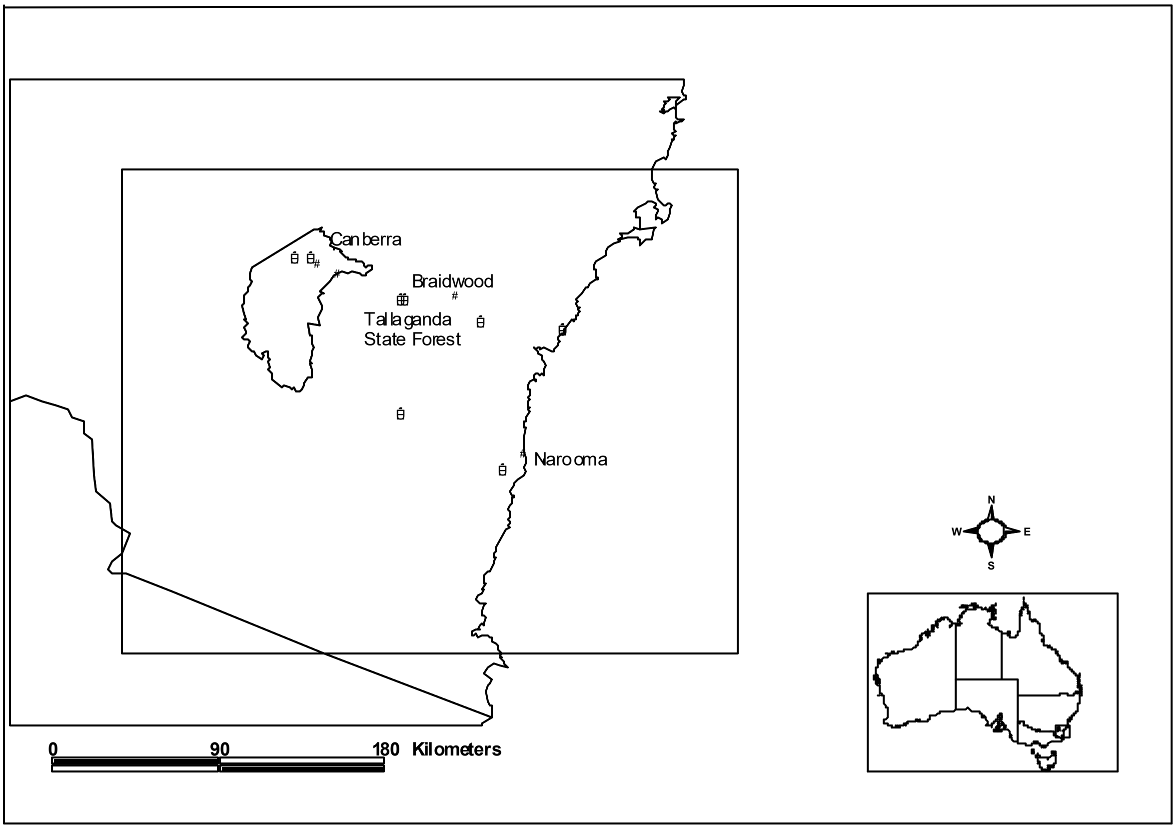
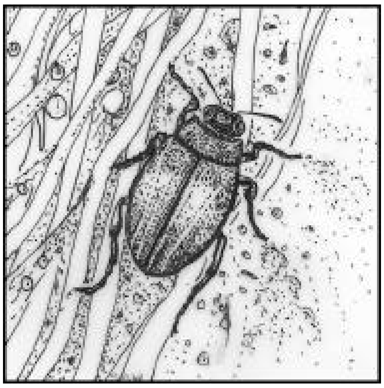


Distribution of *Euperipatoides rowelli* (source: Reid 1996).

Hygrobia australasiae Water Beetle



Phylum: Arthropoda **Class:** Insecta **Order:** Coleoptera
Family: Hygrobiidae
Scientific name: *Hygrobia australasiae*
Common names: Screech beetles/water beetles

1. Taxonomic status (including species and subgroups)

Hygrobia australasiae (Clark) Zimmerman, 1920

The Hygrobiidae are a small family comprising a single genus of six species. In Australia there are four species of *Hygrobia* (*H. nigra*, *H. australasiae*, *H. maculata*, and a new unnamed species found in two swamps in Western Australia (C. Watts personal communication), all of which are believed to be rare (Britton 1981). The other two species of the family include *H. hermanni* from Europe/Northern Africa and *H. davidi* from China. The distribution suggests that at one time the family was widely distributed (Britton 1981).

2. Species survival status

Currently not listed under any State or Commonwealth legislation.

Hygrobia australasiae is not listed on the 2000 *IUCN Red List of Threatened Species*. Assessment of the IUCN categorisation for the species using the *Ramas RedList* software program (Akçakaya and Ferson 1999) indicated that it may be Data Deficient.

3. Distribution

Hygrobia australasiae is found throughout southern Australia, from Tasmania, through Victoria, New South Wales, southern South Australia and southern Queensland (Britton 1981; Lawrence 1987).

4. Habitat

Hygrobia australasiae is found in ponds where there is little to no water movement, often where there is an open substrate of gravel or similar material (Balfour-Browne 1922; Lawrence 1987; Hawking and Smith 1997). These habitats are uncommon and ephemeral as they dry out in summer, and so tend to be isolated and patchy in distribution.

5. Biological overview

Hygrobia are small aquatic beetles up to 10 mm in length, with a thick, chunky body and modified legs which have a fringe of stiff hairs to assist in swimming (Williams 1980; Hawking and Smith 1997). Many water beetles also possess a thin layer of hair to trap air bubbles so that the beetle can remain underwater for long periods (Lawrence and Britton 1991).

The ventral side of *H. australasiae* is predominantly black, while the elytra are a consistent yellow/black colour (Britton 1981). For a more detailed description of *H. australasiae* see Clark (1962) and Britton (1981).

Larvae of *Hygrobia* are club shaped with a triangular head, and have two long filaments (cerci) arising from the base of the last abdominal segment, which is strongly tapered. As they are fully aquatic they also have gill filaments on some of the thoracic and abdominal segments as well as the legs (Balfour-Browne 1922; Williams 1980).

In Australia the genus is found predominantly during the winter months in temporary swamps, with eggs being laid in July or August in southern Australia (C. Watts personal communication).

The biology of *Hygrobia* species is not well known (C. Watts personal communication). It is believed that females may live for three years (Balfour-Browne 1922). Eggs are oval and approximately 1.5 mm long and 0.87 mm wide, and are encased in a material that swells up with water to provide protection and moisture to the larvae. Eggs are laid in rows on plants surrounding the water body (Balfour-Browne 1922). *Hygrobia* larvae undergo three instars before they are able to leave the water, which occurs from August to October in southern Australia (C. Watts personal communication). On leaving the water the larvae locate a soft place, such as mud or sand, and excavate a chamber in which to pupate. The pupal stage lasts two to three weeks (Balfour-Browne 1922; Lawrence 1987). There is a single generation per year with the time from egg to adult being in the range of 9–15 weeks (Balfour-Browne 1922).

Both the adult and the larvae are carnivorous, feeding on insect larvae and tubificid worms found on the bottom of the pond (Balfour-Browne 1922; Lawrence 1987; Hawking and Smith 1997). Adults spend most of their time on the bottom of the pond feeding in the mud, so are rarely seen, only surfacing to 'breathe' every thirty minutes or so. Air is trapped under the elytra by fine hairs (Balfour-Browne 1922; Britton 1981; Lawrence 1987).

Hygrobiidae are commonly referred to as 'screech beetles' due to the strident noise made when alarmed, by rubbing together the apex of the abdomen and the inner part of the elytra (Balfour-Browne 1922; Lawrence 1987).

Hygrobia australasiae, as well as the other species of Australian *Hygrobia* populations are believed to be locally restricted, although they have a wide distribution (C. Watts personal communication).

6. Significance

As an aquatic carnivore, water beetles are opportunistic feeders feeding on larvae of mosquitoes and other aquatic invertebrates. In turn they provide food for other aquatic/semiaquatic spiders, beetles, and dragonflies. They may be important in maintaining levels of mosquitoes and other species of semiaquatic insects.

Like other aquatic species *Hygrobia* may prove useful in water quality monitoring, as it is often present in some water bodies, yet absent from seemingly similar adjacent water bodies (C. Watts personal communication).

7. Threats

Eutrophication caused by the increased levels of nutrients entering the water body, through cow and sheep manure, and agricultural fertilisers, is thought to be a major threat to *Hygrobia* populations (C. Watts personal communication).

Temporary winter and swampy pools, which dry up in the summer months, are a very important resource for many aquatic species. Loss of these seasonal sites may be detrimental to *H. australasiae* and other aquatic invertebrates (C. Watts personal communication).

In many areas throughout the range swamps and wetlands are being drained or modified for agricultural and urban uses.

8. Conservation objectives

Increasing population numbers through maintaining or increasing available good quality habitat (C. Watts personal communication).

9. Conservation actions already initiated

A limited amount of survey work has been undertaken throughout the range.

10. Conservation actions required

Research

- Further surveys to determine the distribution and extent of *Hygrobia* species in Australia, and whether they are present in reserves and significant wetlands.
- Determination of the habitat requirements of *H. australasiae* and other members of the genus.
- More research is required into the life history, reproductive biology and population genetics of the genus.

Management

- Control of nutrient flows into water bodies where the species is found, including restricting access to livestock during winter when the species is most active.

- Control of swamp and wetland modification in areas known to harbour the species.

11. Relevant Experts/Data Providers

Chris Watts – South Australian Museum, Adelaide

12. References

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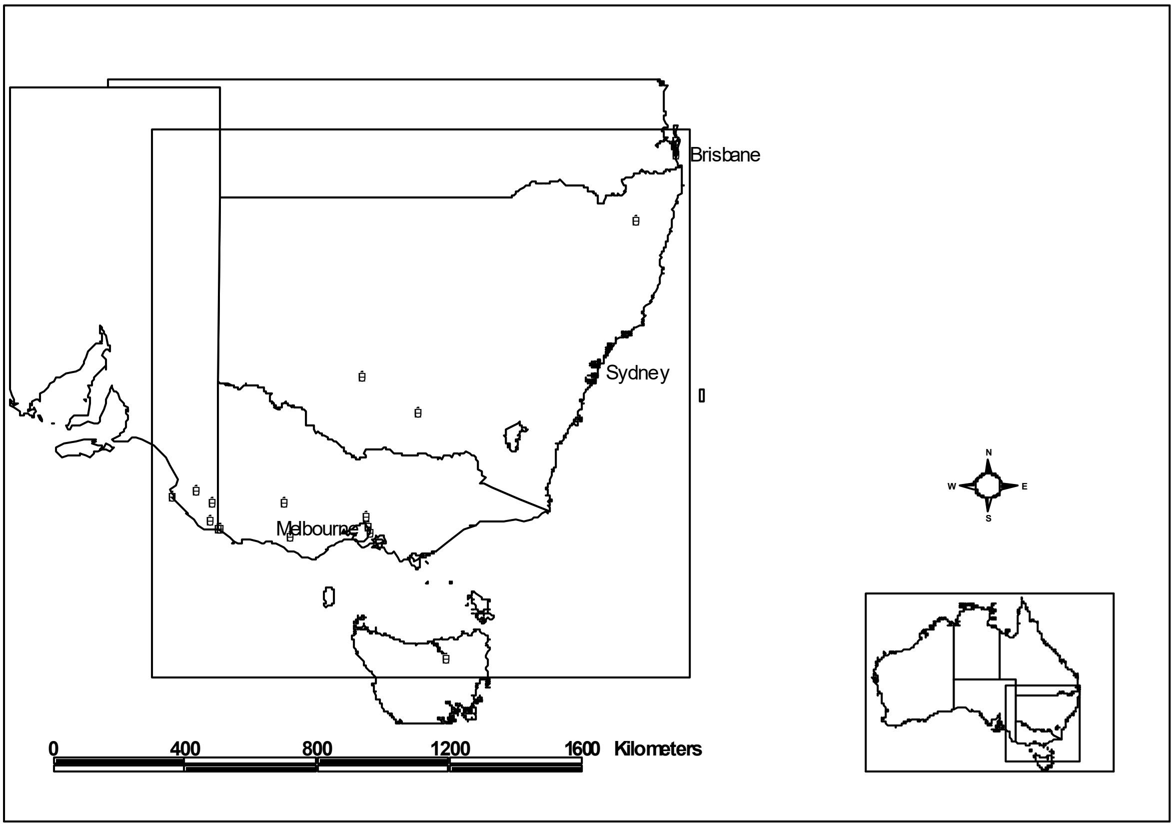
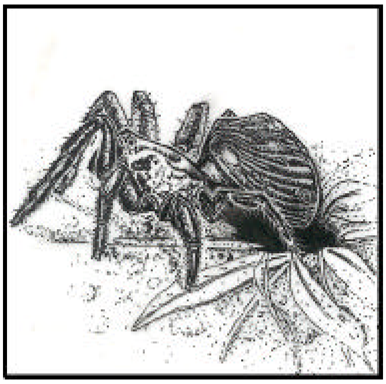


Distribution of *Hygrobia australasiae* (source Britton 1981).

Idiosoma nigrum Shield-Backed Trapdoor Spider



Phylum: Arthropoda **Class:** Arachnida **Order:** Araneae **Suborder:** Mygalomorphae
Family: Idiopidae
Scientific name: *Idiosoma nigrum*
Common names: Shield-backed trapdoor spider

1. Taxonomic status (including species and subgroups)

Idiosoma nigrum Main, 1952

The genus *Idiosoma* comprises of three species, which are endemic to southeastern Western Australia, (Main 1985).

2. Species survival status

Listed as Vulnerable under the Western Australia Wildlife Conservation (Specially Protected Fauna) Notice 1998 Schedule 1 – fauna that is rare or likely to become extinct.

Idiosoma nigrum is not listed on the 2000 *IUCN Red List of Threatened Species*. Assessment of the IUCN categorisation for the species using the *Ramas RedList* software program (Akçakaya and Ferson 1999) indicated that it may be Data Deficient.

3. Distribution

The genus *Idiosoma* is endemic to southwestern Western Australia, with *I. nigrum* being found in the central wheatbelt area (Main 1991). Although once widespread, *I. nigrum* is now restricted to a small area Jam (*Acacia acuminata*) woodland, east of the northern part of the Darling Ranges to Murchison River, and then east to Paynes Find (Main 1982).

4. Habitat

Idiosoma nigrum make its burrows in heavy clay soils in open York gum (*Eucalyptus loxophleba*), salmon gum (*E. salmonophloia*), wheatbelt Wando (*E. capillosa*) woodland, with Jam (*A. acuminata*) forming a sparse understorey (Main 1987, 1991, 1992). Some nests have also been found in granite soils (Main 1992).

A thin layer of permanent *Eucalyptus*, *Casuarina* and *Acacia* litter is required, within which the spiders forage (Main 1987). If the litter layer is too thick the young spiders cannot dig through to establish nests (Main 1992).

5. Biological overview

The body of *I. nigrum* is approximately 14 mm long, and the chelicerae approximately 4 mm long. The legs of the males are longer than the females, thought to be associated with the fact that males wander in the breeding season to look for females in their burrows (Main 1952, 1985). *Idiosoma nigrum* is visually striking with the cephalothorax and appendages black or a very dark brown colour. The venter is generally yellow to grey (Main 1985), with two pairs of spinnerets (Main 1952). The dorsal side of the abdomen is heavily sclerotised, forming a shield with deep ridges. This scleritorisation is an important adaptation of arid spiders as it reduces the risk of desiccation (Main 1952; Main 1982; Main 1991).The eyes are placed in three rows, the two anterior rows each with two eyes and the posterior row with four in a transverse line (Main 1982).

Females can live for at least 20 years, maturing at five years, while the males are not as long lived. This longevity is important as juvenile mortality appears to be high (Main 1982, 1985, 1991). The presence of mature spiders does not necessarily mean that a viable population exists, without evidence for some recruitment of males and juveniles (Main 1987, 1992).

Males leave their burrows during autumn and early winter (after the first rains of the season), to search for females. Males possibly mate with many females then die soon after. Dispersal occurs after rain which reduces the possibility of desiccation (Main 1982, 1985, 1987, 1991). *I. nigrum* spiderlings tend to aggregate around the parental nest, enabling the population to survive in small undisturbed areas (Main 1987, 1991, 1992). During the following spring/summer eggs are laid in flat silk cocoons that are attached inside the females' burrows. Eggs hatch in December/January with spiderlings remaining in the burrow with the mother for up to six months, during which period they do not leave the burrow. The spiderlings leave the nest the following autumn (after rain) to locate a suitable nest site (Main 1985, 1992). Due to the depletion of resources during egg production and fasting, females only produce a brood once every two years. Data on the number of eggs laid are limited (Main 1957).

Most spiders are opportunistic and generalist feeders. The main prey for *I. nigrum* appears to be ants, but they will also eat other small invertebrates, including other spiders (Main 1982; Yen 1995). Spiders themselves are food for birds, small mammals, lizards, frogs, centipedes, and other spiders (Main 1985; Yen 1995).

Idiosoma is adapted to survival in the arid conditions of south western Western Australia (Main 1957, 1982, 1992, 1999) As trapdoor spiders live their sedentary life in burrows in close proximity to one another, they are well adapted to surviving in small fragments of habitat. This also assists males, as they do not have to search far for mates, and also decreases their chances of predation (Main 1987). Another adaptation to aridity is 'twig lining'. When building the burrow, the spider gathers long twigs and fixes one end to the rim of the nest. This is continued in a radial pattern around the nest opening. These twigs act as trip wires signalling the presence of potential prey. The spider positions itself just underneath the trapdoor, with the palps and the anterior legs placed on some of the twigs. When the twigs are touched, the spider quickly exits the burrow and catches the prey (Main 1952, 1985, 1987, 1991). Other trapdoor spiders also exhibit this behaviour, however *Idiosoma* appears to be the only genus in which it is obligatory, rather than an individually-developed behaviour as in other genera (Main 1982).

The burrows themselves are tubular, approximately 20–30 cm deep (Main 1992), and wider at the base and the opening than in the centre. The nest is lined with silk and there is a thin trapdoor attached to the rim (Main 1952). The nest is kept free of fungus and mould by mites, which feed on the refuse at the bottom of the burrow (Main 1985). Trapdoor spiders depend on the moist microclimate that the deep burrow provides, as they are very susceptible to desiccation. *I. nigrum* is more highly adapted to aridity than many other species living in the wheatbelt, being able to tolerate temperatures up to 33°C. As such their burrows are not as deep as those of other species (Gray 1968; Main 1982).

When predators attack the burrow, the spider will hold the door closed by hanging upside down from it. It may also turn around inside the burrow, positioning its hard abdomen is uppermost, making it difficult for a successful attack. However, this also makes it easier for ectoparasitic wasps to lay eggs on the spider (Main 1976, 1985).

There are no data on population abundance or rates of change in *I. nigrum*.

6. Significance

Mygalomorph spiders are vital to the ecology of the dry Western Australia wheatbelt, as they are one of the dominant predatory invertebrates, contributing to the regulation of population growth of many other invertebrates, including other spiders (Main 1981; Yen 1995). Burrowing species also contribute to soil turnover, water percolation and nutrient recycling (Main 1991).

As spiders are predators and sedentary, they may be good indicators of environmental health, as their presence means that many other invertebrates are also present (Main 1987). Trapdoor spiders may be particularly useful indicators as they require a stable soil structure, and do not disperse far from the parent burrow (Main 1992; Yen 1995).

7. Threats

Currently *I. nigrum* suffers the greatest threat of local extinction in the central and southern parts of its range (Main 1991). The main threat to *I.*

nigrum, and the vast array of trapdoor spiders in the Western Australia wheatbelt, is fragmentation of this already sparse habitat due to cropping and sheep grazing (Main 1987, 1991; Yen 1995). Grazing and vehicles compact the soil and reduce the amount of leaf litter on the ground (Yen 1995). Cultivation reduces the number of insect species, through monoculture planting and use of insecticides (Main 1987). *I. nigrum* is also particularly sensitive to habitat changes, as adult spiders cannot dig a new burrow once the old one is destroyed (Main 1985). Rabbits are also a problem in some areas as they disturb the soil profile and reduce the regrowth of native vegetation (B. Main personal communication).

Fire may also represent a threat to *I. nigrum.* It has been shown in another trapdoor spider (*Anidiops villosus*), with similar dispersal patterns to *I. nigrum*, that removal of the understorey and litter layer by fire can lead to local extirpation, with limited potential for recolonisation from nearby patches (Main 1991; Main 1992; Yen 1995). Drought may also have the same effect. Rising salinity is also a potential threat to certain small populations (B. Main personal communication).

8. Conservation objectives

Populations need to be maintained at the current level and allowed to increase if possible. More importantly, current habitat needs to be conserved and expanded.

9. Conservation actions already initiated

Long-term studies have been undertaken into the population biology and distribution of *I. nigrum*.

10. Conservation actions required

Research

- Research is required into the population genetics of the species, as there are morphological variations present over the range of the species, due to its localised nature (B. Main personal communication).
- More research is also required into the biology and distribution of the trapdoor spiders (Yen 1995) in order to better understand their habitat requirements.

Management

- In the short term the current habitat needs to be protected from disturbance so as to ensure the long-term persistence of *I. nigrum* and its genetic variation. The spider primarily occurs on private property, which is heavily grazed (Main 1992), so it is particularly important that the soil structure and the litter remains as natural as possible, by excluding stock and rabbits. In order to regenerate the vegetation in degraded patches, some burning may be required (Main 1987). Since fire may be detrimental to the spiders, other regeneration techniques may need to be practised.
- The removal of any factor that disturbs the soil profile of *I. nigrum* sites is important to the survival of the species. This includes the control of rabbits, the removal of grazing, and the control of fire. If it is not possible to remove fire due to other factors, burning should be done in a mosaic pattern so as to retain well-established patches of habitat that have variable fire intensity (Main 1992).
- As rising salinity also appears to be a problem for some of the isolated populations, action needs to be taken to ameliorate it.
- More focus in needed on educating the wider public about the importance of spiders in the environment (Yen 1995).
- Many species of trapdoor spiders in the wheatbelt require very subtle differences in habitat, which are not going to be available in all patches. It has been suggested by Main (1987) that few of the currently inhabited patches will be able to sustain the current communities of spider species indefinitely. If enough remnants are sustained, then many of these species may be able to persist, but only in highly restricted and fragmented habitats (Main 1992). Ideally fewer remnants of sufficiently large size are preferable to many small remnants, but this may no longer be practical.

11. Relevant Experts/Data Providers

Barbara York Main – University of Western Australia, Perth

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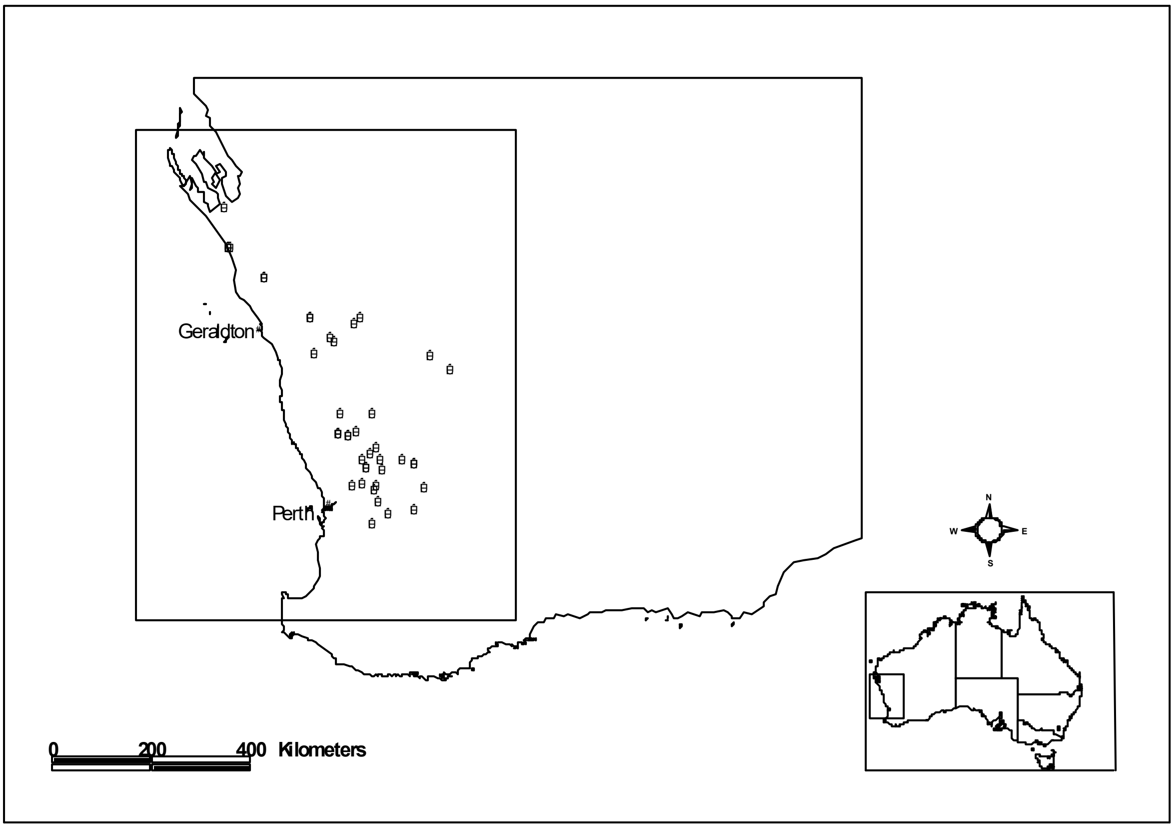
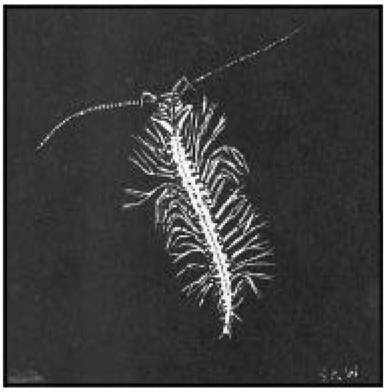


Distribution of *Idiosoma nigrum* (source: Main 1957; Barbara York Main personal communication)

Lasionectes exleyi — Remipede



Phylum: Arthropoda **Subphylum:** Crustacea **Class:** Remipedia **Order:** Nectiopoda
Family: Speleonectidae
Scientific name: *Lasionectes exleyi*
Common names: Remipede

1. Taxonomic status (including species and subgroups)

Lasionectes exleyi Yager & Humphreys 1996.

"*exleyi*": named in memory of Sheck Exley, a pioneer cave diver (Yager and Humphreys 1996).

There are 12 species of remipede in the world (found in two families and six genera). The genus *Lasionectes* currently contains two species (Yager and Humphreys 1996; Yager and Carpenter 1999).

2. Species survival status

The species is listed as Vulnerable in accordance with the *WA Wildlife Conservation (Specially Protected Fauna) Notice 1998* Schedule 1 – fauna that is rare or likely to become extinct. On the recommendation of the WA Threatened Species Scientific Committee the WA Minister for the Environment is currently considering upgrading the species to Critically Endangered. The ecological community at Bundera Sinkhole, of which *L. exleyi* is a part, has also been assessed as Critically Endangered (Andrew Burbidge personal communication).

Listed as vulnerable in accordance with Schedule 1 of the *Commonwealth Environmental Protection and Biodiversity Conservation Act* 1999.

Lasionectes exleyi is not listed on the 2000 *IUCN Red List of Threatened Species*. Assessment of the IUCN categorisation for the species using the *Ramas RedList* software program (Akçakaya and Ferson 1999) indicated that it may be Critically Endangered.

3. Distribution

Lasionectes exleyi has only been found in one location, at Bundera Sinkhole, an anchialine (submerged) cave in Cape Range Peninsula, 1,200km north of Perth, Western Australia (Yager and Humphreys 1996; Sutton 2000). The sinkhole is one of a larger karst system of sinkholes and caves that have been carved out of the limestone over millions of years, and is partially fed from an aquifer underneath it (Sutton 2000).

4. Habitat

Bundera Sinkhole (6C-28) is found on a coastal plain, 1.7km inland from the Indian Ocean (Yager and Humphreys 1996; Humphreys *et al*. 1999). There is a single entrance to the sinkhole, which is about 20 m wide, below which bacterial colonies grow. A 30° incline extends laterally for about 70 m reaching a maximum depth of 33 m: it is dark at the extremities. The surface of the sinkhole is eutrophic which greatly reduces the amount of light penetration (Humphreys *et al*. 1999). *L. exleyi* is found approximately 30 m deep, beneath a density interface (Yager and Humphreys 1996; Humphreys *et al*. 1999).This sinkhole is the only deep anchialine cave known in Australia and the only one found on a continent in the southern hemisphere (Yager and Humphreys 1996; Humphreys *et al*. 1999).

The vegetation on the coastal plain is typical of an arid environment, comprising hummock grasslands with scattered sparse shrubs (Humphreys 1999a). Annual evaporation (3,219 mm) from the site is greater than the rainfall (280 mm), with temperatures greater than 35°C for four months (average temperature for rest of the year is 27°C), resulting in an extremely dry, harsh environment (Humphreys *et al*. 1999).

Anchialine cave communities are found inland, and contain a layer of saline water that moves in with the tides, covered by a layer of freshwater. The water level in the sinkhole fluctuates with the ocean tides, a characteristic of anchialine systems (Yager and Humphreys 1996; Humphreys *et al*. 1999; Humphreys 1999b). The waters of these deep caves contain concentrations of nutrients which are much greater than that of sea water, except in the case of salt (28 gL^{-1}) and potassium which is only 57% of the amount found in sea water (Yager and Humphreys 1996). The chemical concentrations of the sinkhole are different at different levels, which may be important for community balance (Humphreys *et al*. 1999).

Further into the cave the salinity level increases, the pH level decreases and the temperature increases markedly and abruptly at the thermocline (Humphreys *et al*. 1999). *L. exleyi*, like other remepides, is only found in the saline waters, below the density interface of the two water types (Yager and Humphreys 1996). At this level there is a very strong smell of hydrogen sulphide, which may be the result of energy fixation by chemoautotrophic organisms (Humphreys *et al*. 1999; Humphreys 1999a).

The rest of the Bundera sinkhole community is typical of anchialine communities, that is, consisting of relict species of crustacea and some subterranean species found more commonly in brackish or fresh waters and on land (Humphreys *et al*. 1999; Humphreys 1999b).

5. Biological overview

Lasionectes exleyi is a free-swimming remipede crustacean, approximately 15 mm long that is confined to an anchialine cave. The long body is divided into up to 24 segments, each of which is equipped with a pair of paddle shaped appendages. The head is small and has antennae approximately ? the length of the animal (Yager and Humphreys 1996). Larvae are yet to be described but they may resemble the adults (Yager and Humphreys 1996). For a more detailed description see Yager and Humphreys (1996).

Nothing further is known about their life cycle, reproduction or biology, except that they are hermaphrodites (Humphreys personal communication).

6. Significance

Cave systems are found all over the world, from below the sea to high mountain peaks. The north western region of Australia is very rich in cave fauna, both terrestrial and anchialine, with Cape Range being the only limestone formation which is derived from mountain ranges of the Tertiary (Humphreys 1999b).

Lasionectes exleyi is the only species of remipede known from the southern hemisphere (Yager and Humphreys 1996). The genus is highly disjunct, with the other members occurring in the Turks and Caicos Islands in the Caribbean Sea. The species are characteristic of an ancient lineage that has been isolated for a long time. This is believed to be the result of the separation of the genus during the early Cretaceous through tectonic plate movement and regression of the marine environment (Yager and Humphreys 1996).

Due to the antiquity and isolation of populations, many relict species found in these type of caves have very disjunct distributions, which may indicate that dispersal is limited (Yager and Humphreys 1996; Humphreys *et al*. 1999; Sutton 2000).

Bundera Sinkhole, as an anchialine cave environment, is a unique and highly sensitive habitat dependent on slow water turnover (Yager and Humphreys 1996). The site is known to be the only Australian location of the misophrioid copepod genus *Speleophria* and the calanoid copepod families *Epacteriscidae* and *Pseudocyclopiidae* (Jaume and Humphreys 2001; Jaume *et al*. 2001), as well as the only known site of the genus *Danielopolina* (Crustacea: Ostracoda) (Yager and Humphreys 1996; Humphreys *et al*. 1999; Humphreys 1999b).

There have been submissions to list the Cape Range Peninsula as a World Heritage Area for its natural and cultural values (Sutton 2000). Much of this is due to the unusual mix of species from tropical, temperate and arid regions, which is the result of the unique influences on the Peninsula from the Indian Ocean, the arid interior, the interface of temperate and tropical regions, and climate change over geological time (Sutton 2000). The karst community is currently home to 11 species that are considered to be rare in Western Australia.

There is also evidence to suggest that Aboriginal use of the region has occurred for at least the last 30,000 years (Sutton 2000).

7. Threats

As *L. exleyi* was only described in 1996 information on potential threats is limited, but its narrow environmental requirements may make it particularly sensitive to environmental changes (Yager and Humphreys 1996).

Currently Bundera Sinkhole is found on Commonwealth land utilised as a RAAF bombing range while parts of it are grazed by local station owners (Humphreys personal communication).

Bundera Sinkhole has been dived a total of six times since 1991, and is registered with the Australian Karst Index. Divers are believed to be a threatening process (Yager and Humphreys 1996; Humphreys *et al.* 1999). It is thought that diving disrupts the stratification of the water layers, each of which may have a different temperature and chemical composition. As *L. exleyi* is only found below a thermo-halocline (a vertical gradient in ocean salinity), the impact of this disruption on the species is unknown (Humphreys *et al*. 1999).

There are many uses of the Peninsula which conflict with the protection of the site. These include military activities, pastoralism, oil and gas leases, seismic lines, and two operative oil exploration licences, which may contaminate the cave with hydrocarbons and mining fluids (Sutton 2000). There is also mining of water from the aquifer system for the supply of water to urban, industrial and tourism concerns (Sutton 2000).

These sources of potential contamination are very important, as karst environments are highly sensitive to groundwater contamination. There is little filtration into the system from above and, in the case of Cape Range, there is little flushing out of the system to remove any contaminants, which could alter the entire community (Humphreys *et al*. 1999).

High levels of nutrients in the sinkhole may be due to the use of the pool by feral goats. If this continues it may also be a threatening process (Yager and Humphreys 1996).

8. Conservation objectives

To determine the distribution and conservation status of *L. exleyi* and to determine the ecological requirements, so as to help in maintaining the current population.

9. Conservation actions already initiated

- The species is listed as Vulnerable in accordance with the *WA Wildlife Conservation (Specially Protected fauna) Notice* 1998 Schedule 1 – fauna that is rare or likely to become extinct.
- Listed as vulnerable in accordance with Schedule 1 of the *Commonwealth Environmental Protection and Biodiversity Conservation Act* 1999.
- Bundera Sinkhole (6C-28) ecological community has been identified by the Threatened Ecological Community Scientific Advisory Committee as a critically endangered community under the *WA Wildlife Conservation Act* 1950 and a recovery plan has been drafted (J. Pryde, personal communication).
- WA Department of Conservation and Land Management have established the North West Cape Karst Management Advisory Committee, which is, among other things, the recovery team for all listed species and ecological communities on the NW Cape (A. Burbidge, personal communication).

10. Conservation actions required

Research

- A monitoring program needs to be established to identify and assess the impacts of any environmental changes on the species, community and site.

Management

- Currently the site is just outside a conservation reserve (Cape Range National Park). The park should be extended to include the sinkhole and surrounding area. Any protection of the habitat must also include the protection of the associated water flows to the caves (Yager and Humphreys 1996; Humphreys *et al*. 1999; Humphreys 1999b; Sutton 2000).
- As systems such as these are extremely vulnerable, a management plan is required to protect and monitor the site against

pollutants and any other potential threats. Under the *Western Australian Environmental Protection Act* 1986 the EPA could establish a precautionary environmental program and management plan which can cover different land and water tenureships outside conservation reserves (Sutton 2000).

11. Relevant Experts/Data Providers

Bill Humphreys – Western Australian Museum, Perth

12. References

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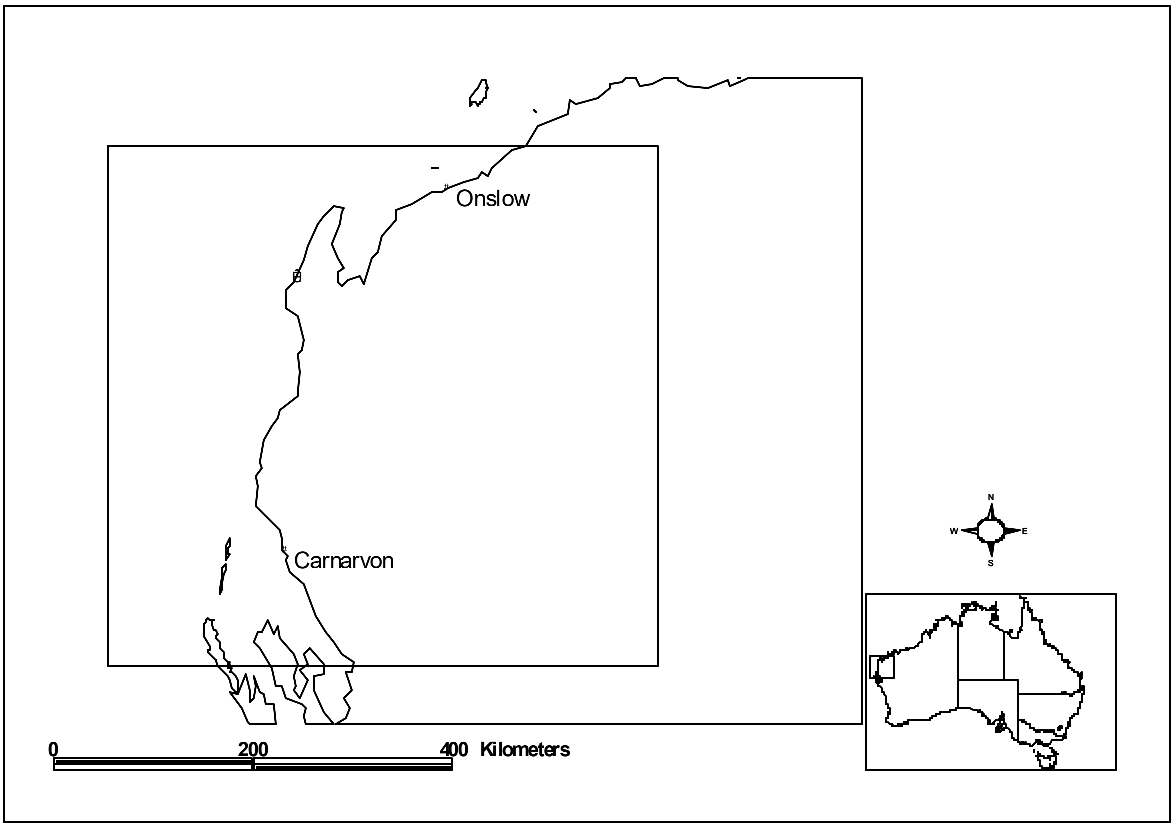
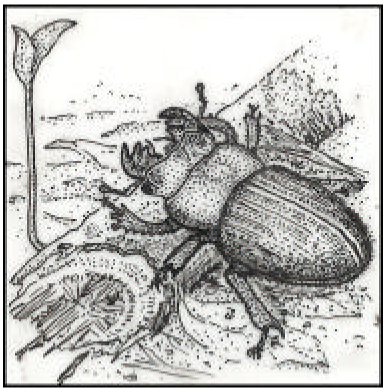


Distribution of *Lasionectes exleyi* (source: Yager and Humphreys 1996)

Lissotes latidens	**Broad-Toothed Stag Beetle**



Phylum: Arthropoda **Class:** Insecta **Order:** Coleoptera
Family: Lucanidae
Scientific name: *Lissotes latidens*
Common names: Broad toothed stag beetle

1. Taxonomic status (including species and subgroups)

Lissotes latidens Westwood 1855.

The genus *Lissotes* is endemic to Australia with 25 species known from Tasmania, and a further three species occurring in Victoria. Most of these species have restricted ranges believed to result from environmental constraints (Bryant and Jackson 1999).

2. Species survival status

Listed as endangered under the *Tasmanian Threatened Species Protection Act* 1995.

Under the Commonwealth–Tasmania Regional Forest Agreement *L. latidens* was identified as a species that was believed to be at risk, but its conservation needs could not be assessed without further research on its distribution and habitat requirements (Meggs 1999).

Lissotes latidens is not listed on the 2000 *IUCN Red List of Threatened Taxa*. Assessment of the IUCN categorisation for the species using the *Ramas RedList* software program (Akçakaya and Ferson 1999) indicated that it may be Critically Endangered.

3. Distribution

Lissotes latidens is found in moist eucalypt forests of southeastern Tasmania and on Maria Island, just off the east coast of Tasmania (Lea 1910; Forest Practices Board 1998; Meggs 1999).

The species is thought to occupy a range of 280 km^2, 5.4 km^2 of which is on Maria Island (Meggs 1999).

4. Habitat

Of the 280 km^2, only 43 km^2 (15.4%) is believed to represent suitable habitat for *L. latidens,* as the remaining consists of dry eucalypt forest and agricultural land, which is considered unsuitable for the species.

Lissotes latidens requires areas of moist eucalypt forest, including damp eucalypt forests, wet eucalypt forests and rainforest. Much of these forest types are found within the eastern part of the mainland range around Weilangta State Forest as well as on Maria Island. In the western parts of the range the habitat is largely restricted to riparian areas and consequently is very patchy and fragmented.

The forest types are dominated by *Eucalyptus obliqua*, *E. regnans, and E. globulus* with some *E. viminalis*, *E. pulchella* and *E tenuiramis* present. The understorey, which appears to be important in the microhabitat requirements of the species (in terms of forest structure, not floristics), includes broad-leaved wet sclerophyll species such as *Pomaderis apetala*, *Olearia argophylla*, *Zieria arborescens*, *Cyathodes glauca*, *Pultenaea juniperina*, *Acacia verticillata* and *Lomatia tinctora*.

The species is cryptic in its behaviour and habitat, appearing to prefer sites where there is both a well-developed overstorey and understorey with a 10% ground cover of fallen and rotting timber, which is believed to be an important microhabitat of the species.

The soils found at *L. latidens* sites vary considerably, suggesting that the main factors determining the presence of the beetle are vegetation and moisture (Meggs 1999).

5. Biological overview

Lissotes latidens is a large (12–18 mm) flightless black beetle with characteristic large 'bulls horn' shaped mandibles in the males (Lea 1910; Forest Practices Board 1998; Meggs 1999).

Little is known of the life cycle of *L. latidens*. It is not, as was thought, a log-dwelling beetle, as both larvae and adults of the species can be found in the upper layer of soil underneath rotting logs (Meggs 1999). Although there is an association between the species and the decaying logs, the exact nature of this relationship remains unclear.

The species is active from September to April, with a possible peak in October or December, which may indicate a specific breeding season. The larval stage is believed to extend for several years (Meggs 1999).

L. latidens appears to be a soil dwelling species throughout its lifecycle, with larva found underneath a log in a shallow depression. The adults also appear to prefer to remain underneath logs where the level of organic matter may be higher resulting in a higher moisture level or a higher food source in the form of more fungal growth (Meggs 1999). This preference for sheltering underneath logs may also provide protection from predators.

Although little is known of absolute size of *L. latidens* populations, there are indications that it occurs at much lower densities than other Tasmanian lucanid species.

6. Significance

Two other stag beetles, the Mount Mangana stag beetle (*L. menalcas*) and Simson's stag beetle (*Hoplogonus simsoni*) are restricted to the same types of habitat as *L. latidens* and are also considered threatened because of their restricted distributions, low numbers and habitat loss (Forest Practices Board 1998). Of these, *L. latidens* is believed to be at greatest risk due to the limited occurrence and level of fragmentation of its preferred habitat type (Bryant and Jackson 1999).

In addition to these species, there are many other organisms that utilise decomposing logs on the forest floor. Many invertebrates and fungi are instrumental in breaking down the fibrous organic matter, releasing nutrients for use by other organisms such as plants (Meggs 1999).

7. Threats

The major threat facing *L. latidens* is habit loss, predominantly through clearing and forestry practices, and the loss of diversity through the conversion of native forest to plantation (Bryant and Jackson 1999). In studies of a related, and similarly threatened species, *Hoplogonus simsoni*, (Simson's stage beetle), populations were found to become locally extinct at sites where native forest was replaced with pine plantations, with the same result expected for conversion to eucalypt plantation. Currently 14.9% of the *L. latidens* suitable habitat is privately owned forest and 61% is State Forest (Meggs 1999).

Forest that is proposed for pine plantation establishment is clearfelled, that is, all the trees present are cut at one time. The timber not taken is then bulldozed into windrows and burned. The site continues to be disturbed at 15-year intervals as the plantation is thinned out. Such disturbance to the soil layer results in the alteration of soil properties and fertility, which may in turn alter the composition of plant species present. The types of invertebrates present may also be altered as more specialised species lose their habitat and more generalist species invade. The ability of a species to re-establish in a clearfelled/burnt site largely depends on the presence of suitable habitat, the presence of the species in any adjacent coups and the species' ability to disperse (Springett 1976; Hansen *et al*. 1991; Neumann 1991; Micheals and McQuillan 1995).

Although only a limited amount of clearfelling is planned in the southeastern State Forests, it is unknown what effect the high intensity regeneration burning following logging may have on the habitat of *L. latidens* (Meggs 1999).

Many private landholders are further compounding this habitat loss through the conversion of native forest to short rotation pulpwood plantations (Meggs 1999).

Although many species may still be present after clearfelling, some will gradually disappear as the habitat becomes unsuitable or is lost. Many of the sites where *L. latidens* occurs show signs of past selective logging (Meggs 1999). It is believed that at least 80 years is needed after a clearfell before large diameter logs, which make up the greatest proportion of potential decaying-log habitat, are replaced from the regenerating stand, and hence become available for many invertebrates (Meggs 1999; Bryant and Jackson 1999). Current proposals indicate that up to 370 hectares (9%) of the wet forest within the species range may become eucalypt plantation over the next three years.

The unnaturally hot fires used to burn the residue from clearfelling are also a threatening process as this removes any remaining understorey, leaf litter and other fine fuels (Bryant and Jackson 1999). This will also impact on the soil and litter invertebrates, with studies suggesting that the populations of these species may not return for two or three years or longer. Other management practices such as thinning out of the regrowth may also prove detrimental if carried out in the beetles' habitat, as it further limits decayed log replacement on the forest floor for future generations of the species (Meggs 1999). The collecting of the remaining 'waste' wood, estimated at 400,000 tonnes annually, by the general public from the southern forests of Tasmania, including logged coupes throughout Weilangta State Forest also diminishes the supply of logs (Meggs 1999; Bryant and Jackson 1999).

As a wingless beetle, *L. latidens* is very limited in its ability to colonise new sites, which is a significant issue as only 15% of its current range consists of potentially suitable habitat. This has serious consequences for the species as it means that small isolated populations are at risk from localised extinction, which in turn will affect the long-term viability of the species. Much of the suitable habitat in the western part of the species range is highly fragmented due to the predominance of dry eucalypt forest, and to a lesser extent the impacts of forestry and agriculture.

Although Maria Island is a National Park, and populations there are well protected from the threats of habitat loss, there are few reserves found on the mainland, particularly in the western part of the range.

Collecting of beetles by amateur and professional enthusiasts and the subsequent destruction of decaying logs may also be a threatening process (Bryant and Jackson 1999).

8. Conservation objectives

To conserve the currently known habitat of *L. latidens* and to determine the ecological requirements of the species, so as to target conservation measures more accurately to ensure the maintenance of current and future populations.

9. Conservation actions already initiated

- Much of Maria Island is National Park, so the known populations there, which form 12% of the known potential habitat, are protected from many of the identified threats. On the mainland there are small streamside reserves (6.1%) and wildlife habitat strips (9.1%) that are currently protected (Meggs 1999). A survey undertaken in 1999 discovered a further 26 sites and raised the known range of the species from 93 km^2 to 280 km^2 (Meggs 1999).
- The species is listed as an endangered taxon under the *Tasmanian Threatened Species Protection Act* 1995, based on the lack of reserves, restricted distribution of the species and the threats from forestry operations.
- Before logging can proceed in an area believed to contain potential habitat for *L. latidens*, forest industry personnel are required to seek advice from the Forest Practices Board and the Parks and Wildlife Service (Forest Practices Board 1998).

10. Conservation actions required

Research

- Future surveys are required on Maria Island where there is potentially up to 22 km^2 of suitable habitat for the species.
- Research is required into the impacts of forestry and fire on the species.
- Research is also required into the basic biology, life history and habitat requirements of *L. latidens* (including the relationship of the species with dead wood and soil characteristics).
- Information on the genetic variation present throughout the range would be valuable in determining the impacts of fragmentation on the species.

Management

- On mainland Tasmania, the habitat of *L. latidens* is currently poorly represented in reserves, which may need to be addressed by retaining links of unlogged forest between existing reserves. Meggs (1999) suggests that where large areas of forest are proposed for conversion to plantation the frequency of wildlife habitat strips should be increased to one every two to 3 km, and these should be a minimum of 200 m wide.
- Where sites are to be logged and regenerated to native forest, clearing should be staggered over time so that sites are given ample time to regenerate avoiding further fragmentation. Where there are no adjacent reserve areas wildlife habitat clumps should be retained in logged coupes. Selective logging and other practices that do not remove logs from the area should be implemented where possible.
- Streamside reserves should be maintained where *L. latidens* may occur, and the width of class three reserves should be increased to 30 m either side of the stream. Wet gully reserves should be retained as coupe boundaries where practicable to reduce the chances of burning the reserves. No trees should be felled in these reserves.
- A program needs to be implemented to monitor where the public are removing firewood from and how much they are removing. The practice of collecting for firewood needs to be banned from wet forest sites that may be potential habitat for the species.

11. Relevant Experts/Data Providers

Jeff Meggs – Forestry Tasmania

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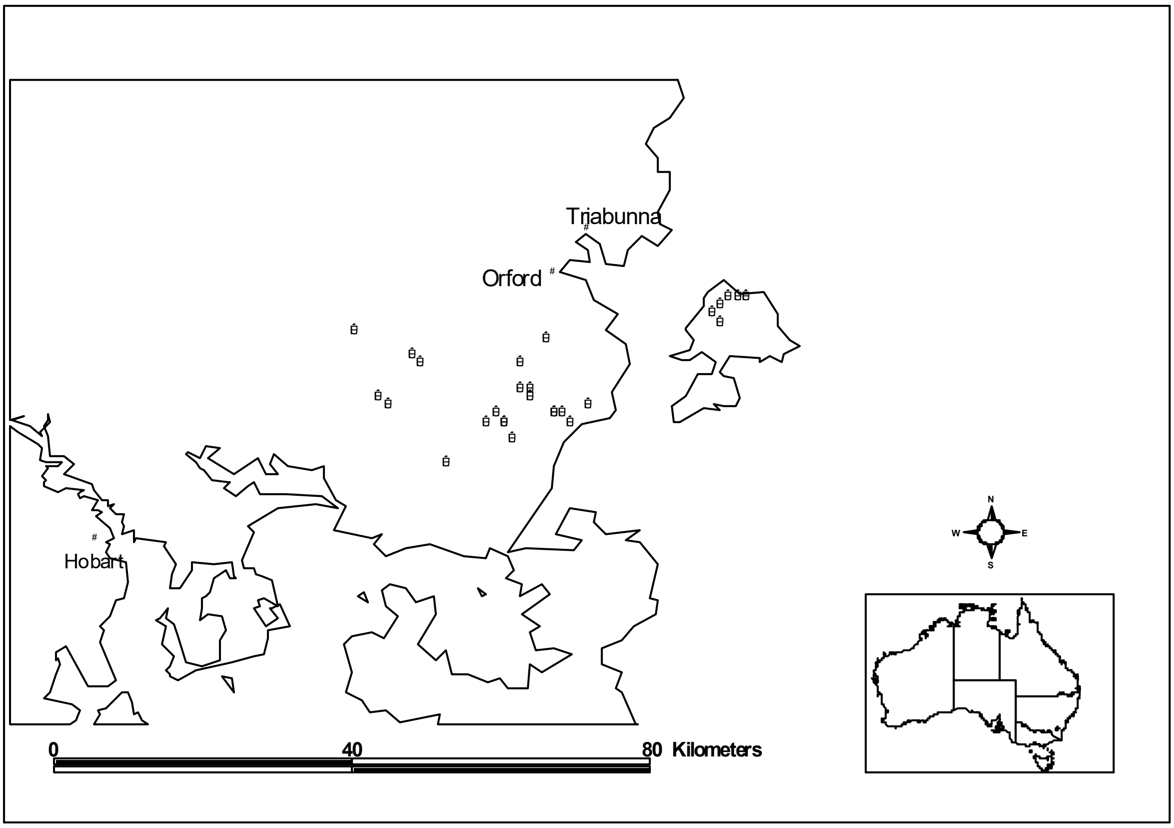
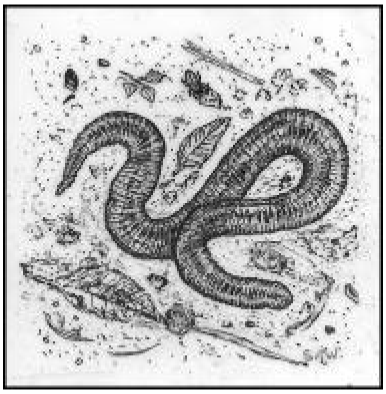


Distribution of *Lissotes latidens* (source: Meggs 1999)

Megascolides australis Gippsland Giant Earthworm



Phylum: Annelida **Class:** Oligochaeta **Superfamily:** Haplotaxida
Family: Megascolecidae **Subfamily:** Megascolecinae
Scientific name: *Megascolides australis*
Common names: Gippsland Giant Earthworm

1. Taxonomic status (including species and subgroups)

Megascolides australis McCoy, 1878.

The family Megascolecidae includes many of the native earthworms in Australia as well as species in South and Central America, Africa, New Zealand and South East Asia. In Australia there have been 325 species of the family described within 28 genera. Reports of giant earthworms exist from each of these regions as well as New South Wales and southern Queensland (Van Praagh 1992, 1997).

The genus *Megascolides* is found in Australia, and New Zealand. In Australia there are currently eight known species, although *M. australis* is the only 'giant' earthworm (Yen *et al*. 1990).

2. Species survival status

Listed on 'Schedule 1 - Listed Species' 'Part 2 – Species that are vulnerable' under the *Commonwealth Environmental Protection and Biodiversity Conservation Act* 1999.

Listed as threatened on Schedule 2 of the *Victoria Fauna & Flora Guarantee Act* 1988.

Megascolides australis is listed in the 2000 *IUCN Red List of Threatened Species* as Vulnerable (VU D2). Assessment of the IUCN categorisation for the species using the *Ramas RedList* software program (Akçakaya and Ferson 1999) indicated that it may be Critically Endangered.

3. Distribution

Since *M. australis* was originally discovered in the Brandy Creek area in the 1870's, there have been many anecdotal reports of their distribution (Smith and Peterson 1982; Yen *et al*. 1990).

Figures in the literature of its distribution vary from an area of 5,000 ha (Endangered Species Scientific Subcommittee (ESSS) 1997), to 40,000 ha (Van Praagh 1997), to 100,000 ha. The worm is only known from South Gippsland, with the centre of its distribution in the areas of Warragul and Korumburra (Wells *et al*. 1984; Yen *et al*. 1990; Van Praagh 1997; Department of Natural Resources and Environment 1999). However, the worm is not continuous throughout this entire area, being limited only to moister patches (Van Praagh 1997).

4. Habitat

The Warragul district predominantly comprises dairy farms, with open forest on an undulating landscape, and a moderate rainfall pattern. The soil of preference appears to be mainly blue-grey clay soils (Smith and Peterson 1982; Wells *et al*. 1984; Yen *et al*. 1990). Within this environment, the worm prefers the moister patches adjacent to creeks, roadsides, or soaks, on south or west facing slopes (Smith and Peterson 1982; Yen *et al*. 1990; Van Praagh 1997). The species appears to prefer the moister undulating areas around Warragul, such as the hilly parts of the Strzelecki Ranges (Wells *et al*. 1984).

5. Biological overview

Megascolides australis is the longest earthworm species in Australia, and one of the largest in the world (Wells *et al*. 1984; Department of Natural Resources and Environment 1999).

Megascolides australis is grey/pink, with between 300 and 500 segments, and the top third of the body purple (Department of Natural Resources and Environment 1999). Mature adults have prominent coloured bands, usually three, on the ventral surface in the clitellar region (Van Praagh 1992).

Although length can be a misleading measurement in worms due to their ability to contract and expand, *M. australis* can grow to over one metre long with a girth of 20 mm (Yen *et al*. 1990; Department of Natural Resources and Environment 1999). Anecdotal reports claim that specimens have been found which are 4 m long and 4 cm in diameter. The weight of a specimen, which may be a more useful measure of size, ranges from 90–400 g with an average of 210 g (Smith and Peterson 1982; Wells *et al*. 1984; Yen *et al*. 1990; Van Praagh 1997).

For a more detailed description of the genus and the species see McCoy (1878) Smith and Peterson (1982) and Yen *at al*. (1990).

Due to the subterranean nature of *M. australis*, little is known about its biology. The worm has an extensive burrow system, with parts that are very close to the surface, where it is suggested that the worms feed (Van Praagh 1992), and other parts which go deep into the subsoil. They live their whole life underground, only coming to the surface if the burrows become flooded or if caught on plough machinery (Smith and Peterson 1982; Yen *et al*. 1990)

The longevity of *M. australis* is not known, but laboratory trials suggest that it may be a long lived species, taking from 3–4.5 years to mature, or a weight of 200 g (Yen *et al*. 1990; Van Praagh 1992; Department of Natural Resources and Environment 1999).

Studies by (Van Praagh 1995) suggest that copulation may not be confined to the breeding season, resulting in sperm being stored for up to 12 months, to allow for breeding in spring/summer. Earthworms are hermaphroditic but it is also assumed that they require external fertilisation (Yen *et al*. 1990; Van Praagh 1992; Department of Natural Resources and Environment 1999). Egg capsules have been found in chambers within the tunnel systems of the worm. They are approximately 5×7cm; light yellow to dark brown hard objects with a stalk at each end of the capsule. Each egg appears to contain a single embryo in liquid. Where the habitat is moist enough, it has been reported that these eggs can be found at a density of 1.6 per m^2, hatching between August and February after an incubation period of 8–12 months (Smith and Peterson 1982; Wells *et al*. 1984; Yen *et al*. 1990; Van Praagh 1992).

Megascolides australis is a detritivore feeding on organic matter such as root particles, grass blades, leaves, seeds and soil (Yen *et al*. 1990; Department of Natural Resources and Environment 1999).

Megascolides australis appears to produce a permanent burrow system. Burrows are approximately 25 mm wide, but it is not clear whether they live in colonies. Unlike other worms, *M. australis* does not leave cast material on the surface, so this is found in the tunnels with eggs and cocoons (Wells *et al*. 1984; Yen *et al*. 1990). Anecdotal accounts claim that worms produce a 'gurgling' sound as they move through tunnels close to the surface, particularly in Autumn when the soil is moist (Smith and Peterson 1982; Yen *et al*. 1990; Department of Natural Resources and Environment 1999).

Megascolides australis also exudes a milky creosote smelling substance from dorsal pores, which could assist the worm in moving rapidly though its burrow. The smell also may repel predators, although Kookaburras have been reported eating these worms (Smith and Peterson 1982; Wells *et al*. 1984).

The current density of the population is unknown. Anecdotal reports indicate that the species may be locally abundant, with worm densities of 0–12 worms m^{-3} (Van Praagh 1992) and 1,590 worms per hectare (Smith and Peterson 1982; Wells *et al*. 1984). There is also local debate as to whether the worm has declined over the last 60 years (Smith and Peterson 1982; Wells *et al*. 1984).

6. Significance

Earthworms are an important component of the soil profile, as they aerate the soil and improve water permeability. The digestion of organic matter that is passed as worm casts also increases the availability of nutrients to the plants. Nitrogen is also released in to the soil profile rapidly when they die, while ammonia is added through their urine. In European species of *Lumbricus*, studies have shown that the earthworm fauna in an average population can turn over between 30–70 tonnes of soil annually (Makeschin 1996). To date no similar studies have been undertaken for the Australian fauna.

Worms are particularly important in compacted soil as they allow vegetation, other soil fauna, and microorganisms, to recolonise by loosening the particles (Makeschin 1996). It is thought that many Australian species of earthworm may have a symbiotic relationship with these microorganisms.

Our understanding of the Australian earthworm fauna is poor. Of the 1,000 species believed to occur, only 325 have been described to date (Kingston and Dyne 1995).

The area of Gippsland where the earthworm occurs is also home to seven species of threatened native fish and five species of threatened native burrowing crayfish, which would benefit from any conservation measures implemented (Department of Natural Resources and Environment 1999).

7. Threats

As a slow growing species with a low dispersal rate, *M. australis* remains at high risk from fragmentation of its habitat (Department of Natural Resources and Environment 1999).

The current distribution of *M. australis* appears to be only a fraction of its original distribution (Endangered Species Scientific Subcommittee (ESSS) 1997). The main threat appears to have been altered land use and clearance of the native vegetation for exotic pastures and dairy farming (Department of Natural Resources and Environment 1999). It is believed that this would have altered the natural microclimates in the soil through the replacement of natural root systems with pasture species, which would have had an impact on the food source, soil microfauna and soil compaction and pH of the soil (Van Praagh 1997; Department of Natural Resources and Environment 1999). Removal of vegetation may also have altered drainage patterns.

Additional threats could include the use of agricultural chemicals, as worms are highly sensitive to accumulations of chemicals through their skin. The use of superphosphate and light harrowing however do not appear to have adversely affected the worms (Wells *et al*. 1984; Department of Natural Resources and Environment 1999). Ploughing may damage large worms which are close enough to the surface and expose cocoons to desiccation (Smith and Peterson 1982; Wells *et al*. 1984). The building of roads, dams, and cable laying may also have a detrimental effect on *M. australis* (Department of Natural Resources and Environment 1999).

8. Conservation objectives

- To identify any further populations of *M. australis*. The Victorian Action Plan indicates a goal to identify all sites on public land and 20 on private land before 2004 (Department of Natural Resources and Environment 1999).
- To protect these sites through habitat conservation.
- Increase public awareness of *M. australis*.
- Undertake further research into the species so as to ensure its long-term survival.

9. Conservation actions already initiated

- The species is listed as a vulnerable species on Schedule 2 of the *Victorian Fauna & Flora Guarantee Act* 1988. In accordance with the *Victorian Flora and fauna Guarantee Act* 1988 an Action Plan for the species was developed by the Department of Natural Resources and Environment in 1999 (Department of Natural Resources and Environment 1999).
- The Species is listed as vulnerable in accordance with Schedule 1 of the *Commonwealth Environmental Protection and Biodiversity Conservation Act* 1999.
- Research has been undertaken to determine the general ecology, behaviour, population viability and distribution of *M. australis*, but has been hampered due to the difficulties associated with studying a subterranean species (Smith and Peterson 1982; Van Praagh *et al*. 1989; Van Praagh 1992). Van Praagh (1992) made efforts to design a technique to make this easier (Edmonds 1994). Kretzschmar & Aries (1992) analysed the structure of the burrow system using 3D images.
- One of the sites of *M. australis* is within Mt Worth State Park, in the western Strzelecki Ranges (Wells *et al*. 1984; Yen *et al*. 1990) but most sites are located on private land. Consequently community involvement is critical to conservation of this species. Fortunately the local community has been very involved in the conservation of this species, and hosts an annual festival called the Karmai in honour of the unusual

creature. Many farmers have already fenced off areas of earthworm habitat as part of the Land for Wildlife Scheme in Victoria (Smith and Peterson 1982; Yen *et al*. 1990; Van Praagh 1997). Some of these private properties have been listed on the Register of the National Estate (Department of Natural Resources and Environment 1999).

- An education program has been implemented by the Victorian Department of Natural Resources and Environment that includes a pamphlet in the Land for Wildlife Notes series.

10. Conservation actions required

Research

- The life history, population dynamics, species associations and habitat requirements of the species need to be better understood.
- Survey work needs to be conducted to gain a better picture of the full extent of the species range and population size, and to develop a clearer idea of the habitat requirements (Wells *et al*. 1984).
- Further monitoring of the populations is also a vital component of any conservation work. Unfortunately, as a subterranean and fragile species this may prove difficult (Smith and Peterson 1982).
- Investigation into the impacts of land uses and management practises such as altered drainage, effluent and chemical use on habitat.
- Investigation of the risk of population reduction through predation

Management

- The Victorian Action Plan recommends the formation of a recovery team consisting of representatives from all interest groups be established (Department of Natural Resources and Environment 1999).
- Yen *et al* (1990) suggest that a reserve should be established near Warragul where the centre of the worms' distribution is located.
- A management plan needs to be developed for riparian zones, as these appear to be the sites preferred by the worms (Yen *et al*. 1990). These areas must be managed in a way that is appropriate for the woms. Realising this many local people have already fenced off creek banks to exclude stock and allow the natural vegetation to regenerate (Van Praagh 1992; Department of Natural Resources and Environment 1999).
- Guidelines are required for protecting and managing the earthworms' habitat on both private and public land (Department of Natural Resources and Environment 1999).
- Consideration of the worms also needs to be made at the local and regional planning levels by liasing with regional authorities and the Port Phillip and West Gippsland Catchment and Land Protection Boards (Department of Natural Resources and Environment 1999).
- More areas of moist hillside need to be reserved which may also be of benefit to landowners in reducing erosion potential (Department of Natural Resources and Environment 1999).
- The use of pesticides and fertilisers should be avoided in these areas as they may be detrimental to the worms (Wells *et al*. 1984; Van Praagh 1992).
- Public education is necessary to counter the belief that it is a common and safe species, and to involve the local community more in the protection of the species. Social studies into why people hold inaccurate perceptions may be useful in focusing any education program (Department of Natural Resources and Environment 1999).
- Ensure that the collection of earthworms from the wild is regulated so as to avoid any damage to the habitat or to the population (Department of Natural Resources and Environment 1999).
- The presence of the earthworm should be considered in the early stages of any urban planning or land subdivision by municipalities or councils so as to reduce conflict later (Department of Natural Resources and Environment 1999).

11. Relevant Experts/Data Providers

Geoff Dyne – Environment Australia, Canberra

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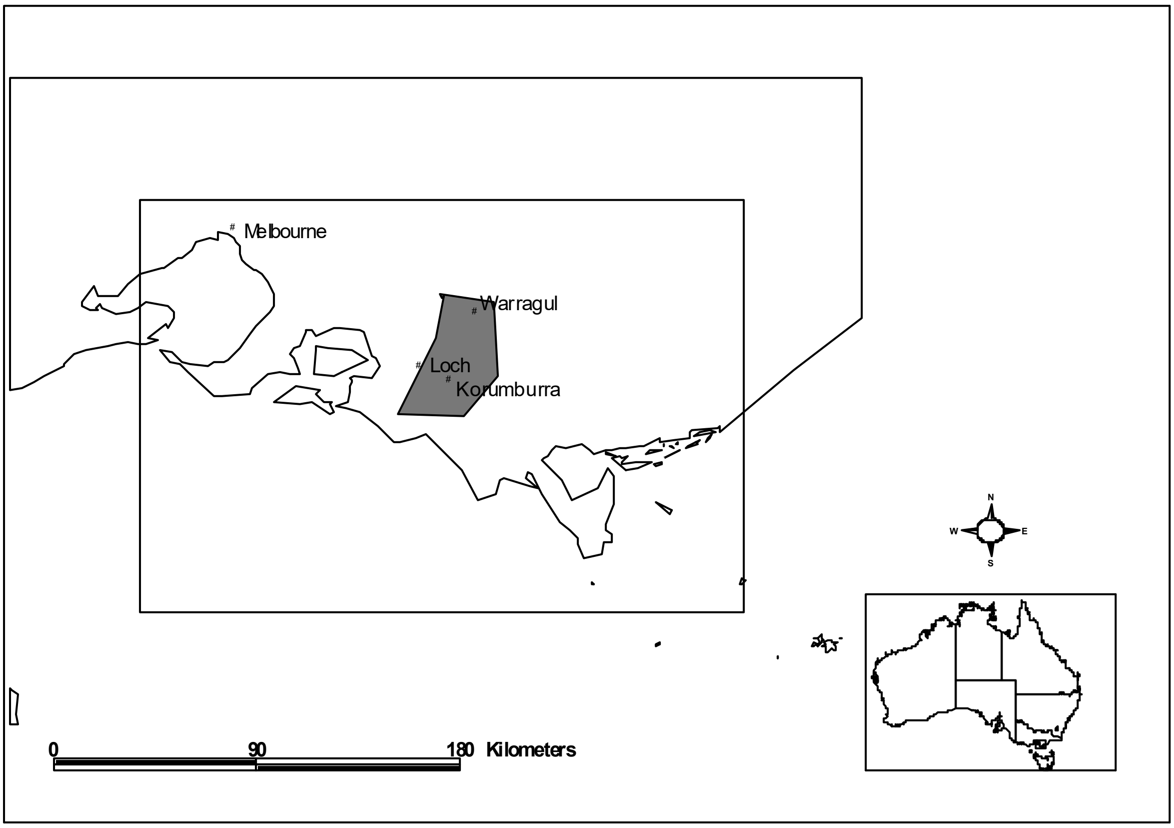
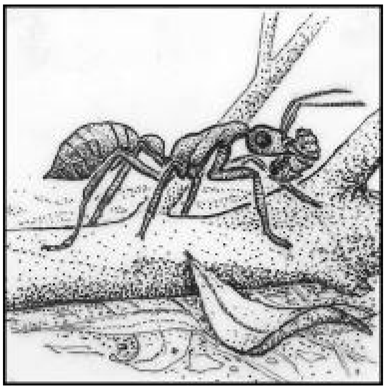


Distribution of *Megascolides australis* (source: Department of Natural Resources and Environment 1999)

Nothomyrmecia macrops Dinosaur Ant



Phylum: Arthropoda **Class:** Insecta **Order:** Hymenoptera
Family: Formicidae
Scientific name: *Nothomyrmecia macrops*
Common names: Dinosaur Ant, Living Fossil Ant, Nothomyrmecia Ant

1. Taxonomic status (including species and subgroups)

Nothomyrmecia macrops Clark, 1934.

"*Nothomyrmecia*": means bastard or false bulldog ant.

'*macrops*': means big eyes.

Nothomyrmecia macrops is the only living representative of the subfamily Nothomyrmeciinae, and a close relative of the subfamily Myrmeciinae (including the Australian genus *Myrmecia*). *Nothomyrmecia macrops* is considered to be the most primitive living ant, exhibiting characteristics of ants living 60 million years ago (Clark 1934; Taylor 1978; Holldobler and Taylor 1983; Wells *et al*. 1984; Jaisson *et al*. 1992).

A collecting party travelling near Balladonia through to Esperance discovered the species in December 1931. It remained unseen again until October 1977 when it was rediscovered near Poochera by a collecting party from the Australian National Insect Collection at CSIRO Entomology (Brown and Wilson 1959; Taylor 1978; Holldobler and Taylor 1983; Bartell 1985; Jaisson *et al.* 1992; Watts *et al*. 1998).

2. Species survival status

Western Australia has listed all species of the genus *Nothomyrmecia* as Protected Fauna under the *Wildlife Conservation Act* 1950, under the provisions of a close season notice (Wildlife Conservation (protected Invertebrate Fauna) Notice 1994), the purpose of which is to restrict collection of the species (Conservation and Land Management 1994; Mawson and Majer 1999).

Nothomyrmecia macrops is listed in 2000 *IUCN Red List of Threatened Species* as critically endangered (CR B1+2C). Assessment of the IUCN categorisation for the species using the *Ramas RedList* software program (Akçakaya and Ferson 1999) indicated that it may be Critically Endangered.

The species is not protected in South Australia; however, the local community are enthusiastic to help in conservation measures, as much of the population is found on private property (Wells *et al*. 1984).

3. Distribution

Along the Eyre Peninsula, South Australia, *N. macrops* been found at 18 sites, spaced over an area of 400 linear km (Wells *et al*. 1984; Watts *et al*. 1998). The validity of the original site in Western Australia has been questioned due to poor labelling of the initial specimens (Taylor 1978; Wells *et al*. 1984; Bartell 1985; Watts *et al*. 1998).

4. Habitat

The species appears to prefer sites that provide very little understorey, with a typically sparse crown provided by tall 'old growth mallee', which maintains an evenly spread thin layer of leaf litter. The dominant species present are *Eucalyptus oleosa*, with *E. brachycalyx*, and *E. gracilis*. Fire appears to be absent from the site at Poochera, and the soil is loose, fine, and has a calcareous nature (Holldobler and Taylor 1983; Wells *et al*. 1984; Watts *et al*. 1998).

5. Biological overview

In many characteristics, *N. macrops* looks similar to *Myrmecia* species, except that *the golden yellow colouring of the workers easily identifies N. macrops*. It is a slender ant, with its head, being the same width as its length, yet wider at the back than at the front (Clark 1934). Individuals are approximately 1cm long, possessing large dark eyes and vestigial ocelli. The mandibles are long and triangular, fitting together when clasped, in contrast to *Myrmecia* in which they are crossed. The waist has a distinctive single node that is bell shaped and covered with long erect hairs. There is a characteristic hook at the anterior end of the gaster (Clark 1934). *Nothomyrmecia* possesses a strong sting which can be retracted (Clark 1934; Brown and Wilson 1959; Wells *et al*. 1984). *Nothomyrmecia* is the only ant that possesses both a sting and a waist (that is, does not have a postpetiole between the first and second gastral segments) (Shattuck 1998). The species also possesses a highly unusual stridulatory organ on the ventral, rather than the dorsal, surface of the abdomen (Taylor 1978; Wells *et al*. 1984). For a more detailed description see Clark (1934) and Taylor (1978).

Ants are social insects that build colonies consisting of a reproductive queen, many sterile workers, pupae, and eggs. Workers are responsible for different functions in the colony, such as guards, nurses, cleaning, and foraging (Greenslade 1979). *Nothomyrmecia macrops* is a eusocial ant, which means that there is a higher level of individuality than in other species, with many tasks shared between workers rather than having a more extreme division of labour as in other social insects, which also indicates the primitive ancestry of the species (Taylor 1978; Ward and Taylor 1981; Holldobler and Taylor 1983; Jaisson *et al*. 1992). One of the most specialised activities that workers exhibit is nest guarding to ward off predators (Jaisson *et al*. 1992). There is very little difference in the appearance of the different castes of *N. macrops*, including the queen, who is just slightly larger than the workers. The queen also possesses ocelli, and reduced wings, which do not appear to be used for flight (Taylor 1978; Ward and Taylor 1981; Wells *et al*. 1984).

The eggs and larvae are also similar to those of *Myrmecia*, giving further suggestion to the primitiveness of the genus (Wheeler *et al*. 1980). For a detailed description of the eggs and larval stage see Wheeler *et al.* (1980). *Nothomyrmecia macrops* possesses 94 chromosomes, which is more than any known species of Hymenoptera (Jaisson *et al*. 1992), and one of the highest in the phylum Arthropoda (Jaisson *et al*. 1992).

It is not known how long *N. macrops* live for, but in many species the queens can live for up to 30 years, with workers dying much earlier than this (Holldobler and Wilson 1990). The queen's lifetime egg production is unknown (Holldobler and Wilson 1990).

Little is known about reproduction in *N. macrops*, although colonies appear to be monogynous (containing a single reproductive queen) (Ward and Taylor 1981; Holldobler and Taylor 1983). A nest may contain up to 100 mature individuals (Wells *et al*. 1984; Bartell 1985; Holldobler and Wilson 1990). The brood is well tended by the workers (Taylor 1978; Holldobler and Wilson 1990).

Winged reproductives leave the nest in late summer to search for new sites for colony establishment (Wells *et al*. 1984). Winged queens that are successful in finding sites will forage while the first brood is developing. There is also evidence that young queens will cooperate at this stage so as to start a new colony, but once the colony is established one will dominate (Taylor 1978; Holldobler and Taylor 1983; Wells *et al*. 1984).

Nothomyrmecia macrops leave the nest after dusk to forage, on nights where the temperature falls below 15°C (Watts *et al*. 1998). It is this behaviour that is partly responsible for the difficulty in locating the species. This behaviour results in reduced competition from other species of ants, and the ability to prey on insects affected by the low night temperature. Insects in cold torpor are captured, stung and taken back to the nest for the developing larvae to eat (Taylor 1978; Greenslade 1979; Holldobler and Taylor 1983). Adults feed on honeydew harvested from lerps, aphids, and scale insects on trees. This behaviour is thought to help stabilise populations in times of reduced prey (Greenslade 1979; Shattuck 1998).

Individuals either return to the nest with prey shortly after leaving, or they remain out foraging until dawn, when they retreat down the tree trunks and return to the nest entrance. It is thought that *N. macrops* navigate back to the nest, which is hidden among the litter, by way of the silhouette given by the tree canopy, as no evidence of chemical trails have been found (Bartell 1985), although nest entrances may be chemically marked (Holldobler and Taylor 1983).

Unlike *Myrmecia*, *Nothomyrmecia* appears to be non-aggressive towards other ants and are not territorial unless conspecifics are found entering the nest. This may explain why there is low intra-colony relatedness in colonies (Holldobler and Taylor 1983; Jaisson *et al.* 1992). Alarm communication also appears to be weak, although workers do use a short-range mandibular chemical alarm (Taylor 1978).

There is little information on the number and sizes of individual populations or their rates of change.

6. Significance

N. macrops is the only living member of the primitive subfamily and thus represent a unique faunal element with significant phylogenetic significance.

Ants provide food for lizards, echidnas, birds, other ants, ant lions and spiders. This predation is important in controlling population size as many individuals are taken when reproductive ants leave the nest (Greenslade 1979).

Many insects, including isopods, crickets, Collembola and beetles have been found living in apparent symbiosis with ants. Hemiptera that produce nectar are benefited by attracting ants, which afford them protection from predators. A number of Australian plants have also evolved elaiosomes; appendages on the seeds and fruit that attract ants. The ants take the seeds back to their nest, where they eat the appendage and leave the seed to germinate protected from fire and seed feeders (Greenslade 1979).

7. Threats

The primary threat to the species is habitat fragmentation due to the presence of wheat fields, roads, railway lines, and development (Wells *et al.* 1984). Watts *et al* (1998) believe that the species will survive if the clearing of the mallee vegetation stops. Unfortunately much of this vegetation occurs along roadsides. This vegetation type is found in the Lake Gilles Conservation Park and the Chadinga Conservation Reserve, as is part of the population of *N. macrops*.

Part of the site at Poochera where the species was originally rediscovered was bulldozed, and the vegetation burnt during the installation of underground telephone cables.

Because the species seems to depend on the tree canopy for navigation and food, tree clearing may be detrimental to the species. For the same reason, fire may also be detrimental.

8. Conservation objectives

- Populations be maintained at the current level or greater through habitat protection and further surveys.

9. Conservation actions already initiated

- A limited amount of preliminary survey work has been conducted for the species (C. Watts personal communication).
- Some populations of *N. macrops* are found in the Lake Gilles Conservation Park and the Chadinga Conservation Reserve and so are protected (Watts *et al.* 1998).
- One of the sites of *N. macrops* now known is on private property, and the current owner is keen to conserve them (Wells *et al.* 1984). The Australian Heritage Commission has listed this site on the Register of the National Estate.

10. Conservation actions required

Research

- More surveys are required to determine the full geographical distribution of *N. macrops* and its habitat requirements, within both South Australian and Western Australia.

Management

- The remaining mallee habitat needs to be protected from further degradation and the quality of that habitat needs to be improved, particularly in regards to regeneration of the understorey and trees. Currently much of the population is not within reserves but rather is in remnant vegetation along roadsides which may be vulnerable (Watts *et al.* 1998).
- A management plan is required to protect the species' range of habitats. Councils need to be provided with information regarding the species so that informed land use decisions can be made on a local level (A. McArthur personal communication).

11. Relevant Experts/Data Providers

Chris Watts – South Australian Museum, Adelaide
Archie McArthur – South Australian Museum
Steve Shattuck – CSIRO Entomology, Canberra
Bob Taylor – CSIRO Entomology, Canberra
Ross Crozier – James Cook University, Townsville
Matthias Senetra – La Trobe University, Bundoora Victoria

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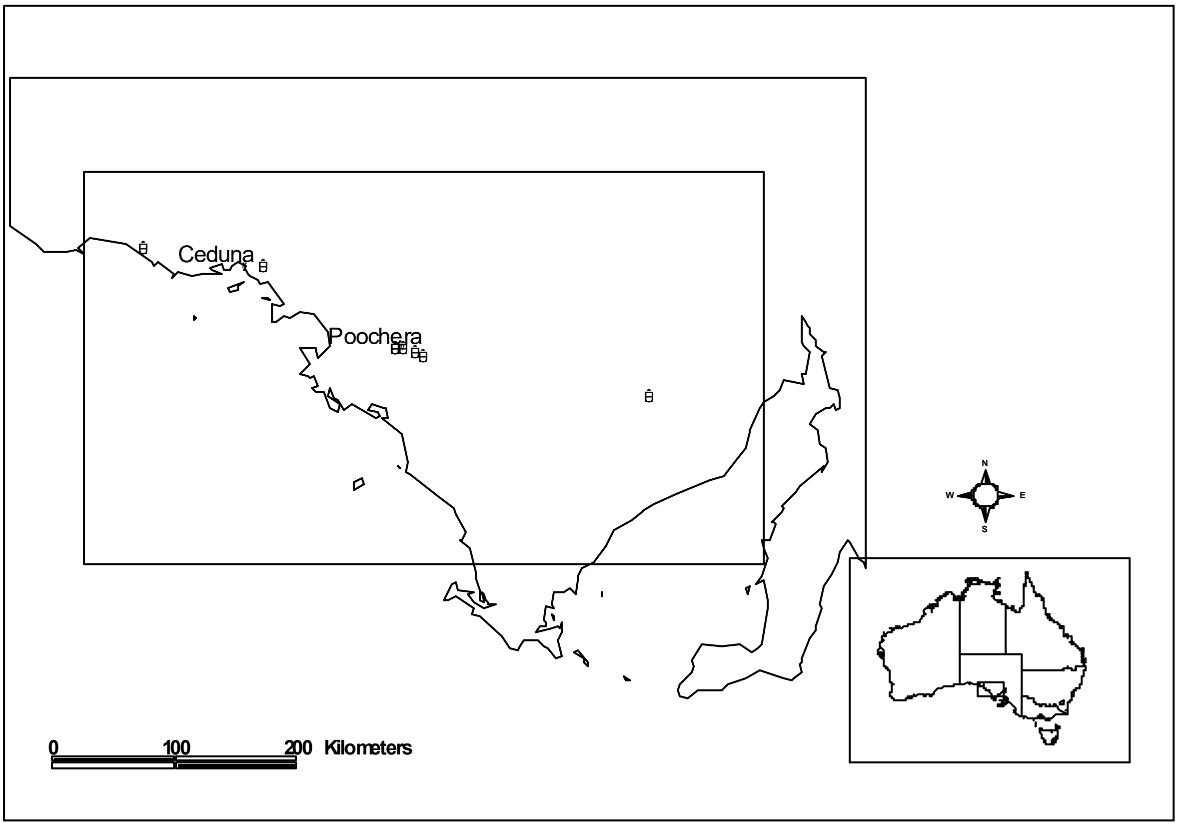
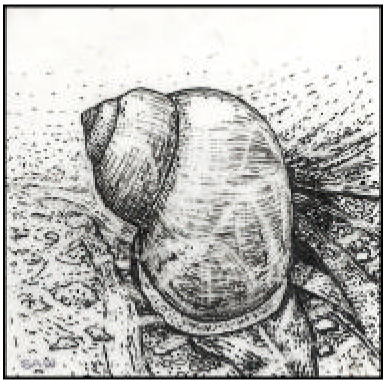


Distribution of *Nothomyrmecia macrops* (source: Steve Shattuck personal communication).

Notopala sublineata sublineata & *N. s. hanleyi* River Snail



Phylum: Mollusca **Class:** Gastropoda **Order:** Caenogastropoda
Family: Viviparidae
Scientific name: *Notopala sublineata sublineata* and *N. sublineata hanleyi*
Common names: River Snail

1. Taxonomic status (including species and subgroups)

Notopala sublineata sublineata Conrad, 1850
Notopala sublineata hanleyi Frauenfeld, 1864

The genus *Notopala* is endemic to Australia with 18 species currently known.

2. Species survival status

Currently not listed under any State or Commonwealth legislation but under consideration in New South Wales.

Notopala sublineata sublineata is listed as Endangered (EN A1ce) on the 2000 *IUCN Red List of Threatened Species*. Assessment of the IUCN categorisation for the species using the *Ramas RedList* software program (Akçakaya and Ferson 1999) indicated that it may be Critically Endangered.

3. Distribution

In Australia this cosmopolitan genus is represented by 18 species found predominantly in the Murray Darling Basin and other large basins in Australia (Smith 1992).

Notopala sublineata is thought to include three subspecies (pending investigation at the molecular level), *N. s. sublineata, N. s. hanleyi* and *N. s. alisoni* (Brazier) (W. Ponder personal communication). *N. s. sublineata* and *N. s. hanleyi* are found in the Murray Darling basin in New South Wales, South Australia and Victoria (Cotton 1935b; Sheldon and Walker 1993b; Ponder 1998). *N. s. sublineata* is restricted to the Darling River and its related tributaries, and *N. s. hanleyi* restricted to the Murray River and its related tributaries (W. Ponder personal communication). The third subspecies (*N. s. alisoni*) is found in inland drainages including the Cooper and Diamantina and a few coastal rivers, notably the Dawson. This subspecies has been incorrectly attributed to *N. sublineata sublineata* by Sheldon & Walker (1993) and is currently not under significant threat.

The ranges of both the Murray-Darling snail species have recently shrunk dramatically, with *N. s. hanleyi* persisting in irrigation pipes in the Murray River (Sheldon and Walker 1993b) and *N. s. sublineata* possibly in a few irrigation pipes in the Darling drainage (W. Ponder, personal communication).

In the lower River Murray it appears that both *N. s. sublineata* and *N. s. hanleyi* are extinct in the natural environment, although *N. s. hanleyi* is in at least one irrigation pipe in the South Australian Riverland, where it is considered a pest as it clogs up the pipes. *N. s. sublineata* also appears to be extinct in the Murray Darling Basin (found in only one location in the last 10 years – in a pipeline).

4. Habitat

Notopala sublineata sublineata and N. s. hanleyi were commonly found on the sediments and hard substrates (rocks, logs etc) of sublittoral areas of freshwater rivers in the Murray River region (Walker 1996; W. Ponder personal communication). Recent populations are now confined to a few irrigation pipes.

5. Biological overview

Members of the family Viviparidae can be identified by the large round shell that whorl around to end in a conical spire (the peak of the shell). The aperture of the shell is approximately ½–? the length of the shell (Cotton 1935a; Smith 1992; Sheldon and Walker 1993b). The outer organic layer of the shell (the periostracum) is thinner in *N. s. sublineata* than in *N. s. hanleyi*.

The periostracum of *N. sublineata* is generally dark green but it may also be greenish brown to dark brown, with or without bands (some other species of *Notopala* have bands) (Cotton 1935b; Sheldon and Walker 1993b).

The body of the animal is similar to other snails but it possesses a prominent snout and short eye stalks on the outside of the tentacles (Cotton 1935b). The radula of *N. sublineata* is shaped like a rake (as in other caenogastropods) and is used to scrape soft organic matter from surfaces (Walker 1996).

Nothing is known of the growth rates or longevity of the species. The family name 'Viviparidae' comes from the ability of these snails to give birth to live young (viviparous), whereas most snails lay eggs (Cotton 1935b; Smith 1992). The young remain with the female until they are large enough to survive independently (W. Ponder personal communication).

The aperture in viviparids can be tightly sealed with the operculum when conditions are harsh, in order to reduce the risk of dehydration (Cotton 1935b; Sheldon and Walker 1993b). Viviparids breath through gills (Cotton 1935b) and feed predominantly by filter feeding, also using their gills.

Little is currently understood of the population rates of change, although population numbers are thought to be extremely low and, on the basis of the information from museum records, have crashed since the 1970's (W. Ponder personal communication).

6. Significance

Australia has 18 representatives of the Viviparidae, found predominantly in the northern tropical region of Australia. There has been much confusion as to the status of the species of the genus *Notopala* in Australia, with *N. waterhousii* and *N. essingtonensis* in the north and the northwest of the continent, *N. s. sublineata* in Lake Eyre and the Murray-Darling basin and *N. s. hanleyi* also in the Murray River basin (Sheldon and Walker 1993b). Another subspecies (*N. s. alisoni*) lives in inland drainages such as Coopers Creek in the Eyre Basin (Sheldon and Walker 1993b). Ponder is currently completing a review of the genus and recognises 18 Australian taxa. One of these, *N. suprafasciata*, is also found in the Murray-Darling system but is confined to billabongs and considered rare (W. Ponder personal communication).

Land and freshwater molluscs make up 22% of the known global extinctions, and are probably one of our least understood invertebrate groups (Ponder 1994). The lack of attention to snails is slowly being addressed as the NSW Threatened Species Conservation Act now lists three species of land snails. The Act does not make provision for protection of any freshwater species (which need to be covered under fisheries legislation).

Many snails have poor dispersal ability. Approximately 72% of the known species in Australia are endemic to one State, with many of these confined to a small range or even a single waterbody (Ponder 1994, 1997). This lack of mobility has also resulted in certain species being limited to relictual habitats, such as rainforest fragments.

Eighteen species of native snails are believed to have disappeared from the Lower Murray River in a period of 30 years. Although many of these are still present in Victoria and NSW the disappearance of so many snails highlights the presence of dramatic changes in the habitat quality of the lower Murray (Sheldon and Walker 1993a; Walker 1996).

7. Threats

Much of the threat to snails is due to their dependence on freshwater, and conflicts between their requirements and human use of water resources. Any construction that changes the flow of water or affects the quality of water such as siltation or nutrients will likely have a detrimental effect upon the snails (Ponder 1997).

Although once believed to be common in the Murray-Darling Basin, it is widely believed that the population has declined dramatically since the 1950's when flow regulations in the Murray were intensified (Walker 1996) W. Ponder personal communication). Further flow restrictions since the 1980's have lead to a belief that the species was extinct (Sheldon and Walker 1993a; Walker 1996).

It is believed that today *N. s. sublineata* is extinct in its natural range, with at least one population (and possibly others) persisting in irrigation pipes. *Notopala sublineata hanleyi* in South Australia is in a similar position, persisting in a few irrigation pipes in the Murray-Darling Basin near Barmera (Walker 1996; Ponder 1998). The status of the latter population is currently unknown as the pipes were recently flushed with chemicals in an attempt to remove the snails (K. Walker and W. Ponder personal communication).

Pipes have also provided refuge to other gastropods such as *Glyptophysa connica*, *Thiara balannensis, Fluvidona* aff. *angasi* and the bivalve *Corbicula australis* (Sheldon and Walker 1993a).

Much of the decline in native snails in the Murray River drainage may be due to a reduction in bacteria present in the biofilm of submerged rocks and wood, which the snails feed on. By altering the river flow it is believed that filamentous algae have replaced the more nutritious bacteria. During the irrigation season (summer to autumn), when oxygen levels are high, irrigation pipes may provide a habitat where these bacteria may persist (Sheldon and Walker 1993a, 1997; Walker 1996).

Increased turbidity from catchment degradation and the introduction of the European carp may also have contributed to the demise of snails through the alteration of the littoral habitat (Sheldon and Walker 1993a).

Increased salinity does not appear to be a major threat as the snails found in irrigation pipes are expected to be exposed to high levels of salt (Sheldon and Walker 1993a).

8. Conservation objectives

To protect the current populations of *N. sublineata* and to ensure that adequate habitat is retained/rehabilitated so as to ensure the long-term survival of the species in the wild.

9. Conservation actions already initiated

- Ponder (1988) has reviewed the taxonomy of the Australian viviparids
- Surveys undertaken in the Darling River and parts of the Murray River failed to locate any living snails. Some small populations may still persist in the Menindee Lakes (W. Ponder personal communication).

10. Conservation actions required

Research

Research is required to examine:

- the current status of existing populations in irrigation pipelines.
- the habitat requirements of *N. sublineata*.
- the impacts of land clearing, salinity and pollution on freshwater habitats and snail populations (Ponder 1997).
- what characteristics, in terms of water flow and quality, have altered in the environments in which these snails exist.
- the impacts of introduced fish on water quality and snail populations (Ponder 1997).
- the viability of relocating snails from pipes to suitable habitat (when identified) in the wild.

Management

- Restoration of some sites may be possible once the species' habitat requirements are confirmed. NSW Forestry is currently developing a natural wetland system in the Murray River at Moira that may be a useful location to relocate the snails (W. Ponder personal communication).

11. Relevant Experts/Data Providers

Winston Ponder – Australian Museum, Sydney

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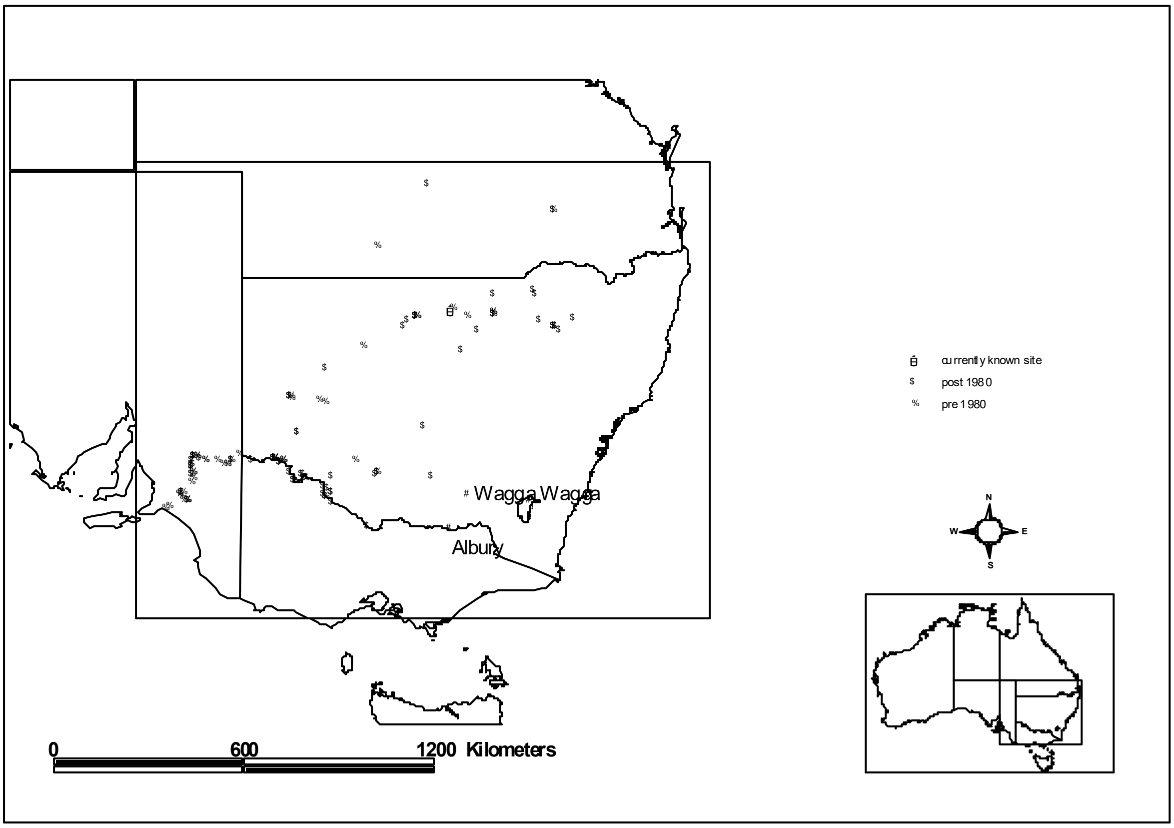

Distribution of *Notopala sublineata sublineata* (source: Winston Ponder personal communication)

Petalura species — Giant Dragonfly

Phylum: Arthropoda **Class:** Insecta **Order:** Odonata **Suborder:** Anisoptera
Superfamily: Aeshnoidea **Family:** Petaluridae
Scientific name: *Petalura gigantea*
Common names: Giant Dragonfly

1. Taxonomic status (including species and subgroups)

Petalura gigantea Leach 1815.

Petalura gigantea is now recognised as two species, *Petalura gigantea* Leach 1815 and *Petalura litorea* Theischinger 1999 (Theischinger 1999).

Worldwide there are currently 10 species of *Petalura* known, five of which are found in Australia. A further two are in North America, and one each on New Zealand, Chile and Japan (Trueman 1997; Theischinger 1999).

2. Species survival status

Petalura gigantea is listed as an endangered species in NSW in accordance with the *Threatened Species Conservation Act* 1995 (NSW National Parks & Wildlife Service 1999a).

Petalura gigantea has been nominated for inclusion on the *IUCN Red List of Threatened Species*.

Assessment of the IUCN categorisation for *Petalura gigantea* and *P. litorea* using the *Ramas RedList* software program (Akçakaya and Ferson 1999) indicated that both species may be Critically Endangered.

3. Distribution

The species is now recognised as two distinct species; *P. gigantea* (southern) and *P. litorea* (northern) (Theischinger 1999).

Petalura litorea is found along coastal Queensland and coastal northern New South Wales, while *P. gigantea* is found along the east coast of NSW from Moss Vale to northern NSW. Neither species is found west of the Great Diving Range (Houston and Watson 1988; NSW National Parks & Wildlife Service 1999b).

4. Habitat

Petalura gigantea has been recorded at sites throughout eastern NSW which are permanently wet, such as swamps and bogs, occurring from montane areas to sea level (Winstanley 1982; Watson *et al*. 1991). As the vegetation appears to be different at each site, it is believed that the important site factors are those related to the aquatic habitat, such as water quality, water permanence, vegetation cover, and the suitability of the substrate for burrow construction (NSW National Parks & Wildlife Service 1999b).

It has been suggested that other important factors in habitat suitability may be the presence of open areas of sedge, less than 0.5 cm high and the absence of ground covers, which may provide a barrier between the swamp itself and individuals (J. Trueman personal communication).

Petalura litorea appears to be restricted to tropical and subtropical coastal swamps and lake margins. The species has been found in Queensland at North Stradbroke Island and in northern NSW near Broome Head. Historical records indicate that *P. litorea* was once present at various sites through southeast Queensland (Theischinger 1999; J. Trueman personal communication).

5. Biological overview

Members of the genus are very large, with *P. gigantea* being the second largest dragonfly in Australia, and among the largest in the world. Males can reach a wingspan of 110 mm, with an abdomen of 63–73 mm and a hindwing of 50–56 mm, while the same measures for females are 120 mm, 82–-96 mm and 54–58 mm respectively (NSW National Parks & Wildlife Service 1999b).

Both sexes have widely spaced eyes and are predominantly a brown-black colour broken up by yellow on the abdominal segments. The pterostigma (a series of highly sclerotised hemolymph filled cells on the wings used for balance) is much longer in members of the *Petaluridae* than in other species of Odonata. The anal appendages of the male are foliate (leaf like) (Watson *et al.* 1991) and the female has a short ovipositor. The larvae are also large (49–50 mm) grub-like creatures with large eyes (Watson *et al.* 1991; Hawking and Theischinger 1999; NSW National Parks & Wildlife Service 1999b). Larvae of *P. gigantea* are reportedly unable to swim, as they prefer terrestrial habitats (NSW National Parks & Wildlife Service 1999a). For a more detailed description of *P. gigantea* see Fraser (1960) and Watson *et al.* (1991).

Courtship is carried out while flying in tandem with the male holding the female by the head and prothorax. Mating occurs on vegetation with the tip of the female's abdomen placed on the secondary genitalia found on the male's abdomen. The female then flies off and lays eggs (up to 137 eggs observed) deeply into a layer of sphagnum along the edges of the swamp (Watson *et al.* 1991; Hawking and Theischinger 1999; NSW National Parks & Wildlife Service 1999b).

The larvae, which live in mud along the edges of swamps, are thought to be only semi-aquatic, avoiding open waters (Tillyard 1911; NSW National Parks & Wildlife Service 1999a). They live in long channels (up to one metre) constructed in the mud below the water table. Exit holes open both into the water and onto the bank so that the larvae can leave the burrow at night to hunt (Trueman 1997; NSW National Parks & Wildlife Service 1999b). This behaviour is unique to the family (Winstanley 1982) (Watson *et al.* 1991). Upon emergence the adults climb up a nearby sedge or other vegetation. The abdomen of some petalurids expands prior to the wings, which occurs first in most species of Odonata (Winstanley 1982).

Petalura gigantea may be slow growing and may persist as larvae for 10–30 years (NSW National Parks & Wildlife Service 1999a), although this estimate is only based on burrow growth rates for a New Zealand species of Petaluridae (J. Trueman personal communication).

All dragonfly larvae are predators, and will eat a variety of insects, including larvae of other dragonfly species. Adults are also generalists, and will catch and eat anything on the wing that is manageable. When not hunting or mating, adults spend much time settled on low vegetation in close proximity to the swamp (NSW National Parks & Wildlife Service 1999b).

Adults are believed to emerge during October and November and are present until February (NSW National Parks & Wildlife Service 1999a).

6. Significance

Of the five genera (containing ten species) within the family Petaluridae, only one, *Petalura*, is found in Australia. This genus, which consists of five species, is endemic to Australia (NSW National Parks & Wildlife Service 1999b; J. Trueman personal communication). It is believed that these species are the remnants of a once abundant taxon which may have persisted for 190 million years from the early Triassic period (Tillyard 1909; Fraser 1957; Trueman 1997).

Petalura gigantea is a highly unusual species because of its huge size and as it is believed to be a predominantly terrestrial species (NSW National Parks & Wildlife Service 1999a).

One *Petalura* site at Wingecarribee Swamp in the Southern Highlands of NSW, is the largest montane peatland site on mainland Australia, and is also home to three rare plant species (*Lysimachia vulgaris var. davurica* (Yellow Loose Strife) (Dorman 1997), *Gentiana wingecarribiensis* and *Prasophyllum fuscum*). It is also recognised internationally as a significant site due to its high floristic and ecological diversity. Although much still has to be learned about swamp invertebrates, many are believed to be specialists, and so by preserving swamps these important species may benefit (NSW National Parks & Wildlife Service 1999b).

7. Threats

Many of the sites where the species is currently known are within National Parks and so should be protected. A few sites, not within reserves, may be threatened by infill for urban development. One site at Hanging Rock Swamp is threatened by the encroachment of pine trees from a surrounding pine plantation (J. Trueman personal communication).

As a species that requires permanent water, anything that may affect the quality or the amount of water, such as draining, filling or mining for agricultural, industrial or urban purposes, could be detrimental to the community. Alterations of water flow and pollution are also important threats (Trueman 1997; NSW National Parks & Wildlife Service 1999b).

Rapid changes in the habitat may cause problems for the species due to the presumed long larval stage. As *P. gigantea* does not seem to readily disperse away from the swamp, nearby sites may not be colonised, resulting in localised extinctions if the swamp is lost (NSW National Parks & Wildlife Service 1999a).

Many previously recorded populations are now extinct as the wetlands have been lost to development and degradation (NSW National Parks & Wildlife Service 1999a). One of the largest populations known was at Wingecarribee Swamp which has been subject to peat mining from the 1960's until this was stopped in 1998 (Dorman 1997; NSW National Parks & Wildlife Service 1999a). In 1998 the site suffered a major landslide after heavy rains. The impact of this on the population is not known, although it probably reduced the available larval habitat to only one hectare on nearby private land (J. Trueman, personal communication).

8. Conservation objectives

- To ensure the long-term survival of *Petalura gigantea* across its range by conserving known sites and undertaking further surveys to determine distribution and habitat requirements.

9. Conservation actions already initiated

- All of the sites where *P. gigantea* is known or believed to be present are within National Parks, State Forests or water catchment areas, which affords some protection to the populations (NSW National Parks & Wildlife Service 1999b).
- During 1998/99 surveys were carried out at the Wingecarribee Swamp site (NSW National Parks & Wildlife Service 1999b). In 1999/2000 a Statewide survey of all historical sites and many potential sites throughout the known range was undertaken for *P. gigantea* and *P. litorea* (J. Trueman personal communication). Researchers have also undertaken survey work on an ad hoc basis during 2000 (J. Trueman personal communication).
- A draft recovery plan for *P. gigantea* has been developed by the NSW NPWS (NSW National Parks & Wildlife Service 1999b).

10. Conservation actions required

Research

- Future surveys may be best served in regions above 800–1,100m north of the sites at Gibraltar Range/Washpool National Parks and south towards Dorrigo/ New England, as recent surveys did not cover these areas in detail (J. Trueman, personal communication).
- Investigation of the habitat requirements of the species
- Investigation of larval and adult biology, particularly in regards to mating behaviour, fecundity and the duration of larval stages
- Investigation of both short- and long-term threats to the survival in the wild
- Investigation and monitoring of population sizes at each site (NSW National Parks & Wildlife Service 1999b).

Management

- Existing sites outside National Parks need to be protected from avoidable threats, such as pollution and runoff.
- Sites within National Parks need to be monitored to ensure that there are no hidden threats.

12. Relevant Experts/Data Providers

John Trueman – Australian National University, Canberra

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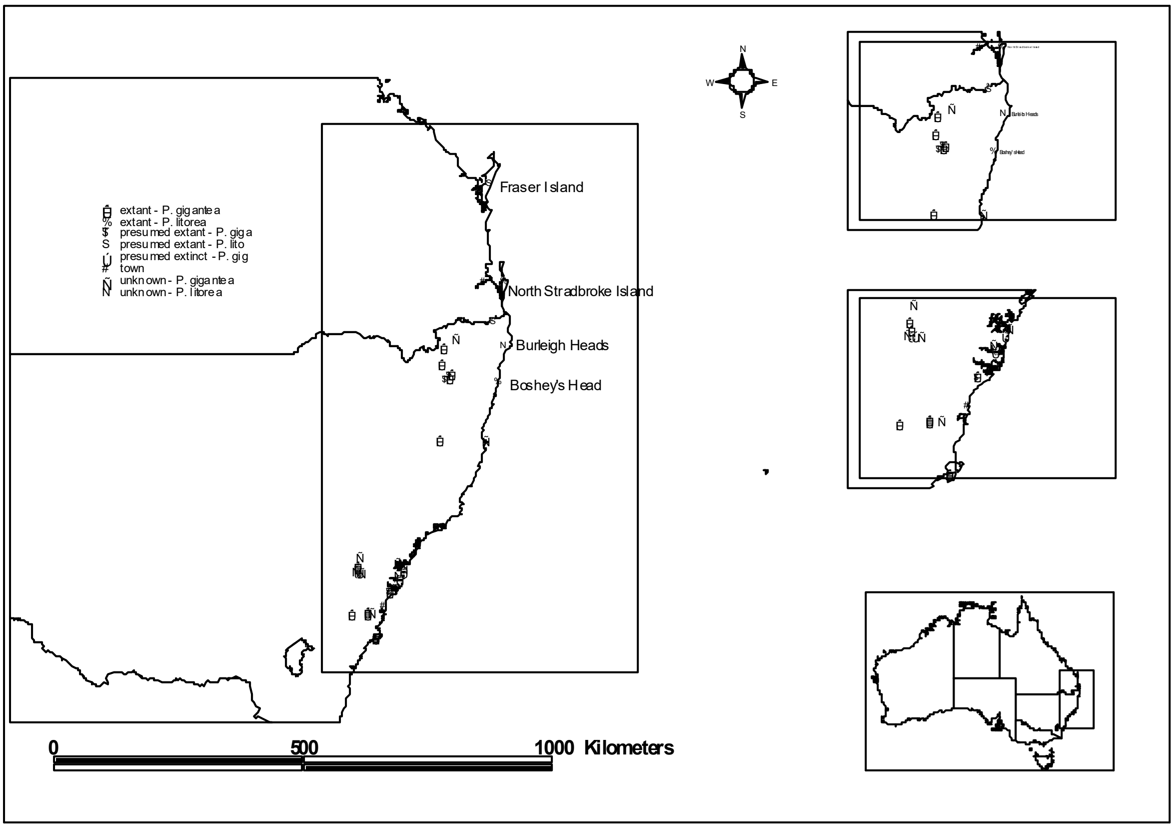

Distribution of *Petalura gigantea* (source: NSW NPWS 1999; John Trueman personal communication)

Petasida ephippigera	**Leichhardt's Grasshopper**

Phylum: Arthropoda **Class:** Insecta **Order:** Orthoptera
Family: Pyrgomorphidae **Subfamily:** Petasidini
Scientific name: *Petasida ephippigera*
Common names: Leichhardt's Grasshopper

1. Taxonomic status (including species and subgroups)

Petasida ephippigera White, 1845.

The subfamily Petasidini is endemic to Australia and only has two species in two genera.

2. Species survival status

Listed as Vulnerable in annexes to the *Northern Territory Parks and Wildlife Conservation Amendment Act* 2000.

Nominated for inclusion on the *IUCN Red List of Threatened Species*. Assessment of the IUCN categorisation for the species using the *Ramas RedList* software program (Akçakaya and Ferson 1999) indicated that it may be Data Deficient.

3. Distribution

Petasida ephippigera is found in heathlands in restricted areas of the wet-dry tropics of the Northern Territory, mainly within the Kakadu National Park and the Keep River National Park (Lowe 1995).

4. Habitat

The occurrence of *P. ephippigera* is associated with rugged sandstone ranges supporting floristically diverse heathlands on sandy and/or skeletal soils. *P. ephippigera* is found in association with shrubs in the genera *Pityrodia* and *Dampiera* (Calaby and Key 1973; Key 1985; Rentz 1996). *Pityrodia* are found in drainage lines, and areas of exposed sandstone outcrops or at the base of escarpments (Calaby and Key 1973; Lowe 1995)

The wet-dry tropics of the Northern Territory receives approximately 1,600 mm of annual rainfall, predominantly from December to March, with temperatures during this period about 5°C warmer than in the dry, with the range of 25°–35°C (Lowe 1995; Greenslade and Lowe 1998).

5. Biological overview

Leichhardt's Grasshopper is one of the most spectacular grasshoppers in Australia with its brilliant blue and orange colouration (Greenslade and Lowe 1998), although there is some variation between populations (Lowe 1995). Males grow to 53 mm, while females are larger, reaching 60 mm (Key 1985; Rentz 1996). Older nymphs are similarly coloured, with the exception that the later instars have small yellowish white spots that fade as they reach adulthood (Key 1985). Younger nymphs are a pale green and yellow colour during the dry season and so are camouflaged by vegetation (Lowe 1995). For a more detailed description of *P. ephippigera* see Key (1985).

Young hatch just after the end of the wet season and start feeding on the *Pityrodia* bushes. Growth is slow until the next wet season when the young appear to undergo a growth spurt (Lowe 1995; Greenslade and Lowe 1998).

Petasida ephippigera is dependent on the food plants *Pityrodia* species, and to a lesser extent *Dampiera* species. It was believed that the grasshoppers sequestered chemicals from these aromatic plants (Rentz 1996), but studies recently completed by Fletcher *et. al*. (2000) at the University of Queensland dismiss this claim. They found no obvious toxin, but instead found terpenes and flavonoid compounds. These compounds are thought to be modified during digestion and may play a role in the insect's defence and communication (Anon 1997). Both adults and nymphs feed on the shrubs (Lowe 1995). The species of shrub appear to differ among sites and the grasshopper has been seen feeding on *Pityrodia jamesii* (Calaby and Key 1973), *P. ternifolia* (Lowe 1995), *P. lanceloata*; *P. puberula*; *D. conospermoides*, and *P. angustisepala* (Key 1985).

Anecdotal evidence suggests that the grasshopper may be present in numbers of 200–2,000 individuals per hectare where it occurs (Lowe 1995). The species appears to be restricted in fire protected locations and dependant on the vegetation and sandstone present (Calaby and Key 1973). Calaby & Key (1973) suggest that the grasshopper may naturally experience prolonged fluctuations in population numbers. Although the adults have wings, and fly well, they are reluctant to do so, which could explain why distribution is patchy. The juveniles also do not appear to have the ability to disperse and may remain on the same shrub until the wet season and subsequent oviposition (Lowe 1995).

6. Significance

Petasida ephippigera is an unusual species due to its vibrant colour, and because of this has become a tourist icon for the Northern Territory. The subfamily Petasidini, to which it belongs is endemic to Australia and comprises only two species in two genera (Rentz 1996).

The species may be a good indicator of fire regimes and success of fire management in conservation reserves.

7. Threats

Leichhardt's Grasshopper appears to have no vertebrate predators although invertebrate predators have been observed feeding on mature adults (L. Lowe personal communication).

A major issue that is currently a concern is the impact of burning in the Parks. The major fire problems affecting sandstone heathlands are uncontrolled wildfires, typically emanating from land surrounding the National Parks and burning over extensive areas in the late dry season. It has been argued that fuel reduction burning practices may also pose a threat to the species. *Pityrodia jamesii* burns readily but regenerates within weeks from rootstock or seed if the plant dies (L. Lowe personal communication).

Currently the species is only known to persist at one of four previously known sites in Kakadu National Park, as it has been eliminated from the others by fire (Greenslade and Lowe 1998). Due to its poor dispersal ability, Leichhardt's Grasshopper does not appear to recolonise sites (Lowe 1995). Lowe (1995) claims that there also appears to be no mechanism for egg diapause, so that regenerated areas have a very low probability of the grasshopper returning.

Leichhardt's grasshopper has also become a drawcard for Kakadu National Park, one of the parks in which the species has been found. The impact of intense tourism may be detrimental to the species (Lowe 1995; Greenslade and Lowe 1998).

8. Conservation objectives

- Populations to be maintained at their current level with further surveys and appropriate land management techniques implemented both within the Parks system and outside it.

9. Conservation actions already initiated

- The grasshopper is protected to some extent from threatening processes due to its presence in Kakadu, Nitmiluk and Keep River National Parks.
- Research is currently being undertaken into the relationship between Leichhardt's grasshopper and its food plants; the effects of fire on the grasshopper and its food plants; and the ecology and conservation of the species.
- There are comprehensive monitoring projects being undertaken in Kakadu and Nitmiluk to assess fire regimes and their impacts on sandstone heathlands
- The importance of maintaining fire-free intervals of at least 4-5 years has been recognised in fire management prescriptions for Kakadu and Nitmiluk
- The main habitat for the species has been nominated as an endangered community under the Commonwealth *Environment Protection and Biodiversity Conservation Act*.

10. Conservation actions required

Research

- Further surveys need to be undertaken to establish the full distribution of the species, particularly outside of the Parks system
- Investigation is needed into the biology (particularly phenology, distribution, site fidelity, dispersal, plant chemistry, and defence mechanisms), habitat requirements and population biology of the species (Lowe 1995; Greenslade and Lowe 1998).
- Investigation into the effects of fire and tourism on the grasshopper and its food sources (Lowe 1995; Greenslade and Lowe 1998) is also required.

Management

- Sites that have been identified as having secure populations should be protected from inappropriate fire regimes.
- Although laboratory breeding has not been successful in the past, this may be a possible conservation method, as more information becomes known about the biology and habitat requirements of Leichhardt's Grasshopper (Greenslade and Lowe 1998).

11. Relevant Experts/Data Providers

David Rentz – CSIRO Entomology, Canberra
Penny Greenslade – Australian National University, Canberra
Lyn Lowe -

12. References

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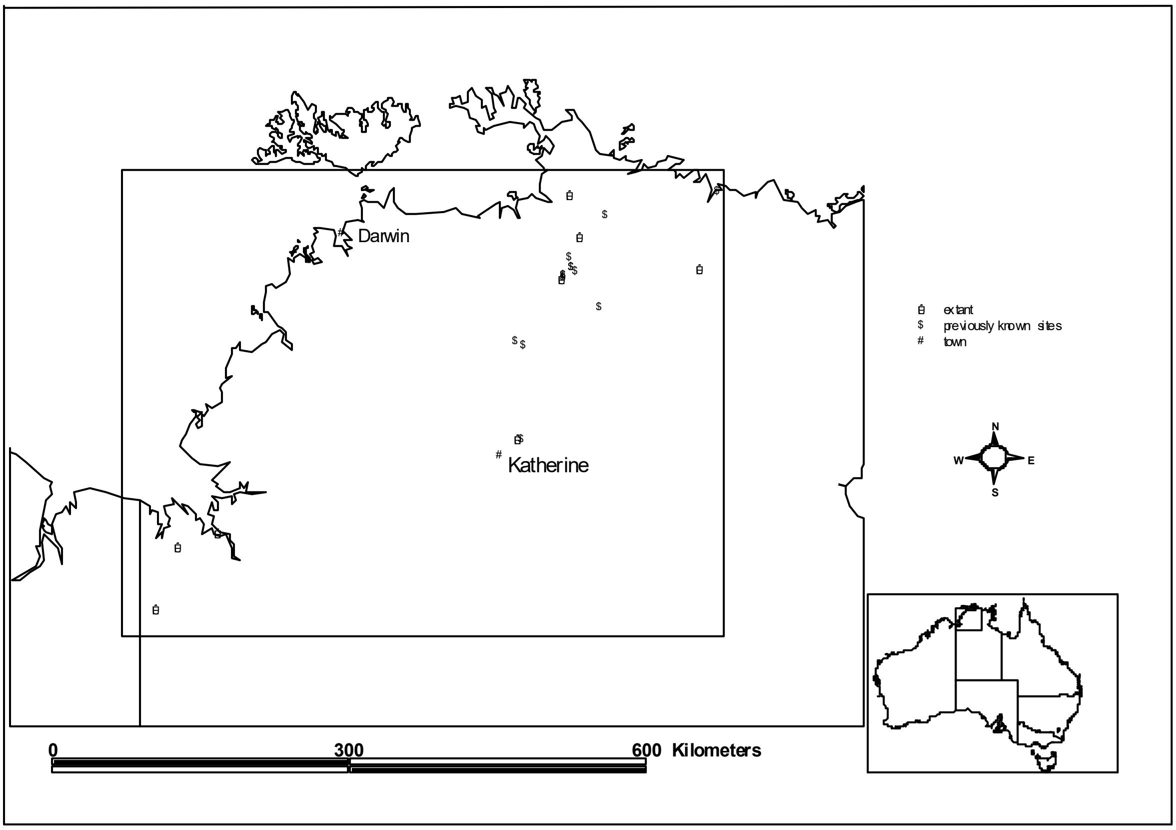
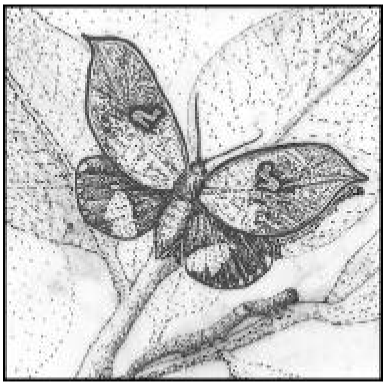


Distribution of *Petasida ephippigera* (source: Lyn Lowe personal communication; Key 1985)

Phyllodes imperialis southern subspecies Pink Underwing Moth



1. Phylum: Arthropoda **Class:** Insecta **Order:** Lepidoptera
2. Superfamily: Noctuidae **Subfamily:** Catocalinae
3. Scientific name: *Phyllodes imperialis*
4. Common names: Pink Underwing moth

1. Taxonomic status (including species and subgroups)

Phyllodes imperialis Druce, 1888. The subspecies in question is currently undescribed.

There appear to be a minimum of four subspecies of *P. imperialis*, in southeastern Queensland, New Caledonia, Vanuatu and the Solomon Islands (only one is described), (D. Sands personal communication).

2. Species survival status

Currently not listed under any State or Commonwealth legislation.

Phyllodes imperialis ssp. is not listed on the 2000 *IUCN Red List of Threatened Species*. Assessment of the IUCN categorisation for the species using the *Ramas RedList* software program (Akçakaya and Ferson 1999) indicated that it may be Critically Endangered.

3. Distribution

Phyllodes imperialis is found throughout northern Queensland, Papua New Guinea, the Solomon Islands (Druce 1888a,b; Sands 1999), Vanuatu, Lifu, and the Bismarck Archipelago (D. Sands personal communication). A southern subspecies of *P. imperialis* is distributed from Nambour, southeast Queensland to Dorrigo, in northern New South Wales (D. Sands personal communication).

4. Habitat

The southern subspecies of *Phyllodes imperialis* is found in the thick primary lower montane rainforests from southeastern Queensland to northern NSW. The vine *Carronia multisepalea,* which provides food for the larvae, is only found in southeastern Queensland. The presence of the vine in these old growth rainforest patches is believed to provide shade that the moths require in order to breed. This darkness is not present where the plants are found in drier less protected sites (D. Sands personal communication). Other forms of *P. imperialis* feed on *Pycnarrhena* vines (D. Sands personal communication).

5. Biological overview

The genus *Phyllodes* is a member of the subfamily Catocalinae, which includes fruit piercing moths, which are most prominent in northern Australia, although some species can also be found in the south of the continent (Edwards 1996). The Catocalinae is a large subfamily with more than 400 known species in Australia.

Phyllodes imperialis (southern subspecies) is currently undescribed but is believed to be morphologically different from the northern subspecies (Sands 1999).

The adults of the northern subspecies of *P. imperialis* are large and have a wingspan of approximately 15–20 mm. They are conspicuous moths with grey brown forewings complete with unusual central white markings, which look similar to a dead leaf, and dark grey hindwings with a large pink patch. In the southern subspecies this patch is a large spot whereas in the northern subspecies it covers about 2/3 of the hindwing. The hindwings also exhibit seven white spots along the lower margins. Colouring is similar on the underside of the wings except that the upper wing is darker with 3 white spots and the pink patch is smaller (Druce 1888a; Hunter 1939). The body of *P. imperialis* is a dark beige colour with brown legs and a black abdomen (Druce 1888a).

The New Caledonian subspecies *P. imperialis dealbata* lacks many of the white markings of *P. imperialis* and the southern subspecies, as well as possessing a wider pink band on the hind wings (Holloway 1979).

Although the early stages of the larvae (semi-loopers) are a dull brown, as they mature they take on a new conspicuous appearance as a defence against predators. If threatened the 12 cm-long caterpillar will curl its head underneath the body revealing an otherwise hidden pattern. This pattern consists of two large black 'eye' spots surrounded by smaller white spots and a double row of white 'teeth' on the dorsal side between the eye spots (Hunter 1939; Common 1990). The pupal stage also is conspicuous with the bronze coloured 5 cm-long case consisting of silk and leaves with metallic brown bands surrounding the outside (Hunter 1939).

The larvae of the subfamily feed exclusively on members of the twining vine family Menispermaceae. The degree of specificity to the one species varies throughout the family, but is thought to be linked to the alkaloids found in the plants. Some fruit piercing moths have also been observed feeding on members of the Ranunculaceae, Lardizabalaceae, Smilacaceae, Leguminaceae and Berberidaceae, which are closely related to and contain similar alkaloids to the Menispermaceae (Fay 1996). Adults feed on overripe fruit or that which has been previously damaged by other organisms (D. Sands personal communication).

The northern subspecies of *P. imperialis,* found in northern Queensland and Papua New Guinea, feeds on *Pycnarrhena australiana* (Common 1990). In northern NSW the larvae of *P. imperialis* (southern subspecies) appear to be wholly dependent on the vine *C. multisepalea* (D. Sands personal communication).

Little is published about the life history, behaviour, population abundance and rates of change for the species.

6. Significance

This moth species would provide an excellent flagship taxa, as do many Lepidopterans, due to its beauty and its dependence on the preservation of a few larval food plants in tropical rainforest (Sands 1999).

A number of species of fruit piercing moths are pests of commercial fruit crops, particularly in Africa and the Pacific, as the adults suck the liquids out of the fruit with the help of a long, very strong, saw-like proboscis (Fay 1996). *Phyllodes* species do not possess this type of proboscis however and cannot inflict any damage on fruit, only utilising fruits that are already damaged (Fay 1996).

7. Threats

The major threat to the species is the loss of much of the primary rainforest on which the larvae depend for their food plant, which is already uncommon (Sands 1999).

Although *C. multisepalea* grows in both undisturbed old growth rainforest and in more open habitats, the moths have only been observed on the plants within rainforest patches.

8. Conservation objectives

- Permanently retain the patches that currently contain the vine and undertake the rehabilitation of degraded sites so as to protect the old growth rainforest habitat of *C. multisepalea* and *P. imperialis* (southern subspecies).

9. Conservation actions already initiated

- The only currently known breeding site known for *P. imperialis* (southern subspecies) is the Mary Cairncross Park in Maleny, which is listed on the National Estate Register. The site has also been designated a Conservation Reserve by the local council.

10. Conservation actions required

Research

- Additional survey work to identify further breeding sites.
- Due to the dependence of the moth on *C. multisepalea,* surveys need to be undertaken for the presence of the vine in old growth forests.

Management

- A recovery plan for the southern subspecies of *P. imperialis* is required so that conservation efforts can be focused, threatening processes identified and recovery actions initiated.
- Focus on protection of remnants of rainforest especially those in which *C. multisepalea* is not yet known but likely to occur.
- Community participation in the protection of the species by organising revegetation programs to restore the rainforest species, particularly *Carronia multisepalea*, may be a beneficial management option in the future (Sands 1999).

11. Relevant Experts/Data Providers

Don Sands – CSIRO Entomology, Brisbane

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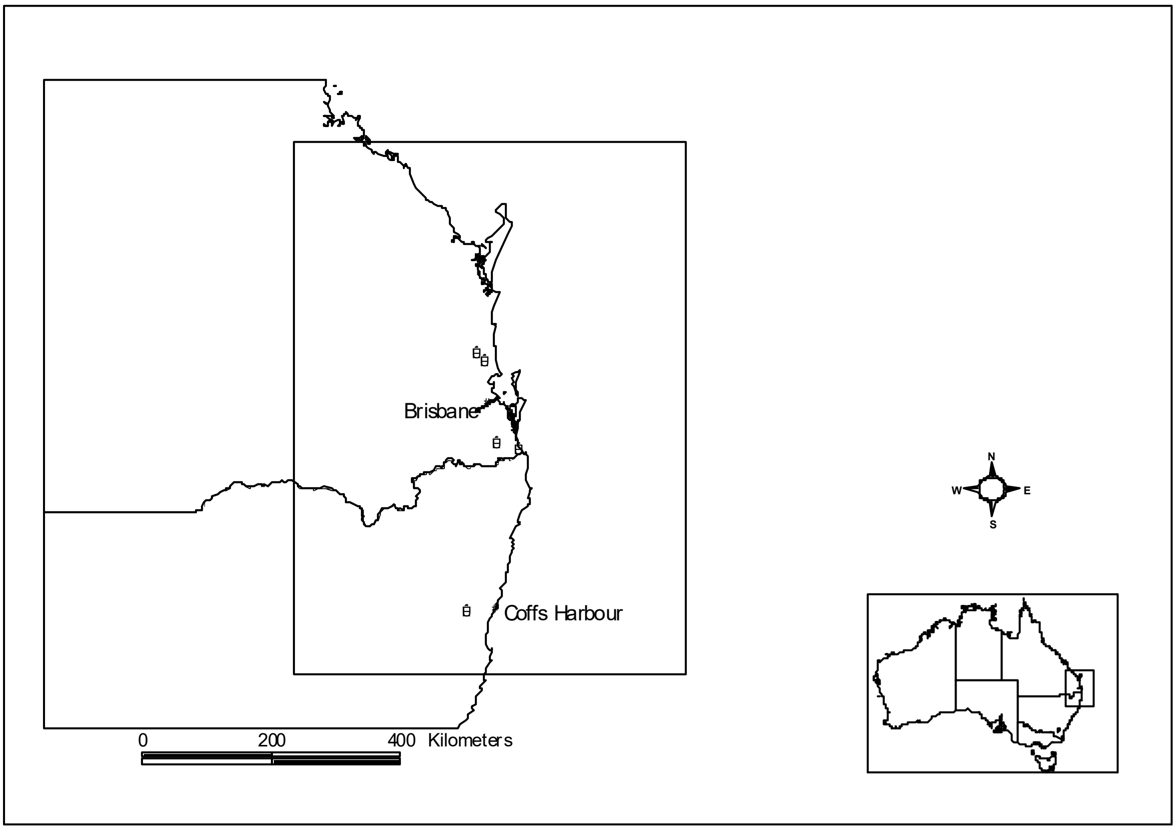
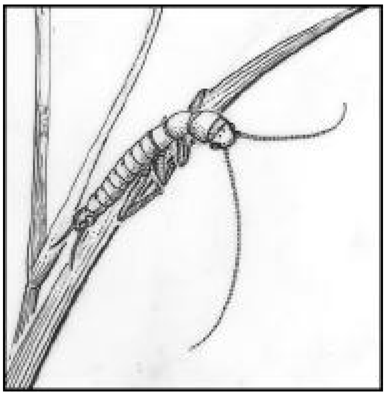


Distribution of *Phyllodes imperialis* (southern subspecies) (source: D. Sands)

Reikoperla darlingtoni Mt. Donna Buang Wingless Stonefly



Phylum: Arthropoda **Class:** Insecta **Order:** Plecoptera
Family: Gripopterygidae
Scientific name: *Reikoperla darlingtoni*
Common names: Mount Donna Buang Wingless Stonefly

1. Taxonomic status (including species and subgroups)

Reikoperla darlingtoni Illies, 1968.

The genus *Reikoperla* contains twenty-seven species (Theischinger 1985). This species is only the second wingless stonefly to be described in Australia, which, combined with its ability to survive drought and its long life span, make it interesting from a scientific viewpoint (Wells *et al*. 1984; Ahern *et al*. 1999).

2. Species survival status

Listed under Schedule 2 of the Victorian *Flora and Fauna Guarantee Act* 1988 as Vulnerable.

Reikoperla darlingtoni is listed as Vulnerable (VU D2) on the 2000 *IUCN Red List of Threatened Species*. Assessment of the IUCN categorisation for the species using the *Ramas RedList* software program (Akçakaya and Ferson 1999) indicated that it may be Critically Endangered.

3. Distribution

Reikoperla darlingtoni has only been found in small, cool, temporary streams with clear water near the summit of Mount Donna Buang, near Warburton in the central highlands of Victoria at 1,000–1,200m above sea level (Wells *et al*. 1984; Michaelis and Yule 1988; Ahern *et al*. 1999).

4. Habitat

Although Illies (1968) described the habitat as typical high alpine grasslands, just above the timberline, Hynes (1974a) states that it is montane wet *Eucalyptus* forest dominated by alpine ash (*E. delegatensis*) and shining gum (*E. nitens*) with a myrtle beech (*Nothofagus cunninghami)* understorey to the summit (Ahern *et al*. 1999).

Adults of *R. darlingtoni* are found in rolled pieces of *E. regnans* bark, close by small temporary streams. The nymphs can be found under stones in the gravel substrate (Hynes 1974a; Michaelis and Yule 1988; Ahern *et al*. 1999).

Much of the land on which the species is found is administered by Melbourne Water (Ahern *et al*. 1999).

5. Biological overview

Reikoperla darlingtoni is a small stonefly 6–12 mm long with bulging eyes and antennae that can be as long as the animal itself (Illies 1968; Wells *et al*. 1984). Mainly brown, the stonefly has both darker and paler markings on the ventral surface of the body. *Reikoperla darlingtoni* does not have wings, but vestiges of wings can be seen on the thoracic segments of the insect (Illies 1968). Two long cerci are also present (Ahern *et al*. 1999). Nymphs are similar to adults in appearance except that they are smaller and possess a terminal gill tuft as they are aquatic (Ahern *et al*. 1999). Eggs resemble tiny (0.5 mm long) yellow buns and are laid on the substratum under water (Hynes 1974a,b; Michaelis and Yule 1988; Ahern *et al*. 1999). For a more detailed description of *R. darlingtoni* see Illies (1968).

The life span of *R. darlingtoni* is believed to be approximately three years, longer than other species in the genus (Wells *et al.* 1984). Generally, females appear to be longer lived than males, with the adult females living for six weeks and the adult males living for only three weeks (Ahern *et al*. 1999). Eggs are laid in spring until December and hatch in the following autumn. The adults emerge at dawn in spring two years later (Hynes and Hynes 1975; Wells *et al*. 1984; Ahern *et al*. 1999).

Species in the southern hemisphere have adapted to more variable environmental conditions than their northern counterparts, so species may change from a univoltine cycle in warm conditions to a semivoltine cycle in colder waters (Hynes and Hynes 1975). In summer, nymphs and eggs appear to be able to withstand drought, with the nymphs burrowing deep into the substratum, but reappearing when flows increase (Hynes and Hynes 1975; Ahern *et al*. 1999). Like many gripopterygids, *Reikoperla darlingtoni* has adapted well to living in the harsh conditions of high elevation areas where snow exists for an extended time. Many stonefly species lose abdominal gills necessary for respiration at such altitudes due to the high oxygen levels of the cold water and the low metabolic rate of oxygen consumption at cold temperatures. They need to respire from the abdominal body wall, which also allows them to breathe when out of water if necessary (Illies 1968). When the snow has melted, food sources for aquatic invertebrates may be in short supply, so there must be a need for the larvae to leave that habitat and search for food on the banks (Illies 1968).

Reikoperla darlingtoni is thought to be a detrivore/herbivore, feeding on the algae growing on twigs and bark, as well as lichen, bark, rotten wood, diatoms and plant tissue (Ahern *et al*. 1999).

The extent of the population is unknown, but the species does not appear to be abundant (Wells *et al*. 1984; Scientific Advisory Committee 1997).

6. Significance

The order Plecoptera, or stoneflies, is a minor order, containing only 2,000 species. Of these 179 are found throughout Australia except the Northern Territory, and the arid regions of South Australia and Western Australia. The dominant family in much of Australia, New Zealand, and mountainous South America is the Gripopterygidae, to which this species belongs, with 12 of the 39 genera present in Australia being endemic (Michaelis and Yule 1988).

Although brachypterous stoneflies have been found in all continents, wingless forms can only develop in an area with a long history of ideal stable conditions. Many relict species are found under such conditions, with Mount Donna Buang being no exception (Illies 1968; Wells *et al*. 1984).

Mount Donna Buang could be useful in education as it represents near-pristine montane community, supporting some very unusual species (Ahern *et al.* 1999).

7. Threats

Little is known about the species despite detailed surveys of the area, suggesting that it is a very rare. It is potentially highly vulnerable to environmental fluctuations, as it cannot readily disperse to new sites.

Mount Donna Buang is a popular tourist attraction all year round, attracting 20,000 visitors per year, which has resulted in car parks and kiosks being developed. Unfortunately some of these are adjacent to the stream in which the largest population of *R. darlingtoni* is known. Any further development could impact on the population by affecting drainage, soil compaction, water pollution and human activities (Wells *et al*. 1984; Scientific Advisory Committee 1997; Ahern *et al.* 1999). Wildfire may also present a threat as the adults live in shed bark.

A fungal disease that is present in the area, and may be spread by human activity, Myrtle Wilt (*Chalara australia*), may be a threat to the *Nothofagus* understorey. This disease has been recommended to the Scientific Advisory Committee for possible listing as a threatening process, but its impact on the stoneflies is unknown (Ahern *et al*. 1999).

8. Conservation objectives

To determine the distribution and conservation status of *Reikoperla darlingtoni* and to determine the species' ecological requirements so as to maintain the current populations (Ahern *et al*. 1999).

9. Conservation actions already initiated

- Mount Donna Buang is included in the Yarra Ranges National Park which was reserved in 1995 (Wells *et al*. 1984). Mount Donna Buang also has been nominated for listing on the Register of the National Estate, based on the presence of *Reikoperla darlingtoni*.
- Surveys undertaken in 1982–3 (Neumann and Morey 1984) and 1993 (Ahern *et al*. 1999) located several new sites.
- A management plan for the Yarra Ranges National Park is currently being drafted. The plan must provide guidelines for the management of recreation areas to ensure that conservation values are upheld.
- An Action Statement for *Reikoperla darlingtoni* has been prepared by the Victorian Department of Natural Resources and Environment and will be reviewed in 2005 whilst the monitoring program will be reviewed in 2003 (Ahern *et al*. 1999).

10. Conservation actions required

Research

- Additional areas that may provide suitable habitat, such as the nearby Mount Juliet, need to be identified.
- Investigate the population size and implement a monitoring program to identify any population size fluctuations.
- Investigation into the ecology of *R. darlingtoni*, including its life history, significant threats and habitat requirements (Ahern *et al*. 1999).
- The potential impact of fire on the stonefly and its habitat needs to be evaluated.
- As the visitor faculties are adjacent to the stonefly's habitat, detailed studies need to assess the impact of tourism as well as develop plans for mitigation of ongoing threats, such as siltation.
- As climate change may impact on the species and its habitat, research may be necessary to assess what impacts may occur.

Management

- Any proposed further additions to the visitor facilities need to be to carefully assessed as to whether they are necessary and whether they will have any detrimental or long-term effect on the ecosystem (Wells *et al*. 1984).
- An education and interpretation program is needed to inform visitors about the species and the threats to it (Ahern *et al*. 1999).

11. Relevant Experts/Data Providers

Edward Tsyrlin – Monash University, Melbourne

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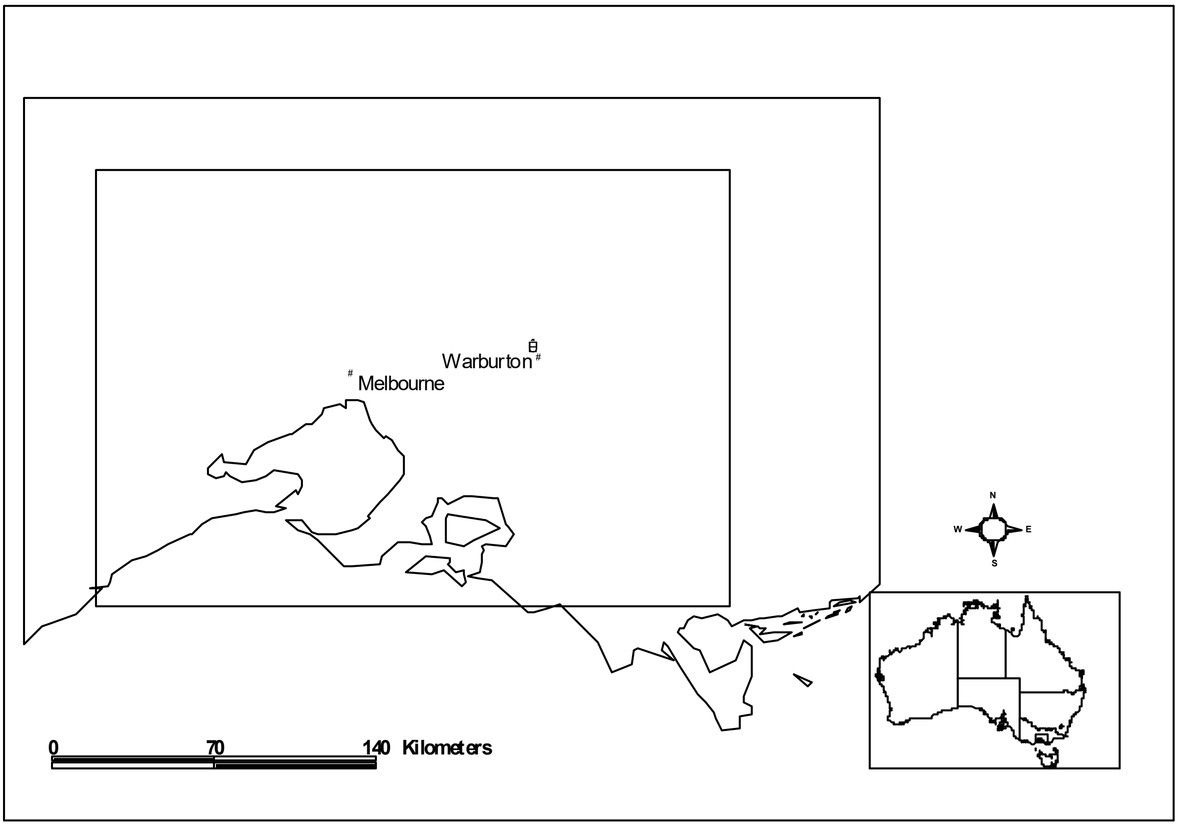
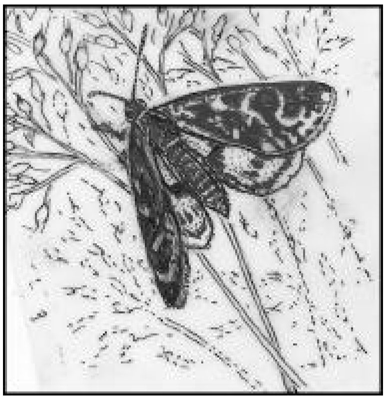


Distribution of *Reikoperla darlingtoni* (source: Ahern *et al* 1999)

Synemon plana Golden Sun Moth



Phylum: Arthropoda **Class:** Insecta **Order:** Lepidoptera
Family: Castniidae
Scientific name: *Synemon plana*
Common names: Golden Sun Moth

1. Taxonomic status (including species and subgroups)

Synemon plana Walker, 1854.

The Australian endemic genus *Synemon* contains 44 species (E.D Edwards personal communication).

2. Species survival status

Listed in the ACT as endangered under the *Nature Conservation Act* 1980, Determination No 7 of 1998 (formerly No 29 of 1996). The species also has special protection status under schedule 6 of the *Nature Conservation Act* 1980, Determination No 77 of 1996.

Listed in NSW as endangered under Part 1 Schedule 1 of the *Threatened Species Conservation Act* 1995. Final determination made by NSW Scientific Committee (1996).

Listed in Victoria as a threatened taxon under the Victorian *Flora and Fauna Guarantee Act* 1988.

Synemon plana is not listed on the 2000 *IUCN Red List of Threatened Species*. Assessment of the IUCN categorisation for the species using the *Ramas RedList* software program (Akçakaya and Ferson 1999) indicated that it may be Critically Endangered

3. Distribution

It is believed that prior to 1950 *S. plana* occupied a range from Bathurst, NSW, through central and southern Victoria to Bordertown in South Australia (Edwards 1993). In Victoria, museum records suggest that 48 of 60 known *S. plana* sites have been lost (Scientific Advisory Committee 1994).

Currently the species is found in small patches where native temperate *Austrodanthonia* grasslands still persist (12 in the ACT, eight in Vic, and 43 in NSW) (Clarke 2001).

Half of the known NSW sites are located on public land, predominantly travelling stock reserves managed by the Rural Lands Protection Boards, sports grounds, and city council lands, with the remaining sites on private rural land, used predominantly for sheep grazing (Clarke 2001).

4. Habitat

Synemon plana is found in native open temperate grasslands and open grassy woodlands dominated by wallaby grass tussocks (*Austrodanthonia* spp). In the ACT the grasses present are predominantly silvertop wallaby grass (*A. carphoides)*, in Victoria, *A. auriculata*. *A. carphoides*, *A. pilosa*, *A. eriantha*, and *A. setacea*, while in NSW the species are *A. carphoides*, *A. setacea*, and *A. auriculata*. Other native grasses such as *Bothrichloa macra*, *Themeda triandra and Austrostipa bigeniculata*, plus herbs such as *Wahlenbergia* spp, *Chrysocephalum apiculatum*, and *Lomandra filiformis* may also be present. At least a 40% cover of *Austrodanthonia* species is optimal for the species (O'Dwyer 1999; O'Dwyer and Attiwill 1999).

Suitable soils are generally low in phosphorus (below 14 µg/g), slightly acidic, sandy, clay loams (O'Dwyer 1999; O'Dwyer and Attiwill 1999). All of the known sites are less than 720 m above sea level, although sites of suitable habitat have been identified above this in central and southwest NSW (Clarke 2001).

5. Biological overview

Synemon plana is an attractive moth with green eyes, clubbed antennae, and no functional mouthparts. Males have a wingspan of about 34 mm with a dark brown forewing with pale grey scales, while the hindwings are bronze/brown and black, with pale grey and black on the underside. The females are slightly smaller at 31 mm, and have a bright orange hindwing with black submarginal spots, while the forewing is similar to the males but more grey than brown, and a white underside (Edwards 1991). The females are poor fliers, which is unique in the genus (Edwards 1991).

The life cycle of *S. plana* is relatively well understood. Longevity is estimated to be about two years (Edwards 1994), however, genetic evidence suggests that generation time may actually be 12 months (Clarke 1999). After mating, it is believed that the females lay up to 200 eggs at the base of the *Austrodanthonia* tussocks. The eggs hatch after 21 days. The larvae tunnel underground where they remain feeding on grass roots before digging a vertical tunnel to the surface where the pupa remains for six weeks until the adult moths emerge (Edwards 1993). The immature stages of *S. plana* have not yet been described. Edwards (1993) suggests that possible variation in the length of the larval stage of *S. plana* may create the flexibility needed for a population to survive harsh years.

When females emerge from the tunnel as adults, they already possess fully developed eggs (Edwards 1993), and begin to search for a mate, flashing the vivid orange hindwings to attract any males flying overhead.

Males of the golden sun moth are generally seen flying about one metre above the ground on bright sunny days during November and December between 11am to 2pm so as to catch the hottest part of the day. This flight period lasts approximately 6–8 weeks (Edwards 1993). The timing and duration of the flying season varies seasonally (Edwards 1993). Adults only live for two to five days, as they cannot feed (Edwards 1993).

Because of the females' inability to fly and the males' reluctance to fly away from suitable habitat, *S. plana* cannot colonise sites further than 200 m away (Clarke and O'Dwyer 1999). Males may be dispersed by wind, however there is little possibility of wind-assisted female movement.

Little is known about population sizes of *S. plana*, but surveys at York Park, ACT, suggest that there may be as many as 1,700 males per hectare, with no estimates on females or larvae (Harwood *et al*. 1995). Census population sizes provide little information on the conservation status of this species as not all individuals observed may be of reproductive status (Clarke 1999).

6. Significance

The family Castniidae is believed to be a relict group from Gondwana, with 30 genera found in the neo-tropical, oriental and Australian region. All 44 Australian species are contained in the single genus, *Synemon* (Edwards 1997).

Many of the *Synemon* species found in the southern States are dependent on species of *Austrodanthonia*, while other species feed on mat rush (Lomandraceae), *Chrysopogon* spp, *Lepidosperma* sedges (Cyperaceae), and other grasses and sedges (Edwards 1997). *Austrodanthonia* grasslands, a habitat once common throughout temperate southeastern Australia, have been highly fragmented due to urbanisation and agriculture in the ACT, NSW and Victoria (Kirkpatrick *et al*. 1995).

This habitat fragmentation has resulted in many other species of *Synemon* also being threatened, such as *S. jcaria* (vulnerable), *S. nais* (endangered), *S. sp.* aff. *selene* (endangered), *S. sp* aff *collecta* (endangered), and *S. theresa* (endangered) (Venn 1994). In Victoria alone most of the seven species present are considered endangered or vulnerable (O'Dwyer 1999).

Synemon plana has proved useful as a 'flagship' taxon, a well-known species that can be used to protect habitat that may also harbour other threatened species. In the temperate grasslands in the ACT and southern NSW region, protection of *S. plana* sites might also protect other grassland species at risk such as the Perunga grasshopper (*Perunga ochracea*), Key's matchstick (*Keyacris scurra*), the Canberra raspy cricket (*Cooraboorama canberrae*), pink-tailed legless lizard (*Aprasia parapulchella)*, Tarengo leek orchid (*Prasophyllum petilum*), Yass daisy (*Ammobium craspedioides*), the button wrinklewort (*Rutidosis leptorrhynchoides*), striped legless lizard (*Delma impar*), eastern lined earless dragon (T*ypanocryptis lineata pinguicolla*) and probably many other species (Edwards 1991, 1993; ACT Government 1998; NSW National Parks & Wildlife Service 2000).

In the ACT, temperate grasslands are listed as an endangered ecological community in accordance with section 21 of the *Nature Conservation Act* 1980 and an Action Plan has been prepared (ACT Government 1997). They are also nationally listed as an Environmental Protection and Biodiversity Conservation Endangered Community under the *Environmental Protection and Biodiversity Conservation Act* 1999.

7. Threats

The main threat to *S. plana*, and many other grassland and grassy woodland species, is the continued destruction of the remaining habitat due to urbanisation, agriculture, mining, roads, rail, and inappropriate tree planting. It has been estimated that 99% of the grasslands present at the time of European settlement have been lost (Kirkpatrick *et al*. 1995). In the ACT only 5% or 1,000 hectares of the original grasslands remain, and the *Austrodanthonia* grasslands are only a small fraction of that total (ACT Government 1998).

In many of these small patches of habitat *S. plana* is locally abundant, but very few of these sites are secured in reserves. Instead they are in public areas such as roadsides where weeds and further destruction are real threats. The largest site in the ACT, the Belconnen Naval Communication Station in Lawson, is at risk from future housing development (Edwards 1993).

This fragmentation means that individuals cannot recolonise new sites due to the species' limited dispersal ability. Fragmentation also reduces gene flow between populations, which may be a threat at individual sites (Clarke 2000a). Evidence collected at the York Park site in the ACT suggests that realised fecundity is only 1% of the potential (Clarke 2000a).

The replacement of native grasses by exotic pasture species such as *Phalaris* and *Paspalum*, or weeds like serrated tussock creates additional problems. Studies have shown that *S. plana* may require sites that have at least 40% coverage of *Austrodanthonia* (Dear 1997). The increase of phosphorus at sites has been shown to increase the levels of weed invasion and decrease native grass cover (Edwards 1993; O'Dwyer and Attiwill 1999). In addition to increasing the number of weeds, large increases in soil fertility can be toxic, and increase soil acidity. In turn this has a detrimental effect on the *Austrodanthonia* or the larvae deep in the soil (O'Dwyer and Attiwill 1999). Evidence suggests that integrity of a grassland site may be more important than the size of the site (NSW National Parks & Wildlife Service 2000). This question of density and of quality of *Austrodanthonia* at a site may be of vital importance in larval development, as a larva may need to feed on more than one grass tussock (Edwards 1993).

Ploughing and inappropriate grazing are also detrimental as they reduce the amount of native grasses allowing invasion of exotic species invade (ACT Government 1998; NSW National Parks & Wildlife Service 2000). However light grazing does not seem to be detrimental to the species, as some populations have thrived at sites where light grazing was practised (Edwards 1991; Clarke and O'Dwyer 1999).

Although there is no evidence to suggest that predation is a factor in the species decline, at least for larger sites, *S. plana* are preyed upon by Willie wagtails (*Rhipidura leucophrys*), starlings (*Sturnus vulgaris*), welcome swallows (*Grallina cyanoleuca*) and predatory insects such as robber flies (ACT Government 1998; NSW National Parks & Wildlife Service 2000). However at small sites with low moth density, such predation may be important. At one site up to 25% of flying males were observed to be taken by birds (Clarke 2000b).

Fire may also be a threat, although little is known about the effect of fire on the species. *S. plana,* while underground, can survive the direct effects of fire. But mobilisation of the plant's reserves for regrowth may affect the larvae (Edwards 1991, 1993; O'Dwyer and Attiwill 1999).

8. Conservation objectives

- To ensure the long term survival and evolutionary potential of the species throughout its range through a coordinated approach to appropriate management of the remaining native temperate grasslands (ACT Government 1998; NSW National Parks & Wildlife Service 2000)
- In NSW an objective is to recover the species habitat sufficiently that its listing can be downgraded from endangered to vulnerable on the schedules of the NSW

Threatened Species Conservation Act in 10 years (NSW National Parks & Wildlife Service 2000).

9. Conservation actions already initiated

- *S. plana* has been listed in the ACT as an endangered species in accordance with section 21 of the *Nature Conservation Act* 1980, which under section 23 requires that an Action Plan be written. This was published in 1998 (ACT Government 1998). A draft Action Plan has been prepared in Victoria in accordance with the *Flora and Fauna Guarantee Act* 1988 and a draft Recovery Plan has been prepared for NSW (NSW National Parks & Wildlife Service 2000).
- Federally the natural temperate grasslands of the Southern Tablelands have also been listed as a threatened community under the *Commonwealth Environmental Protection and Biodiversity Conservation Act* 1999. The native grasslands in the ACT have also been listed an endangered ecological community with an Action Plan being published in 1997 (ACT Government 1997), and as a threatened habitat under Schedule 2 of the Victorian *Flora and Fauna Guarantee Act* 1988 (ACT Government 1997).
- In the ACT the Lawson site, which currently houses the Royal Australian Naval Transmitting Station, and supports the largest *S. plana* population in the ACT and has been listed on the Register of the National Estate (ACT Government 1998).
- As some of the populations in the ACT are within nature reserves, the Canberra Nature Park Management Plan will assist in protecting those populations (ACT Government 1998). The ACT site at York Park has a management plan which focuses on the conservation of *S. plana*. Two of the five known populations in Victoria are also in conservation reserves (NSW National Parks & Wildlife Service 2000).
- Other methods of protecting the species on private and Commonwealth land include provisions of the Land (Planning and Environment) Act 1991, property management plans and reservation through the Territory Plan, and Memoranda of Understanding with Commonwealth government (ACT Government 1998).
- There is close communication between the NSW NPWS, Environment ACT, and research personnel with regard to action planning, research and survey. There is also a coordinated approach to grasslands protection through the Joint Regional Biodiversity Survey of Grassy Ecosystems Project (ACT Government 1998; NSW National Parks & Wildlife Service 2000).
- Surveys have been carried out in much of NSW and the ACT but more is required in the southwest slopes and the Southern Tablelands of NSW and much of Victoria.
- There are many gaps in our current knowledge of the biology and habitat requirements of *S. plana*.
- In the past many of the sites have been subject to pressures from mowing and grazing, yet the populations still persist. With this in mind this regime is being maintained where practical (Edwards 1991, 1993; ACT Government 1998).
- Sites believed to be of high conservation value in the ACT are at Majura Field Firing range, Belconnen Naval Station (Lawson), '*Woden*' property in the Jerrabomberra Valley, and Mulanggary Grassland Reserve in Gungahlin and are being managed to ensure the survival of the populations. Management strategies have to be developed for the other ACT sites (ACT Government 1998).

10. Conservation actions required

Research

- Investigation of the population dynamics, life history, and habitat requirements of *S. plana* (Edwards 1991; O'Dwyer 1999; NSW National Parks & Wildlife Service 2000).
- Surveys to delineate the current distribution of *S. plana* and how much occurs on private lands (ACT Government 1998).
- Investigation of the effects of fire on *S. plana* populations and habitat (NSW National Parks & Wildlife Service 2000).
- Investigation into the impact of grazing and drought (NSW National Parks & Wildlife Service 2000).

Management

- A long term monitoring program is required so as to ensure the management actions being undertaken are appropriate (ACT Government 1998).

- There are currently no conservation reserves in NSW that contain *S. plana* populations, although there are many sites which are suitable for reservation. Reserves need to be established across NSW so as to maintain genetic diversity (NSW National Parks & Wildlife Service 2000).
- Many sites in NSW are located on private land, so other cooperative measures need to be implemented, such as voluntary conservation agreements, Landcare programs, and threatened species property management plans (Venn 1994; ACT Government 1998; NSW National Parks & Wildlife Service 2000).
- A coordinated approach in the form of a recovery team is required which will bring together the activities of all states and organisations involved in the conservation of *S. plana* habitats (NSW National Parks & Wildlife Service 2000). A Recovery Team has recently been established in NSW.
- An education program is also required so as to highlight the need to protect the habitat of *S. plana* and other grasslands species, and what the threats to this habitat are. Information can be disseminated in the form of information packs and management guidelines through conservation groups, schools, landholders and the general public (NSW National Parks & Wildlife Service 2000).

11. Relevant Experts/Data Providers

Ted Edwards – CSIRO Entomology, Canberra
Geoff Clarke – CSIRO Entomology, Canberra
Cheryl O'Dwyer – University of Melbourne, Dookie

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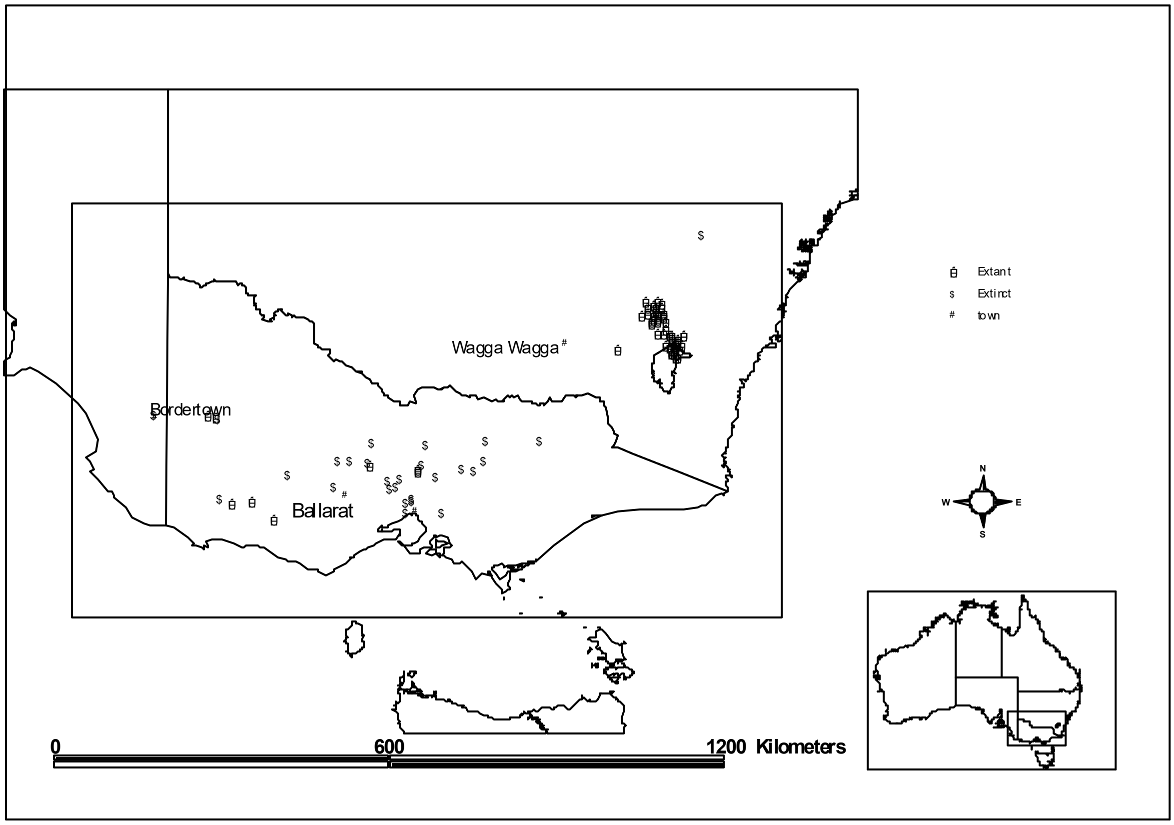
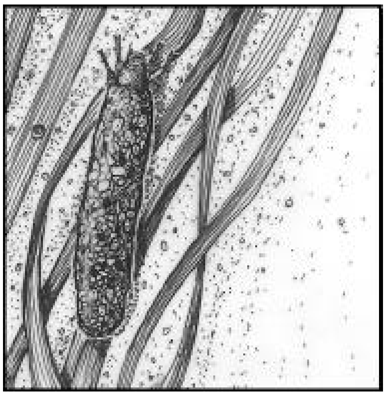


Distribution of *Synemon plana* (Source: G. Clarke personal communication)

Taskiria otwayensis Caddis Fly



Phylum: Arthropoda **Class:** Insecta **Order:** Trichoptera
Family: Kokiriidae
Scientific name: *Taskiria otwayensis*
Common names: Caddis fly

1. Taxonomic status (including species and subgroups)

Taskiria otwayensis Neboiss, 1984.

The family Kokiriidae is found only in Australia and the Neotropical Region and comprises eight species grouped into six genera. Of these, five species grouped into three genera are found in Australia (Neboiss 1992; Mandaville 1999). Before the discovery of *T. otwayensis* in Victoria in 1984, the genus was only known from Tasmania (Neboiss 1984).

2. Species survival status

The species has been identified as endangered in Victoria but is not listed under the *Flora and Fauna Guarantee Act* (Butcher and Doeg 1995).

Taskiria otwayensis is not listed on the 2000 *IUCN Red List of Threatened Species*. Assessment of the IUCN categorisation for the species using the *Ramas RedList* software program (Akçakaya and Ferson 1999) indicated that it may be Data Deficient.

3. Distribution

The species is only known from three sites in the Otway Ranges in Victoria, the Gellibrand River and tributaries (Neboiss 1984, 1992; A. Wells personal communication; J. Dean personal communication).

4. Habitat

First found at Charley's Creek, 5 km south of Gellibrand, the species has been collected near small streams which flow through both eucalypt forest and pine plantation, where the stream bed is sandy, and the water is still to moderately fast flowing (Neboiss 1984). The predominant eucalypt species in the area are *E. obliqua*, *E. cypellocarpa*, *E. viminalis*, *E. globulus*, *E. baxteri*, and *E. radiata*, which are commercially important (Brinkman and Farrell 1990). One of the original sites is a stream flowing through a pine plantation that was at the time of the discovery, heavily silted and overgrown with blackberries (Neboiss 1984). At the pine forest site, an adult was collected by light trap. This may not have emerged from the stream at the collection site, but may have flown down from native forest higher in the catchment (J. Dean personal communication).

5. Biological overview

Adult *T. otwayensis* are stocky, medium-sized insects with a wing span of 11 mm and are generally dark coloured, with thick antennae as long as the forewing, compound eyes, slender legs and well-developed thoracic segments. The wings are covered with a dense layer of brown hairs (Neboiss 1984, 1992; Mandaville 1999). The two pairs of wings are equal-sized and carried in an inverted 'V' at rest. The mouthparts are developed to uptake liquids such as water and nectar (Neboiss 1991). The female of *T. otwayensis* has yet to be discovered (Neboiss

1984). For a more detailed description of *T. otwayensis* see Neboiss (1984).

Eggs of caddisflies are generally laid in or near water, generally hatching within 3–25 days (Neboiss 1991). Caddisflies are readily recognisable from the larvae, which look similar to caterpillars, but are generally fully aquatic, and many are protected in cases made of debris or pebbles (Mandaville 1999)). The larvae of *T. otwayensis* have recently been found to be tube case makers (J. Dean personal communication). The larvae use silk to bind together pebbles and detritus to form their cases or for anchor lines to stop them from drifting (Neboiss 1991). Case building is thought to be a respiratory adaptation to warmer streams with a lower dissolved oxygen level (Neboiss 1991; Mandaville 1999). Feeding habits of tube-making species range from shredding, chewing, grazing, scraping and piercing, with some feeding opportunistically on decomposing vascular plants and algae (Neboiss 1991). The larvae of *T. otwayensis* are thought to be predacious (J. Dean personal communication).

Little is known of the life cycle of *T. otwayensis*. Caddisfly species life cycles vary from a few weeks to several years. Caddisflies remain as larvae for 10 months to two years with the aerial adult stage only living for a few weeks or months. In cool temperate climates such as the Otway Ranges, life cycles may be annual or biennial.

Adult caddisflies are mainly nocturnal, resting during the day in riparian vegetation (Mandaville 1999).

Nothing is known about the population dynamics of *T. otwayensis*. As only a few specimens have been found, it may be rare.

6. Significance

Caddisflies are found in habitats ranging from permanent lakes, temporary ponds and streams to intertidal areas (Mandaville 1999; A. Wells personal communication). Although found in many different habitats, as many as 25% of the known species in Australia are known only from a few specimens, such as *T. otwayensis*.

Larval caddisflies form an important link in the food chain of the aquatic ecosystem, feeding mainly on plant matter and, in turn, being eaten by the larvae of dragonflies, mayflies, beetles, midges, trout, birds, bats, reptiles, frogs and other caddisfly larvae (Neboiss 1991). They also are important in assessments of water quality as indicator species, as their presence in water bodies reflects the surrounding land use, and the natural characteristics of the surrounding ecosystem (Mandaville 1999).

The Otway Ranges is important for its intrinsic values, providing habitat for many interesting endemic invertebrates. It is also significant that several species that might be expected to occur in the Ranges are absent, emphasising the biogeographic significance of the Otways. Endemic species within the forest management area of the Otways include *Victophanta compacta* (large native snail), *Arachnocampa* spp. (glow worms), *Eusthenia nothofagi* (Otway stonefly) and *Taskiria otwayensis* (Brinkman and Farrell 1990).

7. Threats

Little is known about the threats to *T. otwayensis* (A. Wells personal communication).

One of the streams where *T. otwayensis* was found passes through a pine plantation (A. Wells personal communication). The State Forests of the Otways cover an estimated 93,360 hectares, 60% of the land, which is within the Otways Forest Management Area. Forestry operations are regulated by a Forestry Code of Conduct for Timber Production and Roading Prescriptions, particularly in regard to aquatic habitats, and the Flora and Fauna Guarantee Act (Brinkman and Farrell 1990; Department of Natural Resources and Environment 1992). The effects of forestry on aquatic invertebrates remain largely unknown (J. Dean personal communication).

Brinkman & Farrell (1990) indicate both the Gellibrand River and Charley's Creek are of moderate to high environmental value, based on the fisheries value of forest streams in the Otway forests. Any significant land use changes may have a detrimental impact on this standing.

As the larvae are fully aquatic, the species is very sensitive to pollutants and changes in the quality of the water such as leaching from forestry land or land under other uses (Neboiss 1991).

8. Conservation objectives

To determine the distribution and conservation status of *Taskiria otwayensis* and to determine the ecological requirements so as to help maintain the current populations.

9. Conservation actions already initiated

- Many National Parks and reserves are situated within the Otways Forestry Management Area. Figures from a 1990 report indicate that 52,770ha were retained as natural areas free from logging pressure (Brinkman and Farrell 1990). A revision of the Otways Forest Management Plan has been proposed which would be written in conjunction with available action plans produced for species under the *Fauna and Flora Guarantee Act* 1988 (G. Dyne personal communication). Some of the sites are found in National Parks and should ensure some protection for the species (J. Dean personal communication).
- All three sites are in different catchments, which may further protect the population from possible water pollution or other disturbances to water and site quality (J. Dean personal comments).

10. Conservation actions required

- Further surveys are required to ascertain the full distribution of the species before other actions are taken (J. Dean personal comments).

11. Relevant Experts/Data Providers

Alice Wells – Environment Australia, Canberra
Arturs Neboiss – Museum of Victoria, Melbourne
John Dean – Victorian EPA, Melbourne
Ken Walker – Museum of Victoria, Melbourne
Geoff Dyne – Environment Australia, Canberra

12. References

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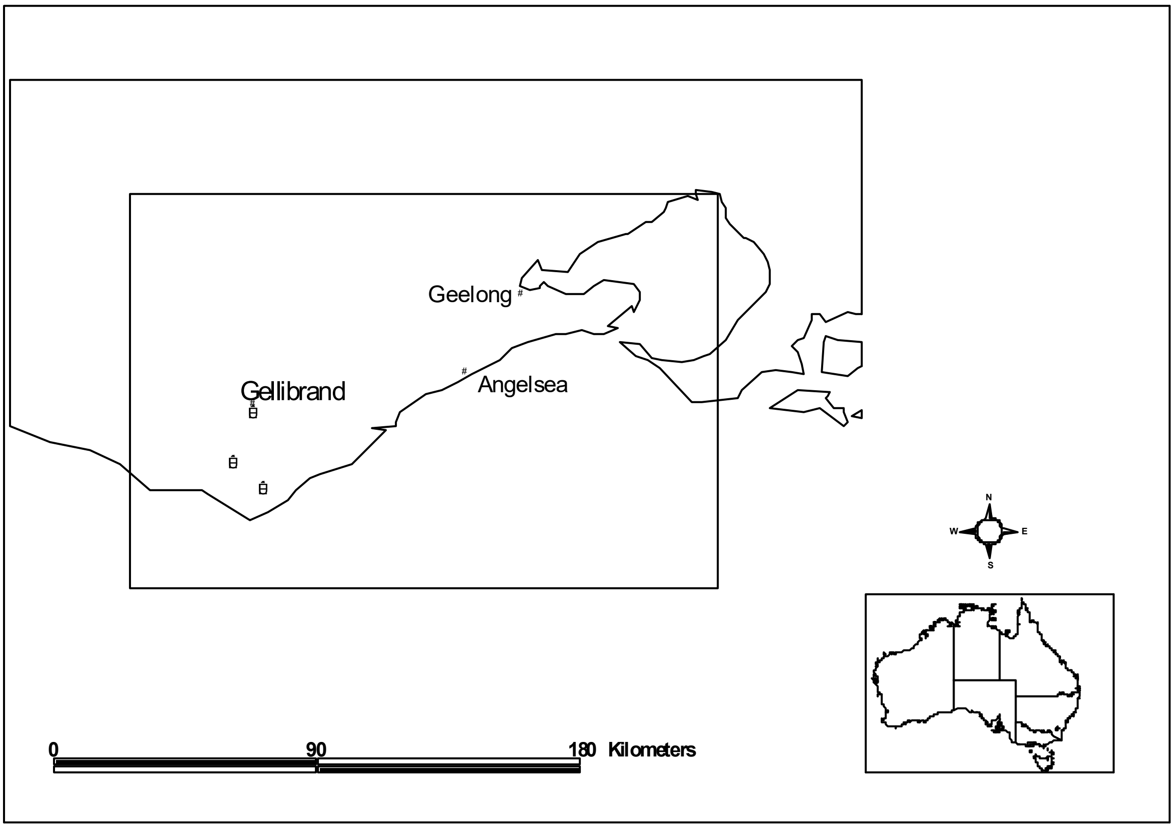
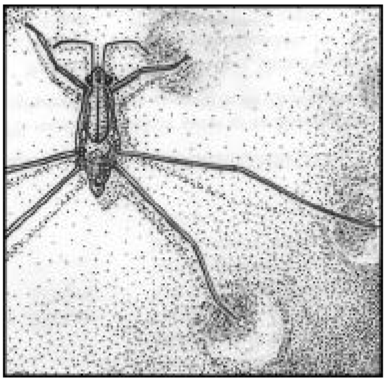


Distribution of *Taskiria otwayensis* (Source: Neboiss 1984)

Tenogogonus australiensis	**Water Strider**



Phylum: Arthropoda **Class:** Insecta **Order:** Hemiptera
Family: Gerridae
Scientific name: *Tenogogonus australiensis*
Common names: water striders / pond skaters

1. Taxonomic status (including species and subgroups)

Tenogogonus australiensis Andersen and Weir, 1997.

Gerridae are cosmopolitan. Five genera are found in Australia, comprising 12 species, 10 of which occur in Queensland and the Northern Territory (Spence and Andersen 1994; Hawking and Smith 1997; Andersen and Weir 1997).

2. Species survival status

Currently not listed under any State or Commonwealth legislation.

Tenogogonus australiensis is not listed on the 2000 *IUCN Red List of Threatened Species*. Assessment of the IUCN categorisation for the species using the *Ramas RedList* software program (Akçakaya and Ferson 1999) indicated that it may be Data Deficient.

3. Distribution

Tenogogonus australiensis is found in north Queensland in scattered populations between Townsville and Cape Tribulation (Andersen and Weir 1997).

4. Habitat

Tenogogonus australiensis is found in streams with a closed rainforest canopy, which restricts sunlight reaching the stream (Andersen and Weir 1997).

5. Biological overview

Tenogogonus australiensis is approximately 7–9 mm in length, with long brown antennae (Andersen and Weir 1997). The most obvious characteristics of a water strider are the long slender reddish brown legs that allow the insect to spread its weight over the surface of the water (Andersen and Weir 1997). Generally the body is dark, with the head being a yellow/reddish brown colouration with black markings and the forewing being brown. Wingless individuals have a row of spots on the topside of the abdomen and a longitudinal dark band on the ventral surface of the abdomen (Hawking and Smith 1997; Andersen and Weir 1997). Like all Hemiptera, *T. australiensis* possesses piercing and sucking mouthparts (Spence and Andersen 1994). For a more detailed description of *T. australiensis* see Andersen and Weir (1997).

Although many Gerridae are winged, populations may also include individuals that are wingless, particularly in habitats that are stable, such as the closed forest streams that *T. australiensis* inhabits. This is thought to be a genetic and environmental adaptation to protect reproductive potential and prevent losses due to dispersal (Spence and Andersen 1994; Andersen and Weir 1997).

Studies undertaken indicate that *T. australiensis* may breed from July to December, although in warmer climates they may breed all year (Andersen and Weir 1997). Species such as *T. australiensis* may have a shorter reproductive life, and produce fewer eggs than many other species that are found in more variable habitats, as there is less environmental fluctuation that may affect the population (Spence and Andersen 1994; Andersen and Weir 1997). Very little is known about the reproductive biology of *T. australiensis.*

Water striders are opportunistic predators, benefiting from the water tension by catching any insects that may trapped by it (Hawking and Smith 1997; Andersen and Weir 1997). Although little is known about the behaviour of *T. australiensis*, work has been undertaken into communication in other Gerridae species in Australia and overseas. It has been discovered that many species communicate by use of surface waves, which are produced by the bug by particular movements of the legs, to indicate to others their readiness to mate, defence of females or oviposition sites, or of danger (Wilcox 1972).

The distribution of *T. australiensis* is widespread but sporadic and it may be locally abundant in some areas (T. Weir, personal communication).

6. Significance

T. australiensis is believed to be one of the most specialised of the Australian species of water striders, as it is only found in heavily shaded streams in northern Queensland, which makes it susceptible to vegetation changes (Andersen and Weir 1997).

Water striders are opportunistic predators and may be important in maintaining levels of pest species, notably mosquitoes. In turn they provide food for other aquatic/semiaquatic organisms as well as birds (Spence and Andersen 1994).

7. Threats

Water striders, particularly those that lack wings, depend on the persistence of suitable water bodies because of their poor dispersal ability. Thus, the disappearance of these streams, or a decline in their quality, would result in a reduction in the population of many gerrid species (Andersen and Weir 1997; T. Weir personal communication).

Another related threat is changes to the vegetation surrounding the streams. As *T. australiensis* is adapted to shaded aquatic habitats, opening up the tree cover through clearing would be detrimental (Andersen and Weir 1997).

8. Conservation objectives

Maintain and increase the number of populations and suitable sites

9. Conservation actions already initiated

Surveys have been undertaken into the distribution of the species.

10. Conservation actions required

Research

- Further surveys need to be undertaken to establish the full range of the species and its habitat.
- Investigation into the population biology, ecological requirements, and life history would be advantageous.
- Identification and/or development of vegetation mapping from which suitably forested streams can be identified.

Management

- The closed rainforests that the species depend on need to be protected against disruption or clearance.

11. Relevant Experts/Data Providers

Tom Weir – CSIRO Entomology, Canberra

12. References

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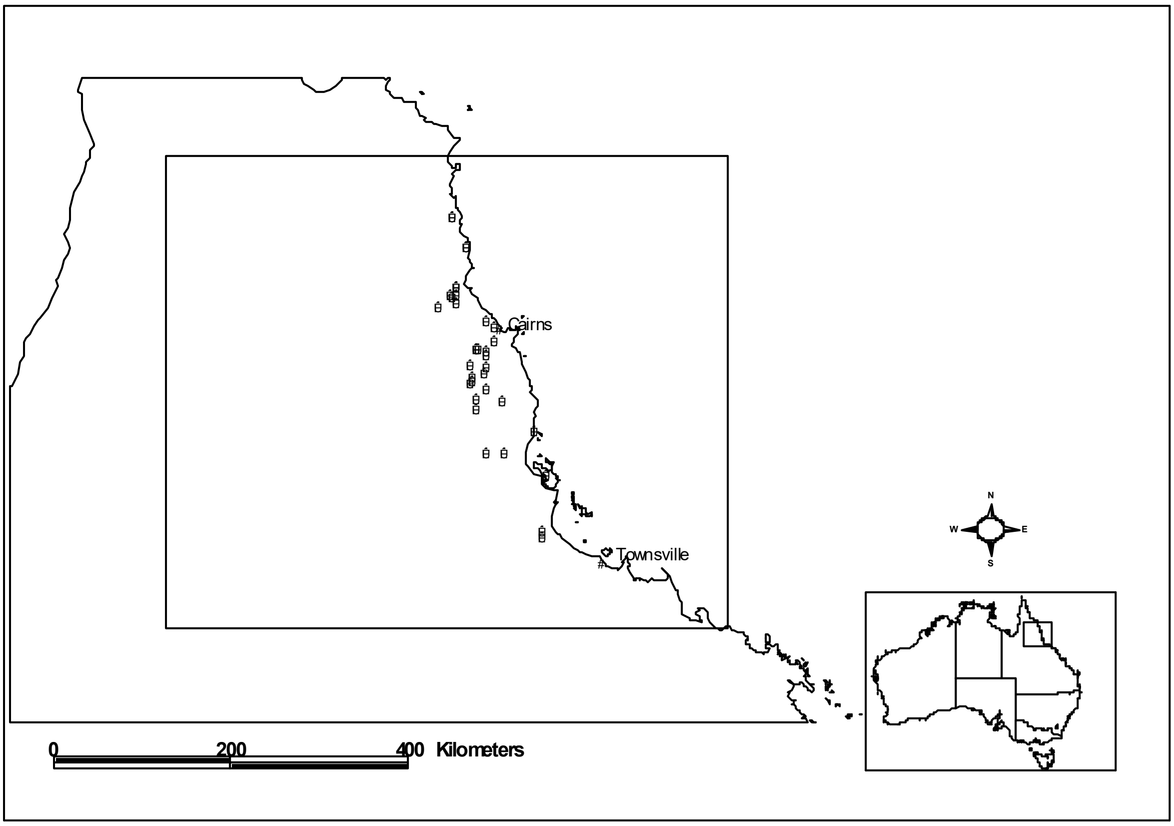
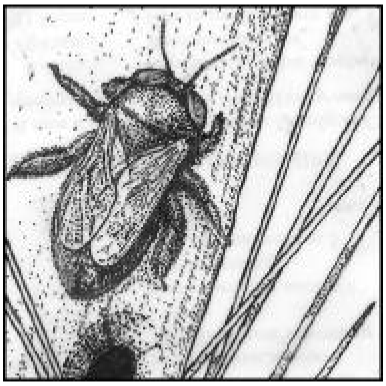


Distribution of *Tenagogonus australiensis* (Source: T. Weir personal communication)

Xylocopa aeratus Metallic Green Carpenter Bee



Phylum: Arthropoda **Class:** Insecta **Order:** Hymenoptera
Family: Anthophoridae
Scientific name: *Xylocopa aeratus*
Common names: Metallic Green Carpenter Bee

1. Taxonomic status (including species and subgroups)

Xylocopa (*Lestis*) *aeratus* Smith, 1851.

'*aeratus*': means 'covered with copper or bronze', referring to the colour of the species.

The endemic genus *Xylocopa* consists of two subgenera, *Koptortosoma* and *Lestis*, with six and two species respectively.

2. Species survival status

Currently not listed under any State or Commonwealth legislation.

Xylocopa aeratus is not listed on the 2000 *IUCN Red List of Threatened Species*. Assessment of the IUCN categorisation for the species using the *Ramas RedList* software program (Akçakaya and Ferson 1999) indicated that it may be Data Deficient.

3. Distribution

The species is widely distributed from Northern New South Wales, along the Great Dividing Range, to Kangaroo Island, South Australia. It is no longer found on mainland South Australia (all records from 1890's) or Victoria (since the 1950's), although records show that it was once common in these areas (Houston 1992; Cardale 1993; Leys 2000a).

4. Habitat

Xylocopa aeratus is found in open forest with a shrub layer. The preferred nesting site appears to be the spikes of large *Xanthorrhoea* species, although it has also been observed nesting in decayed trunks of *Melaleuca*, *Casuarina* and *Banksia* (Rayment 1953; Houston 1992; Steen and Schwarz 2000; Leys 2000a).

5. Biological overview

The metallic green carpenter bee is highly distinctive due to its large size (females 15–20 mm, while males are smaller at 13–18 mm) and its brilliant blue green colour (Rayment 1935; Houston 1992) Wings are large and black with a violet sheen; antennae and legs are black. Males have yellow face markings, enlarged eyes, and three bands of black hairs on their otherwise coppery yellow haired thorax. For more detailed descriptions of *X. aeratus* see Rayment (1935) and Leys (2000).

New nests are founded in spring, in dry flower stalks of large grass tree species, which flower profusely after a fire, or in dead, dry trunks and branches of *Casuarina*, *Leptospermum, Melaleuca* and *Banksia* species (Houston 1992; Steen and Schwarz 2000). Entrance holes are 8–10 mm in diameter. Nests can have one to several tunnels or galleries. These tunnels are all dug out by the bees, but not necessarily by a single individual, because extensive nest re-use occurs over the years (see below). Barrel shaped brood cells are constructed within the tunnels, which are provisioned with a dough-like substance consisting of pollen and nectar.

Pollen and nectar are obtained from a variety of native plant species, including *Hibbertia*, *Eucalyptus*, *Leptospermum*, and *Pultenea*. Unlike many other native bees, carpenter bees are so-called buzz pollinators, which means that they are able to shake flowers to obtain the pollen from the porous dehiscent anthers (Hogendoorn *et al*. 2000). Several native species of plants (e.g. *Hibbertia*, *Leucopogon*, *Darwinia*, *Pultenea* and *Gompholobium* species) depend on buzz pollination for their seed set, and it seems likely that carpenter bees play an important role in the ecosystem as specialised pollinators of these and other native plant species (Gross and Mackay 1998).

The pollen and nectar dough is kneaded into a tetrahedral shaped loaf, upon which a large (12 mm long) egg is laid. The cell is then closed with wood scrapings from the sides of the tunnel mixed with secretions of glandular origin, which probably have a fungicidal function (Gerling *et al*. 1989). Room permitting, additional cells can be made in the same tunnel after the first cell. However, females may also use another tunnel in the same nest, if available. Nests may contain up to 23 cells, with an average of about eight (Z. Steen personal communication).

The brood remains in the cell until eclosion as an adult (Rayment 1935), which is approximately two months after egg laying (Houston 1992; Steen and Schwarz 2000). After eclosion, young adults are fed nectar by the mother, who uses mouth to mouth feeding ('trophallaxis') (Houston 1992). Although the young adults help with cleaning the nest and digging new tunnels (Z. Steen personal communication), they do not become reproductively active until the next spring (Steen and Schwarz 2000). Young males and females hibernate communally in the maternal nest, from which the mother disappears before, during or after winter.

Mating takes place in spring. Two mating strategies have been identified (Leys 2000b), the use of each being governed by the probability of finding a mate (Leys 2000a). When the density of unmated females is relatively high, males actively patrol a number of nests. When the density of receptive females is lower, either later in the season or in areas where nest density is low, males make territories in prominent places such as hill-tops, rocky outcrops and in the canopy of high trees (Leys and Hogendoorn unpublished).

After winter, most females disperse and nests become solitary, but some females may cooperate in re-use of the nest (Steen and Schwarz 2000). In these cases only one female is the reproductive (Z. Steen personal communication), and she does the majority of the foraging, while the non-egg laying female guards the nest. Steen's data (2000) indicate that females join other nests before or during brood rearing. By remaining as a guard, the non-reproductive female has a chance to inherit the nest and rear some of her own brood, and possibly also has some benefits from increasing the reproductive output of the dominant female (sometimes her sister).

Although *X. aeratus* is found over a wide region, it is only patchily abundant. The species is active throughout the year when temperatures reach 20° or higher (Rayment 1935; Houston 1992; Z. Steen personal communication).

6. Significance

Bees are vital to the ongoing health of the environment as they are the primary pollinators of many species of plants in nearly every type of habitat. Many species have no doubt coevolved with our native flowering plants and so have evolved specialised methods of obtaining nectar and thereby pollinating of flowers (Buchanan 1983). It is believed that *X. aeratus* is an important pollinator of many native species (see above).

7. Threats

The greatest threat to native bees generally is the destruction of habitat and loss of nesting substrate (Schwarz and Hogendoorn 1999; Leys 2000a).

Inappropriate fire regimes and wildfire are also a threat, compounding the loss of habitat and leading to the extinction of the species in South Australia and Victoria (Leys 2000a). If fires are too infrequent they will be too hot and will destroy branches instead of softening the tissues so that the bees can hollow them out for burrows. Too frequent fires may not be hot enough and result in too many saplings being destroyed, thus reducing future nesting sites (Schwarz and Hogendoorn 1999).

An additional problem may be competition for resources with the introduced European honey bee (*Apis mellifera*). Based on the results of studies on *Melastoma affine* (Melastomataceae) the honeybee is believed to be a poor pollinator of Australian species of flowering plants compared to the native species, which are better adapted. In addition, they begin foraging later in the day than native species resulting in the pollen placed by the native species being disrupted and removed by the honeybees, reducing the amount of fruit and subsequently seed set that season (Gross and Mackay 1998; Schwarz and Hogendoorn 1999; Leys 2000a). This reduction in fruit and seed produced over time will allow the habitat to be modified dramatically as other plant species, including environmental weeds, take over. If the habitat were to change and a species such as *M. affine* were to disappear, it was estimated that at least eight other bee species, one bird and nine invertebrate herbivores may be affected (Gross and Mackay 1998).

8. Conservation objectives

To protect suitable habitat within the known range of the species and to maintain the known extant populations at the current level or greater.

9. Conservation actions already initiated

- Some research work has been undertaken into the biology, behaviour and nesting requirements of *Xylocopa aeratus* (Steen and Schwarz 2000; Leys 2000a).
- Some of the sites where the species is known are within National Parks, particularly in the Sydney area and on Kangaroo Island.

10. Conservation actions required

Research

- Investigation of mating behaviour, (particularly that of males), and of the social structure of the nest.
- Investigation of the impact of fire on the habitat of *X. aeratus* with a focus on the fire intensities required for the predominant species used for nesting.
- Investigation into the past extinction rate and the reasons for the demise of *X. aeratus* in Victoria and South Australia

Management

- More reserves need to be gazetted in southeastern Victoria and northeastern NSW, so as the species habitat is protected across its range.
- Implementation of mosaic-pattern burning regimes in habitat within the bees' range so as to ensure that parts of the habitat are always available for the bees.
- Management of feral and managed honeybee colonies may be required in areas inhabited by *X. aeratus* in order to reduce resource competition and pollination disruption

11. Relevant Experts/Data Providers

Katya Hogendoorn – Flinders University, Adelaide
Zeta Steen – Flinders University, Adelaide
Michael Schwarz – Flinders University, Adelaide
Allan Spessa – Environment Australia, Canberra
Jo Cardale – CSIRO Entomology, Canberra
Michael Bately – Macquarie University, Sydney

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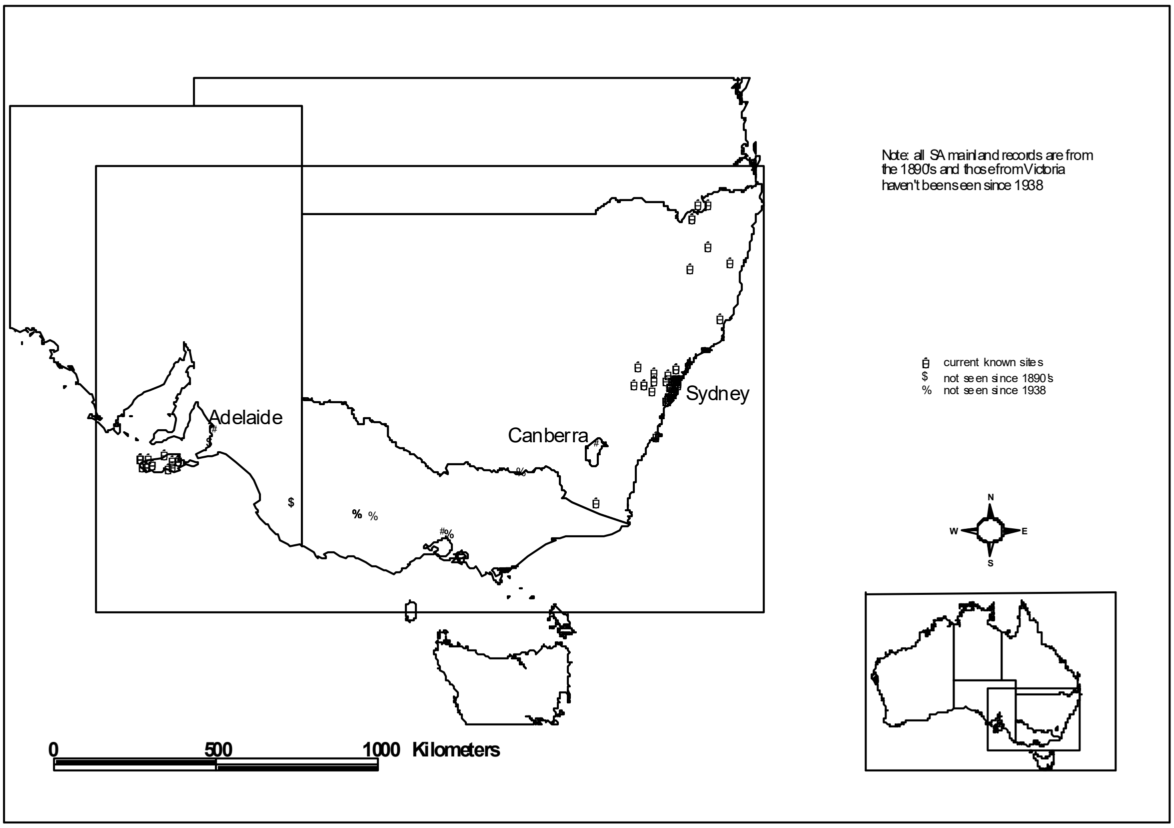

Distribution of *Xylocopa aeratus* (Source: Leys 2000a)

5. Appendix 1: Invertebrate species (excluding butterflies) currently listed as threatened under Commonwealth and State legislation

Group	Species	Common Name	Listed	Category
Annelida	*Diporochaeta pedderensis*	Lake Pedder Earthworm	Tas	Endangered
	Megascolides australis	Giant Gippsland Earthworm	Commwth, Vic	Vulnerable, Threatened
Arachnida	*Acercella poorginup*	Poorginup swamp Water-Mite	WA	Protected Fauna
	Aganippe castellum		WA	Rare/Likely to become extinct
	Austrarchaea mainae	Archaeid Spider	WA	Rare/Likely to become extinct
	Bamazomus sp. nov. (WAM#95/748)	Western cape Range Bamazomus	WA	Rare/Likely to become extinct
	Draculoides bramstokeri	Barrow Island Draculoides	WA	Rare/Likely to become extinct
	Draculoides sp. nov. (WAM#96/1151)	Western Cape Range Draculoides	WA	Rare/Likely to become extinct
	Hadronyche pulvinator		Tas	Extinct
	Hyella sp. nov. (BES 1154.2525.2546.2554)	Camerons cave Pseudoscorpion	WA	Rare/Likely to become extinct
	Idiosoma nigrum	Shield-backed Trapdoor spider	WA	Rare/Likely to become extinct
	Kwonkan eboracum	Yorkrakine Trapdoor Spider	WA	Rare/Likely to become extinct
	Moggridgea sp. (BY Main 1990/24,25)	Stirling Range Trapdoor Spider	WA	Rare/Likely to become extinct
	Plesiothele fentoni	Lake Fenton Trapdoor Spider	Tas	Extinct
	Pseudohydryphantes doegi	Doeg's water-Mite	WA	Protected Fauna
	Tartarus mullamullangensis	Mullamullalang cave spider	WA	Rare/Likely to become extinct
	Teyl sp. (BY Main 1953/2683, 1984/13)		WA	Rare/Likely to become extinct
	Troglodiplura lowryi	Nullarbor Cave Trapdoor spider	WA	Rare/Likely to become extinct
Collembola	*Australomoturus sp. nov.* (SAM#I22621)	Guildford Springtail	WA	Rare/Likely to become extinct
Crustacea	*Abebaioscia troglodytes*	Pannikin Plains cave Isopod	WA	Rare/Likely to become extinct
	Astacopsis gouldi	Giant Tasmanian Freshwater crayfish	Commwth, Tas	Vulnerable, Vulnerable
	Austrogammarus australis	Dandenong Freshwater Amphipod	Vic	Threatened
	Austrogammarus haasei		Vic	Threatened
	Bogidomma australis	Barrow Island Bogidomma	WA	Rare/Likely to become extinct
	Engaeus mallacoota	Mallacoota Burrowing Crayfish	Vic	Threatened
	Engaeus orramakunna	Mt Arthur Burrowing Crayfish	Tas	Vulnerable
	Engaeus phyllocercus	Narracan Burrowing Crayfish	Vic	Threatened
	Engaeus spinicaudatus	Scottsdale Burrowing Crayfish	Tas	Vulnerable
	Engaeus sternalis	Warragul Burrowing Crayfish	Vic	Threatened

Group	Species	Common Name	Listed	Category
	Engaeus yabbimunna	Burnie Burrowing Crayfish	Tas	Vulnerable
	Euastacus armatus	Murray River Crayfish	ACT	Vulnerable
	Euastacus diversus	Orbost Crayfish	Vic	Threatened
	Lasionectes exleyi	Cape Range Lasionectes	Commwth, WA	Vulnerable, Rare/likely to become extinct
	Liagoceradocus branchialis	Cape Range Liagoceradocus	WA	Rare/Likely to become extinct
	Liagoceradocus subthalassicus	Barrow Island Liagoceradocus	WA	Rare/Likely to become extinct
	Nedsia fragilis		WA	Rare/Likely to become extinct
	Nedsia humphreysi		WA	Rare/Likely to become extinct
	Nedsia hurlberti		WA	Rare/Likely to become extinct
	Nedsia macrosculptilis		WA	Rare/Likely to become extinct
	Nedsia sculptilis		WA	Rare/Likely to become extinct
	Nedsia straskraba		WA	Rare/Likely to become extinct
	Nedsia urifimbriata		WA	Rare/Likely to become extinct
	Stygiocaris lancifera	Lance-Beaked Cave Shrimp	WA	Rare/Likely to become extinct
	Cragonyctid sp. (WAM#642-97)	Crystal Cave Cragonyctid	WA	Rare/Likely to become extinct
Diplopoda	*Speleostrophus nesiotes*	Barrow Island Millipede	WA	Rare/Likely to become extinct
	Stygiochiropus isolatus		WA	Rare/Likely to become extinct
	Stygiochiropus peculiaris		WA	Rare/Likely to become extinct
	Stygiochiropus sympatricus		WA	Rare/Likely to become extinct
Mollusca	*Anoglypta launcestonensis*	Granulated Tasmanian Snail	Tas	Vulnerable
	Austroassiminea letha	Cape Leewin Freshwater snail	WA	Rare/Likely to become extinct
	Beddomeia krybetes		Tas	Vulnerable
	Beddomeia tumida	Great lake hydrobiid snail	Tas	Vulnerable
	Meridolum corneovirens		NSW	Endangered
	Miselaoma weldii	Stanley Snail	Tas	Vulnerable
	Placostylus bivaricosus		NSW	Endangered
	Thersites mitchellae		NSW	Endangered
	Rhytidid species (WAM#2295-69)	Stirling Range Rhytidid Snail	WA	Rare/Likely to become extinct
Onychophora	*Tasmanipatus anophthalmus*	Blind velvet worm	Tas	Endangered

Group		Species	Common Name	Listed	Category
Platyhelminthes		*Dasyurotaenia robusta*		Tas	Vulnerable
Insecta	Blattodea	*Nocticola flabella*	Cape Range Blind Cockroach	WA	Protected Fauna
	Coleoptera	*All species of Buprestidae*		WA	Protected Fauna
		Castiarina insculpta	Miena jewel beetle	Tas	Extinct
		Goedetrechus mendumae	Blind Cave Beetle	Tas	Vulnerable
		Hoplogonus bornemisszai	Bornemisszas Stag Beetle	Tas	Endangered
		Hoplogonus simsoni	Simpson's stag beetle	Tas	Vulnerable
		Hoplogonus vanderschoori	Vanderschoors Stag beetle	Tas	Vulnerable
		Lissotes latidens	Broad toothed stag beetle	Tas	Endangered
		Lissotes menalcas	Mt. Mangana stag beetle	Tas	Vulnerable
		Stigmodera insculpta	Miena Jewel Beetle	Tas	Extinct
		Tasmanotrechus cockerilli	Cockerills Cave Beetle	Tas	Vulnerable
	Hymenoptera	*All species of Nothomyrmecia*		WA	Protected Fauna
		Hesperocolletes douglasi	Short tongued native bee	WA	Extinct
		Leioproctus contraries		WA	Rare/Likely to become extinct
		Leioproctus douglasiellus		WA	Rare/Likely to become extinct
		Myrmecia sp. 17	Bull ant	Vic	Threatened
		Neopasiphe simplicior		WA	Rare/Likely to become extinct
	Lepidoptera	*Amelora acontistica*	Chevron Looper Moth	Tas	Vulnerable
		Chrysolarentia decisaria	Tunbridge Looper Moth	Tas	Extinct
		Dasybela achroa	Saltmarsh Looper Moth	Tas	Vulnerable
		Dirce aesiodora	Pencil Pine Moth	Tas	Vulnerable
		Synemon gratiosa	Graceful Sun Moth	WA	Rare/Likely to become extinct
		Synemon nais	Sun Moth	Vic	Threatened
		Synemon plana	Golden Sun Moth	ACT, NSW, Vic	Endangered, Endangered, Threatened
	Odonata	*Hemiphebia mirabilis*	Hemiphlebia damselfly	Vic	Threatened

Group		Species	Common Name	Listed	Category
		Petalura gigantea	Giant Dragonfly	NSW	Endangered
	Orthoptera	*Dryococelus australis*	Lord Howe Island Phasmid	NSW	Endangered
		Perunga ochracea	Perunga grasshopper	ACT	Vulnerable
		Schayera baiulus	Schayers Grasshopper	Tas	Endangered
		Throscodectes xederoides		WA	Rare/Likely to become extinct
	Plectoptera	*Riekoperla darlingtoni*	Mt Donna Buang Wingless Stonefly	Vic	Threatened
		Riekoperla intermedia		Vic	Threatened
		Riekoperla isosceles		Vic	Threatened
		Thaumatoperla alpina		Vic	Threatened
		Thaumatoperla flaveola	Mt Stirling Stonefly	Vic	Threatened
	Trichoptera	*Archaeophylax canarus*		Vic	Threatened
		Costora iena	Great Lake Caddisfly 1	Tas	Extinct
		Diplectrona castanea		Tas	Extinct
		Taskiria maccubbini	McCubbins caddisfly	Tas	Endangered
		Taskirophyche lacustris	Lake Pedder Caddisfly	Tas	Endangered

6. Appendix 2: Invertebrate species currently listed as threatened on the *2000 IUCN Red List of Threatened Species*

Phylum/Class	Order	Family	Species	Common Name	Category	Criteria
Annelida						
Oligochaeta	Haplotaxida	Megascolecidae	*Megascolides australis*	Giant Gippsland Earthworm	Vulnerable	D2
Arthropoda						
Crustacea	Amphipoda	Paramelitidae	*Austrogammarus australis*		Extinct	
	Anaspidacea	Anaspididae	*Allanaspides helonomus*	Tasmanian Anaspid Crustacean	Vulnerable	D2
			Allanaspides hickmani	Tasmanian Anaspid Crustacean	Vulnerable	D2
			Paranaspides lacustris	Tasmanian Anaspid Crustacean	Vulnerable	D2
		Psammaspidae	*Eucrenonaspides oinotheke*		Vulnerable	D2
	Anomopoda	Chydoridae	*Rhynchochydorus australiensis*	Water Flea	Vulnerable	D2
		Daphniidae	*Daphnia jollyi*	Water Flea	Vulnerable	D2
			Daphnia nivalis	Water Flea	Vulnerable	D2
			Daphnia occidentalis	Water Flea	Vulnerable	D2
	Anostraca	Branchipodidae	*Parartemia contracta*	Brine Shrimp	Vulnerable	D2
		Thamnocephalidae	*Branchinella apophysata*	Fairy Shrimp	Vulnerable	D2
			Branchinella basispina	Fairy Shrimp	Vulnerable	D2
			Branchinella denticulata	Fairy Shrimp	Vulnerable	D2
			Branchinella simplex	Brine Shrimp	Vulnerable	D2
			Branchinella wellardi	Fairy Shrimp	Vulnerable	D2
	Calanoida	Centropagidae	*Boeckella bispinosa*		Vulnerable	D2
			Boeckella geniculata		Vulnerable	D2
			Boeckella nyoraensis		Vulnerable	D2
			Boeckella shieli		Vulnerable	D2
			Calamoecia australica		Vulnerable	D2
			Calamoecia elongata		Vulnerable	D2
			Calamoecia Zeidleri		Vulnerable	D2
			Hemiboeckella powellensis		Vulnerable	D2
		Diaptomidae	*Eodiaptomus lumholtzi*		Vulnerable	D2

Phylum/Class	Order	Family	Species	Common Name	Category	Criteria
	Decapoda	Coenobitidae	*Birgus latro*	Coconut Crab	Data Deficient	
		Parastacidae	*Astacopsis gouldi*	Giant Freshwater Crayfish	Endangered	A1ace, B1+2abce
			Cherax destructor		Vulnerable	A1de
			Cherax nucifraga		Data Deficient	
			Cherax parvus		Data Deficient	
			Cherax quadricarinatus		Vulnerable	A1de
			Cherax tenuimanus	Marron	Vulnerable	A1de
			Engaeus australia	Lilly Pilly Burrowing Crayfish	Endangered	B1+2c
			Engaeus curvisuturus		Endangered	B1+2c
			Engaeus disjuncticus		Endangered	B1+2c
			Engaeus granulatus		Endangered	B1+2c
			Engaeus mallacoota	Mallacoota Burrowing Crayfish	Endangered	B1+2c
			Engaeus martigener	Furneaux Burrowing Crayfish	Endangered	B1+2c
			Engaeus nulloporius		Endangered	B1+2c
			Engaeus orramakunna	Mt Arthur Burrowing Crayfish	Endangered	B1+2c
			Engaeus phyllocerus	Narracan Burrowing Crayfish	Vulnerable	B1+2c
			Engaeus rostrogaleatus	Strzelecki Burrowing Crayfish	Endangered	B1+2c
			Engaeus spinicaudatus	Scottsdale Burrowing Crayfish	Endangered	B1+2c
			Engaeus sternalis	Warragul Burrowing Crayfish	Endangered	B1+2c
			Engaeus urostrictus		Endangered	B1+2c
			Engaewa similis		Endangered	B1+2c
			Euastacus armatus	Murray River Cray	Vulnerable	A1ade
			Euastacus bindal		Endangered	B1+2c
			Euastacus bispinosus	Glenelg River Cray	Vulnerable	A1ade
			Euastacus crassus		Endangered	B1+2c
			Euastacus diversus		Endangered	B1+2c
			Euastacus eungella		Vulnerable	B1+2c
			Euastacus fleckeri		Vulnerable	B1+2c
			Euastacus hystricosus		Vulnerable	B1+2c
			Euastacus jagara		Endangered	B1+2c
			Euastacus maidae		Endangered	B1+2c

Phylum/Class	Order	Family	Species	Common Name	Category	Criteria
			Euastacus monteithorum		Endangered	B1+2c
			Euastacus neodiversus		Vulnerable	B1+2c
			Euastacus robertsi		Endangered	B1+2c
			Euastacus setosus		Vulnerable	B1+2c
			Euastacus urospinosus		Endangered	B1+2c
			Euastacus yigara		Endangered	B1+2c
	Harpacticoida	Canthocamptidae	*Canthocamptus dedeckkeri*		Vulnerable	D2
			Canthocamptus echinopyge		Vulnerable	D2
			Canthocamptus longipes		Vulnerable	D2
			Canthocamptus mammillifurca		Vulnerable	D2
			Canthocamptus sublaevis		Vulnerable	D2
			Canthocamptus tasmaniae		Vulnerable	D2
			Fibulacamptus bisetosus		Vulnerable	D2
			Fibulacamptus gracillor		Vulnerable	D2
	Isopoda	Armadillidae	*Echinodillo cavaticus*		Data Deficient	
		Phreatoicidae	*Onchotelson brevicaudatis*		Vulnerable	D2
			Onchotelson spatulatus		Vulnerable	D2
			Uramphisopus pearsoni		Vulnerable	D2
		Styloniscidae	*Styloniscus* sp.		Data Deficient	
	Myodosopida	Cypridinidae	*Zonocypretta kalimna*	Seed Shrimp	Vulnerable	D2
	Podosopida	Limnocytheridae	*Limnocythere porphyretica*	Seed Shrimp	Vulnerable	D2
		Notodromadidae	*Newnhamia fuscata*	Seed Shrimp	Vulnerable	D2
			Newnhamia insolita	Seed Shrimp	Vulnerable	D2
Insecta	Diptera	Blepharoceridae	*Edwardsins gigantea*	Giant Torrent Midge	Endangered	B1+2c
			Edwardsina tasmaniensis	Tasmanian Torret Midge	Critically Endangered	A2c, B1+2c
	Ephemeroptera	Siphlonuridae	*Tasmanophlebi lacus-coerulei*	Large Blue Lake Mayfly	Vulnerable	D2

Phylum/Class	Order	Family	Species	Common Name	Category	Criteria
	Hymenoptera	Formcidae	*Myrmecia inquilina*		Vulnerable	D2
			Nothomyrmecia macrops	Australian Ant	Critically Endangered	B1+2c
			Strumigenys xenos		Vulnerable	D2
	Lepidoptera	Lycaenidae	*Acrodipsas illidgei*	Illidge's Ant Blue	Endangered	B1+2c
			Paralucia spinifera	Bathurst Copper	Endangered	B1+2c
	Odonata	Aeshnidae	*Acanthaeshna victoria*		Vulnerable	B1+2c
		Corduliidae	*Austrocordulia leonardi*		Critically Endangered	B1+2c
		Hemiphlebiidae	*Hemiphlebia mirabilis*		Vulnerable	B1+2c
		Petaluridae	*Petalura pulcherrima*		Endangered	B1+2c
	Orthoptera	Acrididae	*Schayera baiulus*		Critically Endangered	B1+2bd
		Rhaphidophoridae	*Tasmanoplectron isolatum*		Vulnerable	D1+2
		Tettigoniidae	*Austrosaga spinifer*		Vulnerable	B1+2bd
			Hemisaga elongata		Critically Endangered	B1+2bd
			Hemisaga lucifer		Vulnerable	B1+2bd
			Hemisaga vepreculae		Vulnerable	B1+2bd
			Ixalodectes flectocercus		Critically Endangered	B1+2bd
			Kawanphila pachomai		Endangered	B1+2bd
			Nanodectes bulbicercus		Critically Endangered	B2+2bd
			Pachysaga munggai		Vulnerable	B1+2bd
			Pachysaga strobila		Critically Endangered	B1+2bd
			Phasmodes jeeba		Vulnerable	B1+2c
			Pscaadonotus seriatus		Vulnerable	B1+2bd
			Throscodectes xederoides		Endangered	B1+2bd
			Windbalea viride		Vulnerable	B1+2bd
			Zaprochilus ninae		Vulnerable	B1+2bd
			Psacadonotus insulanus		Endangered	B1+2bd
			Throscodectes xiphos		Endangered	B1+2bd
	Phasmatoptera	Phasmatidae	*Dryococelus australis*	Lord Howe Island Phasmid	Extinct	

Phylum/Class	Order	Family	Species	Common Name	Category	Criteria
	Plecoptera	Eusthenidae	*Eusthenia nothofagi*	Otway Stonefly	Data Deficient	
		Gripopterygidae	*Leptoperla cacuminis*	Mount Kosciusko Wingless Stonefly	Vulnerable	D2
			Riekoperla darlingtoni	Mt Donna Buang Wingless Stonefly	Vulnerable	D2
Mollusca						
Bivalvia	Veneroida	Hyriidae	*Westralunio carteri*		Vulnerable	A1c, B1+2bc
		Pisidiidae	*Pisidium fultoni*		Lower Risk	Nt
Gastropoda	Archaegastropoda	Hydrocenidae	*Georissa laseroni*		Vulnerable	B1+2c, D2
			Monterissa gowerensis		Vulnerable	D2
	Basommatophora	Ancylidae	*Simulator consetti*		Lower Risk	Nt
		Planorbidae	*Ancylastrum cumingianus*	Australian Freshwater Limpet	Criitically Endangered	A1e
	Mesogastropoda	Cyclophoridae	*Ditropis whitei*		Vulnerable	B1+2c, D2
		Hydrobiidae	*Angrobia anodonta*		Vulnerable	D2
			Angrobia dulvertonensis		Extinct	
			Angrobia dyeriana		Vulnerable	D2
			Angrobia grampianensis		Critically Endangered	B1+2c
			Angrobia petterdi		Vulnerable	D2
			Beddomeia angulata		Vulnerable	D2
			Beddomeia averni		Vulnerable	D2
			Beddomeia bellii		Vulnerable	D2
			Beddomeia bowryensis		Vulnerable	D2
			Beddomeia briansmithi		Vulnerable	D2
			Beddomeia camensis		Vulnerable	D2
			Beddomeia capensis		Endangered	A1c
			Beddomeia fallax		Endangered	A1c
			Beddomeia forthensis		Vulnerable	D2
			Beddomeia franklandensis		Vulnerable	D2
			Beddomeia fromensis		Vulnerable	D2

Phylum/Class	Order	Family	Species	Common Name	Category	Criteria
			Beddomeia fultoni		Vulnerable	D2
			Beddomeia gibba		Vulnerable	D2
			Beddomeia hallae		Vulnerable	D2
			Beddomeia hullii		Vulnerable	D2
			Beddomeia inflata		Vulnerable	D2
			Beddomeia kershawi		Vulnerable	D2
			Beddomeia kessneri		Vulnerable	D2
			Beddomeia krybetes		Vulnerable	D2
			Beddomeia launcestonensis		Vulnerable	D2
			Beddomeia lodderae		Vulnerable	D2
			Beddomeia mesibovi		Vulnerable	D2
			Beddomeia minima		Endangered	A1c
			Beddomeia petterdi		Vulnerable	D2
			Beddomeia phasianella		Vulnerable	D2
			Beddomeia protuberata		Vulnerable	D2
			Beddomeia ronaldi		Vulnerable	D2
			Beddomeia salmonis		Vulnerable	D2
			Beddomeia tasmanica		Vulnerable	D2
			Beddomeia topsiae		Vulnerable	D2
			Beddomeia trochiformis		Vulnerable	D2
			Beddomeia tumida		Extinct	
			Beddomeia turnerae		Vulnerable	D2
			Beddomeia waterhouseae		Vulnerable	D2
			Beddomeia wilmotensis		Vulnerable	D2
			Beddomeia wiseae		Vulnerable	D2
			Beddomeia zeehenensis		Vulnerable	D2
			Fluviopupa gracilis		Lower Risk	Nt
			Fluvipupa ramsayi		Lower Risk	Nt
			Fonscochlea accepta		Vulnerable	D2
			Fonscochlea aquatica		Vulnerable	D2
			Fonscochlea billakalina		Endangered	A1ce
			Fonscochlea conica		Vulnerable	D2

Phylum/Class	Order	Family	Species	Common Name	Category	Criteria
			Fonscochlea zeidleri		Lower Risk	Nt
			Glacidorbis occidentalis		Vulnerable	D2
			Glacidorbis pawpela		Data Deficient	
			Glacidorbis pedderi		Data Deficient	
			Hemistoma beaumonti		Endangered	A1ce
			Hemistoma flexicolumella		Vulnerable	D2
			Hemistoma gemma		Lower Risk	Nt
			Hemistoma minutissima		Vulnerable	D2
			Hemistoma pusillior		Endangered	A1ce
			Hemistoma whiteleggei		Critically Endangered	A1ce
			Jardinella acuminata		Endangered	A1ce
			Jardinella carnavonensis		Vulnerable	D2
			Jardinella colmani		Critically Endangered	A1ce
			Jardinella coreena		Vulnerable	D2
			Jardinella corrugata		Vulnerable	D2
			Jardinella edgbastonensis		Vulnerable	D2
			Jardinella eulo		Vulnerable	D2
			Jardinella exigua		Vulnerable	D2
			Jardinella isolata		Vulnerable	D2
			Jardinella jesswiseae		Endangered	A1ce
			Jardinella pallida		Endangered	A1ce
			Jardinella zeidlerorum		Vulnerable	D2
			Nanocochlea monticola		Vulnerable	D2
			Nanocochlea parva		Lower Risk	Nt
			Nanocochlea pupoidea		Vulnerable	D2
			Phrantela annamurrayae		Vulnerable	D2
			Phrantela conica		Vulnerable	D2
			Phrantela kutikina		Vulnerable	D2
			Phrantela pupiformis		Vulnerable	D2
			Phrantela richardsoni		Data Deficient	
			Phrantela umbilicata		Vulnerable	D2
			Potamopyrgus oscitans		Lower Risk	Nt

Phylum/Class	Order	Family	Species	Common Name	Category	Criteria
			Trochidrobia inflata		Endangered	A1ce
			Trochidrobia minuta		Vulnerable	D2
			Trochdrobia punicea		Lower Risk	Nt
			Trochidrobia smithi		Vulnerable	D2
			Victodrobia burni		Vulnerable	D2
			Victodrobia elongata		Vulnerable	D2
			Victodrobia millerae		Vulnerable	D2
			Victodrobia victoriensis		Lower Risk	Nt
		Pupinidae	*Hedleya macleayi*		Vulnerable	D2
			Pupina coxeni		Lower Risk	Nt
			Pupina pfeifferi		Lower Risk	Nt
			Suavocallia splendens		Vulnerable	D2
		Viviparidae	*Notopala sublineata*		Endangered	A1ce
	Stylommatophora	Acavidae	*Anoglypta launcestonensis*	Granulated Tasmanian Snail	Vulnerable	D2
		Achatinellidae	*Tornelasmias capricorni*		Extinct	
		Bulimulidae	*Placostylus bivaricosus*		Critically Endangered	B1+2abcde
			Placostylus b. ssp. *Etheridgei*		Extinct	
			Placostylus cuniculinsulae		Extinct	
		Camaenidae	*Amphidromus cognatus*		Lower Risk	Nt
			Amplirhagada astuta		Endangered	C2a
			Amplirhagada herbertena		Data Deficient	
			Amplirhagada montalivetensis		Lower Risk	Nt
			Amplirhagada questroana		Endangered	C2b
			Austrochloritis ascensa		Lower Risk	Nt
			Austrochloritis pusilla		Lower Risk	Nt
			Baccalena squamulosa		Lower Risk	Nt
			Baudinella baudinensis		Lower Risk	Nt
			Carinotrachia carsoniana		Vulnerable	D2
			Cooperconcha centralis		Lower Risk	Nt
			Craterodiscus pricei		Lower Risk	Nt
			Cristigibba wesselensis		Data Deficient	

Phylum/Class	Order	Family	Species	Common Name	Category	Criteria
			Cristilabrum bubulum		Endangered	C2b
			Cristilabrum buryillum		Endangered	C2b
			Cristilabrum grossum		Endangered	C2a
			Cristilabrum isolatum		Vulnerable	D2
			Cristilabrum monodon		Vulnerable	D2
			Cristilabrum primum		Vulnerable	D2
			Cristilabrum rectum		Vulnerable	D2
			Cristilabrum simplex		Vulnerable	D2
			Cristilabrum solitudum		Endangered	C2b
			Cristilabrum spectaculum		Lower Risk	Nt
			Cupedora broughami		Lower Risk	Nt
			Cupedora evandaleana		Endangered	A1c
			Cupedora luteofusca		Lower Risk	Nt
			Cupedora marcidum		Lower Risk	Nt
			Cupedora nottensis		Vulnerable	D2
			Cupedora sutilosa		Lower Risk	Nt
			Cupedora tomsetti		Lower Risk	Nt
			Damochlora millepunctata		Endangered	C2a
			Damochlora spina		Vulnerable	D2
			Divellomelon hillieri		Vulnerable	D2
			Eximiorhagada asperrima		Data Deficient	
			Glyptorhagada bordaensis		Vulnerable	D2
			Glyptorhagada euglypta		Vulnerable	D2
			Glyptorhagada janaslini		Lower Risk	Nt
			Glyptorhagada kooringensis		Vulnerable	B1+2c, D2
			Glyptorhagada silveri		Endangered	A2ce
			Glyptorhagada tattawuppana		Vulnerable	D2
			Glyptorhagada wikawillini		Lower Risk	Nt
			Granulomelon grandituberculatum		Lower Risk	Nt
			Hadra wilsoni		Vulnerable	D2
			Jacksonena delicata		Lower Risk	Nt
			Jacksonena rudis		Lower Risk	Nt

Phylum/Class	Order	Family	Species	Common Name	Category	Criteria
			Kimboraga exanimus		Endangered	C2b
			Kimboraga koolanensis		Vulnerable	D1
			Kimboraga micromphala		Vulnerable	D2
			Kimboraga yammerana		Vulnerable	B1+2bc, D2
			Lacustrelix minor		Lower Risk	Nt
			Lacustrelix yerelinana		Lower Risk	Nt
			Meliobba shafferyi		Lower Risk	Nt
			Meridolum benneti		Vulnerable	D2
			Meridolum corneovirens		Endangered	A2ce
			Meridolum depressum		Vulnerable	D2
			Meridolum marshalli		Lower Risk	Nt
			Mesodontrachia desmonda		Lower Risk	Nt
			Mesodontrachia fitzroyana		Lower Risk	Nt
			Mouldingia occidentalis		Vulnerable	D2
			Mouldingia orientalis		Endangered	C2b
			Mussonena campbelli		Vulnerable	D2
			Ningbingia australis		Vulnerable	B1+2bc, D2
			Ningbingia bulla		Vulnerable	D2
			Ningbingia dentiens		Vulnerable	D2
			Ningbingia laurina		Vulnerable	D2
			Ningbingia octava		Vulnerable	D2
			Ningbingia res		Vulnerable	D2
			Noctepuna muensis		Data Deficient	
			Offachloritis dryanderensis		Vulnerable	D2
			Ordtrachia australis		Lower Risk	Nt
			Ordtrachia elegans		Vulnerable	D2
			Ordtrachia septentrionalis		Lower Risk	Nt
			Papuexul bidwilli		Lower Risk	Nt
			Pleuroxia arcigerens		Lower Risk	Nt
			Pleuroxia hinsbyi		Vulnerable	B1+2bc, D2
			Pleuroxia italowiana		Lower Risk	Nt
			Pleuroxia turneri		Lower Risk	Nt

Phylum/Class	Order	Family	Species	Common Name	Category	Criteria
			Prototrachia sedula		Vulnerable	D2
			Rhagada gibbensis		Vulnerable	D2
			Rhagada harti		Vulnerable	C2b
			Semotrachia euzyga		Vulnerable	D2
			Semotrachia sublevata		Lower Risk	Nt
			Semotrachia winneckeana		Lower Risk	Nt
			Setobaudinia victoriana		Lower Risk	Nt
			Sinumelon bednalli		Vulnerable	D2
			Sphaerospira macleayi		Lower Risk	Nt
			Sphaerospira rockhamptonensis		Lower Risk	Nt
			Sphaerospria whartoni		Lower Risk	Nt
			Thersites mitchellae		Endangered	C2a
			Torresitrachia funium		Lower Risk	Nt
			Torresitrachia thedana		Vulnerable	D2
			Turgenitubulus aslini		Vulnerable	B1+2bc, D2
			Turgenitubulus costus		Vulnerable	D2
			Turgenitubulus depressus		Vulnerable	B1+2bc, D2
			Turgenitubulus foremenus		Vulnerable	B1+2bc, D2
			Turgenitubulus opiranus		Vulnerable	B1+2bc, D2
			Turgenitubulus pagadula		Vulnerable	D2
			Turgenitubulus tanmurrana		Vulnerable	D2
			Vidumelon watti		Vulnerable	D2
			Westraltrachia alterna		Vulnerable	D2
			Westraltrachia inopinata		Vulnerable	D2
			Westraltrachia lievreana		Vulnerable	B1+2bc, D2
			Westraltrachia porcata		Vulnerable	D2
			Westraltrachia recta		Vulnerable	D2
			Westraltrachia subtila		Vulnerable	D2
			Westraltrachia turbinata		Vulnerable	D2
		Charopidae	*Allocharopa erskinensis*		Vulnerable	D2
			Allocharopa okeana		Lower Risk	Nt
			Allocharopa tarravillensis		Lower Risk	Nt

Phylum/Class	Order	Family	Species	Common Name	Category	Criteria
			Bischoffena bischoffensis		Data Deficient	
			Coenocharopa yessabahensis		Data Deficient	
			Cralopa colliveri		Vulnerable	D2
			Cralopa kaputarensis		Data Deficient	
			Dipnelix pertricosa		Data Deficient	
			Discocharopa mimosa		Data Deficient	
			Dupucharopa millestriata		Vulnerable	D2
			Geminoropa scindocataracta		Vulnerable	D2
			Hedleyoconcha ailaketoae		Vulnerable	D2
			Letomola barrenensis		Data Deficient	
			Letomola contortus		Data Deficient	
			Ngairea murphyi		Data Deficient	
			Oreokera cumulus		Data Deficient	
			Oreokera nimbus		Data Deficient	
			Oreomava cannfluviatilus		Data Deficient	
			Oreomava otwayensis		Vulnerable	D2
			Pernagera gatliffi		Vulnerable	D2
			Pillomena aemula		Lower Risk	Nt
			Pilsbrycharopa tumida		Vulnerable	D2
			Planilaoma luckmanii		Data Deficient	
			Rhophodon kempseyensis		Data Deficient	
			Rhophodon problematica		Data Deficient	
			Roblinella agnewi		Vulnerable	D2
			Setomedea nudicostata		Lower Risk	Nt
		Euconulidae	*Tengchiena euroxestus*		Data Deficient	
		Helicarionidae	*Helicarion leopardina*		Vulnerable	B1+2c, D2
			Helicarion porrectus		Vulnerable	B1+2c
			Helicarion rubicundus		Vulnerable	D2
			Theskelomensor creon		Vulnerable	D2
		Orthalicidae	*Bothriembryon bradshaweri*		Vulnerable	D2
			Bothriembryon brazieri		Vulnerable	D2
			Bothriembryon glauerti		Vulnerable	D2

Phylum/Class	Order	Family	Species	Common Name	Category	Criteria
			Bothriembryon irvineanus		Vulnerable	B1+2bc, D2
			Bothriembryon perobesus		Endangered	C2b
			Bothriembryon praecelcus		Endangered	C2b
			Bothriembryon spenceri		Vulnerable	D2
			Bothriembryon whitleyi		Vulnerable	D2
		Punctidae	*Pasmaditta jungermanniae*		Data Deficient	
		Pupillidae	*Gyliotrachela catherina*		Lower Risk	Nt
			Pupilla ficulnea		Lower Risk	Nt
		Rhytididae	*Occirhenea georgiana*		Endangered	C2a
			Ougapia spaldingi		Data Deficient	
			Tasmaphena lamproides		Vulnerable	A2de
			Victaphanta atramenteria		Lower Risk	Nt
			Victaphanta compacta		Endangered	A2c
		Zonitidae	*Trochomorpha melvillensis*		Lower Risk	Nt
Onycophora						
	Onychophora	Peripatopsidae	*Tasmanipatus anophthalmus*		Endangered	B1+2bc

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Phylogeography and population history of the endangered golden sun moth (*Synemon plana*) revealed by allozymes and mitochondrial DNA analysis

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Abstract

A combination of allozyme and mitochondrial DNA markers were used to determine the contribution of recent and ancient causes of patterns of genetic variation within and among 46 populations of the endangered golden sun moth, *Synemon plana*. Allozyme analysis grouped the 46 populations into 5 major genetic clusters that corresponded closely with geographic location following a classic isolation-by-distance model. Phylogenetic analysis of 14 mtDNA haplotypes revealed two reciprocally monophyletic groups. One of these groups (containing 4 geographically distant populations) was clearly identified by allozyme analysis and represents a distinct evolutionary unit. The remaining 4 allozyme groups were not distinguishable by mtDNA analysis. The evidence suggests that the populations within these groups derived from a small founding population that underwent rapid demographic expansion in ancient times. This was followed by more recent population bottlenecks resulting from habitat fragmentation associated with the widespread introduction of agriculture into the region. The generally low levels of allozyme and nucleotide diversity within these populations support this hypothesis.

Introduction

Habitat fragmentation is one of the most ubiquitous and serious environmental threats confronting the long-term survival of plant and animal species worldwide. Fragmented populations become not only smaller with loss of available habitat but also undergo spatial and temporal isolation (Saunders et al. 1991). Smaller populations are generally depauperate in genetic variation (Frankham 1996), due to stochastic processes such as genetic drift, bottlenecks and inbreeding (O'Brien 1994). In fragmented species with low dispersal this is compounded by a decline or loss of migration between populations as a consequence of isolation. Many fragmented populations of species demonstrate a loss of genetic variation and reduced levels of inter-population gene flow (Descimon and Napolitano 1993; Godt et al. 1996; Brookes et al. 1997; Cunningham and Moritz 1998).

The present-day genetic architecture of a fragmented species is a product of fragmentation on the underlying patterns of colonisation and descent. One goal of conservation is to preserve this evolutionary diversity (Vane-Wright et al. 1991; Crozier 1992; Moritz 1994a,b, 1995). This requires the explicit recognition of the relative contributions of recent and evolutionary processes to the genetic patterns within a species. This can be achieved through the application of an intra-specific phylogeographic approach (Dizon et al. 1992; Avise 2000) to populations of fragmented species.

Intra-specific phylogeography is the analysis of the evolutionary relationships among genotypes relative to the geographical location of the populations from which they were sampled. Inevitably the historical demographics of populations (e.g. colonisation, migration, growth and decline) must impact upon structures of gene phylogenies over microevolutionary time scales and thus upon intra-specific phylogeographic patterns (Avise 2000). For instance, populations that have rapidly expanded over evolutionary time are more likely to retain ancient lineages as a consequence of reduced lineage sorting (Avise et al. 1984). Phylogenies of genotypes can be estimated and compared to the predictions of theoretical demographic models to infer the evolutionary history of the populations (Avise 1989).

Mitochondrial DNA possesses several properties that make it uniquely suitable for the purpose of intra-specific phylogeographic analysis, including relatively high mutation rates, maternal inheritance, and no recombination (see Avise 2000).

Investigation of phylogeographic patterns of mtDNA has been exploited to provide an evolutionary perspective to fragmented populations in a number of species (Taberlet and Bouvet 1994; Worthington Wilmer et al. 1994; Sarre 1995; Barratt et al. 1999). However, patterns of mtDNA variation can be sensitive to the recent demographic history of a population. Loss of mtDNA variation and gene flow can occur following recent population fragmentation and decline (Gottelli et al. 1994; Wauters et al. 1994). Nonetheless, threshold effects (magnitude of population change required for genetic patterns to reflect demographic events), time lags (the time required for genetic patterns to reflect demographic events) and the genetic patterns of earlier demographic events can prevent recent demographic events from being reflected in current patterns of mtDNA variation (Lavery et al. 1996). In this light the challenge for mtDNA surveys of fragmented species is to disentangle the recent and ancient processes likely to have produced the observed phylogeographic patterns of matrilines (Avise 2000).

Insights into the evolutionary history of populations provided by intra-specific phylogeographic analysis are directly applicable to the diagnosis of conservation units within species. There is a need to prioritise taxa by classifying them into relevant conservation units in the face of limited resources for their conservation (Vane-Wright et al. 1991; Crozier 1992). Incorrect recognition of such units can lead to the poor management of threatened taxa (Daugherty et al. 1990). Moritz (1994b) proposed a distinction between ‘evolutionary significant units’ (ESUs – (Ryder 1986)) and ‘management units’ (MUs). ESUs represent historically isolated sets of populations that together encompass the evolutionary diversity of a species, while MUs represent sets of populations that are currently demographically independent (Moritz 1995).

The golden sun moth, *Synemon plana* Walker (Lepidoptera: Castniidae) is a conspicuous day-flying moth, the larvae of which feed exclusively on native grasses within the genus *Austrodanthonia*. Historically *S. plana* was widespread throughout southeastern Australia, matching the distribution of temperate native grasslands (Edwards 1994). Temperate native grasslands are among the most threatened ecosystems in Australia with less then 1% surviving as small fragmented remnants, as a consequence of the expansion of agriculture and urban development (Kirkpatrick et al. 1995). Consequently, the remaining populations of *S. plana* are severely fragmented and the species is only known from 62 sites; 44 in New South Wales (NSW), 13 in the Australian Capital Territory (ACT) and 5 in Victoria (refer to Figure 1). Fifty-six of the sites lie in a narrow band 100 km $\times$ 30 km. The majority of sites are smaller than 5 hectares in area. The species is listed as critically endangered under the Australian *Environmental Protection and Biodiversity Conservation* Act. Information concerning the life history of the golden sun moth is scarce (Edwards 1994; O’Dwyer and Attiwill 1999; Clarke 2000).

Although endangered, *S. plana* is locally abundant at suitable sites. However the combination of highly fragmented populations, restriction to temperate native grasslands with *Austrodanthonia*, immobility of females and the inability of males to fly over unsuitable habitat represents a severe threat to the survival of the species. Not only are populations isolated but also local extinctions are unlikely to be countered by recolonisation from other populations. The requirement for a 40% *Austrodanthonia* cover for population maintenance (O’Dwyer and Attiwill 1999) means that any process that degrades this represents an immediate threat to extant populations and a concern for management. Three ACT populations of *S. plana* have gone extinct since 1998 as a consequence of degradation of grassland quality (Clarke and Dear 1998). Thus, the continued survival of *S. plana* is precarious.

Previous genetic studies of 20 extant populations of *S. plana* using allozymes revealed 5 distinct genetic clusters concordant with geographic location consistent with an isolation-by-distance model (Clarke and O’Dwyer 2000). These authors suggested that the observed pattern of structuring and levels of genetic diversity within and among the sampled populations and clusters reflected the recent fragmentation of the

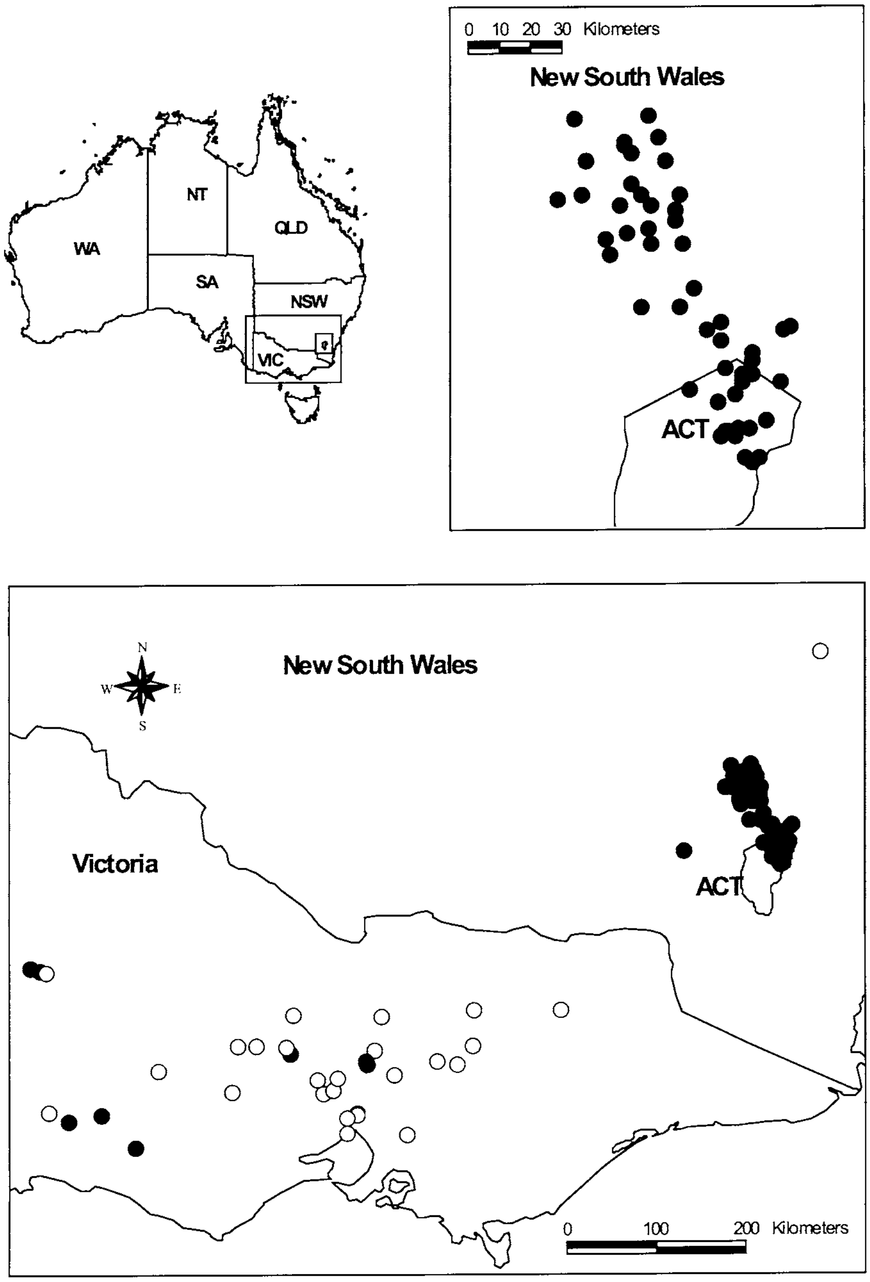

Figure 1. Map showing the distribution of *Synemon plana*. Open circles represent extinct populations. Filled circles represent extant populations.

species' habitat and suggested treating the five clusters as separate management units for conservation.

However, underlying this recent fragmentation is the pattern of colonisation of the region by the species over evolutionary time. It is currently hypothesised that the species originated in central Australia and radiated eastward through Victoria and north into NSW, although the timing is unknown and may be ancient (E.D. Edwards, unpublished). However, evolutionary patterns among allozyme alleles and frequencies are impossible to infer (Roderick 1996). The relationships defined by allozymes within and between the populations, based on the frequencies of shared alleles, thus failed to indicate the underlying evolutionary relationships of the *S. plana* populations. Although the relationships among the populations are consistent with known patterns of fragmentation in the region, they are also consistent with a stepwise colonisation pattern. The allozyme based genetic analysis of *S. plana* demonstrated insufficient resolution to make this distinction. Effective conservation planning for *S. plana* requires distinction between the historic and recent processes that have shaped the current genetic patterns. Conservation recommendations based on information incorrectly assumed to be historically representative are potentially misleading.

Specific life history aspects of *S. plana* make it especially conducive to phylogeographic analysis using mtDNA. The adult females are relatively immobile, which will increase maternal philopatry in the species. Thus, females spend their adult lives proximate to where their offspring later begin independent life. Consequently the immobile adult female offspring are likely to generate spatial structure along matrilines (Avise 2000).

In this study we have expanded the earlier allozyme study of Clarke and O'Dwyer (2000) by including an additional 26 populations. In addition we have undertaken a mtDNA-based phylogeographic study of these 46 populations in an effort to delineate between recent and historic processes shaping current patterns of diversity within the species.

Materials and methods

Collections

Adult males were collected from 4 sites in Victoria (VIC), 31 sites in New South Wales (NSW) and 11 sites in the Australian Capital Territory (ACT) during the 1997–2000 flying seasons using a hand net (Figure 1, Table 1). Although up to 30 males were sampled from each site in any one year, the timing of collections was designed to enhance the collection of post-reproductive males. Captured individuals were returned alive to the laboratory and placed at $-20\,^{\circ}$C until dead. Individual abdomens were then removed and stored at $-80\,^{\circ}$C until required.

Allozyme electrophoresis and analysis

Individual abdomens were homogenised in 100 μl of grinding buffer (100 ml distilled water, 10 mg NADP, 100 μl β-mercaptoethanol). Samples were then centrifuged at 13,000 rpm for 5 min. Approximately 1 μl of homogenate was loaded onto cellulose acetate plates (Titan III, Helena Laboratories) and electrophoresed at 200 V for 15 min. Genotypes were visualised by histochemical staining using recipes modified from Richardson et al. (1986). A total of 16 enzyme systems representing 20 loci were analysed (see Clarke and O'Dwyer 2000 for details).

The following genetic diversity parameters were estimated: P – the percentage of polymorphic loci; A, A_p – *allelic* richness (number of alleles per locus and the number of alleles per polymorphic locus respectively); H_e – gene diversity (expected heterozygosity (Nei 1978)); H_o – observed heterozygosity and f – the inbreeding coefficient (Wright 1978). Population differentiation was assessed using estimates of genetic distance (Nei 1978) and F statistics (Wright 1978). Statistical analysis of genotype data was performed using the software packages BIOSYS ver. 1.7 (Swofford and Selander 1989), POPGENE ver. 1.32 (Yeh et al. 1997), FSTAT ver. 2.93 (Goudet 1995) and GENEPOP ver. 3.2a (Raymond and Rousset 1995).

DNA extraction, polymerase chain reaction and sequencing

Five individual males from each of the 46 populations and single individuals from 4 outgroup taxa (*Synemon collecta*, *S. magnifica*, *S. leucospila* and *S. catocaloides*) were analysed. Total DNA was extracted from the head of individual moths using a CTAB phenol/chloroform method. A 715 bp fragment of the mitochondrial cytochrome oxidase subunit II gene (COII) was amplified using the primers lep-tleu (5′-GTG CAC CCC ATT TAT AAA GG-3′) and mt20 (5′-GTT TAA GAG ACC AGT ACT TG-3′) (Simon et al. 1994). PCR amplifications were carried out in a 50 μl reaction volume containing 6.7 mM Tris-HCl pH 8.8, 16.6 mM $[NH_4]_2SO_4$, 0.45% Triton X-100, 0.04% gelatin, 2.5 mM $MgCl_2$, 0.2 mM of each dNTP, 0.4 μm of each primer, $\sim$400 ng of template DNA and 2.5 U of *Taq* polymerase (Fisher-Biotec). Each reaction mixture was overlaid with one drop of mineral oil. The *Taq* polymerase was added to the reaction mixture after an initial denaturation step of 94 °C for 5 min. Subsequent PCR conditions were 35 cycles of denaturation at 94 °C for 1 min, primer annealing at 52 °C for 1 min 15 s, and extension at 72 °C for 1 min 30 s, followed by a final extension at 72 °C for 5 min. The PCR product was purified by electrophoresis in 0.8% tris-acetate agarose gels containing 10 μg/ml ethidium

Table 1. Site details and genetic assignment of sampled populations of *S. plana*

Site Name	Code	Latitude	Longitude	Allozyme group	Haplotype
Anzac Park	AZP	35.17.30	149.08.25	5	Common
Binalong	BIN	34.40.38	148.37.20	3	Common
Blackburn	BLK	34.42.45	148.57.40	3	Common
Bowning	BOW	34.46.20	148.49.19	3	BWD
Campbell Park	CPK	35.17.13	149.10.16	5	Common
Coolalie	COOL	34.48.02	148.58.40	4	Common
Davis	DAV	34.44.56	148.57.20	3	Common
Derringullen	DER	34.45.29	148.52.45	3	BWD
Dunkeld	DNK	37.41.50	142.21.36	1	Dunkeld
Dunlop	WBC	35.11.25	149.00.16	5	Common
Eady's	EN	34.40.19	148.58.02	3	Common
Ginninderra	GRD	35.08.59	149.10.32	5	Common
Glenlothian	BRD	34.40.08	148.41.23	3	Common
Gocup	GCP	35.15.42	148.12.38	–	Gocup
Gounyan	GYN	34.55.18	149.00.25	4	Common
Grace's Flat	GFR	34.47.12	148.46.34	2	GFU
Gundaroo	GTC	35.01.51	149.16.19	5	Common
Harry's Ck	HCR	34.33.47	148.49.31	3	HCM
Jeffrey's Lane	JFL	37.13.00	145.01.00	1	Jeffrey's Lane
Jeir Ck	JCK	35.01.45	149.02.47	4	Common
Kia-Ora	KIA	35.05.39	149.10.48	5	Common
Lagoon	LGN	34.34.37	148.41.43	4	Common
Lambs	LAM	34.48.04	148.53.40	3	Common/LBU
Laverstock	LAV	34.40.21	148.51.44	–	Common
Lawson	NAV	35.13.00	149.05.00	5	Common/ACT
Letchworth	LTH	35.22.12	149.11.49	5	Common
Majura	MFR	35.16.00	149.13.00	5	Common
McInerneys	MCI	34.41.56	148.47.45	3	Commom/MCU
Merryville	MVL	34.57.56	148.58.08	4	HCM
Mt Piper	MTP	37.12.07	145.00.36	1	Mt Piper
Mulanggary	MGY	35.11.42	149.07.53	5	ACT
Mulligans North	MFN	35.09.02	149.09.06	5	ACT
Mulligans South	MFS	35.09.58	149.08.59	5	ACT
Nanima	NAN	35.00.42	149.05.40	4	Common
Nhill	NIL	36.20.00	141.39.00	1	Nhill
Rye Park	RPK	34.31.05	148.54.28	3	Common/RPU
Silverdale	SIL	34.46.29	148.51.21	3	Common
Sutton	SUT	35.09.39	149.15.25	5	Common
Tarengo	TAR	34.28.19	148.39.56	3	Common/TRU
Wargeila	WARG	34.42.12	148.53.37	3	Common
Warroo	WAR	34.58.27	148.51.22	4	Common
Washpen	WASH	34.49.38	148.46.03	2	Common
Woden	WH	35.22.26	149.09.44	5	Common/ACT
Wolverhampton	WOL	34.27.22	148.52.53	3	Common
Yarralumla	YL	35.18.10	149.06.09	5	ACT
York Park	YPK	35.18.50	149.07.47	5	Common/ACT

bromide, excision of the bands and elution in 30 μl of distilled water.

Direct sequencing was performed with an automated ABI PRISM 377 sequencer. Sequencing was conducted in a single direction from the 3′ end of the fragment. Any ambiguous sequences were repeated and/or sequenced in the opposite direction. Sequencing reactions were carried out in a total reaction volume of 15 μl. Each reaction contained 5 μl of the eluted DNA fragment, 1.6 pM of the mt20 primer (Simon et al. 1994), 3.5 μl sterile distilled water and 5 μl Reaction Big Dye Sequencing Mix version 2.0 from Applied Biosystems Incorporated (ABI), Australia. Cycle sequencing conditions were 30 cycles of 96 °C for 30 seconds, 50 °C for 15 seconds and 60 °C for 4 min. The sequencing reactions were purified according to manufacturer's instructions and loaded. A total of 618 bp was reliably sequenced from all 234 individuals.

Phylogenetic analysis

Sequences were aligned using the program CLUSTAL-X (Thompson et al. 1997) and checked manually. Phylogenetic analyses were performed using PAUP* version 4.0b10 (Swofford 1999). The data set was tested for the most appropriate phylogenetic model by application of ModelTest version 3.06 (Posada and Crandall 1998). Phylogenetic analyses were performed using maximum parsimony, maximum likelihood and neighbour-joining criteria. For the parsimony analysis starting trees were generated by stepwise addition with 100 random addition replicates with branch swapping by the tree-bisection-reconnection (TBR) algorithm. Robustness of the tree topology was tested using the bootstrap (Felsenstein 1985) using 1000 replicates with starting trees generated by simple stepwise addition and branch swapping by TBR. Neighbour joining analysis was performed using the Tamura Nei distance measure. Maximum likelihood analysis was performed using the Tamura Nei plus gamma model using the parameters output by ModelTest. The starting tree was generated by stepwise addition with 10 random addition replicates with branch swapping by TBR.

Results

Allozyme analysis

Both allele and genotype frequencies revealed significant genetic differentiation and structuring among populations (F_{ST} = 0.135, $P < 0.01$) as shown in Figure 2. Full details of all pairwise population differentiation (exact tests), F_{ST} and genetic distance matrices are available from the authors.

These 46 populations cluster in the UPGMA analysis into five major genetic groupings (Figure 2), that also display significant genetic structure (F_{ST} = 0.137, $P < 0.01$). Each of these groups is genetically distinct (based on exact tests of genotype frequencies) from all others (Table 2).

Group 1 consists of the four Victorian populations. There is significant genetic structuring within this group (F_{ST} = 0.245, $P < 0.01$) with all populations significantly different from each other with the exception of the Mt Piper and Jeffrey's Lane populations, which are less than 2 km apart. All four populations are significantly different from the remaining NSW and ACT populations.

Group 2 contains two NSW populations (Washpen Ck and Grace's Flat) located 4 km apart. These populations are not significantly different from each other but are each significantly different from almost all the other populations.

Group 3 contains 15 populations in the general area between Yass and Boorowa. There is some significant additional structuring among populations within this group (F_{ST} = 0.021, $P < 0.01$) with some populations showing significant differences in genotype frequency.

Group 4 includes six populations in a zone centred on Murrumbateman. Surprisingly it also contains a single population (Lagoon) that is located south of Boorowa. There is also some substructuring among populations within this group (F_{ST} = 0.019, $P < 0.01$), again with some populations being genetically different form other group members.

Group 5 contains the remaining 16 populations, primarily occurring in the ACT and immediate environs. There is a low, yet significant, level of structuring among these populations (F_{ST} = 0.006, $P < 0.01$). In general there are very few significant differences in genotype frequencies among these populations and genetic distances are very low.

There are two outlier populations in the NSW group, Gocup and Laverstock. These two populations are significantly different in genotype frequen-

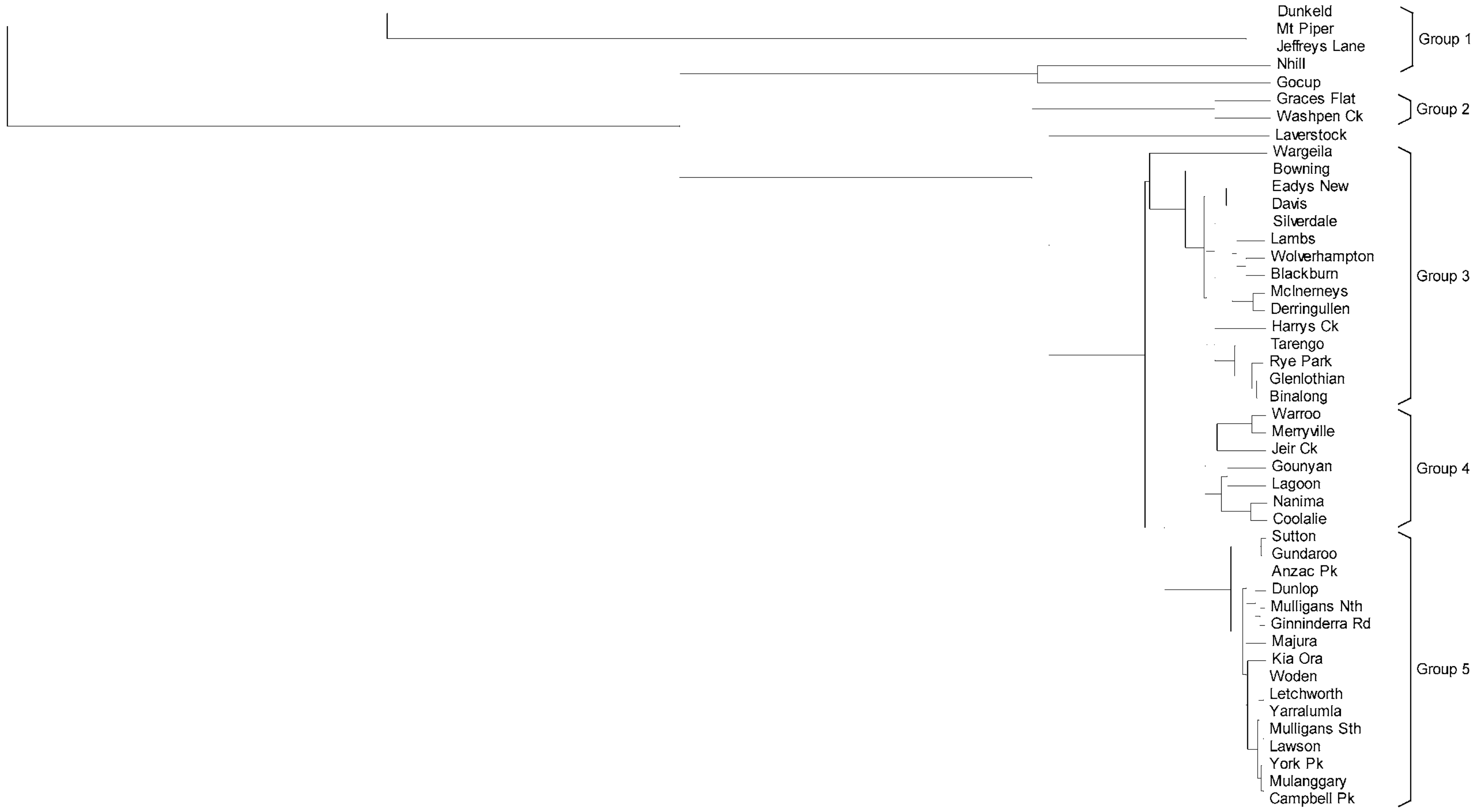

Figure 2. UPGMA phenogram based on Nei’s 1978 genetic distance of allozyme data showing relationships among all sampled *S, plana* populations. Branch lengths represent genetic distance.

Table 2. Pairwise matrix of Wright's F_{ST} (below diagonal) and Nei's (1978) genetic distance D (above diagonal) for population groups of *Synemon plana*. All pairwise comparisons are significant following exact tests

	Group 1	Group 2	Group 3	Group 4	Group 5
Group 1	–	0.0624	0.0538	0.0788	0.0833
Group 2	0.2205	–	0.0133	0.0246	0.0235
Group 3	0.2192	0.0697	–	0.0080	0.0065
Group 4	0.2980	0.1314	0.0465	–	0.0071
Group 5	0.3893	0.1690	0.0498	0.0584	–

cies from each other and from all other populations. However, from the phenogram in Figure 2 it can be seen that the Laverstock population falls within the overall NSW/ACT cluster and that the Gocup population lies between the Victorian and NSW/ACT clusters, as might be expected given its geographic location.

The genetic structuring among these populations and population clusters are concordant with geographic location (Figure 3). The data fit an isolation by distance model for which the closer populations are geographically, the closer they are genetically (r = 0.8451, $P < 0.001$, Mantel test) (Figure 4). This result is still significant after removing the very distant Victorian populations (r = 0.4221, $P < 0.001$).

Mitochondrial DNA analysis

Fourteen unique haplotypes were found among the 46 populations (Table 1). Sequences have been deposited in GENBANK with accession numbers AY033913–AY033926. There were a total of 23 variable sites among the 14 haplotypes with 12 of these being parsimony informative. Each of the Victorian populations contained a unique haplotype. Within NSW/ACT, a single haplotype was common being found in 32 of 42 populations. This was the sole haplotype in 25 of these populations and occurred in the presence of another haplotype in seven other populations. The distribution of haplotypes within populations is given in Table 1. A haplotype restricted to the ACT was also observed. It was the sole haplotype present in 4 of the 10 ACT populations and was also found in a further three ACT populations with the Common haplotype. There is no significant geographic structuring among the NSW/ACT haplotypes.

The haplotypes are all very similar (Table 3). Seven of the haplotypes only differed from the Common haplotype by a single nucleotide (0.16%). The unique Lamb's haplotype differed by two nucleotides (0.32%). In comparison the Victorian haplotypes differed from the Common haplotype by 5–10 nucleotides changes (0.8–1.6%), three of which were common to all Victorian sequences, and differed within themselves by 1–10 nucleotides (0.16–1.6%). Thus the Victorian sequences are not only distinct from the NSW/ACT haplotypes but are more differentiated among themselves than the entire set of NSW/ACT haplotypes, a result consistent with the allozyme analysis. By comparison the *S. plana* haplotypes differed from the outgroup species by between 2.5% and 9.5%.

The phylogenetic relationships among the haplotypes were consistent by all methods of analyses (Figures 5–7) with reasonably good bootstrap support (Figure 6). There are two reciprocally monophyletic clades, one containing the four Victorian haplotypes together with the Gocup haplotype and the other containing the NSW and ACT haplotypes (Figure 5). The relationships among the NSW and ACT haplotypes are relatively unresolved.

Allozyme diversity and variation

Estimates of genetic diversity and variation for each population and Group are given in Tables 4 and 5 respectively. Overall, the level of genetic variation is typical of the Lepidoptera in general, with observed levels of heterozygosity (H_o) averaging approximately 11% (Nevo et al. 1984). There is however considerable variation among populations. These differences among populations are not attributable to differences in population size. In general, populations within Group 5, although displaying comparable levels of allelic diversity, show lower (approximately 30% less) levels of variation (polymorphism and heterozygosity) than those within the other groups (see Table 5). The level of non-random mating within most populations (as revealed by the fixation index) is high. At the group level all fixation index values are significant. Seven populations contain rare unique alleles, not found in other populations. Three of these private alleles are found within Group 1 populations, one in Group 3, one in Group 4 and two in Group 5. These alleles represent unique mutational events and are important in the context of conservation of genetic diversity within the species.

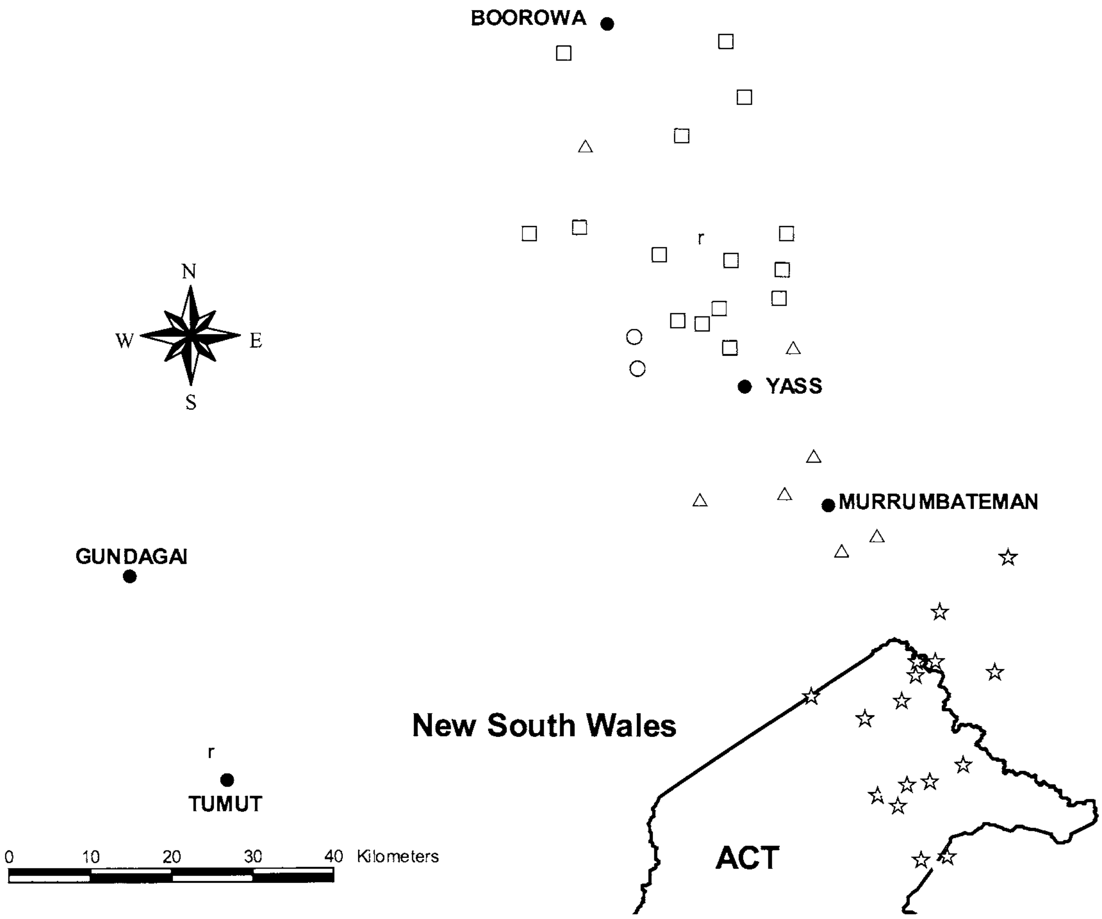

Figure 3. Map showing geographic relationships among populations and population clusters of *S. plana*. ○ = Group 2; □ = Group 3; △ = Group 4; ⋆ = Group 5; ⚹ = Outliers.

Table 3. Pairwise matrix of haplotype differences based on Tamura-Nei distance

Haplotype	Common	ACT	GFU	HCM	BWD	LBU	MCU	RPU	TRU	Gocup	JFL	MTP	Dunkeld	Nhill
Common	–													
ACT	0.002	–												
GFU	0.002	0.003	–											
HCM	0.002	0.003	0.003	–										
BWD	0.002	0.003	0.003	0.003	–									
LBU	0.003	0.005	0.005	0.005	0.002	–								
MCU	0.002	0.003	0.003	0.003	0.003	0.002	–							
RPU	0.002	0.003	0.003	0.003	0.003	0.005	0.003	–						
TRU	0.002	0.003	0.003	0.003	0.003	0.005	0.003	0.003	–					
Gocup	0.015	0.017	0.017	0.017	0.013	0.015	0.017	0.017	0.017	–				
JFL	0.017	0.018	0.018	0.015	0.018	0.020	0.018	0.018	0.018	0.015	–			
MTP	0.015	0.017	0.017	0.013	0.017	0.018	0.017	0.017	0.017	0.013	0.002	–		
Dunkeld	0.008	0.010	0.010	0.010	0.010	0.012	0.010	0.010	0.010	0.017	0.015	0.013	–	
Nhill	0.010	0.011	0.011	0.011	0.011	0.013	0.011	0.008	0.011	0.018	0.017	0.015	0.008	–

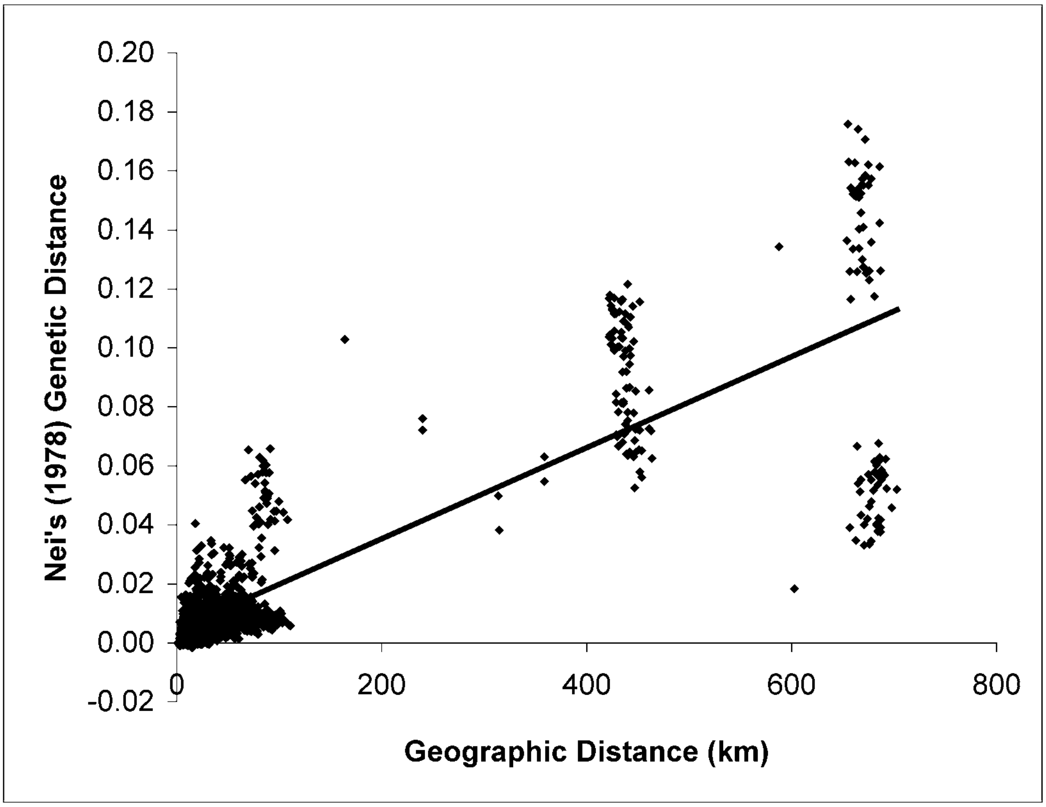

Figure 4. Scatterplot of geographic distance versus genetic distance for all pairwise population comparisons.

Discussion

Sequence variation and phylogenetic relationships

The levels of sequence variation along the COII gene found within *S. plana* are relatively low. Overall, haplotypes demonstrated between 0.16–1.62% sequence divergence. Within the NSW/ACT region diversity was much lower with 0.16–0.32% sequence divergence. In comparison, other lepidopteran species exhibit between 0.84–3.00% intra-specific sequence divergence (Sperling and Harrison 1994; Sperling et al. 1996, 1999). It is possible that the lower variation observed within *S. plana* represents a loss of diversity following demographic decline subsequent to fragmentation. Sequence divergence between the species within the genus *Synemon* included in this study varied from 2.27–9.39%. These values are comparable to sequence divergences observed among species within several lepidopteran genera (Sperling and Harrison 1994; Brown et al. 1999; Caterino and Sperling 1999; Kim et al. 1999).

Despite the observed low levels of genetic variation, the trees generated by the various phylogenetic techniques demonstrated high levels of congruence. For example, all except two of the nodes defined by parsimony received strong bootstrap support of over 70%. Given the low number of parsimony informative characters, this indicates general support across all characters for the same topology. Neighbour joining analysis, which utilises all the variable sites along a sequence, demonstrated a tree of similar topology with improved resolution of the relationships among the NSW/ACT haplotypes. The tree generated by maximum likelihood possessed features consistent with those generated by parsimony and neighbour joining distance, such as the monophyly of Victorian haplotypes with respect to those from NSW/ACT and the inability to clearly resolve relationships among the NSW/ACT haplotypes. The congruent topologies generated by multiple evolutionary models utilising different characters indicates strong support for the depicted evolutionary relationships among the haplotypes. Further discussion will accept the topology

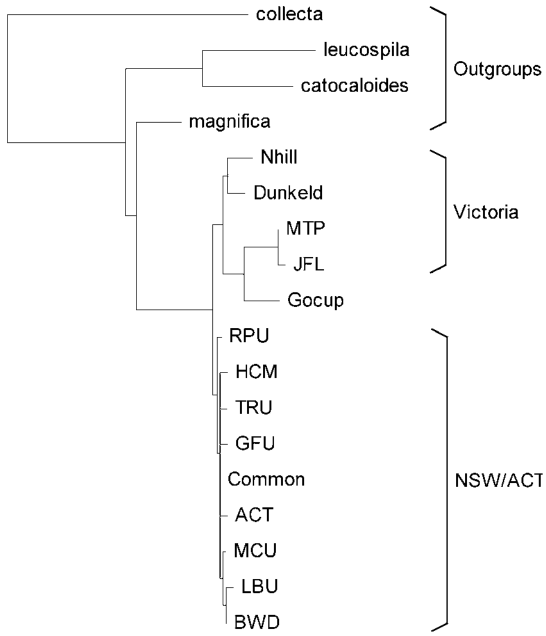

Figure 5. Neighbour-joining tree of mtDNA haplotypes based on Tamura-Nei distance.

given by neighbour joining and parsimony analysis and the branch lengths indicated by neighbour joining as indicative of the evolutionary relationships among the haplotypes.

Evolutionary and population history

From the accepted topology (Figure 5) the Victorian and NSW/ACT haplotypes are reciprocally monophyletic. The greater phylogenetic structuring and higher degree of nucleotide differentiation among the Victorian haplotypes in comparison to the NSW/ACT haplotypes suggest that these populations have been isolated for a longer period of time.

The Gocup haplotype appears to be equally divergent from both the Victorian populations and the NSW/ACT cluster (Table 3), although phylogenetic analyses suggest it is more closely related to the Victorian group. This relatively high level of divergence of this population may reflect an extended period of isolation from the other populations. It should be noted that no other population has been found within a 70 km radius despite extensive searching over a number of years.

The data strongly suggest that *S. plana* underwent rapid evolutionary demographic expansion in the NSW/ACT region. Throughout the region, the Common haplotype is widespread and a series of closely related lineages are restricted to one or few populations. Such a spatial structure of lineages is consistent with populations that are tightly connected in history (Avise 2000). Tight genealogical connectedness is typical of recently expanded populations (Ibrahim et al. 1996). The star-like phylogenetic relationships of the NSW/ACT haplotypes are characteristic of exponentially expanding populations (Slatkin and Hudson 1991). In expanding populations novel sequence types that are generated by the accumulation of unique mutations in individuals are retained (Avise 2000). In a network these new haplotypes radiate star-like from a central ancestral sequence, generating a pattern similar to that observed among the NSW/ACT populations.

Relatively high haplotype and low nucleotide diversity suggests rapid population growth from a small effective population with enough time for the generation of haplotype diversity without time for the accumulation of sequence divergence (Avise 2000). The observation of such a pattern in the NSW/ACT haplotypes is consistent with a recent and rapid demographic expansion from a small founding population in the region. The reciprocal monophyly of the Victorian and NSW/ACT haplotypes suggests that the founding population emerged from Victoria before the more extensive diversification of the Victorian haplotypes. Rapid population expansion typically results in a spatial distribution of haplotypes where the ancestral type is widely distributed and the derived types are more restricted (Avise 2000). The spatial distribution of haplotypes in NSW/ACT conforms to such an expectation.

It must be noted that phylogenetic trees based on mtDNA are primarily trees of the mtDNA molecules themselves and only secondarily trees of the populations from which they were sampled (Crozier 1990; Moore 1995). Care should be taken when drawing conclusions regarding population history from single-gene phylogenies. In effect a gene tree may not accurately reflect the history of a population due to factors such as shared ancestral polymorphisms (Simon et al. 1994). Although investigation of multiple loci is the most reliable technique for revealing such discrepancies, the sampling of multiple individuals, as done in *S. plana*, can increase detection of such polymorphisms (Crozier 1990). Nevertheless, the interpretation of the phylogenetic relationships among the *S. plana* mtDNA haplotypes in the context of their spatial distribution provides a view of the evolutionary patterns in the species.

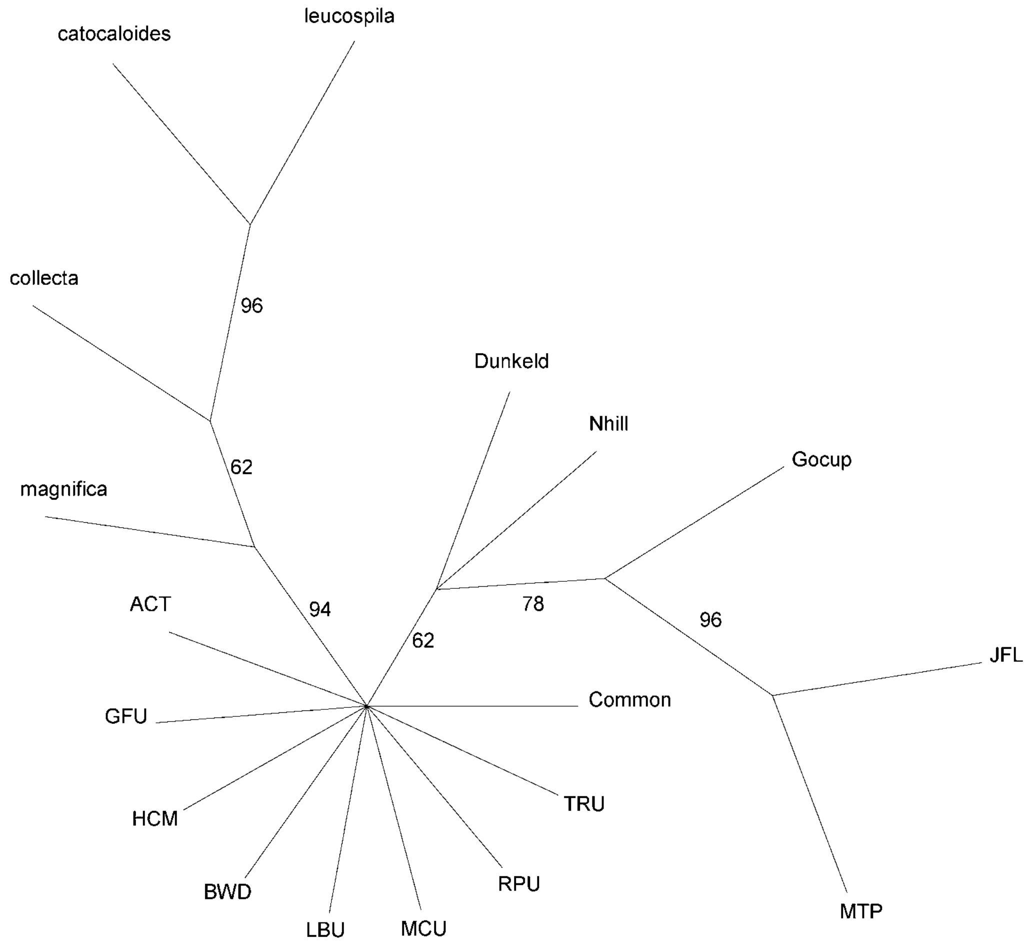

Figure 6. Unrooted bootstrap parsimony tree. Bootstrap values supporting each node are shown alongside branches.

The genetic patterns observed in the mtDNA of the *S. plana* populations in the NSW/ACT region conflict with those revealed by the analysis of allozyme frequencies, although absolute divergence in both data sets is low. The mtDNA data reveal little population structuring or differentiation and a phylogeographic pattern of genetic variation consistent with rapid demographic expansion. In contrast, allozyme frequencies evince patterns of extensive population structuring and differentiation consistent with either recent population fragmentation or a step-wise colonisation originating north of Yass and moving southwards into the ACT.

There is a growing body of literature documenting such inconsistencies in the mitochondrial and allozyme genetic patterns in a variety of species (e.g. Hurst and Skibinski 1995; Estoup et al. 1996; Rosel et al. 1999; Piel and Nutt 2000). These inconsistencies are generally attributed to be the consequence of the more rapid evolution of any changes in allozyme frequencies and the greater ability of mtDNA to reflect intra-specific evolutionary patterns.

There is no evidence for a step-wise colonisation process in NSW/ACT on the basis of the trees generated from the mtDNA data. This is consistent with the patterns of allozyme frequencies in the region being driven by the recent fragmentation of *S. plana* populations following destruction of temperate native grasslands. The greater degrees of genetic differentiation and structuring observed for the allozymes in the populations of Groups 1–4 could be attributed to longer periods of population isolation. Similarly, the lower degrees of genetic variability, structuring and differentiation seen in Group 5 populations suggest more recent population fragmentation (Clarke and O'Dwyer 2000; Clarke 2000).

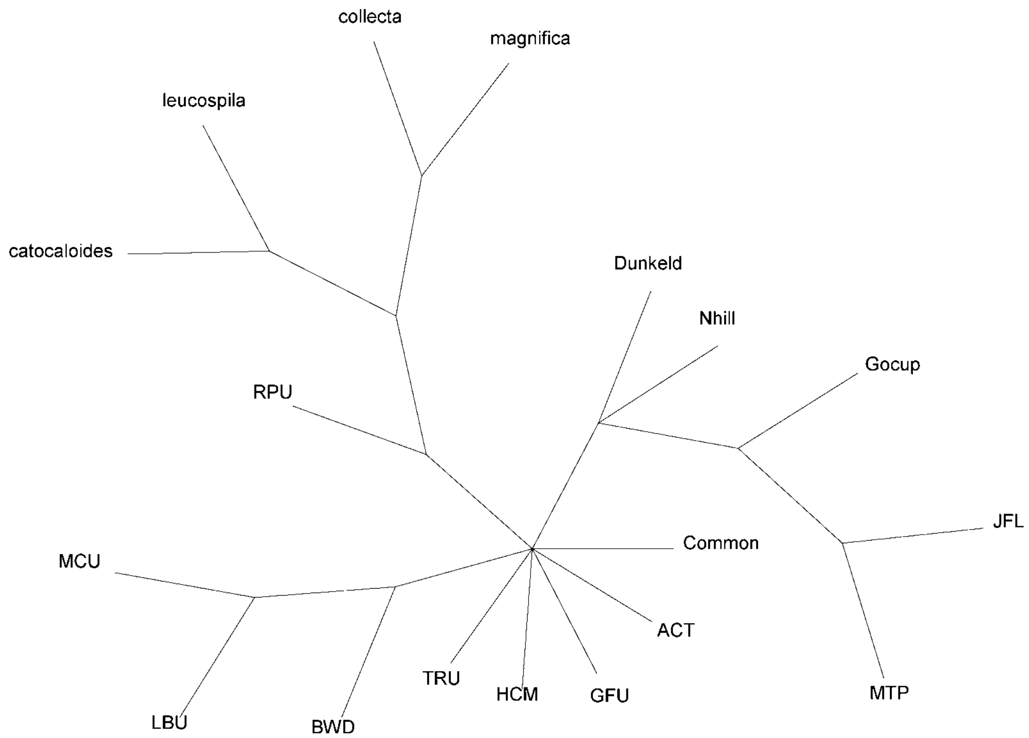

Figure 7. Unrooted maximum-likelihood tree.

Overall levels of allelic richness in *S. plana* in the NSW/ACT region are low in comparison to other lepidopterans (Clarke and O'Dwyer 2000), implying that the significant genetic structuring and differentiation observed among the NSW/ACT populations is based on frequency rearrangements of a common set of alleles. This intimates that the nuclear gene pool of the pre-fragmentation *S. plana* in NSW/ACT was more contiguous across the range of the species in the region. The significant degree of genetic structuring and differentiation among the populations indicates the severity of subsequent local population bottlenecks upon population isolation following fragmentation.

A contiguous nuclear gene pool contrasts with the observed restricted spatial distribution of many mtDNA haplotypes. High levels of female philopatry can cause spatial structure in matrilines that is not apparent in nuclear genes due to increased male dispersal (Rosel et al. 1999). Such a scenario is consistent with more actively flying *S. plana* males maintaining a more homogeneous nuclear gene pool while the low vagility of females inevitably leads to restricted spatial structure of derived mtDNA haplotypes. Consequently, the mtDNA haplotypes that remain after fragmentation are contingent upon the geographic location of surviving native temperate grasslands.

A synthesis of evidence from both the mtDNA and allozyme data sets enables a reconstruction of the history of *S. plana* in the NSW/ACT region. The data suggest that the area was colonised in recent evolutionary time by a small founding population that originated from Victoria. The population subsequently underwent a rapid demographic expansion. As a consequence of the low vagility of females, spatial structure developed along matrilines. Higher levels of male dispersal, a larger effective evolutionary population size of the nuclear genome and the slower rate of nuclear evolution maintained a more homogeneous nuclear gene pool. The introduction of agriculture to the region caused extensive habitat fragmentation and population isolation. This led to a series of severe, independent and sequential population bottlenecks, which had two main genetic consequences. Firstly, the mtDNA haplotypes that survived were contingent on the geographic location of intact native temperate grassland fragments. Secondly, the allozyme frequencies within surviving populations were stochastically rearranged, and reflect the timing and patterns of fragmentation in the region. The contemporary nature

Table 4. Genetic diversity and variation within populations of *Synemon plana*

Population	n	P	A	A_p	H_e	H_o	f
Group 1							
Dunkeld	30	0.65	1.85	2.31	0.173	0.122	0.297
Jeffrey's Lane	21	0.55	2.00	2.82	0.178	0.129	0.284
Mt. Piper	37	0.75	2.20	2.60	0.173	0.139	0.199
Nhill	33	0.60	1.90	2.50	0.081	0.069	0.153
Group 2							
Grace's Flat	22	0.55	1.70	2.27	0.165	0.151	0.091
Washpen Ck	58	0.55	1.85	2.27	0.157	0.128	0.190
Group 3							
Binalong	31	0.75	2.05	2.40	0.147	0.123	0.170
Blackburn	15	0.60	1.80	2.33	0.134	0.126	0.063
Bowning	26	0.80	2.00	2.25	0.167	0.141	0.154
Davis	30	0.70	1.95	2.36	0.172	0.158	0.080
Derringullen	25	0.50	1.85	2.70	0.141	0.117	0.167
Eady's New	28	0.55	1.80	2.45	0.151	0.130	0.138
Glenlothian	30	0.65	1.95	2.46	0.137	0.102	0.257
Harry's Ck Rd	20	0.45	1.55	2.22	0.126	0.108	0.147
Lambs	24	0.65	1.85	2.31	0.139	0.117	0.161
McInerneys	30	0.60	1.90	2.50	0.145	0.140	0.034
Rye Park	20	0.40	1.60	2.50	0.104	0.070	0.326
Silverdale	21	0.60	1.70	2.17	0.146	0.147	−0.008
Tarengo	30	0.70	1.95	2.36	0.159	0.129	0.192
Wargeila	30	0.65	1.90	2.38	0.159	0.161	−0.015
Wolverhampton	31	0.40	1.55	2.38	0.105	0.095	0.095
Group 4							
Coolalie	30	0.60	1.85	2.42	0.121	0.103	0.147
Gounyan	22	0.55	1.70	2.27	0.137	0.134	−0.023
Jeir Ck	24	0.60	1.75	2.25	0.135	0.136	−0.001
Lagoon	30	0.55	1.90	2.64	0.150	0.139	0.076
Merryville	30	0.45	1.60	2.33	0.118	0.100	0.157
Nanima	20	0.55	1.65	2.18	0.111	0.105	0.053
Warroo	30	0.65	1.80	2.23	0.115	0.092	0.205
Group 5							
Anzac Pk	21	0.40	1.40	2.00	0.103	0.103	−0.001
Campbell Pk	80	0.65	1.90	2.23	0.101	0.088	0.134
Dunlop	30	0.45	1.50	2.11	0.083	0.071	0.154
Ginninderra Rd	32	0.35	1.45	2.29	0.087	0.071	0.191
Gundaroo	31	0.50	1.55	2.10	0.097	0.081	0.173
Kia Ora	27	0.55	1.65	2.18	0.116	0.089	0.230
Lawson	76	0.55	1.85	2.36	0.086	0.085	0.016
Letchworth	46	0.50	1.70	2.40	0.097	0.074	0.236
Majura	30	0.40	1.45	2.13	0.098	0.081	0.175
Mulanggary	24	0.40	1.50	2.25	0.098	0.088	0.109
Mulligans Nth	72	0.55	2.00	2.73	0.098	0.096	0.018
Mulligans Sth	33	0.35	1.40	2.14	0.078	0.058	0.256
Sutton	9	0.35	1.40	2.14	0.101	0.078	0.238
Woden	31	0.50	1.50	2.00	0.096	0.084	0.124
Yarralumla	62	0.55	1.80	2.36	0.098	0.077	0.218
York Pk	81	0.50	1.85	2.50	0.098	0.086	0.121
Outliers							
Gocup	11	0.35	1.35	2.00	0.109	0.108	0.014
Laverstock	23	0.50	1.85	2.70	0.140	0.124	0.120

n = sample size; P = proportion of polymorphic loci; A = average number of alleles per locus; A_p = average number of alleles per polymorphic locus; H_e = expected heterozygosity; H_o = observed heterozygosity; f = fixation index.

Table 5. Genetic diversity and variation within population clusters of *Synemon plana*. Values are based on pooled populations within each cluster

Cluster	n	P	A	A_p	H_e	H_o	f
Group 1	121	0.75	2.90	3.40	0.185	0.114	0.386
Group 2	80	0.70	2.00	2.43	0.161	0.134	0.169
Group 3	388	0.75	3.05	3.33	0.147	0.126	0.144
Group 4	184	0.75	2.75	3.07	0.129	0.115	0.109
Group 5	681	0.55	2.75	3.18	0.096	0.083	0.140

n = sample size; P = proportion of polymorphic loci; A = average number of alleles per locus; A_p = average number of alleles per polymorphic locus; H_e = expected heterozygosity; H_o = observed heterozygosity; f = fixation index.

of the habitat fragmentation means that matrilineal lineage sorting in remnant populations is incomplete, leading to the observation of multiple mtDNA haplotypes within single populations.

Conservation implications

The findings of this study have direct relevance to the definition of conservation units in *S. plana*. Moritz (1994b) suggests that ESUs should be recognised on the genetic grounds of the reciprocal monophyly of mtDNA haplotypes and significant divergence of allele frequencies at nuclear loci. Data presented in this study indicate the reciprocal monophyly of the Victorian and NSW/ACT haplotypes. The populations from each of these regions also demonstrate significant divergence in allozyme frequencies and some variation in allozyme alleles. Clearly, the *S. plana* populations from Victoria and the NSW/ACT region represent distinct ESUs. This implies that the long-term conservation planning for the species should recognise this evolutionary heritage and aim to preserve this historical population distinction. Translocation of individuals between the two ESUs should be avoided (Taberlet and Bouvet 1994).

Genetically, MUs can be defined as populations that demonstrate significant differentiation on the basis of nuclear or mitochondrial allele frequencies (Moritz 1994b). Under this criterion, the five different population groupings recognised by allozyme electrophoresis represent separate units for the purposes of short-term management. The Victorian populations merit special management attention as the four constituent populations represent not only an MU but also an entire ESU. On the basis of data presented in this study, Groups 2, 3 and 5 within the NSW/ACT region are of a higher priority as the comprising populations preserve the majority of mtDNA variation in the region.

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Population Monitoring of Endangered Moth *Synemon plana* 1992 - 93, York Park, Barton

Lyn Cook and E.D. Edwards

Report to the
NATIONAL CAPITAL PLANNING AUTHORITY

March 1993

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TABLE OF CONTENTS

SUMMARY

The adult population of *Synemon plana* at York Park was monitored between November 24th, 1992 and January 31st, 1993. The population of adult males of *S. plana* during this period was estimated at about 520. Thirty-five adult females were captured but the recapture rate was too low to allow a reasonable estimate of the numbers present. Although the estimates of the numbers of males present suggest that the *S. plana* population may be sustainable, several factors (discussed in Sections 3 and 4) suggest that caution is required in interpreting these results at this stage.

The capture sites of males were fairly evenly distributed over the whole of the study site, although a shift from higher to lower lying areas was recorded during the study period. Females were mainly captured in areas of short grass or bare ground.

The sex ratio of adults captured exhibited a strong male bias. This is considered unlikely to represent the functional sex ratio of the adult population, but rather a difference in the chance of capture of males and females due to their very different behaviours. The long grass which covered much of the study site probably also contributed to the low number of females captured.

No *S. plana* were observed in Section 29 of York Park (Barton and Sydney Avenue alignment).

1. INTRODUCTION

Synemon plana is a day-flying moth inhabiting native grasslands dominated by *Danthonia carphoides,* upon which the larvae feed, and *D. auriculata*. Although *S. plana* was once widespread in southeastern Australia, the loss of suitable habitat has led to a decline in its range such that it is now considered endangered and known in only a few remnant native grassland sites, eight of which are found in the ACT (Edwards, 1989).

The moth is unique among its family (Castniidae) in that the males and females are very different in both behaviour and appearance. Unlike the bronzy brown wings of the male, the female has bright orange hind wings which she may flash to attract attention when males fly over. The larger-bodied female also has reduced wing area and, although she may fly short distances when disturbed, usually remains amongst the ground cover (Edwards, 1989).

1.1 Purpose of the Study

The purpose of this study was to:

(a) determine the size of the adult *Synemon plana* population on the study site;

(b) determine the sex ratio of the adult population;

(c) map the spread of the population over the study site;

(d) determine whether a population of *S. plana* still exists on Section 29 (Barton and Sydney Avenue alignment) of York Park.

1.2 The Study Site

The 100 metre by 35 metre grassland site is situated in Section 22 of York Park (Fig. 1.1) and, excluding the Belconnen Naval Station, constitutes the largest of the Canberra sites currently known to support a population of *S. plana*. The grassland site is log-fenced on three sides with a wire-mesh fence on the west. The footpath area between the fenced site and National Circuit was also included in the study site.

The footpath and park areas immediately outside the fenced site were mown several times during the study period while the enclosed area was unmown and, in parts, the introduced ground cover exceeded one metre in height.

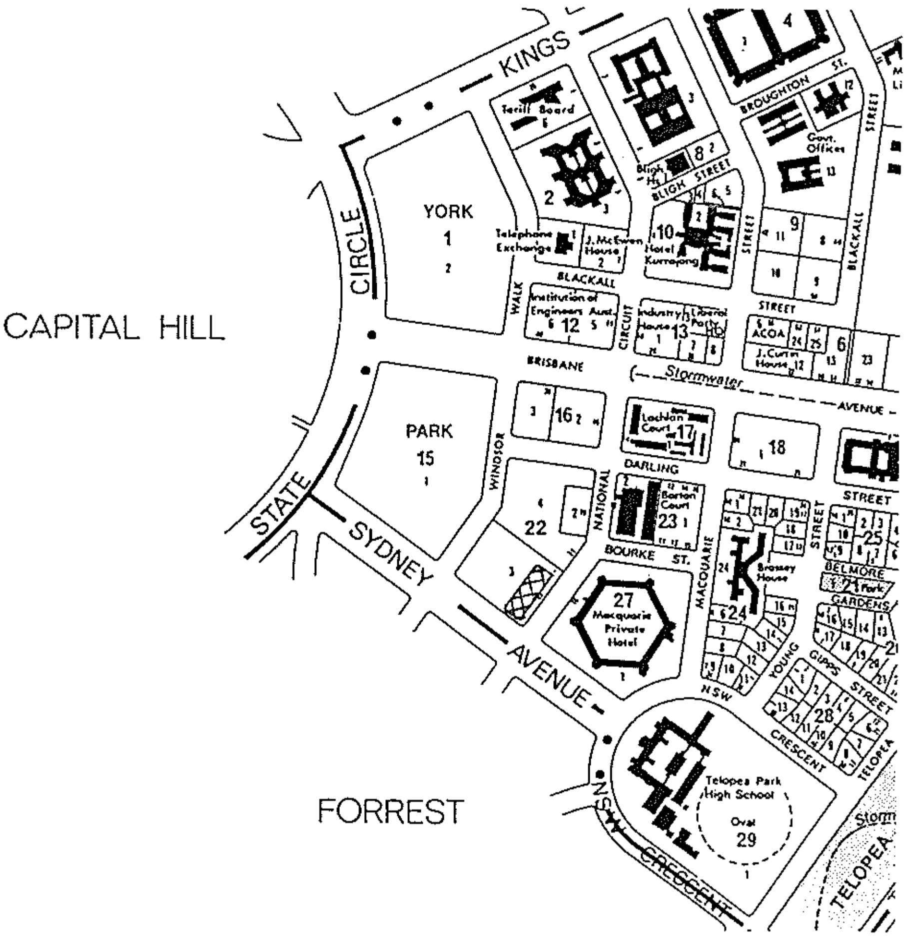

Figure 1.1 Location of the study site. The study site is depicted by the hatched area in Section 22.

2. METHODOLOGY

2.1 Mark-release-recapture

The adult population of *S. plana* on the study site was sampled using mark-release-recapture (MRR) techniques. MRR methods require that individuals from a population be captured and marked, then released. Sampling the population on following occasions allows the determination of the proportion of the population carrying marks and hence an estimate of the number of individuals constituting the population.

The adult population of *S. plana* on the study site was sampled daily over the period during which adults were present. Collection was performed at a time of day when adults were active and usually completed prior to the peak daily period of activity to minimize disruption to mate seeking, mating and oviposition. Collection was conducted for a total search period of one hour per day, which did not include handling and marking time. The site of capture was recorded for each individual.

Moths were marked with nail polish on the underside of the hind wing as recommended by New (1991), the position and colour of the mark/s allowing individual identification. Males were kept in a box until release, not more than an hour after capture. Females were released at their site of capture immediately after marking.

2.2 Section 29 (Barton and Sydney Avenue alignment).

This area was checked on five occasions to investigate whether a previously recorded population of *Synemon plana* remains at the site.

3. RESULTS

3.1 Activity of adults of *Synemon plana*

Adults of *S. plana* emerged later in 1992 than reported for earlier years, possibly in response to the cooler and wetter than average weather experienced in the region throughout the spring. Males were active from as early as 11am (AESST) and as late as 5pm. They were most active during mid-afternoon in dry, warm, bright and windless conditions as they patrolled about a meter above the ground in search of females. Males appeared to detect females visually, attracted by the latter's bright orange hind wings. Males were also attracted to cigarette butts, yellow flowers and broken beer bottles (which glint orange in the sun) and often briefly alighted near these items. Only one female was observed in flight: the others were found resting in the grass, moving between tussocks or flashing their hind wings. Because the chance of detection of males and females probably varies as a result of their behavioural differences, the two sexes were treated separately for population estimates.

3.2 Population Estimates

3.2.1 Males

Adult males of *S. plana* were observed on the study site between November 23rd 1992 and January 31st 1993, a period of 10 weeks. During this period 317 males were captured, 34 of which were captured on more than one occasion (Table 3.1). The majority of recaptures were made on the day after first capture, although one male was recaptured five days after it was first caught. Although adult males were present over a 10 week period, the majority emerged during the four weeks between December 19th and January 15th with a peak towards the end of December (Fig. 3.1). No moths were observed on rainy days and no marked individuals were captured following heavy rain, suggesting that adult males did not survive very wet conditions. Few males were captured in flight on windy or cold days and, on these days, most individuals observed were resting in grass. The days of peak numbers of males occurred during spells of warm dry weather.

Both deaths and emergences of adult males appeared to occur between sampling. The estimated survival rate proved to be constant throughout the study period but exhibited some age-dependency. Under these circumstances, the Manly-Parr method of estimating population would have been preferred except that the rate of recapture was so low as to invalidate this method. Therefore, the Fisher-Ford method of estimating population size was considered the most appropriate for this population (see Begon, 1979).

The Fisher-Ford method estimated the total adult male population of the season to be about 520 (Table 3.1). The daily male population sizes are compared in Figure 3.2. Since a high proportion of the estimated populaton was sampled the sampling error may be as low as 10%. Therefore, the actual number of adult males present in the 10 week period may lie between 468 and 572. Some caution is required, however, since the survival rate may differ from that calculated, due to age-dependent mortality, and the real error may be larger.

3.2.2 Females

Females were first observed five days after the first males and not after January 15th 1993 (Fig. 3.3). Only 35 females were captured during the study period, of which just two were caught on more than one occasion (Table 3.1). The very low recapture rate and low numbers of females caught do not allow MRR estimations of population size.

3.3 Sex Ratio

The observed ratio of males to females among captures was 9:1. Although a strong male bias was also observed in the sex ratio of *S. plana* preyed upon by robber flies (see Sect. 3.5.1), it is probably artifactual. Since the active males are more readily observed than the relatively sedentary females they have a greater chance of being caught. The long grass over most of the site also hindered the sighting of females whose bright orange hind wings are usually not displayed unless a male flies by.

The chromosomal basis of sex determination in Lepidoptera, as in mammals, usually results in a 1:1 sex ratio. Rarely, this sex ratio may be altered in some species through meiotic adjustments or differential mortality of the sexes at various stages of the life cycle. There is no reason to believe that the sex ratio of adults of *S. plana* varies greatly from 1:1. The strong male bias among the moths captured is certainly partly and possibly entirely explained by the fact that the females are very much harder to find than the males because of their sedentary behaviour. Finding females is even more difficult when the grass is as long as in the summer of 1992/93. Most of the females captured were found in areas of short grass.

3.4 Distribution over the site

The sites of capture of males were relatively evenly distributed over the whole of the study site (Fig. 3.4a) and do not appear to fit any of the three vegetation patterns mapped for this site by Davis and Hogg (1992). The distribution of captured males exhibited some change over the course of the study. Prior to December 15th 1992, the majority of captures occurred on the higher and shorter grassed parts of the study site closer to National Circuit (Fig. 3.4b). Later in the study period more captures were made in the longer grass towards the Sydney Avenue end of the study site (Fig. 3.4c). Although males are mobile and the site of capture does not necessarily indicate the site of larval development and adult emergence, the shift in capture sites suggests that the distribution of male emergences from their pupal cases may have changed over time as the soil in different areas warmed and dried at different rates. Alternatively, since males are attracted to females the capture sites of males may have reflected, to some degree, changes in the distribution of females as a result of soil conditions.

The majority of males observed did not fly outside the study site. Occasionally, however, males flew across National Circuit to the nature strip of Sydney Avenue alongside Section 27 (see Fig. 1.1).

One male was followed along Sydney Avenue nature strip for about 100 m towards NSW Cresent before it turned and flew back to the site. Males were observed patrolling the area outside the fence on the Sydney Avenue end of the study site.

The distribution of captured females (Fig. 3.5) does not coincide with the distribution of predominantly native ground cover but more accurately fits the areas of open ground and shortest grass. This pattern probably reflects the greater chance of detection of females in these areas than in areas of taller and more dense ground cover.

3.5 Longevity

One male survived at least five days during cooler climatic conditions (daily maxima about 20°C). The estimated survival rate (0.5), however, suggests that most males live less than two days. There were too few recaptures of females to estimate their longevity.

3.6 Predation

A pair of willy wagtails (*Rhipidura leucophrys*) were observed to take at least 10 males of *S. plana*. The birds swooped on the patrolling moths from vantage points in trees growing in the study site and from the tops of adjacent low buildings. A magpie lark (*Grallina cyanoleuca*) was observed to take a female of *S. plana* from mown grass outside the fenced area.

Robber flies (*Colepia abludo* and *Brachypogon* sp.) were observed feeding on *S. plana* from December 23rd, 1992. Male robber flies were observed to capture males of *S. plana* in flight, rising from long grass as the moth flew over, then giving chase. Forty-five males and two females of *S. plana* were recovered from robber flies.

3.7 Section 29 (Barton and Sydney Avenue alignment)

No *Synemon plana* were observed on this site.

Table 3.1. Summary of mark-release-recapture results

	Males	Females
Total captures	354	37
No. of individuals captured	317	35
Recaptures: One day after first capture	25	2
Two days after first capture	8	0
Three days after first capture	2	0
Four days after first capture	1	0
Five days after first capture	1	0
Estimated population (Fisher-Ford method)	524	not determined

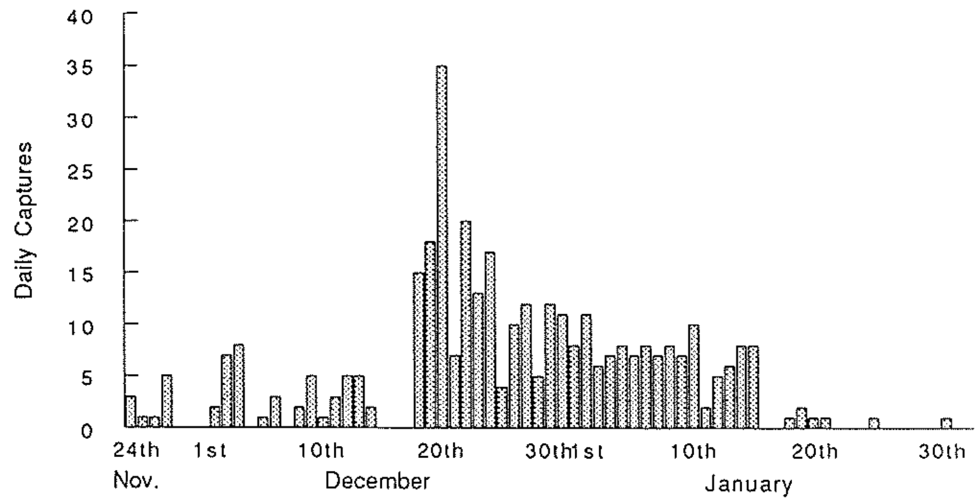

Figure 3.1. The number of males of *Synemon plana* captured each day.

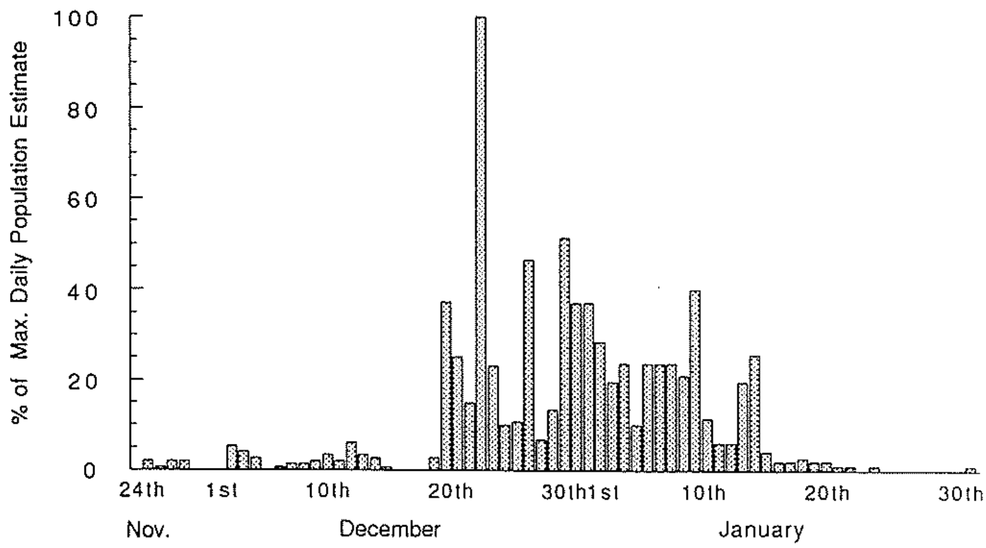

Figure 3.2. The estimated daily male population of *Synemon plana* displayed as a percentage of the maximum estimated daily population.

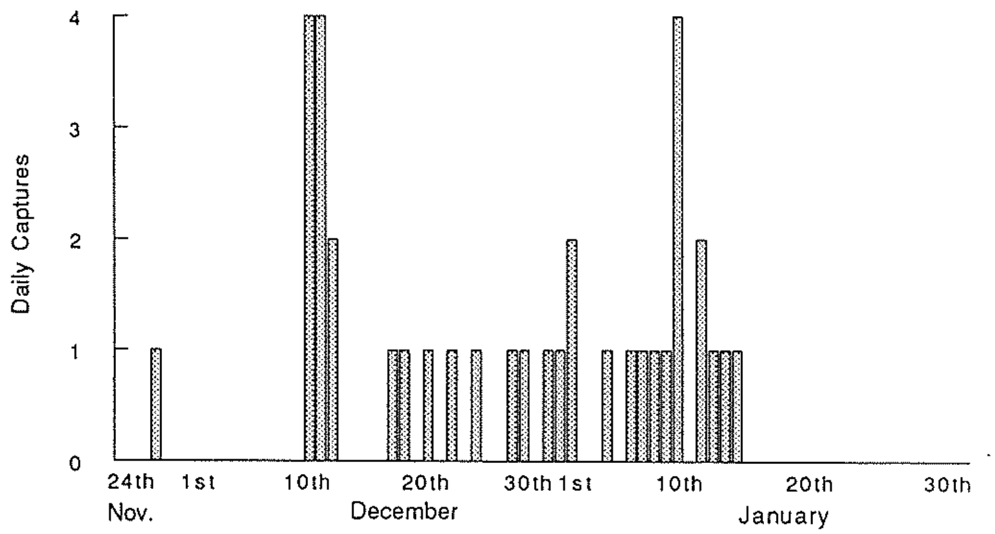

Figure 3.3. The number of females of *Synemon plana* captured each day.

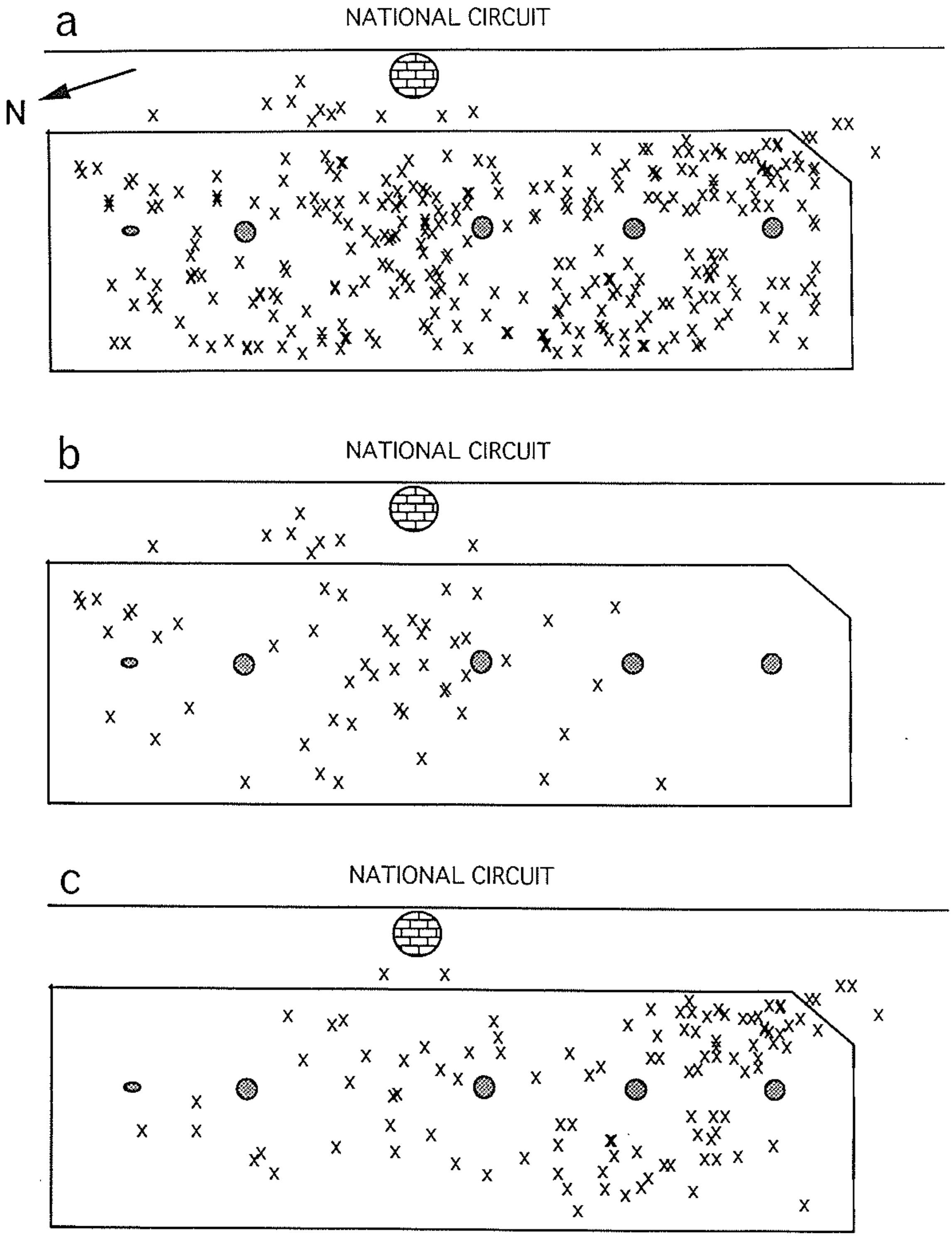

Figure 3.4 (a) The distribution of captures of all males of *Synemon plana* during the study period from November 24th, 1992 to January 31st, 1993. (b) The distribution of captures of males of *Synemon plana* prior to December 15th, 1992. (c) The distribution of captures of males of *Synemon plana* after December 26th, 1992.

tree   bus shelter

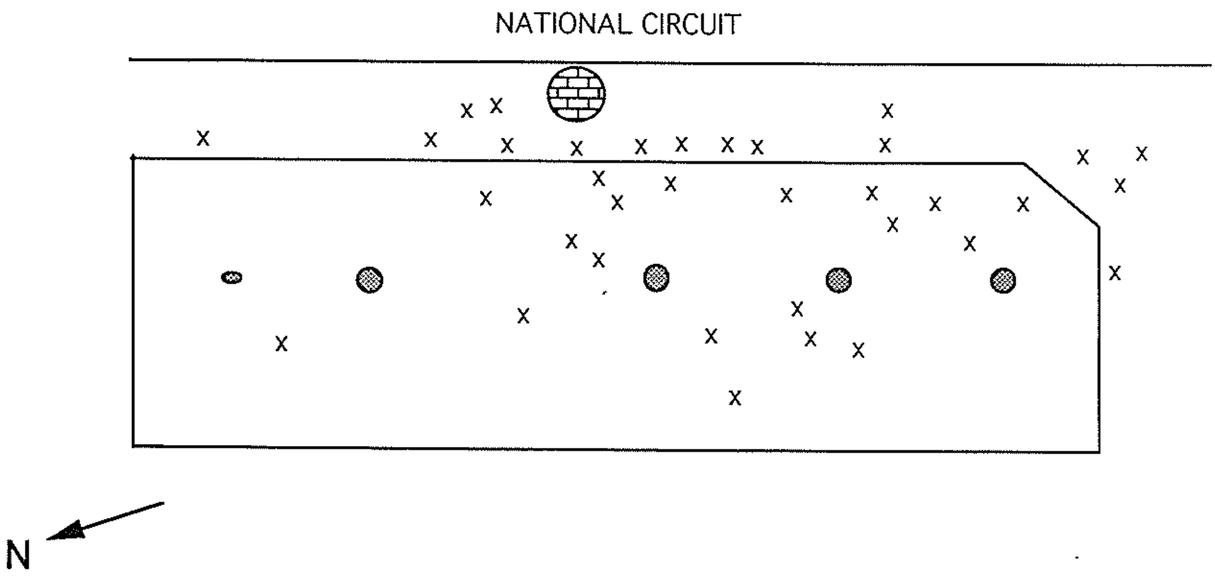

Figure 3.5. The distribution of captures of all females of *Synemon plana* during the study period from November 24th, 1992 to January 31st, 1993. The majority of capture sites correspond with areas of short grass or open ground.

tree bus shelter

4. FURTHER DISCUSSION AND CONCLUSIONS

Assuming that *S. plana* exhibits the usual Lepidopteran sex ratio of 1:1, the adult population may have comprised about 1000 individuals. A moth population of this size should remain viable on the study site as long as there is no further invasion of predators and introduced plants and given favourable climatic conditions. The cooler and wetter than average 1992/93 season may have resulted in less reproductive success than usual.

There is no specific evidence that the effective sex ratio among adults of *S. plana* is 1:1. If the adult sex ratio of *S. plana* does have a strong male bias, the population may be at risk since the number of reproductive females would be a limiting factor in population viability.

The length of the life cycle is also unknown and if maturity takes two years, as occurs in *S. magnifica* (Common and Edwards, 1981), the adult population sampled in 1992/93 may represent only a portion of the total population at the study site.

Capture of males was not confined to regions of predominantly native ground cover but was evenly distributed over the study site. This is probably a result of the mobility of males rather than an indication that pupae were randomly distributed throughout the site. Very few males were observed to fly far from the study site, suggesting that movement between colonies is a rare event. Females were mainly captured in areas of short grass, probably because they were easier to find in these areas.

5. DIRECTIONS OF FURTHER MONITORING

1. The variation in the daily number of captures (Fig. 3.1 and 3.3) suggests that it is necessary to do counts each day during the period over which adults of *S. plana* are present.

2. Monitoring would be greatly assisted if the site were mown in the first five days of November. This may also allow a statistically sound estimate of the female population.

3. The spring and summer of 1992/93 season were cooler and wetter than average. Monitoring should commence earlier when spring is warmer and/or drier. A warmer season may also shorten the period over which adults are present.

4. A major uncertainty in the population estimate is introduced by the lack of knowledge of the length of the life cycle and hence whether all, half or a third of the entire population emerge as adults each year. This may be solved by a study maintaining tussocks of *Danthonia* under natural climatic conditions on which mated females can be induced to lay eggs, then rearing the offspring to maturity. Rearing should also illuminate any deviation from a 1:1 sex ratio. This is a longer term study but until it is completed the interpretation of estimates of the size of the *S. plana* population requires caution.

5. In view of the possibly yearly variation in population size, the unusual weather of the 1992/93 season and the incomplete data on adult sex ratio, monitoring should continue in 1993/94 and possibly longer.

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Report on ACT Lowland Native Grassland Investigation

by Dr Maxine Cooper | Commissioner for Sustainability and the Environment |12 March 2009

Report on ACT Lowland Native Grassland Investigation

by Dr Maxine Cooper
Commissioner for Sustainability and the Environment

12 March 2009

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- Department of Finance and Administration
- Department of Infrastructure, Transport, Regional Development and Local Government
- Department of Territory and Municipal Services
- Department of Treasury
- Emergency Services Australia
- National Capital Authority

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- Professor Arthur Georges (University of Canberra)

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Contents

Executive summary and recommendations

On 15 November 2007 the Australian Capital Territory Minister for the Environment, Water and Climate Change, Jon Stanhope, pursuant to section 12(1) (b) of the *Commissioner for the Environment Act 1993*, directed that I, Dr Maxine Cooper,[1] as the Commissioner for Sustainability and the Environment, undertake an investigation into the Territory's lowland native grasslands.[2]

This investigation has considered 49 lowland native grassland sites in the ACT, on both National and Territory land. These sites are the subject of Australian and ACT Government legislation and have a number of land managers. Complex administrative arrangements exist including memoranda of understanding, licences, leases (including land management agreements) and Conservator's Directions.

Findings and recommendations relating to one site, the Belconnen Naval Transmission Station[3] (referred to as Lawson Commonwealth – Belconnen Naval Transmission Station (BE08(a)) were made public in March 2008. Some recommendations have already been implemented. The report on this site is included as Appendix 1 to this report.

Once this report is given to the Minister, pursuant to section 22 of the *Commissioner for the Environment Act 1993*, the Minister must, within 15 sitting days after the day of receiving the report, present the report or recommendation to the Legislative Assembly.

Lowland native grassland comprises several types of grassland communities; of particular importance is Natural Temperate Grassland, which is one of the Territory's most threatened ecosystems.[4] Only 5% (1,000 hectares) of the estimated 20,000 hectares of Natural Temperate Grassland that existed in the ACT prior to European settlement remains. Nationally, less than 1% of this community remains.[5]

Within lowland native grassland sites, particularly those associated with the Natural Temperate Grassland, the following species can be found:

- Grassland Earless Dragon (endangered under Territory and Commonwealth legislation)
- Golden Sun Moth (endangered under Territory legislation and critically endangered under Commonwealth legislation)
- Striped Legless Lizard (vulnerable under Territory legislation and endangered under

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[1] Dr Cooper was Executive Director, Arts, Heritage and Environment and in this role held the position of Conservator of Flora and Fauna and Chief Animal Welfare Authority. Dr Cooper has not been in this role for over three years. Dr Cooper is currently a member of the Australian Animal Welfare Strategy Advisory Committee.

[2] Lowland native grassland include Natural Temperate Grassland (which has been declared an endangered ecological community in the ACT and nationally) and native pasture derived from Natural Temperate Grassland as per *A Vision Splendid of the Grassy Plains Extended: ACT Lowland Native Grassland Conservation Strategy*, Action Plan No. 28, ACT Government, 2005 (hereafter known as Action Plan No. 28).

[3] *Report on Belconnen Naval Transmission Station (BNTS) Site as part of the Investigations into ACT Lowlands Grasslands*, 26 February 2008.

[4] Natural Temperate Grassland is listed as an endangered ecological community under Territory (*Nature Conservation Act 1980)* and Commonwealth (*Environment Protection and Biodiversity Conservation Act 1999)* legislation.

[5] Action Plan No. 28.

Commonwealth legislation)

- Perunga Grasshopper (vulnerable under Territory legislation)
- Ginninderra Peppercress (endangered under Territory legislation and vulnerable under Commonwealth legislation)
- Button Wrinklewort (endangered under Territory and Commonwealth legislation).[6]

The ACT is fortunate in being in a strong position to be able to advance the protection of lowland native grassland, in particular Natural Temperate Grassland communities and the species it supports, as:

- Significant areas of these communities are afforded protection by being in the Urban Parks and Recreation zone under the *Territory Plan 2008*.[7] An estimated 835 hectares (just under 40%) of the remaining lowland native grassland is in a reserve, therefore having the highest level of protection.
- Legislation and policies exist that afford protection.
- Community groups work on, and promote the need for protecting lowland native grassland.
- Exceptionally skilled native grassland experts are located in Canberra in universities, research institutions and government agencies, and within the community.
- The ACT and Australian governments, private organisations and corporations invest resources in protecting lowland native grassland.

While this is the case, most grassland sites are either in or near Canberra's urban areas, and are fragmented, with connectivity being limited and urban activities frequently adversely affecting them and their associated species. Their location presents land management challenges, which are complicated because of restrictions on actions due to their proximity to urban areas.

Protecting lowland native grassland from development is also a challenge as these areas, being generally flat to gently undulating with no trees, are often prime potential development sites. Much of Canberra's development is on lands that were once lowland native grassland.

Following are recommendations, which if supported, need to be implemented collaboratively by the ACT Government, and the Australian Government, by private agencies and by the community.

Recommendations 21 and 15 need to be given the highest priority and implemented as a matter of urgency, that is, immediately or at least within the next six months, if logistically possible. In the Executive Summary, these recommendations are presented first. The other recommendations are then presented in the order in which they appear in the report, namely:

- Legislation and policy (recommendations 1 to 5)
- Management arrangements (recommendations 6 to 18)

[6] Other threatened plant species are listed in Action Plan No. 28, Table 2.2, page 24.

[7] ACT Planning and Land Authority, Territory Plan March 2008.

- Management issues (recommendations 19 to 21
- Future land use and development (recommendations 22 to 27)
- Adaptive management (recommendations 28 and 29)
- Communication and community awareness (recommendations 30 to 32).

Urgent recommendations

Findings that informed Recommendation 21

Of the Territory's 49 lowland native grassland sites:[8]

- Twenty (40%) are in good condition.
- Twenty (40%) are approaching a critical threshold.[9]
- Ten (20%) are in a critical condition.

Lawson Commonwealth (BE08) site was assessed as two separate areas being Belconnen Naval Transmission Station (BE08(a) (the area behind the secure fence) and Lawson Commonwealth – East (BE08(b) (the area outside the secure fence). Hence the above summary totals 50 instead of 49.

There is an urgent need for land management actions to be undertaken to protect the 60% of the Territory's lowland native grassland sites that are currently in a critical condition or approaching this state. The threatening processes that have caused the demise of the grassland sites include weeds, inappropriate mowing regimes, overgrazing by stock, Eastern Grey Kangaroos[10] and rabbits. The prolonged drought has exacerbated the effect of these processes.

The over abundance of kangaroos[11] is a recent and highly significant threat that has changed the condition of many of the lowland native grassland sites, and likely to adversely affect other sites in the future. It is estimated that a sustainable kangaroo density is approximately one kangaroo per hectare. The most humane methods should be used to reduce kangaroo numbers to achieve this density. This is likely to be shooting. From an animal welfare perspective the most appropriate time to cull is between March and July to avoid the time of year when a high proportion of females are supporting 8- to 12-month-old juveniles. Sectors of the community are likely to find culling at anytime unacceptable. Their views are respected and their submissions to this investigation have been carefully considered; however, there is at present no practical alternative for removing large numbers of kangaroos. Given the limited time for undertaking a cull, the ACT and Australian

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[8] Dr Ken Hodgkinson undertook a field assessment. Based on his work and from discussions with other experts, sites have been classified as good, approaching critical threshold, or being in a critical condition.

[9] Lawson Territory (BE07) site although approaching a critical threshold, is a site that is to be developed. Much of this site is highly degraded, with only small fragmented patches of Natural Temperate Grassland remaining. Accordingly, actions to restore its condition are not appropriate. It needs to be managed, however, so that it does not adversely affect Lawson Commonwealth – Belconnen Naval Transmission Station (BE08(a)).

[10] Hereafter referred to as kangaroos.

[11] The 2007–08 State of the Environment report states that motor vehicle accidents involving kangaroos has increased by 38% (from 563 in 2005–06 to 777 in 2006–07). Rangers have advised that they now attend more than 1,000 roadside kangaroo incidents per year in Canberra. Researchers who undertook an analysis on kangaroos that were culled at Belconnen Naval Transmission Station (BE08(a)) in May 2008, report that the winter of 2008 may have provided a serious threat to the survival of the kangaroos with low marrow fat, had the cull been postponed.

Government departments, who are the relevant land managers, were informed several months ago that there would be a recommendation in this report regarding the need to remove kangaroos from some sites as a matter of urgency. Addressing the over population of kangaroos needs to be given a very high priority.

A Kangaroo Management Plan for the ACT is currently in preparation and will be the subject of consultation.[12] While this is the case, removal of kangaroos should not be delayed, pending adoption of this plan. Existing polices and procedures should be used to guide needed field actions. The Kangaroo Management Plan should, however, be progressed as quickly as possible to guide field and other actions in 2010 and beyond.

Recommendation 21: Improve the ecological condition of sites that are in a critical condition or approaching this state, by reducing current threatening processes of weed invasion, inappropriate mowing and overgrazing by stock, rabbits and kangaroos as a matter of urgency, specifically:

In Majura Valley:

- Grazing pressure should be reduced by:
  - Reducing the number of kangaroos on 'Malcolm Vale' (MA04) and Majura West (MA06). There is also a need to continue to manage kangaroos on the Majura Training Area (MA01) while not detrimentally affecting adjacent native woodland.
  - Strategically managing (and in the short-term temporarily removing) stock and controlling rabbits on Majura West (MA06).
- Weed management controls should be enhanced on Majura Training Area (MA01) and 'Malcolm Vale' (MA04).

(Strategically located temporary kangaroo management fencing should be considered for placement around Campbell Park (MA05) and possibly parts of Majura West (MA06) if the stock and kangaroo densities in this general area are not reduced within the next six months. This is a temporary measure to protect the Grassland Earless Dragon habitat.)

In Jerrabomberra Valley:

- Grazing pressure should be reduced by:
  - Reducing the number of kangaroos on Jerrabomberra East Reserve (JE05).
  - Strategically managing (and in the short-term temporarily removing) stock and controlling rabbits on 'Cookanalla' (JE08).
- Weed management controls should be enhanced on Harman Bonshaw South (JE06) and Harman Bonshaw North (JE07).

In Gungahlin:

- Grazing pressure should be reduced on Crace Nature Reserve (GU03) by:
  - Reducing the number of kangaroos.

[12] Pers. comm., Mr Russell Watkinson, 6 January 2009.

- Strategically managing (and in the short-term temporarily removing) stock and controlling rabbits.

- Weed management controls should be enhanced on Crace Nature Reserve (GU03), at Wells Station Road (GU07) and Nicholls (GU08).

In Belconnen:

- Grazing pressure should be reduced by:
  - Strategically managing (and in the short-term temporarily removing) stock and reducing the number of kangaroos and controlling rabbits on Dunlop Nature Reserve (BE02) and 'Jarramlee' (BE03).
  - Reducing the number of kangaroos on Ginninderra Experimental Station (BE01).
  - Reducing the number of kangaroos and controlling rabbits on Caswell Drive (BE10). Given the size and location of this site, it may be necessary to reduce the number of kangaroos on land in the vicinity of this site rather than concentrating only on this site
- Weed management controls should be enhanced on Umbagong Park North (BE04(b)), and in the areas of Lawson Territory (BE07) that may affect the Lawson Commonwealth – Belconnen Naval Transmission Station (BE08(a)) site.

In Canberra Central:

- Weed management controls should be enhanced on York Park, Barton (CC05); Yarramundi Reach (CC06); Lady Denman Drive, Yarralumla (CC07); Dudley Street, Yarralumla (CC08); and Guilfoyle Street, Yarralumla (CC09).
- Mowing regimes should be revised to enhance grassland conservation for Lady Denman Drive, Yarralumla (CC07); Dudley Street, Yarralumla (CC08); Guilfoyle Street, Yarralumla (CC09); Novar Street, Yarralumla (CC10); and Black Street, Yarralumla (CC11).

Findings that informed Recommendation 15

The 'Cookanalla' (JE08) site, a rural lease, has reached its current degraded state without action being taken by the relevant government department to enforce compliance with the conditions in the Land Management Agreement, which is part of its rural lease (*see* Section 3 Management arrangements).

Recommendation 15: Immediately enforce the provisions and conditions in the land management agreement, which is a part of the rural lease for 'Cookanalla' (JE08).

Other recommendations

Legislation and policy

Findings that informed Recommendation 1

The Territory's planning and nature conservation legislation needs to be streamlined. Some land management matters, such as management plans, are covered in planning legislation; these may be better placed under nature conservation legislation.

Recommendation 1: Streamline ACT Government planning and nature conservation legislation to ensure all land management matters are covered by the *Nature Conservation Act 1980* (ACT) (currently under review).

Findings that informed Recommendation 2

This investigation found limitations in the level of protection that could be secured for Natural Temperate Grassland under the *Environmental Protection and Biodiversity Conservation Act 1991* (Cwlth). Submissions were invited as part of the Commonwealth's review of this legislation. The Commissioner's Office made a submission, which recommended, among many things, that this Act should:

- facilitate consideration of cumulative impacts of proposed developments, on listed and non-listed communities and species, with respect to referrals to the department for assessment
- be triggered by 'no action', that is, not undertaking needed land management actions
- identify the best option for protecting a listed community or species rather than only assessing the presented option
- strongly foster compliance and enforcement activities.

Recommendation 2: The *Environmental Protection and Biodiversity Conservation Act 1991* (Cwlth) should be strengthened so sites and species are more effectively protected and managed.

Findings that informed Recommendation 3

The ACT is unique in having a Conservator of Flora and Fauna whose powers can be used to afford extra protection to specific sites or species. The Conservator's role and functions are broad and it is possible for the Conservator of Flora and Fauna to be the same officer who is responsible for undertaking land management functions on Territory Lands. The legislation that creates the Conservator of Flora and Fauna, the *Nature Conservation Act 1980* (ACT), is currently under review. It is understood that as part of this review issues associated with the Conservator's role and functions will be part of a public discussion paper.

Given that 60% of the Territory's lowland native grassland sites need urgent land management action, it is important that the Conservator have powers to direct that appropriate land management actions be undertaken.

Recommendation 3: As part of the current review of the *Nature Conservation Act 1980* (ACT), ensure that lowland native grassland, in particular Natural Temperate Grassland ecosystems are protected by the Conservator of Flora and Fauna having powers to direct, when necessary, that land management actions be undertaken.

Findings that informed Recommendation 4

To help determine appropriate long-term land use for some lowland native grassland sites, the heritage status of lowland native grassland sites that have been nominated for heritage listing needs to be resolved. The sites nominated for inclusion on the ACT Heritage List (those also nominated on the *Commonwealth Heritage List* are listed in *italics*):

- Majura Training Area (MA01), Air Services Beacon (MA02), Canberra International Airport (MA03), 'Malcolm Vale' (MA04), *Campbell Park* (MA05), *Majura West* (MA06), '*Callum Brae'* (JE02), *Jerrabomberra West Reserve* (JE03), *Jerrabomberra East Reserve* (JE05), *Harmon Bonshaw South* (JE06), Harmon Bonshaw North (JE07), Lawson Territory (BE07), Lawson Commonwealth (BE08(a) and (b)), Kama South (BE12), Black Street, Yarralumla (CC11).

Recommendation 4: Resolve the heritage status of lowland native grassland sites, in a timely manner, to assist long-term planning.

Findings that informed Recommendation 5

Since the gazettal of the *Nature Conservation Act 1980* (ACT), some innovative approaches for managing and strategically protecting ecosystems have emerged. While it is beyond the scope of this investigation to examine these, they should be considered as part of the review of the *Nature Conservation Act 1980* (ACT).

Recommendation 5: As part of the current review of the *Nature Conservation Act 1980* (ACT), ensure that lowland native grassland, in particular Natural Temperate Grassland, ecosystems are protected by innovative mechanisms such as conservation leases, voluntary agreements, bio-banking and offsets are investigated and progressed.

Management arrangements

Findings that informed Recommendation 6

Significant areas of lowland native grassland are located on lands held by Australian Government departments or private agencies. One means of fostering communication and integration of activities between departments and agencies is through development and implementation of memorandum of understanding. Significant effort went into developing memoranda of understanding in 1998; however, it appears implementation was limited. A reason for this may have been lack of an across–department/agency coordination group. Given the challenges in managing lowland native grassland sites that all departments and agencies currently confront, it seems timely to update existing memoranda of understanding and focus on their implementation.

The ACT Government currently has memoranda of understanding with:

- **Department of Defence** for Majura Training Area (MA01), Malcolm Vale (MA04), Campbell Park (MA05), Harmon-Bonshaw South (JE06), Harmon-Bonshaw North (JE07), part of Crace Nature Reserve (GU03), Lawson Commonwealth (BE08(a) and (b))
- **National Capital Authority** for Yarramundi Reach (CC06), Lady Denman Drive (CC07) (part National Land), and Guilfoyle Street, Yarralumla (CC09)
- **CSIRO** for CSIRO Headquarters, Campbell (CC01) and Ginninderra Experimental Station (BE01).

The Australian Government Department of the Environment, Water, Heritage and the Arts is a signatory to each.

In updating memoranda of understanding with the National Capital Authority, to ensure requirements under the National Capital Plan are met, those grassland sites on Territory Land that are Designated Areas – Kaleen East Paddocks (BE09); Caswell Drive (BE10);

Glenloch Interchange (BE11); Constitution Avenue, Reid (CC02); St John's Church, Reid (CC03); Australian Centre for Christianity and Culture (CC04); Lady Denman Drive, Yarralumla (CC07); Dudley Street, Yarralumla (CC08); Novar Street, Yarralumla (CC10); and Black Street, Yarralumla (CC11) – should be included.

Recommendation 6: Existing memoranda of understanding between the ACT Government and Department of Defence, the National Capital Authority and CSIRO, with the Department of Environment, Water, Heritage and the Arts being a signatory, should be updated and implemented.

Findings that informed Recommendation 7

There is also an opportunity to development memoranda of understanding between the ACT Government and the Department of Finance for York Park, Barton (CC05); Air Services Australia for Air Services Beacon (MA02); and the Canberra Airport Group for Canberra International Airport (MA03). The Department of Environment, Water, Heritage and the Arts needs to be a signatory to each of these memoranda of understanding.

Recommendation 7: Develop memoranda of understanding between the ACT Government and the Department of Finance, Air Services Australia and the Canberra Airport Group, with the Department of Environment, Water, Heritage and the Arts being a signatory.

Findings that informed Recommendation 8

A coordination and implementation group needs to be established to ensure implementation of memorandum of understanding.

Recommendation 8: Establish a memorandum of understanding coordination and implementation group with an ACT Government agency being the lead agent.

Findings that informed Recommendation 9

Management plans need to be amended to reflect recent changes and afford greater protection to lowland native grassland.

Recommendation 9: Amend the *Canberra Nature Park Management Plan* (1999) to incorporate:

- Action Plan No. 28, *ACT Lowland Native Grassland Conservation Strategy* (2005)
- the new nature reserves of 'Callum Brae' (part JE02), Jerrabomberra West Reserve (JE03), Jerrabomberra East Reserve (JE05).

Findings that informed Recommendation 10

While several policy and planning documents pertaining to lowland native grassland exist, not all sites are subject to annual site operation plans, or their equivalent, to guide field actions. These plans are important in assisting staff, particularly in large organisations where staff rotations may occur.

Parks Conservation and Lands (Department of Territory and Municipal Services) has developed annual action spreadsheets and management specifications for some sites, both of which are essentially annual site operation plans. These should be used as a model in developing plans for all sites. A cooperative approach between land managers, lessees and

Australian Government and Territory agencies is needed for these to be uniformly adopted and implemented.

Recommendation 10: Develop and implement annual site operation plans for all lowland native grassland sites.

Findings that informed Recommendation 11

An area of Natural Temperate Grassland (Lake Ginninderra (BE06) site) adjoining Lake Ginninderra could be afforded a higher level of protection through being managed under a Plan of Management.

Recommendation 11: Amend the Belconnen Urban Parks, Sportsgrounds and Lake Ginninderra Plan of Management to include the lowland native grassland site of Lake Ginninderra (BE06).

Findings that informed Recommendation 12

From discussions with staff in relevant agencies it seems that the time involved in administering agistment licences could be reduced if these were standardised, including termination dates and if one government agency only was the government signatory to these agreements.

Recommendation 12: Simplify administration of agistment licences covering lowland native grassland sites through standardising their conditions, including termination dates; and have one government agency signatory to an agistment lease.

Findings that informed Recommendations 13

Confusion between some Department of Territory and Municipal Services and ACT Planning and Land Authority staff is apparent over who is accountable for administering Land Management Agreements that support rural leases. The process for administering leases (including land management agreements) is complex and involves both Territory and Municipal Services and ACT Planning and Land Authority staff. This complexity may have led to confusion regarding accountability for enforcement of the conditions in the Land Management Agreement for 'Cookanalla' (*see* Recommendation 15). Given the role of Parks Conservation and Lands (Department of Territory and Municipal Services) it seems appropriate for them to be fully responsible for administering land management agreements.

Recommendation 13: Ensure rural lease processes (including those for land management agreements) are simplified and responsibilities are clarified.

Findings that informed Recommendations 14

Parts of Crace Nature Reserve (GU03) and Caswell Drive (BE10) have rural leases that are managed under land management agreements. Given that these land management agreements have not been reviewed within the required five-year period and these sites are in a critical condition, a review of the conditions in the land management agreements is needed. Once this is done, compliance with the conditions in the land management agreement should be monitored to ensure their implementation.

Recommendation 14: Review the land management agreements covering Crace Nature Reserve (GU03) and Caswell Drive (BE10).

Findings that informed Recommendation 16

Conditions in land management agreements (attached to rural leases) are potentially a powerful mechanism for protecting lowland native grassland areas on leased rural land. However, for their benefit to be realised the conditions must be implemented. Accordingly, the government department responsible for administrating land management agreements needs to monitor compliance and take enforcement action if needed. In this investigation no information was available that indicated that any action had been taken to monitor compliance with, or enforce conditions in the land management agreement for 'Cookanalla' (JE08), a site that needs land management actions to restore its ecological conditions.

Recommendation 16: Foster a strong culture of compliance, monitoring and enforcement within the government department responsible for administering land management agreements.

Findings that informed Recommendations 17

Land management agreements need to be monitored and assessed in order to ensure the required on-the-ground actions are achieving the desired ecological results. There was no evidence of a formal monitoring, assessment or auditing process being in place. Furthermore, information from such a process could be used to help the ACT Government's Flora and Fauna Committee advise on policy issues and monitor implementation of the ACT Government's, 2005 *A Vision Splendid of the Grassy Plains Extended: ACT Lowland Native Grassland Conservation Strategy*, Action Plan No. 28.

Recommendation 17: Establish a formal monitoring, assessment and auditing process aimed at ensuring conditions in land management agreements achieve the desired ecological results.

Findings that informed Recommendation 18

Grazing is an important land management tool currently used to control grassland biomass. However, if this is used inappropriately it can adversely affect the lowland native grassland ecology. Grazing should, therefore, be undertaken as part of the conservation management strategy within an adaptive management process to protect lowland native grassland sites.

Recommendation 18: Permit grazing under rural leases and licences, on lowland native grassland sites if it is part of a long-term conservation management strategy.

Management issues

Findings that Informed Recommendation 19

While not researched fully, it is generally believed that fire enhances grassland diversity to a greater extent than grazing or mowing. Compared with fire, both grazing and mowing are more likely to introduce weeds into a site, or spread them within a site. However, ecological burns are not undertaken as a routine part of managing grasslands within the ACT. As the use of fire is not fully researched, and as lowland native grassland areas are primarily in or near Canberra's urban areas resulting in logistical challenges for undertaking burns, it is recommended that some experimental burns be undertaken to inform decisions about a wider use of fire.

Potential sites for consideration for an ecological burn program are: Air Services Beacon (MA02); Constitution Avenue, Reid (CC02); St John's Church, Reid (CC03); Australian Centre for Christianity and Culture, Barton (CC04); Yarramundi Reach (CC06); Guilfoyle Street, Yarralumla (CC09); Umbagong Park South, Florey (BE04a); Umbagong Park North, Florey (BE04b); Lawson Commonwealth – East (BE08(b)); Evatt Footbridge; Isabella Pond, Monash (TU01); and Mitchell (GU05).

Recommendation 19: Undertake experimental ecological burns on selected sites to determine the appropriateness of a wider application for managing lowland native grassland sites in the ACT.

Findings that informed Recommendation 20

Two of the most threatening processes that usually affect lowland native grassland sites in the ACT are insufficient weed control and inappropriate mowing regimes (*see* Appendix 10).

Recommendation 20: Give priority to weed management and implementing appropriate mowing practices as part of routine work programs.

Future land use and development

Findings that informed Recommendation 22

Lowland native grassland sites, being located in, or close to, Canberra's urban areas and relatively easy to develop, are frequently considered for their development potential. Often when making development decisions these sites are considered in isolation. A strategic approach across the ACT is needed to give the highest level of protection to those lowland native grassland sites with the highest ecological values, provide connectivity between these sites, and foster appropriate development. This approach needs to involve identification of the long-term land uses for all lowland native grassland sites, and use of offsets to allow development of others. Given that there may be difficulties in always having a 'like for like' replacement, offsets that involve the use of offset restoration sites[13], funding research or restoration programs should be considered.

The ACT and Australian governments have enacted legislation that facilitates protection of lowland native grassland areas and species, particularly those listed as threatened; and both these Governments own lands that have significant lowland native grassland areas. Therefore, both governments need to agree on a strategic approach to protect these grassland sites for this to be effectively implemented.

Recommendation 22: The ACT Government and the Australian Government commit to taking a strategic approach to protecting lowland native grassland, in particular Natural Temperate Grassland, threatened grassland species and fostering sustainable development by:

- Giving priority to protecting all Category 1: Core Conservation Sites that contain

[13] Offset restoration sites are strategically selected areas for undertaking on-the-ground field restoration activities. It will not necessarily be ecologically beneficial to have an offset within the same locality as the site that is developed.

Natural Temperate Grassland and key threatened grassland species, and ensuring that these areas are not affected by development proposals.

- Placing in a reserve, where appropriate, Natural Temperate Grassland sites in Category 1: Core Conservation Sites. If this is not possible, these grassland areas and associated species should be conserved and managed as if they were in a reserve.
- Integrating conservation values with development considerations for all Category 2: Complementary Conservation Sites and Category 3: Landscape and Urban Sites and ensuring connectivity is retained or enhanced.
- Developing an offset policy (that includes identification of offset restoration sites) for loss of lowland native grassland, particularly Natural Temperate Grassland, due to development.

Findings that informed Recommendation 23

Within the ACT four main locations – Majura Valley, Gungahlin, Belconnen, Jerrambomberra Valley – still have large, intact lowland native grassland sites. The ACT Government has strategically committed to reserve lands it owns that have Natural Temperate Grassland and are Category 1: Core Conservation Sites. The largest sites in Gungahlin and Jerrabomberra Valley are already in reserve. It has also negotiated with the Commonwealth for a Core Conservation Site, that is, the Lawson Commonwealth – Belconnen Naval Transmission Station (BE08(a)), to be planned as a reserve. Majura Valley's large, intact lowland native grassland area, which consists of a number of sites under the control of various government agencies, does not have long-term planning protection; it is not in a reserve and there is no commitment for this to occur.

Given the significance of the Majura Valley grassland, arguably one of the largest areas of Natural Temperate Grassland remaining in southeast Australia, the presence of five threatened species including the Grassland Earless Dragon, it is strongly recommended that a commitment be made to create a reserve in this locality. This proposed reserve should be defined in the near future and include part of the Majura Training Area (MA01), and potentially parts of Air Services Beacon (MA02) and 'Malcolm Vale' (MA04). Connectivity with the Canberra International Airport (MA03) will be particularly important in protecting the Grassland Earless Dragon. As current land uses on these sites, if managed effectively, are compatible with sustaining the ecological values of the grassland, areas nominated for inclusion in the proposed reserve could continue being used for their current purposes and managed by the existing land managers.

While defining the site of the proposed Majura Valley reserve would constrain future development options, for example, the potential Canberra International Airport northern link road and the potential east-west Kowen road, it would provide a more certain context for potential developments. It would also ensure that the Natural Temperate Grassland, the Grassland Earless Dragon and other threatened species are not adversely affected through incremental developments, as would be the case if the potential Canberra International Airport northern link road and the potential east-west Kowen road were to be progressed according to existing concept plans.

The lands for the proposed reserve could be the subject of a formal conservation agreement between the ACT and Australian governments.

Recommendation 23: Plan a Majura Valley Reserve to protect Natural Temperate Grassland and its supporting species, particularly the Grassland Earless Dragon, by defining the boundaries of this proposed reserve in the near future.

Findings that informed Recommendation 24

Campbell Park (MA05) in the Majura Valley is a small parcel of Commonwealth land in good condition that contains Natural Temperate Grassland, has a population of the Grassland Earless Dragon and is classified as a Core Conservation Site. It adjoins Majura West (MA06), Territory Land, which is a large area that contains the endangered Grassland Earless Dragon. Majura West (MA06) is an important ecotone (where the two ecosystems of lowland native grassland and Yellow–Box Red Gum Grassy Woodland merge), is the only Category 1: Core Conservation Site that does not contain Natural Temperate Grassland, and lends itself to being an offset restoration site for actions to be implemented to improve the habitat of the Grassland Earless Dragon.

Majura West (MA06) is contiguous with Campbell Park (MA05) and Mount Ainslie Reserve. From information considered in this investigation, it appears that potential developments in the Majura Valley have been planned to avoid these areas. Given this and their ecological value it seems appropriate for all or parts of these sites to be included in Mount Ainslie Reserve.

Recommendation 24: Expand the Mount Ainslie Reserve to include areas of lowland native grassland in Campbell Park (MA05) and Majura West (MA06).

Findings that informed Recommendation 25

Caswell Drive (BE10) and Glenloch Interchange (BE11) are Territory Lands that contain small areas of Natural Temperate Grassland and have been classified as Category 1: Core Conservation Sites. These are currently managed under a rural lease and as a roadside. Given their ecological value, amalgamation with nearby reserves would offer long-term protection.

Recommendation 25: Expand Aranda Bushland and Black Mountain Reserve by including areas of lowland native grassland in Caswell Drive (BE10) and Glenloch Interchange (BE11).

Findings that informed Recommendation 26

There is a need to clarify the long-term land use for some lowland native grassland sites. This investigation found that the condition of some sites suggests that their ecological value may have declined to such a degree that they may need to be reassessed. These sites need to be subjected to an ecological assessed in the appropriate season/s.

In determining the long-term land use of lowland native grassland sites it is important to consider how best to strategically protect lowland native grassland, particularly Natural Temperate Grassland and threatened species, and also develop Canberra. Retaining some small areas of grassland may be appropriate in some circumstances, but not in others. Where retention on a site is inappropriate an offset, for example, undertaking restoration activities on another grassland site or funding research, should be required. It is likely that in many circumstances there will be benefit in having offsets undertaken in a strategic manner by nominating specific offset restoration sites. Recommendations 5 and 22 promote the development of an offset policy (that includes identification of offset restoration sites). Possible offset sites include:

- Majura West (MA06) to enhance its habitat to better support the Grassland Earless Dragon
- Yarramundi Reach (CC06), Caswell Drive (BE10) and Glenloch Interchange (BE11) to enhance the overall grassland quality.

Depending on the land use for 'Cookanulla' (JE08), this site may also be appropriate as an offset site.

Recommendation 26: Define the long-term land use for lowland native grassland sites, while strategically protecting lowland native grassland, particularly Natural Temperate Grassland, and progressing appropriate developments, specifically:

- 'Callum Brae' (part JE02) – excluding the land swap site. The areas of ecological connectivity need to be defined. Areas of ecological connectivity could be managed under a conservation lease or, depending on location, amalgamated with the adjoining rural lease. If development occurs, an offset should be required.
- 'Cookanalla' (JE08) – a Grassland Earless Dragon survey is needed in conjunction with a survey to identify habitat that would support this species. Given the condition of the site, it may be appropriate to undertake surveys when the site has recovered, at least to some degree, from its current threatening processes. This site appears to lend itself to a land use that integrates conservation values with development. If areas of grassland are developed an offset should be required.
- AMTECH (JE09) – reassess the site's ecological values as these may have changed. If this site no longer meets criteria for its current classification as a Category 2: Complementary Conservation Site and changes to Category 3: Landscape and Urban Sites, its development potential could be realised. If areas of grassland are developed an offset should be required.
- Kaleen East Paddocks (BE09) – reassess the site's ecological values, as they were not obvious at the time of inspection. If these values still exist and development were to occur, given the likelihood that there is only a small area of Natural Temperate Grassland remaining, this may be able to be integrated with any future developments.
- Lawson Commonwealth – East (BE08(b)) – Given the overall context of this site it appears to lend itself to a land use that integrates conservation values with development. An offset should be required if areas of grassland are developed.
- Constitution Avenue, Reid (CC02) – If a decision is made to develop the Natural Temperate Grassland area, an offset should be required.

Findings that informed Recommendation 27

During the investigation, the Commissioner's Office found it difficult to identify the location of lowland native grassland sites relative to planning zones that guide land use. To help the community and developers gain information on grassland sites relative to planning zones it is recommended that a map of the location of lowland native grassland sites relative to planning zones be published.

Recommendation 27: Publish a map that shows the location of lowland native grassland sites relative to planning zones. This should be readily available through the ACT Planning and Land Authority and the Department of Territory and Municipal Services.

Adaptive management

Findings that informed Recommendation 28

Only 40% of the Territory's lowland native grassland sites are in good condition. This percentage may have been higher if an adaptive management approach had been used to manage all sites. An adaptive management approach is designed to improve environmental management by learning from results. It uses management actions as the primary tool for learning about the system being managed. An adaptive management approach focuses on achieving field results through, among other things, regular site inspections and monitoring (this could include photographic recordings), using research findings to inform management practices, undertaking controlled and monitored experiments, such as, reintroducing targeted species (plants and animals).

An adaptive management approach relies on regular site inspections and routine monitoring, something that was not being undertaken for many of the Territory's sites. Without regular site inspections and monitoring, threatening processes can go undetected until damage becomes obvious, at which stage the effort and resources needed to restore a site may be significant.

Recommendation 28: Use adaptive management to guide land management so that sites in good condition (40%) are maintained, and those in a critical condition (20%) or approaching a critical condition (40%) are restored.

Findings that informed Recommendation 29

The North Belconnen Landcare Group has nominated an area near the Evatt Footbridge as a lowland native grassland site. This site needs to be assessed before it is considered for designation as lowland native grassland.

During the investigation it was found that the ecological values on some sites may have changed and therefore these sites need to be reassessed to determine their appropriate classification. These sites are Wells Station Road (GU07); Nicholls (GU08); Novar Street, Yarralumla (CC10); Belconnen Pony Club (GU06); Lawson Commonwealth – East (BE08(b)); and Mitchell (GU05).

Recommendation 29: Assess the ecological values of Evatt Footbridge; Wells Station Road (GU07); Nicholls (GU08); Novar Street, Yarralumla (CC10); Belconnen Pony Club (GU06),; Lawson Commonwealth – East (BE08(b)); and Mitchell (GU05).

Communication and community awareness

Findings that informed Recommendation 30

Many stakeholders, researchers and experts were concerned about not having the opportunity to meet with each other and land managers, as a group, to share information. This could be overcome by conducting an annual community and stakeholder forum to, among other things coordinate research, monitoring and data collection, and raise awareness. The Commissioner's Office would be willing to convene the initial forum.

Recommendation 30: Conduct an annual community and stakeholder lowland native grassland forum to, among other things, coordinate research, monitoring and data collection, and raise awareness.

Findings that informed Recommendation 31

There is a wealth of information and expertise in the Capital region on lowland native grassland, but it is dispersed and therefore difficult to access. This difficulty could be addressed by establishing an accessible central register of information on lowland native grassland that includes current research and studies. This could be made available through a website.

Recommendation 31: Establish an accessible central register of information and expertise on lowland native grassland.

Findings that informed Recommendation 32

While in some spheres, community awareness of the importance of the ecological value of lowland native grassland and the species it supports has increased significantly over the past 15 years, awareness within the general public still appears limited. Awareness could be increased, for example, by:

- placing signage with interpretative material at key sites, such as Canberra International Airport (MA03); St John's Church, Reid (CC03); Australian Centre for Christianity and Culture, Barton (CC04); 'Callum Brae' (JE02); Jerrabomberra West Reserve (JE03); Jerrabomberra East Reserve (JE05); Mulanggari Nature Reserve (GU01); Gungaderra Nature Reserve (GU02); Crace Nature Reserve (GU03); North Mitchell (GU04); and Dunlop Nature Reserve (BE02)
- promoting sites as part of the Territory's Tracks and Trials Heritage Interpretative Tour
- encouraging use of lowland native grassland in restoration and rehabilitation projects following development activities such as new suburbs and road construction
- encouraging use of native grasslands to replace lawns and gardens in private and public places, which could lead to lower ongoing maintenance costs and reduced water use
- adopting a patron for Natural Temperate Grassland and endangered grassland species.

Recommendation 32: Increase community awareness of the importance of lowland native grassland, in particular Natural Temperate Grassland and the endangered grassland species.

Specific recommendations for Belconnen Naval Transmission Station (BE08(a)) site

Findings and recommendations for Lawson Commonwealth – Belconnen Naval Transmission Station (BE08(a)) site were made public in March 2008. Some recommendations have been progressed (*see* Section 1.4 of this report) the government is yet to formally respond to these recommendations.

1 Introduction

1.1 Terms of reference

On 15 November 2007 the then Australian Capital Territory Minister for the Environment, Water and Climate Change, Jon Stanhope, pursuant to section 12(1) (b) of the *Commissioner for the Environment Act 1993*, directed that I, as the Commissioner for Sustainability and the Environment, undertake an investigation into the lowland native grassland in the ACT, and specified the Terms of Reference (*see* box).

TERMS OF REFERENCE FOR THE INVESTIGATION

The ACT Government has prepared a number of significant strategies for the conservation of grasslands and woodland. The Lowland Native Grassland Conservation Strategy and the Lowland Woodland Conservation Strategy along with the Aquatic Species and Riparian Zone Conservation Strategy, provide a strong framework for planning and management of the key threatened ecological communities in the ACT and species that are dependent upon them.

In recent months the ACT Government has become extremely concerned about the deterioration of some of our significant lowland native grasslands, particularly at Majura, Belconnen, Jerrabomberra and Gungahlin.

An inquiry into the situation is required under the following Terms of Reference:

(1) Review existing management arrangements, and if necessary, identify comprehensive conservation management principles and immediate actions to ensure the protection and long-term sustainability of native lowland grasslands and their vulnerable ecosystems.

(2) Identify the causes of the deterioration of lowland native grasslands. In doing this, the impact of eastern grey kangaroos, both in the long and short term, is to be explicitly addressed.

(3) Identify any impediments to implementing short and long-term management practice for conservation of lowland grasslands within the ACT. In doing this, identify any deficiencies (including development controls, data collection, monitoring and reporting programs), which need to be remedied to further protect native lowland grasslands, their vulnerable ecosystems and associated fauna adequately.

(4) Identify ways for ensuring effective communication with stakeholders, whose actions potentially, indirectly or directly affect, threatened grasslands.

(5) Determine whether any policy/legislative changes are needed for the protection of threatened lowland native grasslands.

The Commissioner is to consult with all relevant experts and key stakeholders, including the Department of Territory and Municipal Services, to canvas measures needed to ensure the long term sustainability of native lowland grasslands.

Commissioner's comment: Following release of the above terms of reference some stakeholders sought clarity regarding the scope of the inquiry/investigation, in particular the inclusion of the Grassland Earless Dragon, the Striped Legless Lizard and the Golden Sun Moth. I was advised by the Minister, letter dated 29 November, that the investigation of lowland native grasslands should include their associated threatened communities and species, as well as threats to, and identification of measures for protecting these, and other species are an inherent part of the Terms of Reference. Accordingly the specific species mentioned above are included.

This investigation has followed the Terms of Reference and these have been addressed throughout this report.

1.2 Lowland native grassland

Natural Temperate Grassland is one of Australia's most threatened ecosystems.[14] It is estimated that 20,000 hectares of Natural Temperate Grassland occurred in the ACT before European settlement. Approximately 5% (1,000 hectares) of the estimated original area of 20,000 hectares of grassland remains in the ACT and nationally, less than 1% of this community remains.[15] Currently in the ACT, 49 lowland native grassland sites[16] totalling approximately 2,200 hectares still exist; 43 of these sites contain approximately 1,000 hectares of Natural Temperate Grassland. Table 1 presents the ecological characteristics of the lowland native grassland sites, the subject of this investigation, and Appendix 3 shows the distribution of lowland native grassland sites in the ACT.

The temperate grassland (and woodlands areas) were the home of Aboriginal people, whose activities helped to shape the flora and fauna communities found by the first Europeans.[17] Since European settlement, the Natural Temperate Grassland has been modified by agricultural use, urbanisation and infrastructure development. As a result, the Natural Temperate Grassland community in the ACT now consists mainly of highly fragmented and isolated small patches (such as Guilfoyle Street, Yarralumla (CC09); Wells Station Road (GU07); and Tennant Street, Fyshwick (JE10), many of which are less than 1 hectare), with only 11 (23%) sites being greater than 100 hectares: Majura Training Area (MA01), Canberra International Airport (MA03), Jerrabomberra West Reserve (JE03), Harman Bonshaw North (JE07), Gungaderra Nature Reserve (GU02), Crace Nature Reserve (GU03), and Lawson Commonwealth – Belconnen Naval Transmission Station (BE08(a)).[18]

Some areas that once supported the Natural Temperate Grassland ecosystem have been degraded to such an extent that they no longer represent this ecological community. Typically such sites contain or are dominated by one or more native grasses, but few other native species associated with natural grasslands remain. They are considered to be so modified that conservation management, unless very intense and significant, is unlikely to result in an increase in native diversity. Such sites are termed 'native pasture', and while botanically they do not constitute the community, some sites still retain populations of threatened species. In such cases, these sites are significant, but primarily as habitat for threatened species. Together, Natural Temperate Grassland and native pasture comprise the lowland native grassland of the ACT that is the subject of this investigation.

Four threatened fauna species and two flora species, all declared threatened (endangered or vulnerable) under the *Nature Conservation Act 1980* (ACT), occur within lowland native grassland in the ACT. The **endangered species** are the Grassland Earless Dragon (*Tympanocryptis pinguicolla*), the Golden Sun Moth (*Synemon plana*), the Button Wrinklewort (*Rutidosis leptorrhynchoides*), and the Ginninderra Peppercress (*Lepidium ginninderrense*). The **vulnerable species** are the Striped Legless Lizard (*Delma impar*) and the Perunga

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[14] Action Plan No. 28.

[15] Action Plan No. 28.

[16] The sites in this report are the same as those in Action Plan No. 28, except for the inclusion of Kama South (BE12) and Evatt Footbridge. Lowland native grassland are defined as the areas that have separate land uses or ownership, or are separated by a major road or development, or by a significant other vegetation (native or exotic). Some sites are adjacent to each other, forming larger grassland units. Two of the very large sites have been considered in two sections due to the change in vegetation characteristics. These are Lawson Commonwealth (BE08) and Umbagong Park, Florey (BE04).

[17] Action Plan No. 28.

[18] Action Plan No. 28.

Grasshopper (*Perunga ochracea*). Table 1 lists the lowland native grassland sites that contain these threatened species.

Many other plant and animal species are found only in native grasslands and are wholly dependent on these remnant patches for survival. These species have become threatened as a direct consequence of the loss, degradation and fragmentation of native grassland. The populations of threatened species within these small and isolated patches are highly vulnerable to extinction. Compounding their vulnerability, such small populations are inherently more fragile than large populations, so any further disturbance or factors that lead to less favourable conditions for these species are likely to increase the risk of extinction.[19]

Under the *Nature Conservation Act 1980* (ACT), the Minister for the Environment, on the recommendation of the Flora and Fauna Committee, has declared that the Natural Temperate Grassland is an endangered community. Natural Temperate Grassland is also listed as an endangered ecological community under the *Environment Protection and Biodiversity Conservation Act 1999* (Cwlth).

Natural Temperate Grassland is a special ecological community, with less than 5% remaining in the ACT in sites generally less than 100 hectares. These grasslands, together with other sites that support threatened grassland species, require high conservation priority. The conservation of some of the remaining species of the lowland native grassland will need to be given exceptional priority if these threatened species are not to follow others which have previously disappeared (such as, brolgas and bettongs). The remaining fragments of Natural Temperate Grassland deserve special conservation protection.[20]

Action Plan No. 28 assesses the lowland native grassland sites on the basis of their conservation value and classifies each site according to its conservation significance, namely:

- **Category 1**: Core Conservation Sites – sites in this category meet the following criteria:
  - high botanical significance rating, or
  - key threatened species habitat, or
  - large sites (more than 100 hectares) with a botanical significance rating of 3.
- **Category 2**: Complementary Conservation Sites – sites in this category meet the following criteria:
  - moderate botanical significance rating, or
  - threatened species habitat, or
  - medium area sites (10 to 100 hectares) with a botanical significance rating of 4.
- **Category 3**: Landscape and Urban Sites – sites in this category meet the following criteria:
  - low to very low botanical significance rating; and small to very small area (less than 10 hectares); and

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[19] Report from Parks Conservation and Lands to the ACT Commissioner for Sustainability and the Environment for the Inquiry into the Management of Lowland Native Grasslands, Parks Conservation and Lands, August 2008, page 5.

[20] Report from Parks Conservation and Lands to the ACT Commissioner for Sustainability and the Environment for the Inquiry into the Management of Lowland Native Grasslands, Parks Conservation and Lands, August 2008, page 6.

— may contain small populations of threatened species in marginal or fragmented habitat that is considered to be not viable in the medium to long term.[21]

This classification also helps prioritise sites for protection. The category of each lowland native grassland site is shown in Table 1.

While this investigation focuses on one of the threatened ecosystems in the ACT, it is important to acknowledge that the Yellow Box (*Eucalyptus melliodora*)–Red Gum (*E. blakelyi*) Grassy Woodland (declared endangered under the *Nature Conservation Act 1980* (ACT)) is also a threatened ecosystem. In addition, the Flora and Fauna Committee is currently considering a nomination for the Snow Gum (*E. pauciflora*)–Candlebark (*E. rubida*) Tableland Woodland to be declared endangered under the *Nature Conservation Act 1980* (ACT).

The Yellow Box–Red Gum Grassy Woodland and Snow Gum-Candlebark Tableland Woodland ecosystems are of relevance to this investigation as they interconnect with the Natural Temperate Grassland on the lower slopes, forming a vegetation mosaic.[22] As such, these ecosystems are subject to similar pressures and threatening processes as the lowland native grassland.[23] Accordingly, some findings from this investigation may be relevant to these two ecosystems.

1.3 Investigation process

Action Plan No. 28 identifies the lowland native grassland sites in the ACT and defines the sites considered in this investigation. The distribution of lowland native grassland sites in the ACT is included at Appendix 3. A summary for each lowland native grassland site is included in Appendix 4.

This investigation was undertaken in two stages in response to the need for urgent action to be taken on Lawson Commonwealth – Belconnen Naval Transmission Station site (BE08(a)), a Core Conservation Site. As such, this site was the focus of the first stage of this investigation.

On 21 November 2007 a meeting was held with key stakeholders for a roundtable discussion concerning relevant matters relating to the investigation.

A media release from this Office advising of the investigation and inviting submissions was issued on 30 November 2007 (*see* Appendix 5). On 1 December 2007 an advertisement was placed in *The Canberra Times* that also advised of this investigation and invited submissions (*see* Appendix 6). Both the media release and the advertisement advised that the time for lodging submissions relating to Lawson Commonwealth – Belconnen Naval Transmission Station (BE08(a)) closed on 14 December 2007 and that the closing date for all other submissions was 25 January 2008. This Office received and considered submissions from 17 individuals, groups and organisations (*see* Appendix 7).

Since publication of Action Plan No. 28 an area (38.5 hectares) of native grassland on Kama South (BE12), adjacent to the Molonglo River has been identified as an additional remnant of

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[21] Action Plan No. 28, pages 56–59.

[22] National Recovery Plan for Natural Temperate Grassland of the Southern Tablelands (NSW and ACT), Commonwealth, 2006.

[23] Environment ACT, *Woodland for Wildlife, ACT Lowland Woodland Conservation Strategy*, Action Plan No. 27.

the Natural Temperate Grassland. In addition, following a submission from the North Belconnen Landcare Group, Evatt Footbridge was included making a total of 49 sites considered in this investigation.

On 26 February 2008, the *Report on Belconnen Naval Transmission Station (BNTS) Site as part of the Investigations into ACT Lowlands Grasslands*, which included 11 recommendations was submitted to the Chief Minister, then also Minister for the Environment. It was publicly released in early March 2008.

Between February 2008 and January 2009, the remaining lowland native grassland sites were investigated. This included site visits with staff from this Office and the responsible land managers and rural lessees. Meetings were also held with the responsible land managers and stakeholders to discuss issues relevant to specific sites and lowland native grassland in general.

This Office engaged Dr Ken Hodgkinson from the Commonwealth Scientific and Industrial Research Organisation's (CSIRO) Sustainable Ecosystems Division to undertake an ecological assessment of all sites, except Lawson Commonwealth – Belconnen Naval Transmission Station (BE08(a)). Dr Hodgkinson's terms of reference are set out in the box on the following page and his report is at Appendix 8.

Upon finalisation of Dr Hodgkinson's report, this Office conducted:

- meetings with the responsible land managers for sites on National Land
- a roundtable discussion with relevant offices from the Department of Territory and Municipal Services, on 10 October 2008
- a meeting of all relevant Australian Government departments about the proposed excision of the Majura Training Area (MA01) site from the Department of Defence, on 14 October 2008.

A draft report, in particular the recommendations, were discussed with the relevant Commonwealth and Territory officers in early January 2009. The views from these discussions and submissions have been considered in finalising this report. Expert advice was sought from Ms Sarah Sharp (an independent ecologist with expertise in lowland native grassland) and Dr Lyn Hinds (CSIRO, eminent marsupial expert). In January 2009, a draft of this report was considered by an expert panel comprising:

- Dr Andrew Baird (CSIRO Veterinarian)
- Dr Ken Hodgkinson (CSIRO Ecologist)
- Dr Sue McIntyre (CSIRO Senior Principal Research Scientist)
- Dr Will Osborne (University of Canberra).

Mr Darro Stinson, the ex-Commissioner for the Environment, facilitated the expert panel and Ms Sarah Sharp provided technical advice. The advice from this expert panel is included as Appendix 10.

This report was given to the Minister on 12 March 2009. Pursuant to section 22 of the *Commissioner for the Environment Act 1993*, the Minister must, within 15 sitting days after the day of receiving the report, present the report or recommendation to the Legislative Assembly. He may choose to publicly release it earlier. This report also includes the *Report on*

Belconnen Naval Transmission Station Site as part of the Investigation into ACT Lowlands Grasslands, February 2008 (*see* Appendix 1).

Table 1: Ecological characteristics of ACT lowland native grassland sites[a]

Site name	Site no.	Total area of site (ha)	Area NTG (ha) endangered community	Threatened species	Conservation category[b]
Majura Valley					
Majura Training Area	MA01	126.6	113.7	BW, GED, GSM, PG, SLL	1
Air Services Beacon	MA02	10.7	10.7	SLL	1
Canberra International Airport[e]	MA03	203.6	73.6	GED, GSM	1
'Malcolm Vale'	MA04	155.4	-	GED	2
Campbell Park	MA05	11.7	10.9	BW, GED, GSM, PG, SLL	1
Majura West	MA06	133.3	-	GED	1
Jerrabomberra Valley					
Mugga Mugga Homestead	JE01	15.0	15.0	-	2
'Callum Brae'	JE02	162.7	-	GED	1
Jerrabomberra West Reserve	JE03	116.9	115.2	GSM, GED, PTWL, SLL	1
Woods Lane	JE04	10.3	10.3	BW	2
Jerrabomberra East Reserve	JE05	72.0	62.2	GED, SLL	1
Harman Bonshaw South	JE06	105.7	-	GED, GSM	1
Harman Bonshaw North	JE07	114.6	46.3	BW, GED, SLL	1
'Cookanalla'	JE08	81.5	-	GED	2
AMTECH	JE09	18.0	18.0	GED	2
Tennant Street, Fyshwick	JE10	0.3	0.3	BW	2
Gungahlin					
Mulanggari Nature Reserve	GU01	68.5	58.6	GSM, SLL	1
Gungaderra Nature Reserve	GU02	187.3	41.9	GSM, SLL	1[˜]
Crace Nature Reserve	GU03	136.0	61.5	BW, GSM, PG, SLL	1
North Mitchell	GU04	15.9	14.8	GSM	2
Mitchell	GU05	1.6	1.6	SLL	2
Canberra Riding Club	GU06	0.3	0.3	-	3

Site name	Site no.	Total area of site (ha)	Area NTG (ha) endangered community	Threatened species	Conservation category[b]
Wells Station Road	GU07	0.2	0.2	-	3
Nicholls	GU08	0.3	0.3	-	3
Belconnen					
Ginninderra Experimental Station	BE01	19.4	18.9	-	2
Dunlop Nature Reserve	BE02	81.9	81.9	GSM	1
‘Jarramlee’	BE03	52.0	52.0	-	2
Umbagong Park South, Florey[c]	BE04(a)	15.5	9.0	-	2
Umbagong Park North, Florey	BE04(b)	-	-	-	3
Evatt Powerlines	BE05	1.1	1.1	-	3
Lake Ginninderra	BE06	1.9	1.9	GSM	2
Lawson Territory	BE07	59.2	3.3	GSM	3
Lawson Commonwealth (Belconnen Naval Transmission Station)[d]	BE08(a)	120.3	120.3	GP, GSM, PO	1
Lawson Commonwealth (east)	BE08(b)				
Kaleen east paddocks	BE09	28.2	4.0	-	3
Caswell Drive[e]	BE10	5.8	5.8	-	1
Glenloch Interchange	BE11	2.2	2.2	-	1
Kama South[f]	BE12	38.5	38.5	-	1
Central Canberra/Tuggeranong					
CSIRO Headquarters, Campbell	CC01	3.0	3.0	GSM	2
Constitution Avenue, Reid	CC02	0.7	0.7	GSM	2
St Johns Church, Reid	CC03	0.9	0.9	GSM	2
Australian Centre for Christianity and Culture, Barton	CC04	1.9	1.9	BW, GSM	1
York Park, Barton	CC05	0.4	0.4	GSM	2
Yarramundi Reach	CC06	21.2	21.2	GSM, SLL	2
Lady Denman Drive, Yarralumla	CC07	0.4	0.4	GSM	2

Site name	Site no.	Total area of site (ha)	Area NTG (ha) endangered community	Threatened species	Conservation category[b]
Dudley Street, Yarralumla	CC08	2.2	1.5	GSM	2
Guilfoyle Street, Yarralumla[g]	CC09	0.8	0.8	BW	2
Novar Street, Yarralumla	CC10	0.2	0.2	-	3
Black Street, Yarralumla	CC11	3.6	3.6	GSM	2
Isabella Pond, Monash	TU01	1.2	1.2	-	1

Notes:

BW = Button Wrinklewort; GED = Grassland Earless Dragon; GP = Ginninderra Peppercress; GSM = Golden Sun Moth; PG = Perunga Grasshopper; PTWL = Pink-tailed Worm Lizard; SLL = Striped Legless Lizard.

a Lowland native grassland sites are defined as the areas that have separate land uses or ownership, or are separated by major road or development, or by a significant area of other vegetation (native or exotic). Some sites are adjacent to each other, forming larger grassland units.

b **Category 1**: Core Conservation Sites – sites in this category meet the following criteria: high botanical significance rating, or key threatened species habitat, or large sites (more than 100 hectares) with a botanical significance rating of 3.

Category 2: Complementary Conservation Sites – sites in this category meet the following criteria: moderate botanical significance rating, or threatened species habitat, or medium area sites (10 to 100 hectares) with a botanical significance rating of 4.

Category 3: Landscape and Urban Sites – sites in this category meet the following criteria: low to very low botanical significance rating; and small to very small area (less than 10 hectares); and may contain small populations of threatened species in marginal or fragmented habitat that is considered to be not viable in the medium to long term (see Action Plan No. 28, pages 56–59).

c Umbagong Park North and South are identified as one site in Action Plan No. 28 and counted as one site in this investigation.

d Lawson Commonwealth is identified as one site in Action Plan No. 28 and counted as one site in this investigation.

e Since 2005 part of the grassland in the site has been destroyed.

f Since publication of Action Plan No. 28 an area (38.5 hectares) of native grassland on Kama South, adjacent to the Molonglo River, has been identified as an additional remnant of the Natural Temperate Grassland (NTG).

g This site is incorrectly named as Kintore Street in Action Plan No. 28.

TERMS OF REFERENCE FOR ECOLOGICAL ASSESSMENT OF LOWLAND NATIVE GRASSLAND SITES UNDERTAKEN BY DR HODGKINSON

1. Review the:

(a) Action Plan No. 28 *A Vision Splendid of the Grassy Plains Extended ACT Lowland Native Grassland Conservation Strategy*

(b) National Recovery Plan for Natural Temperate Grassland of the Southern Tablelands (NSW and ACT): An Endangered Ecological Community, January 2006

(c) ACT Nature Conservation Strategy

(d) advise whether any conservation management principles in addition to those set out in these documents are required to protect the Natural Temperate Grassland of the ACT.

2. Inspect and take at least one photograph of each Natural Temperate Grassland site in the ACT except for the Belconnen Naval Transmission Station site.

3. Identify, through a visual inspection, those sites, if any, approaching a critical threshold beyond which unacceptable degradation will occur and identify the causes of the deterioration.

4. Review the existing management arrangements in relation to each grassland site and:

(a) in relation to each site approaching a critical threshold beyond which unacceptable degradation will occur identify the actions needed to protect the Natural Temperate Grassland on the site in the:

(i) immediate to short-term; and

(ii) long term.

(b) in relation to all other grassland sites identify, for specific individual sites and/or a group of sites, any management changes that are needed to protect the Natural Temperate Grassland on the site or sites in the:

(i) short term; and

(ii) long-term.

1.4 Update on Belconnen Naval Transmission Station site

The Lawson Commonwealth – Belconnen Naval Transmission Station site (BE08(a)) was the focus of the first stage of this investigation (*see* Section 1.3), and on 26 February 2008, the report on this site was submitted to the ACT Government and subsequently made public in March 2008. An update on the progress in implementing the 11 recommendations contained in this report is presented in Table 2.

A meeting was held between the Department of Defence, the ACT Environment Protection Authority and the Office of the Commissioner for Sustainability and the Environment on 10 October 2008 regarding remediation of the Belconnen Naval Transmission Station (BE08(a)) site, in particular the need to ensure the integrity and protection the lowland native grassland.

Officers from the Department of Territory and Municipal Services at a meeting on 5 January 2009 indicated that Recommendation 11 – review of the memorandum of understanding between the Department of Defence and ACT Government (Department of Territory and Municipal Services) – is yet to be finalised.

Table 2: Progress on implementation of recommendations contained in the Commissioner for Sustainability and the Environment Report on Belconnen Naval Transmission Station

Recommendation	Implementation
Recommendation 1 Urgent action is to be taken to restore the ecological condition of the Grasslands, and provide opportunities for the Perunga Grasshopper, Golden Sun Moth and Ginninderra Peppercress to survive and thrive at BNTS.	The culling of kangaroos on the site has significantly reduced the grazing pressure. The Department of Defence has fenced off the areas containing the Ginninderra Peppercress.
Recommendation 2 Kangaroos are to be removed immediately from BNTS to achieve a stocking rate of 1 kangaroo per hectare or less. This is to be done by the land manager, preferably before the end of April 2008 to prevent impacts on pasture biomass occurring during the dormant 2008 winter season.	A cull was completed by the end of May 2008.
Recommendation 3 Kangaroo population numbers are to be maintained at the targeted level for the foreseeable future using fertility-controlled kangaroos only. A program to maintain this situation is to be implemented as needed. (This recommendation is made on the assumption that all remaining kangaroos at BNTS will be part of fertility control research programs.)	It is understood that 100 animals in the long-term will remain on-site and that these will be used for fertility control research.
Recommendation 4 Further reductions in the number of kangaroos at BNTS (that is, even below the proposed stocking rate of 1 kangaroo per hectare) is to occur if recovery of the grasslands does not improve over the next growing season even if research projects are compromised.	An issue to be addressed in the future.
Recommendation 5 Kangaroos are to be removed from BNTS by the most humane method suitable for that site having regard to advice from the AFP that firearms are not to be used at BNTS. (The Expert Panel has recommended sedating by darting followed by euthanasia by lethal injection.)	The kangaroos were culled by herding, sedation by darting followed by euthanasia by lethal injection. AFP would not give permission to use firearms due to site conditions and the proximity to residential areas.
Recommendation 6 The policy of the Conservator of Flora and Fauna, to the effect that translocation of eastern grey kangaroos is not an appropriate management technique, is to remain unchanged and that this policy position be confirmed to the Department of Defence immediately.	No translocation has been undertaken.
Recommendation 7 The interim grasslands management plan and interim kangaroo management plan for BNTS are to be completed by the end of August 2008, by the land manager, in consultation with key stakeholders. These plans are to adopt adaptive management principles and be based on a stocking rate of 1 kangaroo per hectare or less prior to the 2008 winter.	It is understood that the Department of Defence has informally provided Territory and Municipal Services with a draft management plan for comment.
Recommendation 8 Conditions at BNTS are to be reported on a quarterly basis to all relevant agencies and to the Commissioner's Office. The Commissioner is to establish an independent group to assist her evaluate progress and report on this in her annual report.	Defence has informed the Office that conditions are stable. The post-Spring quarterly report will be important in assessing recovery.

Recommendation	Implementation
Recommendation 9 A long-term grasslands management plan covering BNTS is to be developed prior to the abutting Lawson lands being developed for residential purposes. This plan should incorporate clear management objectives and be based on an adaptive management approach to protect the Grasslands, Perunga Grasshopper, Golden Sun Moth and Ginninderra Peppercress at the BNTS. (The interim grasslands management plan and interim kangaroo management plan (Recommendation 7) should be incorporated into the long-term plan. This long-term plan could cover all ACT natural temperate grasslands areas.)	If the site comes into government ownership, this will be the responsibility of Territory and Municipal Services.
Recommendation 10 The Territory is to ensure that legal measures are implemented to protect and preserve the high conservation value of the Grasslands and its threatened species when the land at BNTS is transferred from the Commonwealth to another entity. (This recommendation is made on the assumption that Territory laws will fully prevail post the transfer.)	An issue to be addressed in the future.
Recommendation 11 The review of the memorandum of understanding between the Department of Defence and ACT Government (Territory and Municipal Services) is to be completed by August 2008.	It is understood that the Executive Director, Environment and Recreation has written to the Department of Defence and the Department for Environment, Water, Heritage and the Arts as a first step towards achieving this recommendation. No response has been received to date.

Source: Commissioner for Sustainability and the Environment Australian Capital Territory Annual Report 2007–08, 2008, pages 12–13.

2 Legislation and policy

An understanding of legislation relevant to ACT lowland native grassland sites and the species they support is important as it establishes the legal framework for what can, and should, occur. Four types of legislation are relevant to this investigation, they are:

- planning
- conservation
- heritage
- animal welfare.

2.1 Planning legislation

The planning legislation relevant to the ACT lowland native grassland sites is:

- *Australian Capital Territory (Planning and Land Management) Act 1988* (Cwlth)
- *Planning and Development Act 2007* (ACT).

2.1.1. Australian Capital Territory (Planning and Land Management) Act 1988

The *Australian Capital Territory (Planning and Land Management) Act 1988* (Cwlth) provides for two categories of land in the ACT:

- National Land, which is used by or on behalf of the Commonwealth, and managed by the Commonwealth.
- Territory Land, which is all the remaining land of the ACT. The ACT Government manages this on behalf of the Commonwealth.

The National Capital Plan (2003) sets out general land use policies for the Territory as a whole and specifies areas of land that have the special characteristics of the National Capital. These areas are called Designated Areas. The National Capital Plan provides detailed planning policies and guidelines for Designated Areas. The National Capital Authority has planning responsibility for these areas, which may be either National Land or Territory Land. Planning for Territory Land that is not a Designated Area is the responsibility of the ACT Planning and Land Authority and planning policies are set out in the Territory Plan 2007.

Sixteen lowland native grassland sites are wholly or partially on National Land (*see* Table 4). As such, the Australian Government has primary responsibility for managing these sites. Recommendations made in this report relative to these sites are aimed at fostering action by an Australian Government agency.

2.1.2 *Planning and Development Act 2007*

The *Planning and Development Act 2007* (ACT) establishes the ACT Planning and Land Authority and its functions including to:

- prepare and administer the Territory Plan
- grant, administer, vary and end leases on behalf of the Executive

- grant licences over unleased Territory Land.[24]

The objective of the Territory Plan 2008 is to ensure, in a manner not inconsistent with the National Capital Plan, the planning and development of the ACT provides an attractive, safe, and efficient environment for the people of the ACT to live, work and have their recreation.[25]

All land that falls within the Territory Plan (Territory Land) is defined according to allowable land uses, including public land (for example, Nature Reserves, Special Purpose Reserves, and Urban Open Space), Industrial and Residential Land and Rural. To change a land use requires a Variation of the Territory Plan. Land is managed in accordance to defined land uses. For each land use, the Territory Plan defines objectives by which the sites are to be protected and managed.

Sites on Territory Land that are defined as Nature Reserve, Special Purpose Reserve or National Park have the highest level of protection; eight lowland native grassland sites are zoned as Nature Reserves, they are:

- 'Callam Brae' (part JE02), Jerrabomberra West Reserve (JE03), Jerrabomberra East Reserve (JE05),[26] Mulanggari Nature Reserve (GU01), Gungaderra Nature Reserve (GU02), Crace Nature Reserve (GU03), North Mitchell (GU04) and Dunlop Nature Reserve (BE02).
- Mugga Mugga Homestead (JE01) is a Special Purpose Reserve.

While not having the same level of protection through defined objectives for land use and management, all unleased Territory Land that is declared Urban Open Space requires a plan of management; such plans must be reviewed at least every 10 years.[27] The 10 sites zoned Urban Open Space are:

- Nicholls (GU08); Umbagong Park, Florey (BE04); Evatt Powerlines (BE05); Lake Ginninderra (BE06); Evatt Footbridge; CSIRO Headquarters, Campbell (CC01); Constitution Avenue, Reid (CC02); Dudley Street, Yarralumla (CC08); Novar Street, Yarralumla (CC10); Black Street, Yarralumla (CC11); and Isabella Pond, Monash (TU01).

Chapter 9 of the *Planning and Development Act 2007* (ACT) provides details about the lease and licence system for lands in the ACT. Leases generally offer a long-term arrangement whereas licences are temporary in nature. Twelve leases are held over Territory Land, which are lowland native grassland sites (*see* Table 4). Grassland sites that are subject to various leases range from rural to site-specific activities. The majority of leases (seven) over grassland sites are rural. All rural leases are subject to land management agreements that specify how the land is to be managed. There are eight grazing licences on lowland native grassland sites (*see* Table 4).

The ACT Planning and Land Authority is responsible for the policy and overall administration and enforcement of the Territory's licence and lease system. Licences and

[24] *Planning and Development Act 2007.*

[25] *Planning and Development Act 2007*, sections 25 and 48.

[26] Requires a variation to the Territory Plan 2008; the ACT Planning and Land Authority is currently awaiting comments from the Department of Territory and Municipal Services.

[27] Section 332 (2)(a).

rural leases with the supporting land management agreements can be used to protect lowland native grassland. This investigation found that there was some confusion between ACT Planning and Land Authority and Territory and Municipal Services staff about enforcement responsibility for land management agreements. The rural lease administration system is complex and this seems to have contributed to the confusion. However, the Department of Territory and Municipal Services is the government's land management agency and therefore it seems to be the appropriate agency to exercise enforcement powers with respect to land management agreements. This department is also responsible for ensuring Action Plan No. 28 is implemented)

This complex administration system appears to have no significant advantages. During this investigation it became apparent that enforcement of conditions in land management agreements in rural leases seemed to be lacking, possibly because it is too difficult given the current system. Licences also appear to vary for no apparent reason. Standardising these licences make their administration easier. The administrative and legislative arrangement for rural licences and leases needs to be streamlined.

Chapter 10 of the *Planning and Development Act 2007* (ACT) provides details about the management of public land, which includes Nature Reserves, Urban Open Space and Special Purpose Reserves. There are 18 (37%) lowland native grassland sites on public land; this potentially affords a very high level of protection. Section 319 of the Act deals with plans of management and provides that the custodian for an area of public land must prepare a draft plan of management of the area as soon as practicable after the area is identified as public land in the Territory Plan. Section 332 of the Act provides that the custodian of the land must review the plan of management at least once every 10 years. This is an important way of ensuring that ACT Government agencies keep plans current that affect the 18 lowland native grassland sites on public land (this is further discussed in Section 3 in relation to specific sites). It is questionable as to whether the planning legislation is the appropriate vehicle for directing management planning of nature conservation areas. It maybe more appropriate for this, and other land management issues associated with nature conservation to be enshrined in nature conservation legislation. The current review of the *Nature Conservation Act 1980* (ACT) provides an opportunity for this to be considered and addressed.

Recommendation 1: Streamline ACT Government planning and nature conservation legislation to ensure all land management matters are covered by the *Nature Conservation Act 1980* (ACT) (currently under review).

2.2 Conservation legislation

Three pieces of conservation legislation are relevant to ACT lowland native grassland sites, namely the:

- *Environment Protection and Biodiversity Conservation Act 1999* (Cwlth)
- *Nature Conservation Act 1980* (ACT)
- *Heritage Act 2004* (ACT).

2.2.1 Environment Protection and Biodiversity Conservation Act 1999

The *Environment Protection and Biodiversity Conservation Act 1999* (Cwlth) provides a legal framework for protection and management, nationally and internationally, of important flora, fauna, ecological communities and heritage places defined in the Act as matters of national environmental significance.

Natural Temperate Grassland of the Southern Tablelands (NSW and ACT) is listed as an endangered ecological community under the *Environment Protection and Biodiversity Conservation Act 1999* (Cwlth) (and also under Territory legislation). In addition, with the exception of the Perunga Grasshopper, all the flora (Button Wrinklewort and Ginninderra Peppercress) and fauna (Striped Legless Lizard, Grassland Earless Dragon and Golden Sun Moth) species associated with the Natural Temperate Grasslands that are declared threatened under Territory legislation are also listed under the *Environment Protection and Biodiversity Conservation Act 1999* (Cwlth).

National Heritage System

The National Heritage System, which operates under the *Environment Protection and Biodiversity Conservation Act 1999* (Cwlth), is a framework for listing and protecting natural and cultural heritage places across Australia.

In line with a 1997 intra-governmental agreement, the Australian Government focuses on protecting heritage places of outstanding significance to the nation or places the Australian Government owns or manages. The *Commonwealth Heritage Lists*, implemented in 2004, is an important mechanism for protecting heritage places.

The *Commonwealth Heritage Lists* is a list of places the Australian Government either owns or manages that have 'significant heritage value to the Nation'. Only one grassland site in the ACT is listed and this is Lawson Commonwealth – Belconnen Naval Transmission Station (BE08(a)) for Golden Sun Moth (*Synemon plana*) habitat. This listing affords the grassland an 'additional layer of protect' from any future development proposals. Another six ACT lowland native grassland sites are being considered for listing as 'Natural Areas' on the *Commonwealth Heritage Lists* (*see* Table 3).

The Register of the National Estate, implemented in 1975, lists over 13,000 places (253 in the ACT). Following changes to the heritage system in 2007, the Australian Government decided to freeze the Register and remove its statutory provisions (relating mainly to Australian Government agencies and Commonwealth land) by February 2012. Lawson Commonwealth – Belconnen Naval Transmission Station (BE08) is listed on the Register of the National Estate.

Any proposed action in relation to species or places listed under the *Environment Protection and Biodiversity Conservation Act 1999* (Cwlth) must be referred to the Australian Government Minister for the Environment, Water, Heritage and the Arts if the planned action could have a 'significant impact', as defined by that Act, on the environment. If the proposed action (or 'referral') is found likely to have a significant impact on matters of national environmental significance, the Minister's approval must be sought. In these situations, the Minister seeks public comment and considers these, along with social, economic and other potential impacts in making a decision.

On 31 October 2008, the Minister for the Environment, Water, Heritage and the Arts commissioned an independent review of the *Environment Protection and Biodiversity Conservation Act 1999* (Cwlth). This is the first review of the Act since its commencement on

16 July 2000. The review will assess the operation of the Act and the extent to which its objectives have been achieved.

This investigation found limitations in the level of protection that could be secured for Natural Temperate Grassland under the *Environmental Protection and Biodiversity Conservation Act 1991* (Cwlth). Submissions were invited as part of the Commonwealth's review of this legislation. The Commissioner's Office made a submission, which recommended, among many things, that this Act should:

- facilitate consideration of cumulative impacts of proposed developments, on listed and non-listed communities and species, with respect to referrals to the department for assessment
- be triggered by 'no action', that is, not undertaking needed land management actions
- identify the best option for protecting a listed community or species rather than only assessing the presented option
- strongly foster compliance and enforcement activities.

Recommendation 2: The *Environmental Protection and Biodiversity Conservation Act 1991* (Cwlth) should be strengthened so sites and species are more effectively protected and managed.

2.2.2 Nature Conservation Act 1980

The *Nature Conservation Act 1980* (ACT) makes provision for protecting and conserving native animals and native plants and for reserving areas for those purposes.

Part 2 of the *Nature Conservation Act 1980* (ACT) establishes the role of Conservator of Flora and Fauna and provides authority for the Conservator to manage public land reserved for conservation of the natural environment. It also establishes the Flora and Fauna Committee with the functions of:

- providing advice to the responsible Minister in relation to nature conservation
- exercising such powers as are provided for under the Act.

Section 21 of the *Nature Conservation Act 1980* (ACT) authorises declaration of a species or ecological community, by the Minister for the Environment, based on advice from and recommendations made by the ACT Flora and Fauna Committee, with respect to:

- vulnerable or endangered species
- an endangered ecological community
- a threatening process.

Part 3 of the *Nature Conservation Act 1980* (ACT) makes provision for the Conservator to prepare action plans for species, communities or processes declared to be vulnerable or endangered. Once declared, the ACT Government is obligated under the Act to prepare an action plan that sets out strategies for reducing threats to the species and strengthening protection measures. The ACT Government's adopted policies and actions for protecting threatened grassland communities are defined in Action Plan No. 28, which is discussed in Section 2.4: Conservation policy of this report.

A declaration under this section is a disallowable instrument, which once tabled in the Legislative Assembly becomes a government policy that must be considered in making decisions on matters to which it is relevant. Action Plan No. 28 is a disallowable instrument and although it must be considered with respect to development decisions it is not binding. As such, when a new development is proposed on a lowland native grassland site unless the site has threatened species under the provisions of either the *Nature Conservation Act 1980* (ACT) or the *Environment Protection and Biodiversity Conservation Act 1999* (Cwlth), these sites do not have any legal status for protection. This highlights the need for the ACT Planning and Land Authority to seek advice on these sites and make information available to the community and developers on their location.

Section 47 of the *Nature Conservation Act 1980* (ACT) empowers the Conservator of Flora and Fauna to issue directions to the occupier of land for protection or conservation of significant natural values. Conservator's Directions have been issued to some leases on lowland native grassland sites to ensure protection of the grassland and of the Grassland Earless Dragon habitat.

The ACT is unique in having a Conservator of Flora and Fauna whose powers can be used to afford extra protection to specific sites or species. The Conservator's role and functions are broad and it is possible for the Conservator of Flora and Fauna to be the same officer who is responsible for undertaking land management functions on Territory Lands. The legislation that creates the Conservator of Flora and Fauna, the *Nature Conservation Act 1980* (ACT), is currently under review. It is understood that as part of this review issues associated with the Conservator's role and functions will be part of a public discussion paper.

Given that 60% of the Territory's lowland native grassland sites need urgent land management action, it is important that the Conservator have powers to direct that appropriate land management actions be undertaken.

Recommendation 3: As part of the current review of the *Nature Conservation Act 1980* (ACT), ensure that lowland native grassland, in particular Natural Temperate Grassland ecosystems are protected by the Conservator of Flora and Fauna having powers to direct, when necessary, that land management actions be undertaken.

2.3 Heritage and animal welfare legislation

Other legislation that is relevant to ACT lowland native grassland sites are the:

- *Heritage Act 2004* (ACT)
- *Animal Welfare Act 1992* (ACT)

2.3.1 Heritage Act 2004

The *Heritage Act 2004* (ACT) provides for recognition, registration and conservation of places and objects of natural and cultural or other significance. Under the *Heritage Act 2004* (ACT), natural items, such as native grassland sites, can be protected and conserved using heritage agreements, heritage orders, conservation management plans and guidelines.

A number of lowland native grassland sites have been nominated for listing on the Heritage Register. These sites are currently under assessment and are presented in Table 3.

Where development affects the conservation requirements of sites of heritage significance, controls become applicable under provisions of the *Planning and Development Act 2007* (ACT). Sometimes there is an opportunity to include clearance controls in land occupancy conditions (such as leases, land management agreements or agistment conditions).[28]

To help determine appropriate long-term land use for some lowland native grassland sites, the heritage status of lowland native grassland sites that have been nominated for heritage listing needs to be resolved. The sites nominated for inclusion on the ACT Heritage List (those also nominated on the *Commonwealth Heritage Lists* are listed in *italics*):

- Majura Training Area (MA01), Air Services Beacon (MA02), Canberra International Airport (MA03), 'Malcolm Vale' (MA04), *Campbell Park* (MA05), *Majura West* (MA06), '*Callum Brae*' (JE02), *Jerrabomberra West Reserve* (JE03), *Jerrabomberra East Reserve* (JE05), *Harmon Bonshaw South* (JE06), Harmon Bonshaw North (JE07), Lawson Territory (BE07), Lawson Commonwealth (BE08(a) and (b)), Kama South (BE12), Black Street, Yarralumla (CC11).

Recommendation 4: Resolve the heritage status of lowland native grassland sites, in a timely manner, to assist long-term planning.

Table 3: Protection status of lowland native grassland sites under Commonwealth and ACT Heritage Acts

Site name	Site no.	Commonwealth Heritage List	ACT Heritage Register
Majura Valley			
Majura Training Area	MA01	–	Nominated
Air Services Beacon	MA02	–	Nominated
Canberra International Airport	MA03	–	Nominated
'Malcolm Vale'	MA04	–	Nominated
Campbell Park	MA05	Nominated	Nominated
Majura West	MA06	Nominated	Nominated
Jerrabomberra Valley			
'Callum Brae'	JE02	Nominated	Nominated
Jerrabomberra West Reserve	JE03	Nominated	Nominated
Jerrabomberra East Reserve	JE05	Nominated	Nominated
Harman Bonshaw South	JE06	Nominated	Nominated
Harman Bonshaw North	JE07	–	Nominated
Belconnen			
Lawson Territory	BE07	–	Nominated
Lawson Commonwealth – Belconnen Naval Transmission Station	BE08(a)	Listed	Nominated
Kama South	BE12	–	Nominated
Central Canberra/Tuggeranong			
Black Street, Yarralumla	CC11	–	Nominated

[28] *Nature Conservation Act 1980* (ACT) page 32, para 5.

2.3.2 Animal Welfare Act 1992

The *Animal Welfare Act 1992* (ACT) is an Act for promoting animal welfare and related purposes. This Act has relevance to this investigation in terms of all animals including kangaroos, which need to be reduced in numbers on some sites, to ensure survival of endangered Natural Temperate Grassland ecosystems and other animals.[29]

2.4 Conservation policy

Conservation policies encompassing management principles for the lowland native grassland can be found in:

- the ACT Nature Conservation Strategy 1997
- Action Plan No. 28 (ACT)
- National Recovery Plan for Natural Temperate Grassland of the Southern Tablelands (New South Wales and ACT), (Commonwealth) 2006.

Dr Hodgkinson reviewed these policies and advised on whether any conservation management principles, in addition to those set out in these documents, are required to protect the Natural Temperate Grassland of the ACT. Dr Hodgkinson's findings are quoted in the box on the following page.

2.5 Policy and legislative directions

The ACT is in a strong position to protect the last remaining viable examples of lowland native grasslands and the threatened species that rely on them. The challenge will be to manage these areas so as to improve their ecological condition and to enhance the habitat of threatened species so that populations increase to levels where their viability may be more assured.

Conservation of the lowland native grassland is currently being directed through a series of agreements, in particular memoranda of understanding (between Australian Government agencies and the ACT Government) or licences and leases (between rural lessees and the ACT Government). These agreements, if implemented, can be effective for formalising administrative arrangements for the lowland native grassland sites. However, this investigation found that these arrangements have some limitations (*see* Section 3: Management arrangements) and could be enhanced.

2.5.1 Conservation leases

Rural lands contribute substantially to the Territory's biodiversity value. A conservation lease could replace some rural leases, particularly in areas with significant environmental value, such as Natural Temperate Grasslands. Conservation lease conditions could provide incentives for the leaseholder to protect this value. Some form of incentive would ensure landholders are recognised for activities they undertake that benefit the wider community.

Community groups or individuals could be encouraged to hold conservation leases to actively manage sites.

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[29] Two codes of practice are also relevant (*see* Section 4.2.1 of this report).

DR HODGKINSON'S FINDINGS:

THE ACT NATURE CONSERVATION STRATEGY

Earlier, a strategy for nature conservation in the ACT was developed (ACT Government 1998). In broad terms, the need for reserving important natural areas in the ACT was established, the importance of complementary off-reserve systems was recognised, the task of restoring species and plant communities threatened with extinction was understood, the need to monitor biodiversity was seen to be critical for management and reporting, the threats to biodiversity in the ACT were identified to be pest animals, environmental weeds, changed fire regimes, degradation of aquatic systems and the clearing of natural vegetation, and finally the imperative to involve the community in nature conservation was stated clearly. This foundation document adequately brought together the best practice that had emerged from Australia's ecological research. The document is comprehensive; it has not been weakened by subsequent scientific theories or research. The strategy does not require revision at this time and can be used with confidence into the near future.

ACTION PLAN NO. 28[30]

In the following seven years, programs to implement the strategy (ACT Nature Conservation Strategy) were developed, including a strategy for conservation of the ecological community recognised as Natural Temperate Grassland (Environment ACT 2005). The strategy was built on the knowledge derived by ecological survey, that before European settlement this grassland occupied 11% of the ACT and that today 1% of the ACT contains this community and that much of this remaining grassland is degraded and continually threatened by human activity and exotic species. The strategy for conservation of this threatened grassland ecosystem is comprehensive and based on all the scientific knowledge available at the time. In the strategy, remnant sites of the Natural Temperate Grasslands are categorised and appropriate managements outlined. Category 1 sites are core conservation sites because they are of high botanical significance or they are habitat for key threatened species or they are large sites of moderate botanical significance. Category 2 sites are complementary conservation sites of moderate botanical significance or threatened species habitat or medium area sites of high botanical significance. Category 3 sites are landscape and urban sites of low to very low botanical significance or unlikely to support small populations of threatened species. In addition, two principles for general management of these grasslands, whatever their Conservation Category, are advocated; best practice and adaptive. Best practice management is extensively explored in the document but adaptive management is only outlined and as such is insufficient for implementation.

NATIONAL RECOVERY PLAN FOR NATURAL TEMPERATE GRASSLAND OF THE SOUTHERN TABLELANDS (NSW AND ACT) (CWLTH)

A national recovery plan for the Natural Temperate Grassland was published recently. This detailed document outlines the process and resourcing required. The plan is visionary, practical and achievable.

2.5.2 Voluntary agreements

Voluntary agreements can enable landholders to acknowledge the conservation values of their land through mechanisms designed to provide a level of protection but allow for current land use to continue. Some agreements that are used in other jurisdictions are binding on future landholders and some are only binding for current landholders, while others can be revoked by landholders at any time.[31] Such agreements could be used in conjunction with existing rural leases. They could also be used with respect to non-rural lands.

[30] In June 2008, Parks Conservation and Lands' Research and Planning section prepared a Draft Implementation Report on Action Plan No. 28 for the ACT Flora and Fauna Committee.

[31] Action Plan No. 28, page 80.

For example, the New South Wales Department of the Environment and Climate Change supports the Conservation Partners Program. This initiative provides opportunities to protect and conserve significant natural and cultural heritage values on private and non-reserved public land. Long-term legal commitments are made through conservation agreements and establishment of wildlife refuges under the *National Parks and Wildlife Act 1974* (NSW). Agreements are entered into voluntarily, and complement the public national park and reserve system. Lands under the Conservation Partners Program play a critical role in connecting conservation areas to facilitate species survival and movement. They also strengthen the resilience of protected areas by acting as a buffer to threats, including the potential implications of climate change. Appropriate signage can be posted to inform the wider community of the environmental assets on the land.

Another option is property registration, for example, in New South Wales, a property that is to be managed for conservation is registered with the Department of the Environment and Climate Change. This is not legally binding and it does not change the legal status. Registration ceases when the property is sold. Appropriate signage can be posted to inform the wider community of the environmental assets on the land.

2.5.3 Bio-banking and offsets

Environmental banking programs allow investment in the environment. Developers can buy credits from authorised credit providers to offset any environmental damage caused by a proposed development. Creating a market in biodiversity credits gives incentives to protect biodiversity values.

For example, the New South Wales Department of the Environment and Climate Change has established a market-based approach Biodiversity Banking and Offsets to help address the loss of biodiversity and threatened species caused by development and to simplify the development assessment process. Such a scheme allows 'biodiversity credits' to be generated by landowners/lessees who commit to enhance and protect biodiversity values on their land. These credits can then be sold. Developers can buy these credits and use them to counterbalance (offset) the impacts on biodiversity values that are likely to occur as a result of the development.

If significant modification of a proposal to minimise impacts on subject species, populations or ecological communities is not possible, then compensatory strategies can be considered. These may include other off-site or local area proposals that contribute to long-term conservation of the subject species, populations or ecological communities.[32]

This type of strategy should be investigated in the ACT given the proposed amount of development with potential impacts on lowland native grassland sites including areas within the Eastern Broadacre Planning Study and the new suburbs of Lawson and Crace.

Since the gazettal of the *Nature Conservation Act 1980* (ACT), some innovative approaches for managing and strategically protecting ecosystems have emerged. While it is beyond the scope of this investigation to examine these, they should be considered as part of the review of the *Nature Conservation Act 1980* (ACT).

Recommendation 5: As part of the current review of the *Nature Conservation Act 1980* (ACT), ensure that lowland native grassland, in particular Natural Temperate Grassland,

[32] Department of the Environment and Conservation website at <http://www.environment.nsw.gov.au>.

ecosystems are protected by innovative mechanisms such as conservation leases, voluntary agreements, bio-banking and offsets are investigated and progressed.

3 Management arrangements

The 49 lowland native grassland sites are subject to a variety of management arrangements depending upon whether the site is on National Land or Territory Land, or if it is a Designated Area,[33] whether it is the subject of a lease, licence or if it is on public land. Furthermore, it can be the subject of a memorandum of understanding, a plan of management, and/or conservator's directions. As evident from this, management arrangements are complex.

This section examines these complex management arrangements and makes recommendations to ensure the protection and long-term sustainability of the lowland native grassland sites and their vulnerable ecosystems. The jurisdictional and management arrangements for the lowland native grassland sites are shown in Table 4.

A lowland native grassland site may have more than one responsible land manager, for example, CSIRO Headquarters, Campbell (CC01) is on both National and Territory Land. A site may also have more than one management regime, for example, Gungaderra Nature Reserve (GU02) has a Management Plan, an agistment licence and two non-rural leases (Print Handicapped Radio and Broadcast Australia). With such complex management arrangements, the aim should be to have consistent management across the entire site.

3.1 National Land

3.1.1 Memoranda of understanding

Sixteen grassland sites are either wholly or partly on National Land (*see* Table 4).

The Australian Government has legislative (planning and management) responsibility for National Land in the ACT. To encourage a coordinated approach to conservation management at all grassland sites in the ACT, the ACT Government established memoranda of understanding with national custodial land managers. This provides a formal means by which consultation between responsible land manager and the ACT Government can occur.

The memoranda of understanding relate specifically to particular sites and provide that the land manager will consult the other signatories about planning, development control policies and actions that may affect the sites. The objective of each memorandum of understanding is to establish an agreed framework and management guidelines and arrangements to:

- promote a land use and management regime that will provide for long-term protection of the ecological values of the grassland sites
- foster development of a productive and harmonious partnership between parties
- encourage a cooperative approach to resolving conservation issues that arise, including research and monitoring, information management, and liaison arrangements.

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33 Designated Areas are specified in the National Capital Plan. They are areas of land that have special characteristics of the National Capital. Any buildings or structures, demolition, landscaping or excavation works in these areas require the prior written approval of the National Capital Authority.

Table 4: Summary of jurisdictional and management arrangements for ACT lowland native grassland sites

Site name	Site no.	Jurisdiction	Custodial land manager	Purpose/land use	Management arrangement	Additional conservation specifications
Majura Valley						
Majura Training Area	MA01	National	Department of Defence	Defence	MoU	Majura Training Area Management Plan
Air Services Beacon	MA02	National (Designated)	Air Services Australia	Airport Services		
Canberra International Airport	MA03	National (Designated)	Canberra International Airport	Airport		Canberra International Airport Management Plan
'Malcolm Vale'	MA04	National	Department of Defence	Defence	MoU	
Campbell Park	MA05	National	Department of Defence	Defence	MoU	
Majura West	MA06	Territory	TAMS	Rural (agisted)	Licence (agistment)	
Jerrabomberra Valley						
'Mugga Mugga' Homestead	JE01	Territory	ACT Historic Places	Special Purpose Reserve		Management Plan for Historic Sites MS
'Callum Brae'	JE02	Territory	TAMS	Nature Reserve (part) Leases (part)	CNP MP Lease (rural) (part) Lease – Model Aircraft Club (part) Lease – Caravan park and camping ground (part)	MS LMA, CD
Jerrabomberra West Reserve	JE03	Territory	TAMS	Nature Reserve	CNP MP Lease (rural) (part)	MS LMA, CD
Woods Lane	JE04	Territory	TAMS	Roadside	Roadsides MP	
Jerrabomberra East Reserve [a]	JE05	Territory	TAMS	Nature Reserve (proposed)	CNP MP	
Harman Bonshaw South	JE06	National and Territory	Department of Defence and TAMS	Defence Rural lease	MoU Lease (rural) (part)	LMA, CD
Harman Bonshaw North	JE07	National and Territory	Department of Defence	Defence	MoU	LMA, CD

Site name	Site no.	Jurisdiction	Custodial land manager	Purpose/land use	Management arrangement	Additional conservation specifications
			and TAMS	Rural lease	Lease (rural) (part)	
‘Cookanalla’	JE08	Territory	TAMS	Rural lease	Lease (rural)	LMA, CD
AMTECH	JE09	Territory	TAMS	Vacant (General, industrial + rural)		
Tennant Street, Fyshwick	JE10	Territory	TAMS	Rural (agisted)	Licence (agistment)	
Gungahlin						
Mulanggari Nature Reserve	GU01	Territory	TAMS	Nature Reserve	CNP MP	MS
Gungaderra Nature Reserve	GU02	Territory	TAMS	Nature Reserve	CNP MP Lease – Broadcast Australia (part) Lease – Print Handicapped Radio (part) Licence (agistment)	MS
Crace Nature Reserve	GU03	National and Territory	Department of Defence and TAMS	Defence Nature Reserve	MoU CNP MP Lease (rural) (part) Licence (agistment)	MS LMA
North Mitchell	GU04	Territory	TAMS	Non-Urban: Hills, Ridges and Buffers		
Mitchell	GU05	Territory	TAMS	Vacant (General + Industrial)	Licence (agistment)	
Canberra Riding Club	GU06	Territory	TAMS	Community use	Lease	
Wells Station Road	GU07	Territory	TAMS	Roadside	Roadsides MP	
Nicholls	GU08	Territory	TAMS	Urban Open Space	UOS MP	
Belconnen						
Ginninderra Experimental Station	BE01	National	CSIRO	Research	MoU	MS
Dunlop Nature Reserve	BE02	Territory	TAMS	Nature Reserve	CNP MP Licence (agistment)	MS

Site name	Site no.	Jurisdiction	Custodial land manager	Purpose/land use	Management arrangement	Additional conservation specifications
'Jarramlee'	BE03	Territory	TAMS	Rural (agisted)	Licence (agistment)	
Umbagong Park South, Florey [b]	BE04(a)	Territory	TAMS	Urban Open Space	UOS MP	MS
Umbagong Park North, Florey	BE04(b)	Territory	TAMS	Urban Open Space	UOS MP	MS
Evatt Powerlines	BE05	Territory	TAMS	Urban Open Space	UOS MP	MS
Lake Ginninderra	BE06	Territory	TAMS	Urban Open Space	UOS MP	MS
Lawson Territory	BE07	Territory	TAMS	Rural (agisted)	Licence (agistment)	
Lawson Commonwealth – Belconnen Naval Transmission Station	BE08(a)	National	Department of Defence	Defence	MoU	Belconnen Naval Transmission Station Management Plan
Lawson Commonwealth – East	BE08(b)	National	Department of Defence	Defence	MoU	
Kaleen east paddocks	BE09	Territory (Designated)	TAMS	Rural (agisted)	Horse Paddock Contract	MS
Caswell Drive	BE10	Territory (Designated)	TAMS	Rural Lease	Lease (rural)	LMA
Glenloch Interchange	BE11	Territory (Designated)	TAMS	Roadside	Roadside MP	
Kama South [c]	BE12	Territory	TAMS	Rural (agisted)	Licence (agistment)	
Evatt Footbridge [d]		Territory	TAMS	Urban Open Space	UOS MP	
Central Canberra/Tuggeranong						
CSIRO Headquarters, Campbell	CC01	National and Territory	CSIRO TAMS	CSIRO Roadside	MoU UOS MP	MS
Constitution Avenue, Reid	CC02	Territory (Designated)	TAMS	Urban Open Space	UOS MP	MS
St John's Church, Reid	CC03	Territory (Designated)	TAMS	Urban Lease	Lease	
Australia Centre for Christianity and Culture, Barton	CC04	Territory and National (Designated)	TAMS	Urban Lease	Lease	Draft Management Plan MS
York Park, Barton	CC05	National	Department of Finance	Vacant		Draft maintenance plan
Yarramundi Reach	CC06	National	NCA	Urban Open Space	MoU	
Lady Denman Drive, Yarralumla	CC07	National and Territory (Designated)	NCA TAMS	Roadside	MoU Roadsides MP	MS
Dudley Street, Yarralumla	CC08	Territory (Designated)	TAMS	Urban Open Space	UOS MP	MS

Site name	Site no.	Jurisdiction	Custodial land manager	Purpose/land use	Management arrangement	Additional conservation specifications
Guilfoyle Street, Yarralumla [e]	CC09	National	NCA	Vacant	MoU	
Novar Street, Yarralumla	CC10	Territory (Designated)	TAMS	Urban Open Space	UOS MP	MS
Black Street, Yarralumla	CC11	Territory (Designated)	TAMS	Urban Open Space	UOS MP	MS
Isabella Pond, Monash	TU01	Territory	TAMS	Urban Open Space	UOS MP	MS

Notes:

CD = Conservator's Directions; CNP MP = Canberra Nature Park Plan of Management (1999); CSIRO = Commonwealth Scientific and Research Organisation; LMA = Land Management Agreement; MoU = memorandum of understanding; MS = Site Maintenance Specifications; NCA = National Capital Authority; TAMS = Department of Territory and Municipal Services; UOS MP = Urban Parks, Sportsgrounds Management Plan; (Designated) = Designated areas under the National Capital Plan.

a Draft Variation to the Territory Plan in progress.

b Umbagong Park North and South are identified as one site in Action Plan No. 28.

c This site is additional to the Action Plan No. 28, to be added to Canberra Nature Reserve.

d Included following a submission from the North Belconnen Landcare Group.

e This site is incorrectly named as Kintore Street in Action Plan No. 28.

Significant areas of lowland native grassland are located on lands held by Australian Government departments or private agencies. One means of fostering communication and integration of activities between departments and agencies is through development and implementation of memorandum of understanding. Significant effort went into developing memoranda of understanding in 1998; however, it appears implementation was limited. A reason for this may have been lack of an across–department/agency coordination group. Given the challenges in managing lowland native grassland sites that all departments and agencies currently confront, it seems timely to update existing memoranda of understanding and focus on their implementation.

The ACT Government currently has memoranda of understanding with:

- **Department of Defence** for Majura Training Area (MA01), Malcolm Vale (MA04), Campbell Park (MA05), Harmon-Bonshaw South (JE06), Harmon-Bonshaw North (JE07), part of Crace Nature Reserve (GU03), Lawson Commonwealth (BE08(a) and (b))
- **National Capital Authority** for Yarramundi Reach (CC06), Lady Denman Drive (CC07) (part National Land), and Guilfoyle Street, Yarralumla (CC09)
- **CSIRO** for CSIRO Headquarters, Campbell (CC01) and Ginninderra Experimental Station (BE01).

The Australian Government Department of the Environment, Water, Heritage and the Arts is a signatory to each.

These memoranda of understanding were signed on 7 September 1998. It appears, from the Department of Defence memorandum of understanding, that revised schedules were prepared in October 2001. Otherwise, it would seem that there have been no revisions over the past 10 years. As such, these memoranda of understanding are somewhat dated and predate commencement of the *Environment Protection and Biodiversity Conservation Act 1999* (Cwlth). All these memoranda of understanding need to be revised, reviewed and strengthened. Furthermore, while a significant effort went into developing the memoranda of understanding, in recent years implementation has been lacking.

In updating memoranda of understanding with the National Capital Authority, to ensure requirements under the National Capital Plan are met, those grassland sites on Territory Land that are Designated Areas – Kaleen East Paddocks (BE09); Caswell Drive (BE10); Glenloch Interchange (BE11); Constitution Avenue, Reid (CC02); St John's Church, Reid (CC03); Australian Centre for Christianity and Culture (CC04); Lady Denman Drive, Yarralumla (CC07); Dudley Street, Yarralumla (CC08); Novar Street, Yarralumla (CC10); and Black Street, Yarralumla (CC11) – should be included.

Recommendation 6: Existing memoranda of understanding between the ACT Government and Department of Defence, the National Capital Authority and CSIRO, with the Department of Environment, Water, Heritage and the Arts being a signatory, should be updated and implemented.

There is also an opportunity to development memoranda of understanding between the ACT Government and the Department of Finance for York Park, Barton (CC05); Air Services Australia for Air Services Beacon (MA02); and the Canberra Airport Group for Canberra International Airport (MA03). The Department of Environment, Water, Heritage and the Arts needs to be a signatory to each of these memoranda of understanding.

Recommendation 7: Develop memoranda of understanding between the ACT Government and the Department of Finance, Air Services Australia and the Canberra Airport Group, with the Department of Environment, Water, Heritage and the Arts being a signatory.

A coordination and implementation group needs to be established to ensure implementation of memorandum of understanding.

Recommendation 8: Establish a memorandum of understanding coordination and implementation group with an ACT Government agency being the lead agent.

3.2 Territory Land

Thirty-nine lowland native grassland sites are either wholly or partly on Territory Land (*see* Table 4). The ACT Government is responsible for managing Territory Land on behalf of the Commonwealth.[34] The Territory Plan provides a range of legislated land management arrangements that afford a degree of protection to lowland native grassland sites in the ACT according to their allowable land use or zone via:

- plans of management on nature reserves, urban open space and special purpose reserves
- licences and leases on other lands particularly rural.

The Territory Plan 2008 is the ACT Government's key statutory planning document and provides the policy framework for administering planning in the ACT. It directs management of land use change and development so it is consistent with strategic directions set by the ACT Government, the Legislative Assembly and the community but also so that it is consistent with the National Capital Plan.

All land that falls within the Territory Plan (Territory Land) is defined according to allowable land uses via zones including public land (for example, Nature Reserve and Urban Open Space), Industrial, Transport and Services, Residential and Non Urban. Land use is managed in accordance to the defined zones. For each zone, the Territory Plan defines objectives by which the sites are to be protected and managed. A variation of the Territory Plan is required to change a zone.

3.2.1 Plans of management

Grassland sites on public land are administered in accordance with provisions of the *Planning and Development Act 2007* (ACT). These sites generally include nature reserves, urban open space and special purpose reserves. Plans of management are mandatory under the Act for areas of public land. Grassland sites, which are subject to plans of management, are listed in Table 4.

Sites on Territory Land defined as nature reserve or national park have the highest level of protection. No lowland native grassland sites are within Namadgi National Park.[35] The primary objective defined in the Territory Plan for nature reserves is conservation of the site and associated species.

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[34] Section 29 (1) (a) of the *Australian Capital Territory (Planning and Land Management) Act 1988* (Cwlth).

[35] Montane grasslands in Namadgi National Park are included in the nationally threatened Natural Temperate Grassland of the Southern Tablelands (NSW and ACT) but are not the subject of this investigation.

Under the *Planning and Development Act 2007* (ACT) a plan of management for an area of public land must be reviewed at least once every 10 years.[36] If the plan of management is no longer appropriate for the land, a draft variation of the plan of management must be prepared.[37]

Canberra Nature Park Management Plan (1999)

The *Canberra Nature Park Management Plan* (1999) applies to all grassland sites, which are nature reserves or part nature reserves. The Management Plan does not address the specific requirements of the four grassland reserves declared since 1999 – Jerrabomberra West Reserve (JE03), Jerrabomberra East Reserve (JE05), and 'Callum Brae' (part JE02) – but the strategic directions of the Management Plan are relevant and Action Plan No. 28 guides management.

The *Canberra Nature Park Management Plan* must be reviewed by 29 July 2009.

The Management Plan states that a management strategy is to be developed for each Canberra Nature Park reserve. The strategy is to include identification of values, features and facilities, fire history, exotic species, specific management objectives, management zones, actions and priorities, and opportunities for volunteer participation.[38]

One grassland site on public land is a special purpose reserve, namely, the Mugga Mugga Homestead (JE01). The management objectives for a special purpose reserve are to provide for public and community use of the area for recreation and education.[39] The Management Plan for Historic Sites covers the Mugga Mugga Homestead (JE01).

Relationship between Canberra Nature Park Management Plan and Action Plan No. 28

The first action plan prepared for Natural Temperate Grasslands (Action Plan No. 1) predates the *Canberra Nature Park Management Plan*, and Action Plan No. 28 post-dates it. Action Plan No. 1 stated that a management plan for Natural Temperate Grassland was prepared in 1994 and that it included recommendations for management and protection of each recorded natural grassland site in the ACT. Action Plan No. 1 further stated that:

- management guidelines will incorporate principles and objectives based on scientific study, regional conservation requirements, and site-specific prescriptions that take into account the component biodiversity, habitat diversity, historical land management and processes occurring in each site
- the updated management guidelines for ACT natural grassland sites will be implemented on a site-specific basis in cooperation with relevant landholders.

It would therefore seem that the Action Plan No. 1 envisaged that there would be site-specific prescriptions as to what was to occur on each grassland site and that these prescriptions would be embodied in management guidelines. In this context, the *Canberra Nature Park Management Plan*, in referring to the grassland sites within the Gungahlin grassland nature reserves – Mulanggari (GU01), Gungaderra (GU02) and Crace (GU03) and

[36] *Planning and Development Act 2007* section 3.3.2 (2)(a).

[37] *Planning and Development Act 2007* section 3.3.2 (2)(b).

[38] *Planning and Development Act 2007* section 3.2.1.

[39] *Planning and Development Act 2007* section 3.1.6(a) and Schedule 3 Item 4.

Dunlop (BE02) – states that specific guidelines will be developed[40] and implemented.[41] This is consistent with development and implementation of reserve management strategies identified in the *Canberra Nature Park Management Plan*. However, these strategies need to be kept simple and focused on achieving results through specifying land management actions.

One of the purposes of Action Plan No. 28 is to provide a basis for planning and land management decisions with regard to areas containing lowland native grassland.[42] Action Plan No. 28 provides that the directions it contains about public land should be expressed through management plans.[43] The action plan is to inform management plans such as the *Canberra Nature Park Management Plan* (for further information, see Figure 1.1 of Action Plan No. 28).

Management plans need to be amended to reflect recent changes and afford greater protection to lowland native grassland.

Recommendation 9: Amend the *Canberra Nature Park Management Plan* (1999) to incorporate:

- Action Plan No. 28, *ACT Lowland Native Grassland Conservation Strategy* (2005)
- the new nature reserves of 'Callum Brae' (part JE02), Jerrabomberra West Reserve (JE03), Jerrabomberra East Reserve (JE05).

Annual action spreadsheets

Officers in the Research and Planning Unit in conjunction with officers in the Parks and Reserves unit of the Department of Territory and Municipal Services have developed a one-page annual action spreadsheet for each grassland site in the nature reserves of Mulanggari (GU01), Gungaderra (GU02), Crace (GU03), Dunlop (BE02) and Jerrabomberra West (JE03).

These annual action spreadsheets are essentially the same as the management strategies identified in the *Canberra Nature Park Management Plan*. The spreadsheets are seasonal in orientation, and cover a period of six years from 2005 to 2011; they also indicate that management actions are to be reviewed every two years.

Officers in the south district of the Parks and Reserves unit have advised that the spreadsheets for 'Callum Brae' (part JE02) and Jerrabomberra West Reserve (JE03) are used in a general way; however, they need updating.

While several policy and planning documents pertaining to lowland native grassland exist, not all sites are subject to annual site operation plans, or their equivalent, to guide field actions. These plans are important in assisting staff, particularly in large organisations where staff rotations may occur.

Parks Conservation and Lands (Department of Territory and Municipal Services) has developed annual action spreadsheets and management specifications for some sites, both of which are essentially annual site operation plans. These should be used as a model in developing plans for all sites. A cooperative approach between land managers, lessees and

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[40] *Canberra Nature Park Management Plan*, paragraph 3.3.

[41] *Canberra Nature Park Management Plan*, paragraph 3.3.8.

[42] Action Plan No. 28, page 1 section 1.2.

[43] Action Plan No. 28, page 1 section 1.7.

Australian Government and Territory agencies is needed for these to be uniformly adopted and implemented.

Recommendation 10: Develop and implement annual site operation plans for all lowland native grassland sites.

Regional plans of management

Three regional plans of management are applicable to lowland native grassland sites:

- Belconnen's Urban Parks, Sportsgrounds and Lake Ginninderra, which commenced on 16 October 1998
- Inner Canberra's Urban Parks and Sportsgrounds, which commenced on 23 May 2000
- Tuggeranong's Urban Parks and Sportsgrounds, which commenced on 23 May 2000.

Under the *Planning and Development Act 2007* (ACT) a plan of management for an area of public land must be reviewed at least once every 10 years.[44] If the plan of management is no longer appropriate for the land, a draft variation of the plan of management must be prepared.[45]

Therefore, Belconnen's Urban Parks, Sportsgrounds and Lake Ginninderra Plan of Management should have been reviewed by 16 October 2008. Inner Canberra's Urban Parks and Sportsgrounds Plan of Management and Tuggeranong's Urban Parks and Sportsgrounds Plan of Management must be reviewed by 23 May 2010.

All three plans of management commenced after Action Plan No. 1 was prepared in 1997[46] but before commencement of Action Plan No. 28. All three plans state that there will be specific site management guidelines applied for native grassland sites as per Action Plan No. 1. In addition, each contains a one-page chart dealing with matters relevant to native grassland sites. However, the charts are not site-specific.

The Department of Territory and Municipal Services has developed guidelines that identify a mowing and burning regime for lowland native grassland sites in urban open space on Territory Land.

An area of Natural Temperate Grassland (Lake Ginninderra (BE06)) adjoining Lake Ginninderra could be afforded a higher level of protection through being managed under the plan of management covering the land adjoining Lake Ginninderra.

Recommendation 11: Amend the Belconnen Urban Parks, Sportsgrounds and Lake Ginninderra Plan of Management to include the lowland native grassland site of Lake Ginninderra (BE06).

3.2.2 Licences

The ACT Planning and Land Authority grants licences under the *Planning and Development Act 2007* (ACT) to occupy or use unleased Territory Land. Licences must be in writing and

[44] *Planning and Development Act 2007* Section 332 (2)(a).

[45] *Planning and Development Act 2007* Section 332 (2)(b).

[46] Action Plan No. 28.

state the period for which they are granted.[47] A licence is subject to the conditions stated in it. The ACT Planning and Land Authority must not grant a licence to occupy or use public land unless the Conservator of Flora and Fauna agrees in writing to the grant.[48]

Nine agistment licences are held over unleased Territory Land, which are grassland sites (*see* Table 4). Agistment licences are three-party licences between the ACT Planning and Land Authority, the custodian of the land, and the licencee. Three of these licences are in the nature reserves of Dunlop (BE02), Crace (GU03) and Gungaderra (GU02), which provide for grazing to be undertaken for conservation purposes only, in compliance with the licence conditions.

Agistment licences are not standardised in their conditions; for example, six of the licences can be terminated on seven days notice and the other two licences can be terminated on one months notice. None of the agistment licences contain specific provisions relating to protecting the lowland native grassland. However, all agistment licences contain a provision requiring the licensee to comply with any direction as to the maximum number and type of stock to be grazed on the land within seven days of such directions being given.

From discussions with staff in relevant agencies it seems that the time involved in administering agistment licences could be reduced if these were standardised, including termination dates and if one government agency only was the government signatory to these agreements.

Recommendation 12: Simplify administration of agistment licences covering lowland native grassland sites through standardising their conditions, including termination dates; and have one government agency signatory to an agistment lease.

3.2.3 Leases

The ACT Planning and Land Authority grants leases under the *Planning and Development Act 2007* (ACT). There are seven whole or part rural leases over lowland native grassland areas. The Authority must not grant a lease of public land unless the Conservator of Flora and Fauna has provided a written recommendation that the lease be granted. Fourteen leases are held over Territory Land on lowland native grassland sites (*see* Table 4).

Rural leases

Land management agreements are mandatory under the *Planning and Development Act 2007* (ACT) for granting rural leases, granting further rural leases, varying rural leases or consenting to transfer of a rural lease.[49] A land management agreement defines the natural values of a lease, provides a map of the land area, and describes the environmental values. It also sets out terms and conditions for maintaining or improving those values while enabling operation of a rural enterprise. The Conservator of Flora and Fauna and the rural lessee sign the rural land management agreement. Rural land management agreements are commercial-in-confidence documents. Managing land held under a rural lease, other than in accordance

[47] *Planning and Development Act 2007* Section 304(1).

[48] *Planning and Development Act 2007* Section 303(2).

[49] See section 283.

with a rural land management agreement that applies to it, is a controlled activity[50] for which enforcement action can be taken under the *Planning and Development Act 2007* (ACT).[51]

Confusion between some Department of Territory and Municipal Services and ACT Planning and Land Authority staff is apparent over who is accountable for administering Land Management Agreements that support rural leases. The process for administering leases (including land management agreements) is complex and involves both Territory and Municipal Services and ACT Planning and Land Authority staff. This complexity may have led to confusion regarding accountability for enforcement of the conditions in the Land Management Agreement for 'Cookanalla' (*see* Recommendation 15). Given the role of Parks Conservation and Lands (Department of Territory and Municipal Services) it seems appropriate for them to be fully responsible for administering land management agreements.

Recommendation 13: Ensure rural lease processes (including those for land management agreements) are simplified and responsibilities are clarified.

The Commissioner and staff, in the company of Dr Hodgkinson, met with most rural lessees who had a rural lease with a lowland native grassland site and participated in an inspection of their leasehold properties. All the rural lessees were cooperative during the course of the investigation and provided a copy of their rural land management agreements on a confidential basis.

The land management agreements all contain provisions that aim to protect the grassland sites and the threatened species they contain; for example, requirements relating to grazing, weed control and fertiliser use. Each contains a provision that the agreement will be reviewed no later than at five-year intervals.

Parts of Crace Nature Reserve (GU03) and Caswell Drive (BE10) have rural leases that are managed under land management agreements. Given that these land management agreements have not been reviewed within the required five-year period and these sites are in a critical condition, a review of the conditions in the land management agreements is needed. Once this is done, compliance with the conditions in the land management agreement should be monitored to ensure their implementation.

Recommendation 14: Review the land management agreements covering Crace Nature Reserve (GU03) and Caswell Drive (BE10).

One grassland site on a leasehold property, 'Cookanalla' (JE08), was approaching a critical threshold beyond which unacceptable degradation would occur because of grazing and weeds. The rural land management agreement for this property is due for review by August 2009 at the latest. In the interim, this rural land management agreement contains provisions and conditions that can be used to regulate grazing and weed control. Enforcement of the provisions and conditions should occur immediately.

It is of concern that the 'Cookanalla' (JE08) site, a rural lease, has reached its current degraded state without action being taken by the relevant government department to enforce compliance with the conditions in the Land Management Agreement, which is part of its rural lease.

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[50] Section 339 and Schedule 2 Item 6.

[51] See sections 352 to 361.

Recommendation 15: Immediately enforce the provisions and conditions in the land management agreement, which is a part of the rural lease for 'Cookanalla' (JE08).

Conditions in land management agreements (attached to rural leases) are potentially a powerful mechanism for protecting lowland native grassland areas on leased rural land. However, for their benefit to be realised the conditions must be implemented. Accordingly, the government department responsible for administrating land management agreements needs to monitor compliance and take enforcement action if needed. In this investigation no information was available that indicated that any action had been taken to monitor compliance with, or enforce conditions in the land management agreement for 'Cookanalla' (JE08), a site that needs land management actions to restore its ecological conditions.

Recommendation 16: Foster a strong culture of compliance, monitoring and enforcement within the government department responsible for administering land management agreements.

Land management agreements need to be monitored and assessed in order to ensure the required on-the-ground actions are achieving the desired ecological results. There was no evidence of a formal monitoring, assessment or auditing process being in place. Furthermore, information from such a process could be used to help the ACT Government's Flora and Fauna Committee advise on policy issues and monitor implementation of the ACT Government's, 2005 *A Vision Splendid of the Grassy Plains Extended: ACT Lowland Native Grassland Conservation Strategy*, Action Plan No. 28.

Recommendation 17: Establish a formal monitoring, assessment and auditing process aimed at ensuring conditions in land management agreements achieve the desired ecological results.

Grazing is an important land management tool currently used to control grassland biomass. However, if this is used inappropriately it can adversely affect the lowland native grassland ecology. Grazing should, therefore, be undertaken as part of the conservation management strategy within an adaptive management process to protect lowland native grassland sites.

Recommendation 18: Permit grazing under rural leases and licences, on lowland native grassland sites if it is part of a long-term conservation management strategy.

Other leases

Currently, there are seven non-rural leases on lowland native grassland sites in the ACT. These non-rural leases are not required to have land management agreements. These non-rural leases are:

- Caravan park and camping ground – 'Callum Brae' (part JE02)
- Model Aircraft Club – 'Callum Brae' (part JE02)
- Telecommunications – Gungaderra Nature Reserve (GU02)
- Print Handicapped Radio – Gungaderra Nature Reserve (GU02)
- Canberra Riding Club (GU06)
- Church purposes – St John's Church, Reid (CC03)
- Religious purposes – Australian Centre for Christianity and Culture, Barton (CC04).

No specific management arrangements appear to be in place for these leases except for the Australian Centre for Christianity and Culture, Barton (CC04). This grassland site straddles two leasehold areas occupied by the Australian Centre for Christianity and Culture and St Mark's Anglican Church. Both leases contain a requirement that a conservation management plan be developed for the Natural Temperate Grassland on the site. Parks Conservation and Lands, in consultation with the lessees, has developed a draft Conservation Management Plan and Specifications for the site.[52]

While the Department of Territory and Municipal Services can request that a land management agreement is completed before a lease is granted this cannot be done retrospectively.[53] Therefore, for all these sites it is recommended that annual site operation plans be developed, as stated in Recommendation 10.

3.2.4 Unleased Territory Land

Unleased Territory Land includes roadsides and other areas for which leases have not been developed, such as the undeveloped industrial land at Mitchell (GU05) and AMTECH (JE09). Other unleased Territory Land, while managed by the ACT Government, is not required to have statutory management plans. In many cases, there are no existing conditions for use that ensure consideration of conservation issues. However, Roads ACT in consultation with Parks Conservation and Lands has developed the Roadside Management Plan to define responsibility between agencies and also identify areas of conservation value. In addition, the Bushfire Operational Plan for each financial year is sent to relevant agencies. These plans allow for inclusion of certain provisions in activities that may affect conservation issues. To help manage these sites, it seems prudent that the annual site operation plans be developed for unleased Territory Land with lowland native grassland sites. Therefore, for all these sites it is recommended that annual site operation plans be developed, as stated in Recommendation 10.

3.2.5 Conservator's Directions

The *Nature Conservation Act 1980* (ACT) provides for the Conservator of Flora and Fauna to issue directions to the lessee relating to protection of significant natural values. To ensure protection of Grassland Earless Dragon habitat, the Conservator of Flora and Fauna issued Conservator's Directions relating to the grassland sites on leasehold land at Harman Bonshaw North (JE07) and 'Cookanalla' (JE08) issued in January 2004; and 'Callum Brae' (JE02), Jerrabomberra West Reserve (JE03), and Harman Bonshaw South (JE06) issued in February 2004. These Directions came into effect 14 days from the date of issue. Failure to comply with a Conservator's Direction is an offence under section 60(3) of the *Nature Conservation Act 1980* (ACT).

These Directions were superseded by land management agreements. However, as previously mentioned, the conditions in these land management agreements do not appear to be subject to compliance monitoring and enforcement, when appropriate.

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[52] Pers. comm., Sarah Sharp, Parks Conservation and Lands.

[53] Email from Sharon Harmer, ACT Planning and Land Authority, 13 January 2009.

4 Management issues

Natural Temperate Grassland is considered endangered under the *Environment Protection and Biodiversity Conservation Act 1999* (Cwlth) and the *Nature Conservation Act 1980* (ACT). This is due to the severe decline in its extent, the fragmented distribution and isolation of many remaining sites, and modification of the community composition, structure and ecological processes.[54]

Following European settlement, a number of factors have been responsible for the loss of grassland and modification of the remnants. These factors generally remain as ongoing threats. The major threats to the lowland native grassland as identified in the National Recovery Plan and Action Plan No. 28 are:

- pastoral and agricultural development
- urban and infrastructure development
- weed invasion
- changes in or inappropriate fire regimes
- other forms of disturbance including:
    - inappropriate grazing regimes
    - physical disturbance
    - use of fertilisers and other soil ameliorants
    - mowing and slashing
    - tree planting
    - herbicide use
    - collection of grass seed.

The changes that have occurred to the grasslands since European settlement need to be considered when applying management to sites. In particular, the loss of many areas of grassland has resulted in extensive fragmentation, thus causing isolation of species with, in many cases, minimal or no opportunities for re-colonisation following local extinction. The modifications to grassland has resulted in:

- elevated nutrient levels
- increased soil acidity
- increased soil compaction
- loss of topsoil
- changes to drainage
- loss of native species diversity (including soil biota and digging mammals such as bettongs and bandicoots).

[54] National Recovery Plan, page 21.

4.1 Threatening processes currently impacting grassland sites

Dr Hodgkinson undertook an assessment (from February to August 2008) of the key threatening processes impacting the Territory's lowland native grassland sites.[55] Threats assessed were grazing, mowing/slashing, lack of fire, significant weed invasion and physical disturbance. He also consulted the relevant Commonwealth land managers and the Department of Territory and Municipal Services land managers and staff, rural lessees, particularly in relation to historic events, past management, and survey results.

The threatening processes and condition of each lowland native grassland site are presented in Table 5. Using a critical threshold analysis (a point at which one or more threats will cause irreversible damage to a site, beyond which native plant and animal survival and reproduction is compromised)[56] each site's condition has been classified as:

- Good (**G**) – these sites require ongoing management.
- Approaching a Critical (**AC**) threshold – these sites require urgent management action.
- Critical (**C**) threshold – these sites require urgent management action.

As shown in Table 5, the threatening processes for sites classified as approaching a critical threshold (**AC**) or at critical threshold (**C**), were:

- weed invasion on 14 sites
- overgrazing by kangaroos on 11 sites
- overgrazing by rabbits on four sites
- overgrazing by stock on seven sites
- inappropriate mowing on five sites
- lack of biomass management (that is, closed canopy) on eight sites.

The conservation significance of a site needs to be considered with respect to that site's ecological classification (*see* Table 1). Sites in the highest Conservation Category (Category 1: Core Conservation Sites)[57] should be given priority for action over sites in other categories.

An analysis of Table 5 shows that of the Territory's 49[58] lowland native grassland sites:

- Twenty (40%) are in good condition.
- Twenty (40%) are approaching a critical threshold.
- Ten (20%) are in a critical condition.

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[55] 49 sites were assessed with Lawson Commonwealth (BE08) site being assessed as two separate areas being Belconnen Naval Transmission Station (BE08(a) (the area behind the secure fence) and Lawson Commonwealth – East (BE08(b) (the area outside the secure fence). Harmon Bonshaw North (JE06) and Harmon Bonshaw South (JE07) were assessed as one site.

[56] Ken Hodgkinson, report to the Commissioner for Sustainability and the Environment.

[57] Action Plan No. 28, page 57.

[58] Lawson Commonwealth land (BE08(a) and BE08(b)) was considered in two sections with each being rated differently. Hence the summary totals 50.

The main threat to the lowland native grassland in the Majura Valley (all sites are in Category 1: Core Conservation Sites, except 'Malcolm Vale' (MA04)) is overgrazing by kangaroos. Sites in the Majura Valley that are not in critical condition due to overgrazing, most notably Canberra International Airport ((MA03), which is in good condition, have generally been fenced for a considerable time, hence preventing kangaroo grazing. This good condition is also due to the overall effective management that takes place at Canberra International Airport. Overgrazing by kangaroos is also an issue for some sites in Jerrabomberra, Gungahlin and Belconnen.

Weeds and inappropriate mowing regimes were the main threatening process for sites in the urban areas of Central Canberra/Tuggeranong.

Dr Hodgkinson's full report is in Appendix 8 and a summary of all the lowland native grassland sites is in Appendix 4.

4.2 Conservation management requirements

Management is required to maintain the optimal composition, structure and function of lowland native grassland ecosystems to reduce its vulnerability to threatening processes. The optimal condition of lowland native grassland includes:

- dominance by vigorous native perennial grasses
- presence of inter-tussock spaces that provide habitat for smaller less vigorous native forbs[59]
- a diversity of native grasses and forbs
- opportunities for plants to flower and set seed and regeneration to occur.[60]

The resulting high diversity of structure and composition is considered essential to provide habitat for a range of fauna species. In addition, it will result in improved resistance to weed invasion, a healthy soil biota that is important for functioning, and a reduction in soil disturbance and water erosion.[61]

4.2.1 Management of biomass

A mix of tall tussock and shorter inter-tussock species is important for conserving a range of grassland plants and animals. In the absence of some form of removal of excess foliage (defoliation or biomass reduction) the dominant grasses tend to become overgrown and rank, and the result is a loss in the heterogeneity of structure and biological composition and subsequent reduction in habitat diversity. The consequence of protecting grassland from all processes of defoliation is an elevated risk that native plant species and many fauna species will be lost from the site.

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[59] Forbs are a group of non-woody plants, other than grasses, sedges and rushes.

[60] Action Plan No. 28.

[61] Pers. comm., Sarah Sharp, Parks Conservation and Lands.

Table 5: Threatening processes and condition of lowland native grassland sites in the ACT, as assessed by Dr Ken Hodgkinson in mid 2008

Site name	Site no.	Land ownership	Stock grazing	Kangaroo grazing	Rabbits	Weed invasion	Mowing	Physical disturbance	Closed canopy	Condition
Majura Valley										
Majura Training Area	MA01	N		P		#				**C**
Air Services Beacon	MA02	N							#	**G**
Canberra International Airport	MA03	N				#				**G**
‘Malcolm Vale’	MA04	N		P		P				**C**
Campbell Park	MA05	N				#				**G**
Majura West	MA06	T	P	P	P					**C**
Jerrabomberra Valley										
‘Mugga Mugga’ Homestead	JE01	T								**G**
‘Callum Brae’	JE02	T				#				**G**
Jerrabomberra West Reserve	JE03	T				#				**G**
Woods Lane	JE04	T						#		**G**
Jerrabomberra East Reserve	JE05	T		P		#				**AC**
Harman Bonshaw South	JE06	N&T				P				**AC**
Harman Bonshaw North	JE07	N&T				P				**AC**
‘Cookanalla’	JE08	T	P		P	P				**AC**
AMTECH	JE09	T				#				**G**
Tennant Street, Fyshwick	JE10	T				#				**G**
Gungahlin										
Mulanggari Nature Reserve	GU01	T								**G**
Gungaderra Nature Reserve	GU02	T				#				**G**
Crace Nature Reserve	GU03	N&T	P	P	P	P				**C**
North Mitchell	GU04	T								**G**
Mitchell	GU05	T							P	**G**
Canberra Riding Club	GU06	T	P							**AC**

Site name	Site no.	Land ownership	Stock grazing	Kangaroo grazing	Rabbits	Weed invasion	Mowing	Physical disturbance	Closed canopy	Condition
Wells Station Road	GU07	T				P				**AC**
Nicholls	GU08	T				P				**AC**
Belconnen										
Ginninderra Experimental Station	BE01	N		P						**C**
Dunlop Nature Reserve	BE02	T	P	P						**C**
'Jarramlee'	BE03	T	P	P	P					**C**
Umbagong Park South, Florey[a]	BE04(a)	T							P	**AC**
Umbagong Park North, Florey[a]	BE04(b)	T				P			P	**AC**
Evatt Powerlines	BE05	T				#				**G**
Lake Ginninderra	BE06	T						#		**G**
Lawson Territory	BE07	T	P			P				**AC**
Lawson Commonwealth (Belconnen Naval Transmission Station)[b]	BE08(a)	N		P						**C**
Lawson Commonwealth (East)[b]	BE08(b)	N				#			#	**G**
Kaleen east paddocks[c]	BE09	T				#				**G**
Caswell Drive	BE10	T		P						**C**
Glenloch Interchange	BE11	T								**G**
Kama South	BE12	T								**G**
Evatt Footbridge	–	T							P	**AC**
Central Canberra/Tuggeranong										
CSIRO Headquarters, Campbell	CC01	N&T		P						**C**
Constitution Avenue, Reid	CC02	T							P	**AC**
St John's Church, Reid	CC03	T				#			#	**G**
Australian Centre for Christianity and Culture, Barton	CC04	N&T							P	**AC**
York Park, Barton	CC05	N				P				**AC**
Yarramundi Reach	CC06	N				P			P	**AC**

Site name	Site no.	Land ownership	Stock grazing	Kangaroo grazing	Rabbits	Weed invasion	Mowing	Physical disturbance	Closed canopy	Condition
Lady Denman Drive, Yarralumla	CC07	N&T				P	P			**AC**
Dudley Street, Yarralumla	CC08	T				P	P			**AC**
Guilfoyle Street, Yarralumla[d]	CC09	N				P	P			**AC**
Novar Street, Yarralumla	CC10	T					P			**AC**
Black Street, Yarralumla	CC11	T					P			**AC**
Isabella Pond, Monash	TU01	T							#	**G**

Notes:

N = National Land; T = Territory Land; N&T = National and Territory Land; P = present on site; # = Minor ongoing management required, site otherwise in good condition.

Threatening processes are grazing, weed invasion, mowing, physical disturbance and closed canopy.

Condition is identified as:

AC = approaching a critical threshold

C = at a critical threshold: A critical threshold is identified as being a point at which one or more threats will cause irreversible damage to a site, beyond which native plant and animal survival and reproduction is compromised (Ken Hodgkinson, report to the Commissioner for Sustainability and Environment). Sites identified as being in a critical condition or approaching a critical threshold require immediate action.

G = in good condition

a This site is identified as one site in Action Plan No. 28.

b This site is identified as one site in Action Plan No. 28.

c Fireweed removed after inspection.

d This site is incorrectly named as Kintore Street in Action Plan No. 28

The amount of defoliation needed relates to the productivity of the site and the growth forms of the dominant grass species. Where tall species, such as River Tussock (*Poa labilliardieri*) or Kangaroo Grass (*Themeda triandra*), dominate a lack of defoliation leads to development of a dense mat of vegetation material, which inhibits the growth and development of other plant species with consequent effects on fauna habitat. Where low-growing species dominate, minimal defoliation reduction may be needed to maintain the diversity of species and heterogeneity of habitat.[62] Any management should be applied as a mosaic, with only part of a site affected by defoliation at a time. This will increase heterogeneity of habitat and provide refuge when biomass is low.[63]

The three main forms of removal of foliage that can be applied are fire, slashing and mowing, and grazing.[64] While all three options can achieve good ecological outcomes, all are influenced by changes that have occurred since European settlement and can in some ways negatively affect the grassland habitat.[65]

Action Plan No. 28 describes the issues related to using these practices to achieve conservation outcomes in detail in Sections 3.7 and 2.1.7. However, Action Plan No. 28 fails to address overgrazing by kangaroos as an issue as no such threat was perceived at the time the strategy was produced in 2005. Consequently the issues related to kangaroo grazing are dealt with in some detail in this report.

Fire

While not researched fully, it is generally believed that fire enhances diversity to a greater extent than grazing or mowing.[66] Both grazing and slashing are more likely to introduce weeds into a site, or to spread them within a site. Fire has been an integral part of the evolution of native grasslands and is used as a management tool to maintain plant diversity. For many grassland sites, application of occasional burns is probably the optimal management regime to achieve conservation outcomes.

If burning is to be used as a management tool the following factors need to be considered (*see* Action Plan No. 28 for more detail):

- **Timing**: Plants need to be able to flower and set seed to regenerate. Some grassland species may require fire to enhance germination. It is likely that the most optimal period for burning is late summer or early autumn, although winter burns (if a fire can be carried at that time) may enhance growth of native grasses.
- **Intensity**: High intensity fires may affect soil biota including lichens and mosses (cryptogams), which are important for functional purposes of water absorption, nutrient cycling and maintenance of soil structure.
- **Frequency**: While research undertaken in Victoria in productive Kangaroo Grass dominated sites recommended a fire interval of between three and five years, the intervals should be assessed based on biomass density. Fires should only be applied when the biomass is high and structural heterogeneity is reduced, rather than at a fixed interval. It is considered that in the ACT sites it is more likely that an interval of

[62] Action Plan No. 28.

[63] Action Plan No. 28.

[64] Action Plan No. 28.

[65] Action Plan No. 28.

[66] Pers. comm., Sarah Sharp, Parks Conservation and Lands, 21 October 2008.

between four and 10 years would reflect actual biomass accumulation and sustain populations of a range of species.

- **Fauna impacts**: Patch burning (mosaics) is recommended to minimise risk to animals during a fire and to provide habitat before regeneration occurs. The size of the patch should relate to the taxonomic group of animals that are of most concern, or that required for ongoing survival by the largest animals of concern.

  There is considerable debate about the effects of regular burns (as opposed to occasional wildfire) on grassland fauna. In particular in fragmented sites there is limited or no opportunities for repopulation from neighbouring areas if animals are killed due to fire or other impacts. It is important to look at the ecology of each species (or threatened species as indicator species) to determine when they are least vulnerable to the immediate (heat, flame and smoke) and short-term (loss of vegetation cover and food resources) effects of fire.

- **Firebreaks** may need to be established to prevent the accidental spread of fire from or into a grassland site. This may require a mown strip. Ploughing or spraying will only spread or introduce weeds. Where possible such firebreaks should be outside the lowland native grassland site (for example, on a roadside or adjacent developed block).
- **Weed infestation** needs to be considered when applying burns. Bare ground resulting from the fire provides an optimal bed for establishment of weeds from seed store or from seeds arriving onto the site. The subsequent management of such weeds needs to either be incorporated into the program or the timing needs to be reconsidered. Of particular concern is the invasive capability of major weeds, such as African Lovegrass and Chilean Needlegrass, after a fire. Fire may also be an optimal approach to reducing some annual weeds, if they are burnt before setting seed. To minimise weed spread vehicles controlling the fires that enter the site need to be cleaned before entry.

Parks Conservation and Lands has produced an internal report that summarises known current information about the impact of fire and fuel reduction operations on threatened species and some ecological communities (including Natural Temperate Grasslands). These guidelines will aid development and implementation of annual Bushfire Operational Plans.

In addition, practical considerations to applying conservation burns on the lowland native grassland sites need to be considered. Such considerations include:

- restrictions to the seasons in which burns can safely occur
- restriction of suitable days as a result of fire hazard considerations and air pollution
- cost and availability of approved personnel and equipment
- risk of too frequent burns when used as control burns to protect adjacent property
- community concern about amenity.

Dr Hodgkinson visually assessed sites as requiring a burn by the degree of canopy closure. If the canopy was generally closed he judged the site to be approaching a critical threshold beyond which lack of fire to open the canopy would inhibit reproduction and establishment of forbs. He has advised that:

- species in grassland communities are adapted to fire and may require prescribed fire to persist
- there is a need to develop a fire management plan for each site and allocate resources

to conduct environmental burns

- the following sites should be considered for burning:
    - Air Services Beacon (MA02); Constitution Avenue, Reid (CC02); St John's Church, Reid (CC03); Australian Centre for Christianity and Culture, Barton (CC04); Yarramundi Reach (CC06); Guilfoyle Street, Yarralumla (CC09); Umbagong Park South (BE 04a); Umbagong Park North (BE 04b); Lawson Commonwealth – East (BE08(b)); Evatt Footbridge; Isabella Pond, Monash (TU01); and Mitchell (GU05).

While not researched fully, it is generally believed that fire enhances grassland diversity to a greater extent than grazing or mowing. Compared with fire, both grazing and mowing are more likely to introduce weeds into a site, or spread them within a site. However, ecological burns are not undertaken as a routine part of managing grasslands within the ACT. As the use of fire is not fully researched, and as lowland native grassland areas are primarily in or near Canberra's urban areas resulting in logistical challenges for undertaking burns, it is recommended that some experimental burns be undertaken to inform decisions about a wider use of fire.

Potential sites for consideration for an ecological burn program are: Air Services Beacon (MA02); Constitution Avenue, Reid (CC02); St John's Church, Reid (CC03); Australian Centre for Christianity and Culture, Barton (CC04); Yarramundi Reach (CC06); Guilfoyle Street, Yarralumla (CC09); Umbagong Park South, Florey (BE04a); Umbagong Park North, Florey (BE04b); Lawson Commonwealth – East (BE08(b)); Evatt Footbridge; Isabella Pond, Monash (TU01); and Mitchell (GU05).

Recommendation 19: Undertake experimental ecological burns on selected sites to determine the appropriateness of a wider application for managing lowland native grassland sites in the ACT.

Slashing and mowing

Defoliation/biomass removal by slashing or mowing is often used for landscape amenity, to improve access and to reduce fire hazard. Mowing and slashing are used on small sites, such as urban areas and cemeteries, and on roadsides where there may be small grasslands patches. However, it also has the effect of maintaining open structured grassland conducive to germination of a wide range of wildflowers associated with native grasslands. As is the case with burning or grazing, timing, frequency and intensity (slashing height) are keys to achieving a good or poor outcome.

Any slashing regime should allow for periods of good plant growth between each mowing and permit the grassland species to flower and set seed at least every few years.[67]

Slashing as a form of biomass reduction has the advantage of being highly manageable in terms of timing (it can be carried out at any time), cost (it is relatively cheap to undertake), frequency (it can be carried out at any required frequency), and selectivity (all plants are removed at the same height).

[67] Action Plan No. 28, page 76.

Slashing has three major disadvantages:

- **The spread of weed seeds on machinery**: Hygiene of slashers is important so seed is not spread between sites. Within sites weeds may be spread from infested to non-infested areas.
- **The litter it produces**: If the cuttings are not removed they can form mulch, which initially inhibits or kills the species underneath, and as it decomposes the area is often invaded by more aggressive introduced species.[68]
- **Reduction in natural regeneration**: Too frequent mowing does not allow for natural regeneration, as flower heads and/or ripening seed heads are removed. It is very likely that too frequent defoliation in many sites that have been regularly mown for decades (predominantly urban grasslands or roadsides) has led to loss of the taller species, such as Kangaroo Grass, resulting in dominance by low-growing grasses and forbs in those sites.[69]

Issues that need to be considered are:

- **Removal of thatch**: Prevent build up of mulch by using a catcher on mowers or collect and remove thatch (mower clippings) immediately after mowing.
- **Hygiene of machinery**: Machinery needs to be clean when brought onto sites and the least weedy areas should be mown first.
- **Season**: Allow for regeneration events, so generally avoid mowing within the growing season to the maturation of seed (late winter/early spring through to autumn). This may cause considerable difficulties when areas are mown for aesthetics, access, and/or fire hazard reduction.
- **Height**: Cutters should be set no lower than 10 centimetres.
- **Frequency**: Should be undertaken no more than twice a year to prevent loss of vigour and persistence of native grasses.

Dr Hodgkinson assessed sites in terms of requiring mowing/slashing based on whether it was being mowed regularly and if the grass was mown below 10 centimetres. He also considered the level of reproduction that had occurred if there was a presence of Chilean Needlegrass and/or African Lovegrass, or if native species known to be sensitive to mowing were observed. Based on these factors, he assessed whether the site was approaching a critical threshold beyond which native species were being compromised.

Dr Hodgkinson has advised that:

- mowing is threatening the functioning and integrity of some of the grassland sites
- urban mowing practices need to be reviewed in the short term at all lowland native grassland sites where mowing occurs.

He identified the following sites as approaching a critical threshold as a result of inappropriate mowing:

- Lady Denman Drive, Yarralumla (CC07); Dudley Street, Yarralumla (CC08); Guilfoyle

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[68] Action Plan No. 28, page 76.

[69] Pers. comm., Sarah Sharp, Parks Conservation and Lands.

Street, Yarralumla (CC09); Novar Street, Yarralumla (CC10); and Black Street, Yarralumla (CC11).

All threatening processes that require urgent action to be taken, relative to each site, are the subjects of Recommendation 21.

Grazing

Of concern for this investigation are the environmental impacts of excessive grazing pressure on lowland native grasslands, which results in both degradation of the natural integrity of these grasslands and loss, and degradation of habitat critical to threaten species of these grasslands. All native grasslands are affected by grazing by mammals and invertebrates, but the effect depends on its timing, selectivity, intensity and duration. Total grazing pressure from all major herbivores, including kangaroos, rabbits, horses, sheep and cattle should be taken into consideration.[70] In addition, grazing by livestock, kangaroos and rabbits has differing effects on the grasslands; for example, grazing by sheep is considered to be more destructive than by cattle and the selection of fodder of kangaroos is different to that of livestock.[71]

Action Plan No. 28 identifies grazing as capable of having both major positive and negative impacts on the ecological integrity and function of the lowland native grasslands. The effects depend on factors such as the circumstances and attributes of particular sites and the intensity and duration of the grazing.

Sustained heavy grazing pressure can lead to deleterious impacts on native grasslands for habitat, whether it is caused by domestic stock, kangaroos or feral herbivores. Overgrazing is of particular concern where impacts affect the endangered Natural Temperate Grassland community or other grassland that provides habitat for threatened flora and fauna. This is because any reduction in the suitability or quality of their habitat places them at a higher risk of extinction.[72] For this reason the Lawson Commonwealth – Belconnen Naval Transmission Station (BE08(a)) was the first site investigated.

Grazing by livestock

As native grasslands have evolved under grazing by native herbivores, grassland ecologists consider removal of grazing altogether to be detrimental to the grassland (where it is currently occurring) unless replaced by an alternative form of biomass reduction. Thus native grasslands lightly or moderately grazed by kangaroos or livestock in general will be in better condition than native grasslands that are not grazed (or burnt) for a long time.

However, grazing by stock and development of associated infrastructure (fencing, watering points, tracks and stock yards) over the past 200 years has caused significant impact on the composition and structure of grasslands. The effects are:

- soil compaction and erosion, especially along tracks, near watering points and yards,

[70] Action Plan No. 28.

[71] Report from Parks Conservation and Lands to the ACT Commissioner for Sustainability and the Environment for the Inquiry into the Management of Lowland Native Grasslands, Parks Conservation and Lands, August 2008.

[72] Report from Parks Conservation and Lands to the ACT Commissioner for Sustainability and the Environment for the Inquiry into the Management of Lowland Native Grasslands, Parks Conservation and Lands, August 2008.

and pugging[73] after rain and at open watering points

- selection pressures on more palatable species, leading to reduction or loss of some species), and increase of others (weeds and disturbance tolerant native species
- loss of taller plants and subsequent replacement by short species that set seed at a lower height (particularly the loss of Kangaroo Grass and replacement by smaller wallaby grasses and the less palatable spear grasses)
- increase in nutrients, particularly around stock camps and as a result of addition of superphosphate
- introduction of weeds through animal dung, on animal hides, through introduction of weed-infested feed, on vehicles and through cropping.

Grazing can be used to manipulate both structure and composition to achieve conservation outcomes. An advantage of using livestock grazing for biomass reduction is the ease by which domestic stock can be moved on and off sites, allowing a site to be rested or destocked, which in turn maintains heterogeneity of structure and provides opportunities for regeneration of desired plants and control of undesired plants.

Considerations include:

- **Timing**: Allow for maintenance of native plants through replenishment of root reserves and regeneration of new plants. Remove grazing during flowering and maturation of seed.

  Grazing can occur at any time and is not dependent on the condition of the foliage, though grazing generally occurs when plants are actively growing and providing the highest levels of nutrients to livestock. However, grazing can still occur in less than optimum periods, to achieve a particular effect on the herbage mass or control particular species' growth or seed-set (such as annual weed control), as long as animal welfare considerations are taken into account.[74]

- **Selectivity**: Light grazing pressure over long periods encourages selectivity of more palatable plants, while very short periods of grazing by high numbers of stock will encourage more even grazing pressure overall. However, grazing may be used to encourage selectivity by, for example, allowing grazing while weeds are most palatable.
- **Intensity and duration**: These follow from the two previous issues, to optimise the ability to move stock easily on and off sites to control the amount of biomass removed and the selectivity of species that are grazed.
- **Weed control**: Ensure animals are free of weed (including in dung) before entering a site; do not enhance feed on site to minimise introduction of weeds; use grazing to control weeds while palatable to reduce their vigour and/or seed set.

To achieve optimal conservation outcomes, grazing should be undertaken over very short periods with a high number of animals to minimise selectivity and then allow for long periods of recovery.

[73] Pugging occurs when stock intensively tramples and compacts wet soil. The results include poor drainage and plant growth, greater fertiliser need, and increased topsoil and contaminant runoff to waterways.

[74] Report from Parks Conservation and Lands to the ACT Commissioner for Sustainability and the Environment for the Inquiry into the Management of Lowland Native Grasslands, Parks Conservation and Lands, August 2008.

Dr Hodgkinson has advised that there is a need to reduce or cease stock grazing at:

- Dunlop Nature Reserve (BE02), 'Jarramlee' (BE03), Lawson Territory (BE07), Crace Nature Reserve (GU03), 'Cookanalla' (JE08), Majura West (MA06), and Canberra Riding Club (GU06) (horses).

All threatening processes that require urgent action to be taken, relative to each site, are the subjects of Recommendation 21.

Grazing by rabbits

The herbage mass removed by rabbits may be insignificant compared to that removed by livestock or kangaroos, but the effect of their digging and establishment of burrows may be considerable. As a result of their selective grazing, rabbits are known to have significant effects on particular native species. Rabbits have a strong preference for smaller and more succulent plants and plant parts, which are frequently native herbs, including lilies and orchids, thus targeting species not usually selected by domestic stock or kangaroos.

Dr Hodgkinson has advised that the selective grazing by rabbits is a particular problem in:

- Dunlop Nature Reserve (BE02), Crace Nature Reserve (GU03), 'Cookanalla' (JE08), and Majura West (MA06).

However, from observation and discussions with land managers it is an emerging problem across all sites.

All threatening processes that require urgent action to be taken, relative to each site, are the subjects of Recommendation 21.

Grazing by kangaroos

Kangaroos occur, often in high densities, throughout much of the ACT, including areas protected primarily for conservation of grassy ecosystems. Monitoring indicates kangaroo densities are considerably lower on rural leases where culling occurs.[75] Examples include:

- Majura Training Area (MA01) and Majura West (MA06), where sustained heavy grazing by kangaroos over several years has removed almost all of the grassland vegetation, leaving mostly bare ground in an area of endangered Natural Temperate Grassland, which is also habitat for threatened species such as the Grassland Earless Dragon, Striped Legless Lizard, Golden Sun Moth and Perunga Grasshopper that depend upon grassland cover.
- Lawson Commonwealth – Belconnen Naval Transmission Station (BE08(a)), where heavy grazing led to concerns that the Natural Temperate Grassland and associated species were at the point of being deleteriously impacted. The subsequent cull that occurred at the site has significantly reduced that pressure.
- Crace Nature Reserve (GU03) and Dunlop Nature Reserve (BE02) are sites where the overgrazing of kangaroos is a land management problem.

In the grassland areas, uncontrolled kangaroo population growth, and therefore grazing pressure, is likely to be inconsistent with conservation objectives. In the longer term, it can be expected that kangaroo population increases will be at the expense of other species,

[75] Report from Parks Conservation and Lands to the ACT Commissioner for Sustainability and the Environment for the Inquiry into the Management of Lowland Native Grasslands, Parks Conservation and Lands, August 2008.

including their long-term survival. Monitoring of population numbers also indicates that kangaroos have an enormous capacity for population recovery after drought.[76] For this reason grazing by kangaroos has emerged as a key issue to be addressed for the long term management of the lowland native grassland and is an important issue considered in this investigation.

There has been a significant change in abundance of kangaroos during the last half century. For example, the Tidbinbilla grasslands, which now support more than 500 kangaroos per square kilometre,[77] had none in 1963, according to the first employees of the Tidbinbilla Fauna Reserve.[78] Crace Nature Reserve (GU03) at Gungahlin had approximately 18 kangaroos in 2002 and in September 2008 it had about 124. Such increases are rarely linear. On the current pattern, the Crace kangaroo population will reach 250 in only three years if not controlled.

The main habitat for kangaroos in the ACT is grasslands and grassy woodlands. Although kangaroos contribute to the experience of the 'bush capital', high populations and densities have a number of environmental, social, economic and animal welfare impacts. The ACT is unique compared with other major Australia urban areas in having populations of free ranging kangaroos within and on the margins of the urban area.[79]

Kangaroos have increased to their current levels because of:

- reduced impact by natural predators
- reduced hunting and shooting[80]
- reduction in the area over which culling can occur[81]
- reduced or eliminated competition from grazing livestock in many grasslands reserved for conservation, for example Crace Nature Reserve (GU03) and Majura Training Area (MA01).

Compounding the above is the continual reduction by development of land available for grazing, either obviously through large areas of urban expansion or through less immediately obvious development such as provision of utility services and roads.

Rangers now attend more than 1,000 roadside kangaroo incidents per year in Canberra. Accidents involving kangaroos have increased by 38%in 2006–07 (from 563 in 2005–06 to 777

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[76] Pers. comm., Lyn Hinds, 8 December 2008.

[77] Fletcher D, *Population dynamics of Eastern Grey Kangaroos and the expansion of the ACT urban footprint*, 2006, PhD Thesis, University of Canberra.

[78] ACT Kangaroo Advisory Committee 1997, 'Living With Eastern Grey Kangaroos in the ACT – public land: Third Report to the Minister for the Environment, Land and Planning', Australian Capital Territory, Canberra.

[79] ACT Kangaroo Advisory Committee 1997, 'Living With Eastern Grey Kangaroos in the ACT – public land: Third Report to the Minister for the Environment, Land and Planning', Australian Capital Territory, Canberra.

[80] In the first half of the 1900s there was little or no regulation of kangaroo shooting in the ACT. There were few kangaroos and those were persecuted severely, partly because they made holes in rabbit-proof fences; rabbits were important economically at the time. In the 1970s growing numbers of kangaroos led to a scheme by which ACT graziers received compensation payments from the government for kangaroo damage. A culling program for rural leases based on an annual licence system commenced in 1998.

[81] The combined result of the policy of not issuing licences near urban areas because of safety considerations and the expansion of the ACT urban footprint.

in 2006–07).[82] Kangaroo populations in most open space areas in and near the suburbs continue to increase. Data from ranger attendances over a 17 year period (1990–2008) indicate there has been a significant increase in the rate per car of vehicle collisions with kangaroos (collisions per 1,000 vehicles registered). From these data collision 'hotspots' have also been identified, which are roads that have the most kangaroo carcasses per kilometer of roadside. These are typically road sections with a high level of traffic flow adjacent to bush and grassland areas and include Limestone Avenue, Caswell Drive, Monaro Highway, Fairbairn Avenue, Hindmarsh Drive, Mugga Lane and Majura Lane. The cost of these kangaroo-vehicle collisions is significant, the average cost being $7,000.[83]

Taking into account ACT kangaroo populations and vegetation, maintaining a kangaroo population of about one kangaroo per hectare will facilitate herbage mass levels likely to be associated with higher groundcover and better habitat for grassland fauna.[84]

Dr Hodgkinson visually assessed each site for grazing and in so doing considered the species of herbivores present and the level of current grazing as indicated by the height of grasses, grass seed reproduction in the last growing season, inter-tussock spaces, the appearance of soil surface and presence of current erosion. The prevailing drought was taken into account. Based on his observations, he determined that the sites that had reached a critical threshold in terms of grazing pressure from kangaroos were:

- Majura Training Area (MA01), 'Malcolm Vale' (MA04), Majura West (MA06), Ginninderra Experimental Station (BE01), Crace Nature Reserve (GU03), Dunlop Nature Reserve (BE02), and 'Jarramlee' (BE03).

Two sites had been identified as being at critical thresholds, in terms of grazing by kangaroos, before Dr Hodgkinson's inspections, namely:

- Belconnen Naval Transmission Station (BE08(a)), where urgent action to control kangaroo numbers has been taken but a long period of recovery and possibly enhanced recovery will be needed.
- Majura Training Area (MA01) where removal of grazing pressure has been temporarily achieved through erection of a kangaroo enclosure fence, but this has only transferred the threat into the surrounding woodlands. A long period of recovery and possibly enhanced recovery will be needed.

Dr Hodgkinson advised that:

- kangaroo grazing is now threatening survival of some grassland sites
- there is a need to develop a kangaroo management program to reduce the number of kangaroos as soon as possible to prevent further environmental damage especially to Ginninderra Experimental Station (BE01), Dunlop Nature Reserve (BE02), 'Jarramlee' (BE03), Caswell Drive (BE10), CSIRO Headquarters (CC01), Crace Nature Reserve (GU03), 'Malcolm Vale' (MA04), Majura West (MA06), and Jerrabomberra East Reserve (JE05).

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[82] ACT State of the Environment Report 2007–08, Community Wellbeing Issues Paper, page 3.

[83] Pers. comm., Dr Don Fletcher, 10 October 2008.

[84] Report from Parks Conservation and Lands to the ACT Commissioner for Sustainability and the Environment for the Inquiry into the Management of Lowland Native Grasslands, Parks Conservation and Lands, August 2008.

- total grazing pressure is approaching critical levels at many sites in this drought period.

All threatening processes that require urgent action to be taken, relative to each site, are the subjects of Recommendation 21.

The current action needed to protect the Territory's lowland native grassland, is to immediately reduce grazing impacts from kangaroos on a number of sites that are in a critical condition or approaching a critical condition. From an animal welfare perspective the most appropriate time to cull is between March and July to avoid the time of year when a high proportion of females are supporting 8- to 12-month-old juveniles.

Some sectors of the community are likely to find removing kangaroos through humane culling at any time unacceptable. Their views are respected and their submissions to this investigation have been carefully considered; however, there is at present no practical alternative for removing large numbers of kangaroos. Given the limited time for undertaking a cull, the ACT and Commonwealth departments that are the relevant managers, were informed several months ago there would be a recommendation in this report regarding the need to remove kangaroos from some sites as a matter of urgency.

As kangaroo numbers increase there are also animal welfare issues for the kangaroos themselves. Following the kangaroo cull at Lawson Commonwealth – Belconnen Naval Transmission Station (BE08(a)), data collected on the condition of the carcasses showed that:

> few of the kangaroos were in good condition and 42% of females and 56% of males had no kidney fat left (by comparison, of kangaroos culled to avert starvation at Tidbinbilla in 1997, only 8% had no kidney fat left.) More telling is that 38% of female kangaroos at BNTS (BE08(a)) and 47% of males had less than half of their marrow fat remaining, which is comparable to kangaroo samples during the most severe drought conditions ever recorded in this region. Thus, the winter of 2008 may have provided a serious threat to the survival of the kangaroos with low marrowfat had the cull been postponed.[85]

In the longer term, an active program of kangaroo management to achieve a population of one kangaroo per hectare needs to be coordinated across the ACT and New South Wales border. This will fundamentally be a culling program. Fertility control via oral delivery of immuno-contraceptives (vaccines) for broad scale interventions will not be possible for about 10 years.[86]

A Kangaroo Management Plan for the ACT is currently in preparation.[87] The purpose of this plan is to set out the approach to be adopted in managing the environmental, economic and social impacts of kangaroos in the ACT, while ensuring the welfare of the animal. Particular consideration will be given to managing grazing pressure on lowland native grasslands and grassy woodlands.[88]

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85 Memo to Director, Parks Conservation and Lands prepared 1/10/08 by Claire Wimpenny and Don Fletcher, Parks Conservation and Lands.

86 Pers. comm., Lyn Hinds, 8 December 2008.

87 Pers. comm., Russell Watkinson, 6 January 2009.

88 Pers. comm., Russell Watkinson, 6 January 2009.

The primary goals of kangaroo management in the ACT are:

- to manage viable populations of kangaroos as part of the fauna of the 'bush capital'
- to manage and minimise the environmental, economic and social impacts of those kangaroo populations on other biota, ACT residents and visitors.[89]

Recommendations of the ACT Kangaroo Advisory Committee include:

- the most appropriate way to kill large numbers of kangaroos on public land is by shooting according to the Code of Practice for the Human Destruction of Kangaroos in the ACT[90]
- lethal injection is only applicable where small numbers of animals are involved and in specific circumstances, such as a controlled environment[91]
- research to develop human alternatives to shooting, such as fertility control, needs to be encouraged.[92]

This is supported by the expert panel convened by the Office of the Commissioner for Sustainability and the Environment for the Belconnen Naval Transmission Station (BE08(a)) site that agreed that the most humane method of removing the kangaroos from this site would be through shooting.[93]

Two codes of practice relevant to culling in the ACT are:

- The *National Code of Practice for the Humane Shooting of Kangaroos and Wallabies for Commercial Purposes* sets an achievable standard of humane conduct and is the minimum required of persons shooting kangaroos and wallabies.
- The *National Code of Practice for the Humane Shooting of Kangaroos and Wallabies for Non-commercial Purposes* sets an achievable standard of humane conduct and is the minimum required of persons shooting kangaroos and wallabies for reasons other than commercial use of kangaroo products (skins and meat).

A Kangaroo Management Plan for the ACT is currently in preparation and will be the subject of consultation.[94] While this is the case, removal of kangaroos, where needed, should not be delayed, pending adoption of this plan. Existing polices and procedures should be used to guide needed field actions. The Kangaroo Management Plan should, however, be progressed as quickly as possible to guide field and other actions in 2010 and beyond.

In developing the Kangaroo Management Plan for the ACT, as culling is the most appropriate way to reduce large numbers of kangaroos, it may be appropriate to investigate allowing kangaroo carcasses to be used rather than buried. Commercial harvesting operates under state-based management plans that are approved by the Australian Government under provisions of the *Environment Protection and Biodiversity Conservation Act 1999* (Cwlth).

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[89] Pers. comm., Russell Watkinson, 6 January 2009.

[90] Kangaroo Advisory Committee 3rd report – recommendation 8.

[91] Kangaroo Advisory Committee 3rd report – recommendation 7.

[92] Kangaroo Advisory Committee 1st and 3rd reports – recommendation 9.

[93] *Addendum Report to the report on Belconnen Naval Transmission Station (BNTS) Site as part of the Investigation into the ACT Lowland Native Grasslands*, 28 March 2008 (see Appendix 2).

[94] Pers. comm., Mr Russell Watkinson, 6 January 2009.

Currently, the ACT is not a participant in the industry. Some of the proceeds from revenue sourced from sustainably using carcasses could go back into kangaroo fertility control research via a royalty. This concept requires further investigation, but is outside the scope of this investigation.

Kangaroo management fencing may be appropriate to temporarily control grazing. However, fencing should only be erected where there is an overall ecological benefit and in so doing care needs to be taken to ensure that this does not adversely affect other areas. Fencing is likely to be only a temporary means of controlling grazing pressures.

4.2.2 Weed invasion

The control of weeds is a critical component in the management of the lowland native grassland sites. All lowland native grassland sites in the ACT contain weeds. It is likely that this is a result of the past use of grasslands for agriculture, and caused by inadvertent spread of weeds on animals, stock fodder and machinery, as well as deliberate planting of agricultural plants such as Phalaris. In addition, many urban or landscape species have proven to be highly invasive. Other weed-spread pathways include introduction in landscape material and topsoil, discarded garden refuse, spread by wind or water, and recreational users such as bush walkers or recreational vehicles.[95] The stored seed of introduced species present in soils in grasslands is very high, which results in a continuous stock of seed available for further regeneration.

Weeds have a high impact on the Territory's economy and environment, and are recognised as being one of the most significant threats to biodiversity in the ACT. Weeds displace native species, reduce habitat quality, modify vegetation structure and alter ecological functions. In economic terms, weeds increase the cost of management programs, result in a loss of agricultural productivity and impair landscape function. Some weeds also constrain recreational access and use and harbor animal pests.[96] Many weeds also increase fire hazard, in particular annual grasses, African Love Grass and shrubby woody species that can increase fire intensity and height of flames. It is expected that the predicted changes in temperature and rainfall caused by climate change will result in changes in weed threats, with new weed introductions likely to occur. It is suggested that ecosystems are likely to be more resilient to the threats of weeds under such changed conditions if the natural functioning is maintained.[97]

Weeds that are a particularly severe threat to the grassland due to their high level of aggressive invasion are the perennial species of Serrated Tussock (*Nassella trichotoma*), Chilean Needle Grass (*Nassella neesiana*), both of which are Weeds of National Significance, African Love Grass (*Eragrostis curvula*) and St John's Wort (*Hypericum perforatum*). These species are highly invasive and can become extremely dense.

Systematic surveys of Chilean Needle Grass in grassland sites along roadsides and adjacent to other areas of high conservation areas has indicated that the species is spreading within sites and between sites. In 2002 minimal Chilean Needle Grass was found in Gungahlin, whereas surveys along roadsides in 2008 indicate it has spread along roadsides and has

[95] ACT Weeds Strategy 2007–17, ACT Government 2007.

[96] ACT Weeds Strategy 2007–17, ACT Government 2007, Chapter 2.

[97] ACT Weeds Strategy, 2007–17.

reached Horse Park Drive. As a result of this survey, Parks Conservation and Lands has undertaken an intensive spraying of the species near Mulligan's Flat Nature Reserve.[98]

Many other weed species also occur in grasslands, and are of varying levels of threat to ecosystem structure, function and habitat. The degree of impact that particular weeds may have is often variable in different sites, depending on the past land uses and disturbance in the sites. Most weeds are annual or biennial grasses or forbs that are not a problem if their numbers are kept low,[99] through minimising soil disturbance and maintaining native grass cover.

Woody weeds have also invaded into grasslands. Briar Rose is the most common woody weed, followed by Hawthorn, Blackberry and urban escapees including Cotoneaster, Radiata Pine and African Boxthorn.

The aim of weed management should be to reduce populations of the most invasive weeds present, rather than all exotic species. Mechanisms for weed control include hand weeding, strategic grazing, slashing, burning, and herbicide application. At the same time, all of these mechanisms can result in an increase in weeds, by creating bare ground, spread of weeds on animals and on machinery.

A key aspect of weed control is to avoid management activities that facilitate introduction or expansion of weeds, such as too frequent burning, addition of nutrients, exposure of bare ground, soil disturbance and/or using machinery that has not been cleaned.[100]

The ACT Weeds Strategy provides a focused approach to coordinate weed control on all sites in the Territory and to encourage collaboration between all land managers in the ACT and regionally. Membership of the group includes all Territory and Commonwealth land managers as well as the ACT Rural Lessees Association. All members of this government-instigated group have committed themselves to be guided by the ACT Weeds Strategy. The Weeds Working Group (and recently an additional group, the Weeds Advisory Group) has been overseeing control of weeds on 'conservation sites' according to a list provided by Parks Conservation and Lands and has given high priority to weed control in these sites, whether they are in a reserve or not. Significant effort has been made to reduce Serrated Tussock at Jerrabomberra West Reserve (JE03) following declaration of the site as a nature reserve, and Chilean Needle Grass at Crace Nature Reserve (GU03).

Dr Hodgkinson visually assessed sites for weed invasion and considered whether weeds were present and if they were the degree to which they had invaded the sites. If weeds were becoming dominant he considered the site was approaching a critical threshold beyond which the density of weeds would compromise native plant survival and reproduction. He made this judgment with the understanding that weeds may remain at low densities for a long time but then irrupt because of changed climate and/or disturbance.

Dr Hodgkinson advised that weeds are a threat to many grassland ecosystems and that management of weeds in the short term should be reviewed and an assessment made of the appropriateness of the level of resources allocated to their control.

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[98] Pers. com., Mr Steve Taylor, Parks Conservation and Lands.

[99] Action Plan No. 28, page 78.

[100] Action Plan No. 28, page 78.

He identified the following sites as approaching a critical weed threshold:

- York Park, Barton (CC05); Yarramundi Reach (CC06); Lady Denman Drive, Yarralumla (CC07); Dudley Street, Yarralumla (CC08); Guilfoyle Street, Yarralumla (CC09); 'Malcolm Vale' (MA04); Umbagong Park North, Florey (BE04(b)); Lawson Territory (BE07); Wells Station Road (GU07); Crace Nature Reserve (GU03); Nicholls (GU08); Harman Bonshaw South (JE06); Harman Bonshaw North (JE07); and 'Cookanalla' (JE08).

All threatening processes that require urgent action to be taken, relative to each site, are the subjects of Recommendation 21.

Two of the most threatening processes that usually affect lowland native grassland sites in the ACT are insufficient weed control and inappropriate mowing regimes (*see* Appendix 10).

Recommendation 20: Give priority to weed management and implementing appropriate mowing practices as part of routine work programs.

As already mentioned, 20% of the lowland native grassland sites are in a critical condition and 40% are approaching a critical condition. These sites need urgent management action to improve their ecological condition. This action needs to address the current threatening processes that affect the lowland native grassland sites.

Recommendation 21: Improve the ecological condition of sites that are in a critical condition or approaching this state, by reducing current threatening processes of weed invasion, inappropriate mowing and overgrazing by stock, rabbits and kangaroos as a matter of urgency, specifically:

In Majura Valley:

- Grazing pressure should be reduced by:
  - Reducing the number of kangaroos on 'Malcolm Vale' (MA04) and Majura West (MA06). There is also a need to continue to manage kangaroos on the Majura Training Area (MA01) while not detrimentally affecting adjacent native woodland.
  - Strategically managing (and in the short-term temporarily removing) stock and controlling rabbits on Majura West (MA06).
- Weed management controls should be enhanced on Majura Training Area (MA01) and 'Malcolm Vale' (MA04).

(Strategically located temporary kangaroo management fencing should be considered for placement around Campbell Park (MA05) and possibly parts of Majura West (MA06) if the stock and kangaroo densities in this general area are not reduced within the next six months. This is a temporary measure to protect the Grassland Earless Dragon habitat.)

In Jerrabomberra Valley:

- Grazing pressure should be reduced by:
  - Reducing the number of kangaroos on Jerrabomberra East Reserve (JE05).

- Strategically managing (and in the short-term temporarily removing) stock and controlling rabbits on 'Cookanalla' (JE08).
- Weed management controls should be enhanced on Harman Bonshaw South (JE06) and Harman Bonshaw North (JE07).

In Gungahlin:

- Grazing pressure should be reduced on Crace Nature Reserve (GU03) by:
  - Reducing the number of kangaroos.
  - Strategically managing (and in the short-term temporarily removing) stock and controlling rabbits.
- Weed management controls should be enhanced on Crace Nature Reserve (GU03), at Wells Station Road (GU07) and Nicholls (GU08).

In Belconnen:

- Grazing pressure should be reduced by:
  - Strategically managing (and in the short-term temporarily removing) stock and reducing the number of kangaroos and controlling rabbits on Dunlop Nature Reserve (BE02) and 'Jarramlee' (BE03).
  - Reducing the number of kangaroos on Ginninderra Experimental Station (BE01).
  - Reducing the number of kangaroos and controlling rabbits on Caswell Drive (BE10). Given the size and location of this site, it may be necessary to reduce the number of kangaroos on land in the vicinity of this site rather than concentrating only on this site
- Weed management controls should be enhanced on Umbagong Park North (BE04(b)), and in the areas of Lawson Territory (BE07) that may affect the Lawson Commonwealth – Belconnen Naval Transmission Station (BE08(a)) site.

In Canberra Central:

- Weed management controls should be enhanced on York Park, Barton (CC05); Yarramundi Reach (CC06); Lady Denman Drive, Yarralumla (CC07); Dudley Street, Yarralumla (CC08); and Guilfoyle Street, Yarralumla (CC09).
- Mowing regimes should be revised to enhance grassland conservation for Lady Denman Drive, Yarralumla (CC07); Dudley Street, Yarralumla (CC08); Guilfoyle Street, Yarralumla (CC09); Novar Street, Yarralumla (CC10); and Black Street, Yarralumla (CC11).

4.2.3 Physical disturbance

Another threat to the future management of lowland native grassland sites is that of physical disturbance which includes construction of tracks, movement of machinery or vehicles in wet conditions, dumping of organic or inorganic material and erosion on sloping sites.[101]

Ploughing, earthworks that alter drainage patterns, clearing of vegetation, rock removal, cultivation, pasture improvement (fertiliser addition), excessive grazing pressure or soil

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[101] Action Plan No. 28.

removal or addition all significantly compromise the integrity of lowland native grasslands and should be avoided.[102]

Dr Hodgkinson assessed sites for physical disturbance with respect to earth disturbance resulting in erosion or potential for erosion. If there was disturbance and it was significant he considered the site to be at a critical threshold or approaching a critical threshold beyond which native plant and animal species would be compromised. He considered that no sites were at a critical threshold or approaching a critical threshold as a result of physical disturbance.

[102] Action Plan No. 28.

5 Future land use and development

Areas of lowland native grassland in the ACT, are located in the Majura Valley, Jerrabomberra Valley, Gungahlin, Belconnen and parts of Central Canberra/Tuggeranong (*see* Table 6) and development is potentially a threatening process in these areas. This is in addition to the key threatening processes assessed by Dr Hodgkinson that need to be addressed by land management actions. Unfortunately, most of the lowland native grassland areas deemed suitable for conservation are also valuable development sites because they are relatively flat and usually have no or few trees. Since adoption of Action Plan No. 28, five hectares of Natural Temperate Grassland has been removed as a result of development at:

- Canberra International Airport (MA03) – four hectares to create the Brand Depot
- Caswell Drive (BE10) – one hectare as part of the Gungahlin Drive Extension roadworks.

A further 9.4 hectares of lowland native grassland at 'Callum Brae' (part JE02) has been identified for development as a long stay caravan park under the ACT Government land swap arrangement for the Narrabundah Long Stay Caravan Park.

Such development pressures on the lowland native grassland and associated endangered species highlight the difficulty the government faces in conserving ecosystems within the envelope of developable land around the ACT. A challenge for Canberra's planners and developers is to simultaneously maintain an effective balance between providing for urban development and protecting the environmental values of the urban open space and natural areas. Therefore a strategic approach is needed that simultaneously protects the lowland native grassland, in particular Natural Temperate Grass, and facilitates development.

As outlined in Section 2, both Commonwealth and ACT law and policy governs planning in the ACT. The *Australian Capital Territory (Planning and Land Management) Act 1988* (Cwlth) established the National Capital Authority. This Act also enables the Legislative Assembly to establish a statutory planning authority, currently the ACT Planning and Land Authority, to develop and implement the Territory Plan. The *Planning and Development Act 2007* (ACT) requires the Territory Plan to set out the planning principles and polices for giving effect to its object in a way that gives effect to sustainability principles, including policies that contribute to achieving a healthy environment in the ACT.[103]

The Natural Temperate Grassland component of the lowland native grassland is one of Australia's most threatened ecosystems (*see* Section 1.2). Therefore, conservation of the remaining areas of lowland native grassland is critical for national biodiversity conservation. The ACT retains significant remnants of the original extent of Natural Temperate Grassland, however, the small size and fragmented nature of many of the remaining grassland areas pose particular difficulties for conservation planning.

Central Canberra/Tuggeranong and Belconnen geographic areas have large areas of grassland that were used for rural land uses and then extensively cleared for residential development, primarily more than 30 years ago. As a result, there are a relatively high number of sites within these geographic areas but they are, on average, much smaller than other areas. These sites generally occur on land that has been defined as open space, such as

[103] *Planning and Development Act 2007*, section 49.

Constitution Avenue, Reid (CC02), on land that was to be used for other purposes, such as the Australian Centre for Christianity and Culture, Barton (CC04), which was to be used for erection of a cathedral, or as an edge to a development, such as CSIRO Headquarters (CC01). Despite their high level of isolation and small size, there remains some very floristically diverse grassland, particularly the Australian Centre for Christianity and Culture, Barton (CC04).

Table 6: Areas of lowland native grassland in the ACT, based on geographic location

Region	Total LNG area	Total area of LNG	Total NTG	Total area of NTG	Sites	Av. size of sites	Category 1 sites
	ha	%	ha	%	no.	ha	no. (%)
Majura Valley	641.3	29	208.9	20.3	6	107	5 (83)
Jerrabomberra Valley	697.1	31.5	267.4	26.0	10	70	5 (50)
Gungahlin	410.1	18.5	179.2	17.4	8	51	3 (38)
Belconnen	426.0	19.3	338.6	32.8	12	36	5 (42)
Central Canberra/ Tuggeranong	36.5	1.7	35.8	3.5	12	3	2 (17)
Total	**2211.0**	**100**	**1,029.9**	**100**	**48**	**–**	**–**

Notes:

LNG = lowland native grassland; NTG = Natural Temperate Grassland.

Category 1: Core Conservation Site – sites in this category meet the following criteria: high botanical significance rating, or key threatened species habitat, or large site (more than 100 hectares) with a Botanical Significance Rating of 3.

Category 2: Complementary Conservation Site – sites in this category meet the following criteria: moderate botanical significance rating, or threatened species habitat, or medium site (10 to 100 hectares) with a Botanical Significance Rating of 4.

Category 3: Landscape and Urban Site – sites in this category meet the following criteria: low to very low botanical significance rating small to very small area (less than 10 hectares), and may contain small populations of threatened species in marginal or fragmented habitat that is considered to be not viable in the medium to long term (*see* Action Plan No. 28, pages 56–59).

Source: Action Plan No. 28, pages 48-49.

On the other hand, large areas remain in the Majura Valley and Jerrabomberra Valley that often contain significant habitat for threatened species, are connected by corridors to other native grassland or woodland, and retain sufficient buffers to provide protection from edge effects. Importantly, there is proportionally more Category 1: Core Conservation Sites in the undeveloped, larger sites in the Majura and Jerrabomberra valleys than in any other area in the Territory.

Recognition of the importance of grasslands has increased and is reflected through legislation (declarations of Natural Temperate Grassland and associated threatened species), communication, and education; the rate of loss of sites has reduced in the past 15 or so years.[104] However, some proposed developments have the potential to involve removal of areas of lowland native grassland or will compromise the integrity of sites by increasing fragmentation of sites and populations of threatened species.

Lowland native grassland sites, being located in, or close to, Canberra's urban areas and relatively easy to develop, are frequently considered for their development potential. Often when making development decisions these sites are considered in isolation. A strategic

[104] Pers. comm., Sarah Sharp, Parks Conservation and Lands.

approach across the ACT is needed to give the highest level of protection to those lowland native grassland sites with the highest ecological values, provide connectivity between these sites, and foster appropriate development. This approach needs to involve identification of the long-term land uses for all lowland native grassland sites, and use of offsets to allow development of others. Given that there may be difficulties in always having a 'like for like' replacement, offsets that involve the use of offset restoration sites, funding research or restoration programs should be considered.

The ACT and Australian governments have enacted legislation that facilitates protection of lowland native grassland areas and species, particularly those listed as threatened; and both these Governments own lands that have significant lowland native grassland areas. Therefore, both governments need to agree on a strategic approach to protect these grassland sites for this to be effectively implemented.

Recommendation 22: The ACT Government and the Australian Government commit to taking a strategic approach to protecting lowland native grassland, in particular Natural Temperate Grassland, threatened grassland species and fostering sustainable development by:

- Giving priority to protecting all Category 1: Core Conservation Sites that contain Natural Temperate Grassland and key threatened grassland species, and ensuring that these areas are not affected by development proposals.
- Placing in a reserve, where appropriate, Natural Temperate Grassland sites in Category 1: Core Conservation Sites. If this is not possible, these grassland areas and associated species should be conserved and managed as if in a reserve.
- Integrating conservation values with development considerations for all Category 2: Complementary Conservation Sites and Category 3: Landscape and Urban Sites and ensuring connectivity is retained or enhanced.
- Developing an offset policy (that includes identification of offset restoration sites) for loss of lowland native grassland, particularly Natural Temperate Grassland, due to development.

5.1 Northern access road – Majura Valley (East)

The Majura Valley is one of the most significant areas in the ACT for threatened species conservation.[105] It contains some of the most diverse and valuable areas of Natural Temperate Grassland and is one of only a few areas containing large contiguous areas of Natural Temperate Grassland (*see* Table 6). Of the approximate 2,200 hectares of lowland native grassland in the ACT, Majura Valley (East), at approximately 500 hectares constitutes around 23% of that total. The Majura Valley (East) contains arguably one of the largest areas of Natural Temperate Grassland remaining in southeastern Australia .[106] It also provides habitat for five threatened species (Button Wrinklewort, Striped Legless Lizard, Grassland Earless Dragon, Perunga Grasshopper and the Golden Sun Moth) (*see* Table 7). The Jerrabomberra and Majura valleys provide the only known habitat for the Grassland Earless Dragon in the ACT, and these sites form the largest remaining contiguous area of habitat for

[105] David Hogg Pty Ltd, Eastern Broadacre Planning Study, Assessment of Ecological Opportunities and Constraints, June 2008, page 19.

[106] Pers. comm., Sarah Sharp, Parks Conservation and Lands.

the species. Three sites in the Majura Valley, Air Services Beacon (MA02), Canberra International Airport (MA03) and Malcolm Vale (MA04), are being considered for listing as Natural Areas on the *Commonwealth Heritage List*.

Currently, the Majura Valley is an outstanding example of co-existence of lowland native grassland with a range of land uses including Majura Training Area (MA01) (including a firing range), Air Services Beacon (MA02) and Canberra International Airport (MA03). Canberra International Airport (MA03) is a key location on Canberra's eastern ring road, only eight minutes from Canberra's Central Business District and identified as an Activity Node in the Canberra Spatial Plan.[107] Airport expansion will likely affected lowland native grassland sites. This site comprises Natural Temperate Grassland, which is the highest priority for conservation, and areas of native pasture and exotics, which are of comparative lower conservation value (*see* Table 7).

Development within the airport precinct, including development of runway infrastructure in 2001 and construction more recently of the Brand Depot has reduced the area of Natural Temperate Grassland and habitat for the Grassland Earless Dragon and Golden Sun Moth; it also required salvage of five specimens of Grassland Earless Dragon.

There is a proposal for a potential northern access road to link the Fairbairn precinct of the airport to Majura Road, immediately north of the airport. Currently land to the north of the airport is National Land owned by the Department of Defence (Majura Training Area (MA01)).

Under this proposal, the Australian Government would excise 38 hectares of land adjoining the northern boundary of the airport from the Majura Training Area (MA01) to the Department of Transport and Regional Services for incorporation into the lease area of Canberra International Airport (MA03). The Canberra Airport Group intends constructing a dual carriageway (four lanes) including a median strip and cycle path. The planned route for this road is through a Category 1: Core Conservation Site, containing the largest remaining patch of endangered Natural Temperate Grassland in the ACT that provides habitat for a number of threatened species, including the Grassland Earless Dragon (*see* Table 7).

The current proposed road location would likely jeopardise the long-term viability of this Core Conservation Site as it would remove some of the grassland for construction of the road and associated infrastructure of drainage and piping, and will fragment the remaining areas of grassland. The ability of the Grassland Earless Dragon to cross obstacles, such as roads or drainage ditches, is uncertain[108] and a major road through this area would probably create a significant barrier to the movement of this species, fragmenting its population and isolating the population within the airport. This may prevent or constrain repopulation, should the population decline under unfavourable conditions (such as the recent population decline in the Majura Training Area (MA01)). The future planned development will also likely remove habitat, if allowed to proceed.[109]

[107] Canberra Spatial Plan, ACT Planning and Land Authority, 2004.

[108] David Hogg Pty Ltd, Eastern Broadacre Planning Study, Assessment of Ecological Opportunities and Constraints, June 2008.

[109] Action Plan No. 28, page 62.

This development proposal, in its current location, creates a conflict between airport expansion and protection of Category 1: Core Conservation Sites [110] areas of Natural Temperate Grasslands. However, it appears to be possible to provide access by a number of alternative routes and protect the Natural Temperate Grassland and known contiguous habitat of the Grassland Earless Dragon.

As this land contains Natural Temperate Grassland, which is listed as an endangered ecological community under the *Environment Protection and Biodiversity Conservation Act 1999* (Cwlth), a referral of this proposed action was made by the Department of Defence to the former Australian Government Department of the Environment and Water Resources in September 2007. This was assessed on 9 November 2007.

As mentioned in Section 1.3, this Office held a meeting with the Australian Government agencies involved in the proposed excision of a section of the Department of Defence land at the Majura Training Area (MA01) and its potential transfer to the Canberra Airport Group to accommodate construction of a road on 14 October 2008. As the approval for the excision resides with the Prime Minister, the Commissioner wrote to him on 16 October 2008 seeking reassessment of the proposal; taking into account the need for the road against the potential extinction of a species, the availability of more recent data and the increased pressures on the land since the department undertook its assessment in December 2007. The Minister for Finance and Deregulation, the Hon Lindsay Tanner MP, responded in late November 2008 on behalf of the Prime Minister indicating that a formal decision on whether to proceed with the proposed disposal of the site had not been made. The Minister for Environment, Heritage and the Arts, the Hon Peter Garrett AM MP, responded on 20 January 2009 indicating that the department is currently reviewing the result of recent monitoring of the apparent decline in the population of Grassland Earless Dragon and the Natural Temperate Grassland in the Majura Valley and will consider that information if a referral is made under the *Environment Protection and Biodiversity Conservation Act 1999* to build a road through the site.

Given the significance of the Majura Valley grassland, the presence of the Grassland Earless Dragon and other threatened species, it is strongly recommended that a commitment be made to create a reserve in the Majura Valley. This reserve should be defined in the near future and include part of the Majura Training Area (MA01), and potentially parts of Air Services Beacon (MA02) and 'Malcolm Vale' (MA04). Connectivity with the Canberra International Airport (MA03) will be particularly important in protecting the Grassland Earless Dragon. As current land uses on these sites, if managed effectively, are compatible with sustaining the ecological values of the grassland, areas nominated for inclusion in the proposed reserve could continue being used for their current purpose and managed by the existing land managers.

While defining the site of the proposed Majura Valley reserve would constrain future development options, for example, the potential Canberra International Airport northern link road and the potential east-west Kowen road, it would provide a more certain context for potential developments. It would also ensure that the Natural Temperate Grassland, the Grassland Earless Dragon and other threatened species are not adversely affected through incremental developments, as would be the case if the potential Canberra International Airport northern link road and the potential east-west Kowen road were to be progressed according to existing concept plans.

[110] Action Plan No. 28, page 57.

Table 7: Grassland type and conservation significance for the Majura Valley (East).

Site name	Site no.	Site size (ha)	Dominant grassland type	Key habitat	Species present	Comments	Conservation category
Majura Training Area	MA01	126.6	Natural Temperate Grassland	Grassland Earless Dragon Striped Legless Lizard Golden Sun Moth Button Wrinklewort	Perunga Grasshopper	Links with extensive woodland	1
Air Services Beacon	MA02	10.7	Natural Temperate Grassland	Grassland Earless Dragon Striped Legless Lizard Golden Sun Moth	Perunga Grasshopper	Surrounded on three sides by MA01	1
Canberra International Airport	MA03	203.6	Natural Temperate Grassland	Grassland Earless Dragon Golden Sun Moth	Perunga Grasshopper	Contiguous with MA01	1
Malcolm Vale	MA04	155.4	Native Pasture		Grassland Earless Dragon Golden Sun Moth	Contiguous with MA01	2
Total contiguous area (ha)		**496.3**					

Notes:

Category 1: Core Conservation Sites – sites in this category meet the following criteria: high botanical significance rating, or key threatened species habitat, or large sites (more than 100 hectares) with a botanical significance rating of 3.

Category 2: Complementary Conservation Sites – sites in this category meet the following criteria: moderate botanical significance rating, or threatened species habitat, or medium area sites (10 to 100 hectares) with a botanical significance rating of 4.

Category 3: Landscape and Urban Sites – sites in this category meet the following criteria: low to very low botanical significance rating; and small to very small area (less than 10 hectares); and may contain small populations of threatened species in marginal or fragmented habitat that is considered to be not viable in the medium to long term (*see* Action Plan No. 28, pages 56–59).

The lands for the proposed reserve could be the subject of a formal (conservation) agreement between the ACT and Australian governments.

Recommendation 23: Plan a Majura Valley Reserve to protect Natural Temperate Grassland and its supporting species, particularly the Grassland Earless Dragon, by defining the boundaries of this proposed reserve in the near future.

5.2 Eastern Broadacre Planning Study

The eastern broadacre area (Majura–Symonston–Jerrabomberra area) is located on the eastern edge of the ACT. It is close to the New South Wales border and contains key infrastructure including Majura Road, the Monaro Highway and the Canberra International Airport.

The Eastern Broadacre Planning Study is a preliminary investigation of the economic potential of the eastern broadacre area as a future employment corridor, as identified in the Canberra Spatial Plan.[111] The area includes industrial areas at Symonston, Hume and Fyshwick. A number of lowland native grassland sites are located in the eastern broadacre area.

The Jerrabomberra Valley contains large and diverse areas of Natural Temperate Grassland, a range of threatened flora and fauna and connectivity between the grassland–woodland ecological communities. The valley is divided east–west by the Monaro Highway. Key issues for protection of the lowland native grassland are maintenance of large heterogeneous areas and provision of connectivity between the high value areas east and west of the highway, across the ACT–NSW border and between the grassland and woodlands.

The eastern broadacre area provides habitat for threatened grassland species. Of particular concern for the eastern broadacre area are the populations of the Grassland Earless Dragon and the Striped Legless Lizard. The habitat in the Majura and Jerrabomberra valleys is of high priority nationally for survival of the Grassland Earless Dragon; existing populations have been confirmed within the study area.[112]

The Eastern Broadacre Planning Study will help identify areas that may be suitable for future development for employment uses, and those that should be set aside for environmental, transport or other needs. It may require changes to the Territory Plan to provide a greater range of employment uses (such as industry, commercial, warehousing, tourism). Areas already in reserve are not identified as suitable for future development.

In addition to the values of the Majura Valley (East) grasslands that have been discussed in Section 5.1, the values in the remainder of the study area Majura Valley (West) and the Jerrabomberra Valley are discussed below.

[111] Canberra Spatial Plan, ACT Planning and Land Authority, 2004.

[112] David Hogg Pty Ltd, Eastern Broadacre Planning Study, Assessment of Ecological Opportunities and Constraints, June 2008.

A potential key constraint for development in this area is that of the endangered Grassland Earless Dragon which appears to survive only in the study area and adjacent low-lying areas in New South Wales.[113]

Campbell Park (MA05) in the Majura Valley is a small parcel of Commonwealth land in good condition that contains Natural Temperate Grassland, has a population of the Grassland Earless Dragon and is classified as a Core Conservation Site. It adjoins Majura West (MA06), Territory Land, which is a large area that contains the endangered Grassland Earless Dragon. Majura West (MA06) is an important ecotone (where the two ecosystems of lowland native grassland and Yellow–Box Red Gum Grassy Woodland merge), is the only Category 1: Core Conservation Site that does not contain Natural Temperate Grassland, and lends itself to being an offset restoration site for actions to be implemented to improve the habitat of the Grassland Earless Dragon.

Majura West (MA06) is contiguous with Campbell Park (MA05) and Mount Ainslie Reserve. From information considered in this investigation, it appears that potential developments in the Majura Valley have been planned to avoid these areas. Given this and their ecological value it seems appropriate for all or parts of these sites to be included in Mount Ainslie Reserve.

Recommendation 24: Expand the Mount Ainslie Reserve to include areas of lowland native grassland in Campbell Park (MA05) and Majura West (MA06).

5.2.1 Potential east-west Kowen road

The origins of the potential Kowen link in the Majura Valley are in the Canberra Spatial Plan,[114] which identifies Kowen for long-term urban development. This concept is being investigated, at a preliminary level as part of the Eastern Broadacre Planning Study work, whereby high-level traffic and transport modeling to the years 2031 and 2051 has been undertaken. Any future urban development at Kowen is likely to require at least two high-capacity road links. This could include:

- A Kowen link road potentially extending from Northcott Drive, across Majura Parkway and then across Defence land north of the airport site to Kowen. This road would be two lanes each way, and would need to connect with the Canberra International Airport northern link road if approved.
- A second link (the northern link road) potentially as an extension of Wakefield Avenue across Defence land to Kowen.

These roads could have environmental impacts, particularly on lowland native grassland areas; of which Natural Temperate Grasslands is of particular concern.

Given the potential significant impact such a development could have on the grasslands in the Majura Valley, the Commissioner wrote to the Director Roads ACT on 16 October 2008 asking that road access to the proposed Kowen development be located outside areas of Natural Temperate Grassland, so as to not adversely impact the Natural Temperate Grassland areas in the Majura Valley.

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113 David Hogg Pty Ltd Eastern Broadacre Planning Study, Assessment of Ecological Opportunities and Constraints, June 2008.

114 Canberra Spatial Plan, ACT Planning and Land Authority, 2004.

At a meeting on the Majura Parkway Environmental Impact Assessment on 19 December 2008, the Commissioner and her staff were informed that the east-west Kowen road had been removed from the options.[115] While this is the case, security for the Natural Temperate Grassland in the Majura Valley could be more assured if Recommendation 23 were adopted and a Majura Valley reserve was planned that has connectivity with the Canberra International Airport (MA03) to particularly protect the Grassland Earless Dragon.

5.2.2 Mugga Mugga Homestead

The Mugga Mugga Homestead (JE01) is a Category 2: Complementary Conservation Site and is not affected by the proposed future employment corridor.

5.2.3 'Callum Brae'

'Callum Brae' (part JE02) is a Category 1: Core Conservation Site and provides habitat for the Grassland Earless Dragon, Golden Sun Moth and Perunga Grasshopper. As previously mentioned, 9.4 hectares of this site has been identified for development as a long-stay caravan park. The 'Callum Brae' grassland (under lease) forms a very important link for maintaining habitat connectivity with Jerrabomberra West Reserve (JE03) and the 'Callum Brae' Woodland Reserve. The areas of ecological connectivity need to be defined. Areas of ecological connectivity could be managed under a conservation lease or, depending on location, amalgamated with the adjoining rural lease. If development occurs, an offset should be required.

5.2.4 Jerrabomberra West Reserve

Jerrabomberra West Reserve (JE03) is a Category 1: Core Conservation Site and is contiguous with 'Callum Brae' (JE02) to the north and woodland to the east. This site contains Golden Sun Moth, Grassland Earless Dragon and Pink-tailed Worm Lizard (*Aprasia parapulchella*). The reserve was gazetted in March 2008.

5.2.5 Woods Lane

Woods Lane (JE04) is a Category 2: Complementary Conservation Site. It is part of a habitat corridor between the Letchworth lowland native grasslands and Queanbeyan Nature Reserve to the east in New South Wales, separated by the railway line and the proposed Jerrabomberra East Reserve (JE05) to the west. This site provides connectivity between the proposed Jerrabomberra East Reserve (JE05) and grassland within New South Wales. Efforts should be made to retain this connectivity.

5.2.6 Proposed Jerrabomberra East Reserve

The proposed Jerrabomberra East Reserve (JE05) is a Category 1: Core Conservation Site. It is contiguous with other lowland native grassland in Harman Bonshaw, the Alexander Maconochie prison site and Woods Lane (JE04), which forms a corridor with grasslands in New South Wales. The site contains populations of Grassland Earless Dragon and Golden Sun Moth. In May 2004 in the ACT Government announced creation of the East Jerrabomberra Nature Reserve. The ACT Planning and Land Authority has invited the Conservator of Flora and Fauna to identify the boundaries of the East Jerrabomberra area recommended as public land for the purpose of a nature reserve, pursuant to section 314 of

[115] This does not mean that this option will not be re-investigated at some future time.

the *Planning and Development Act 2007* (ACT). The ACT Planning and Land Authority will progress a draft variation to the Territory Plan upon receipt of the relevant information from the Conservator.

5.2.7 Harman Bonshaw South

Harman Bonshaw South (JE06)[116] is a Category 1: Core Conservation Site and is contiguous with Harman Bonshaw North and the proposed East Jerrabomberra Nature Reserve. The site contains populations of Grassland Earless Dragon and Golden Sun Moth. This site needs to be appropriately managed to retain habitat for threatened species.

5.2.8 Harman Bonshaw North

Harman Bonshaw North (JE07)[117] is a Category 1: Core Conservation Site providing habitat for the Grassland Earless Dragon and connectivity through the grassland sites in the Jerrabomberra Valley. It provides a native vegetation corridor with Harman Bonshaw South and with grassland within New South Wales.

5.2.9 'Cookanalla'

'Cookanalla' (JE08) is a Category 2: Complementary Conservation Site. It has previously been identified as habitat for the Grassland Earless Dragon; however, it appears that due to fragmentation and overgrazing during the prolonged drought the habitat may have deteriorated.

Based on field assessment, information and advice collected during the course of this investigation, it appears that this site is able to accommodate a long-term land use that integrates conservation and development. However, before this can occur a Grassland Earless Dragon survey is needed in conjunction with a survey to identify habitat that would support this species. Given the condition of the site, it may be appropriate to undertake surveys when the site has recovered, at least to some degree, from its current threatening processes. This site appears to lend itself to a land use that integrates conservation values with development. If areas of grassland are developed an offset should be required.

5.2.10 Advanced Manufacturing Technology Estate

The Advanced Manufacturing Technology Estate (AMTECH (JE09)) is a Category 2: Complementary Conservation Site. The AMTECH site contains 18 hectares of Natural Temperate Grassland. In 1993 the ACT Government developed Stage 1 of the estate after an approach from Canberra Region Advanced Technology Manufacturing Association seeking suitable sites for their members to co-locate. The estate is approximately 30 hectares with 18 blocks available in Stage 1 and about 34 blocks identified for Stage 2; the grassland site is located in part of Stage 2.

The Grassland Earless Dragon population has in the past been located within Stage 2 of the estate. However, a survey in the summer of 2007–08 found no evidence of the dragon remaining on the site.[118] The loss of the Grassland Earless Dragon population may be a result

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[116] The ACT Government has indicated it would make this site a nature reserve when it is sold.

[117] The ACT Government has indicated it would make this site a nature reserve when it is sold.

[118] David Hogg Pty Ltd, Eastern Broadacre Planning Study, Assessment of Ecological Opportunities and Constraints, June 2008.

of ongoing drought conditions in recent years.[119] The prospect of the area being re-populated naturally under better conditions is not favourable due to the likely barrier effect of Hindmarsh Drive, which separates the site from 'Cookanalla' (JE08) and is likely to be a significant barrier to the dragons' movement.

Reassess the site's ecological values as these may have changed. If this site no longer meets criteria for its current classification as a Category 2: Complementary Conservation Site and changes to Category 3: Landscape and Urban Sites, its development potential could be realised. If areas of grassland are developed an offset should be required.

5.2.11 Tennant Street, Fyshwick

The 0.3 hectares of Natural Temperate Grassland within a matrix of disturbed lowland native grassland alongside Tennant Street, Fyshwick (JE10) is a Category 2: Complementary Conservation Site. The site is located on the edge of the Fyshwick industrial zone and has been identified for retention within a recreation corridor linking Tennant Street and the Molonglo River, if the remainder of the site is developed. The site should be managed for conservation values within its future situation within a low-key recreational area.

5.3 Belconnen

5.3.1 Lawson Concept Planning Study – Lawson Territory and Lawson Commonwealth

Lawson Territory (BE07) is a Category 3: Landscape and Urban Site comprising mainly native pasture. There is a population of the Golden Sun Moth adjacent to the Belconnen Naval Transmission Station. Under the Territory Plan it is zoned residential.

The ACT Government has engaged consultants to conduct an environmental, planning and development study for part of the future suburb of Lawson. The study area is 157.38 hectares, of which an estimated 58.5 hectares is developable area and includes Lawson Territory (BE07) which is on Territory Land. The former Belconnen Naval Transmission Station site (BE08a) is not part of the study area.

The planning study is currently scheduled for completion in early 2009. Following finalisation of a concept plan, a variation to the Territory Plan will occur in 2009 to include the concept plan as a precinct code in the Territory Plan. It is anticipated that the land release will occur in two stages in 2009–10 and 2011–12.[120]

As the abutting land, Lawson Commonwealth – Belconnen Naval Transmission Station (BE08(a)), is one of the most important remaining grasslands in the ACT, with three threatened species, including the only known population of the Ginninderra Peppercress, every endeavour should be made to ensure an adequate buffer is situated outside the site (that is, within the Lawson Territory (BE07) land) to provide a habitat buffer and an asset protection zone to the residential area.

A long-term grassland management plan needs to be developed (*see* Recommendation 9 in Table 2). The ACT Government has stated that it wishes to retain this site as a nature reserve, once the Australian Government has relinquished it.

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[119] David Hogg Pty Ltd, Eastern Broadacre Planning Study, Assessment of Ecological Opportunities and Constraints, June 2008.

[120] Pers comm., Ms Trina Mcfarlane, ACT Planning and Land Authority, 5 November 2008.

5.3.2 Kaleen East Paddocks

Kaleen East Paddocks (BE09) is a Category 3: Landscape and Urban Site and comprises 28.2 hectares of lowland native grassland, including 4 hectares of Natural Temperate Grassland. Reassess the site's ecological values, as they were not obvious at the time of inspection. If these values still exist and development were to occur, given the likelihood that there is only a small area of Natural Temperate Grassland remaining, this may be able to be integrated with any future developments.

5.3.3 Caswell Drive

The Caswell Drive (BE10) site is a Category 1: Core Conservation Site of 4.8 hectares of Natural Temperate Grassland. One hectare of this site was lost to the Gungahlin Drive Extension roadworks. This small site is contiguous with the Aranda Bushland Reserve. This site is currently managed under a rural lease. Given is ecological value, amalgamation with nearby reserves would offer long-term protection.

5.3.4 Glenloch Interchange

The Glenloch Interchange (BE11) site is a Category 1: Core Conservation Site of 2.2 hectares of Natural Temperate Grassland that contains a small remnant Snow Gum–Candlebark Tableland Woodland, otherwise isolated by roads. This site is currently managed as a roadside. Given its ecological value, amalgamation with nearby reserves would offer long-term protection.

Recommendation 25: Expand Aranda Bushland and Black Mountain Reserve by including areas of lowland native grassland in Caswell Drive (BE10) and Glenloch Interchange (BE11).

5.3.5 Molonglo and North Weston – Kama South

The future development of Molonglo and North Weston potentially affects the lowland native grassland site of Kama South (BE12), which lies between West and East Molonglo. This is a Category 1: Core Conservation Site comprising 38.5 hectares of Natural Temperate Grassland contiguous with areas of Yellow Box–Red Gum Grassy Woodland. The site is currently zoned as rural and is managed by a licence (agistment).

Territory Plan Variation 281 – Molonglo and North Weston has been approved and commenced on 12 December 2008. This variation enables parts of the Molonglo Valley and North Weston to become urban development areas. The variation does not include the Central Molonglo area, formerly proposed in the preliminary studies for development.[121]

The Variation designates Kama South (BE12) as public land (nature reserve) It also proposes that a buffer to the reserve be located in the development area, not in the nature reserve.

Preliminary environmental investigations in Molonglo and North Weston identified several matters of national environmental significance. These include:

- the Pink-tailed Worm Lizard, listed under the *Environment Protection and Biodiversity Conservation Act 1999* (Cwlth) as vulnerable,
- the White Box–Yellow Box Blakely's Red Gum Grassy Woodland and Derived Native

[121] Pers. comm., Bruce Frazer, ACT Planning and Land Authority, 6 November 2008.

Grassland listed as critically endangered

- the Natural Temperate Grasslands of the Southern Tablelands of New South Wales and the ACT listed as endangered.

Given the presence of these vulnerable and endangered species, the impacts of development in Molonglo and North Weston must be assessed under the *Environment Protection and Biodiversity Conservation Act 1999* (Cwlth).

The Australian Government Minister for the Environment, Water, Heritage and the Arts and the ACT Minister for Planning have agreed to undertake a strategic assessment of the proposed Molonglo and North Weston Structure Plan under section 146 of the *Environment Protection and Biodiversity Conservation Act 1999* (Cwlth). The Structure Plan sets out the planning and development guidelines and principles for urban development and associated infrastructure at Molonglo and North Weston. Development actions that do not adhere to the Structure Plan will be required to go through the standard referral and assessment process.

The ACT is an area that is still being planned and developed and it is particularly important that the few remaining areas of Category 1: Core Conservation Sites be given priority for protection and that conservation values are integrated with development considerations in Category 2: Complementary Conservation Sites and Category 3: Landscape and Urban Sites.[122] It is also important for corridors and connectivity to exist between the various sites, regardless of classification (*see* Section 6).

5.4 Central Canberra

5.4.1 Constitution Avenue, Reid

Constitution Avenue, Reid (CCO2) is a Category 2: Complementary Conservation Site of 0.7 hectares of Natural Temperate Grassland. The grassland site is vacant unleased Territory Land and contains the endangered Golden Sun Moth; the entire site is a Designated Area. If a decision is made to develop the Natural Temperate Grassland area, an offset should be required.

There is a need to clarify the long-term land use for some lowland native grassland sites. This investigation found that the condition of some sites suggests that their ecological value may have declined to such a degree that they may need to be reassessed. These sites need to be subjected to an ecological assessed in the appropriate season/s.

In determining the long-term land use of lowland native grassland sites it is important to consider how best to strategically protect lowland native grassland, particularly Natural Temperate Grassland and threatened species, and also develop Canberra. Retaining some small areas of grassland may be appropriate in some circumstances, but not in others. Where retention on a site is inappropriate an offset, for example, undertaking restoration activities on another grassland site or funding research, should be required. It is likely that in many circumstances there will be benefit in having offsets undertaken in a strategic manner by nominating specific offset restoration sites. Recommendations 5 and 22 promote the development of an offset policy (that includes identification of offset restoration sites). Possible offset sites include:

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[122] Action Plan No. 28.

- Majura West (MA06) to enhance its habitat to better support the Grassland Earless Dragon
- Yarramundi Reach (CC06), Caswell Drive (BE10) and Glenloch Interchange (BE11) to enhance the overall grassland quality.

Depending on the land use for 'Cookanulla' (JE08), this site may also be appropriate as an offset site.

Recommendation 26: Define the long-term land use for lowland native grassland sites, while strategically protecting lowland native grassland, particularly Natural Temperate Grassland, and progressing appropriate developments, specifically:

- 'Callum Brae' (part JE02) – excluding the land swap site. The areas of ecological connectivity need to be defined. Areas of ecological connectivity could be managed under a conservation lease or, depending on location, amalgamated with the adjoining rural lease. If development occurs, an offset should be required.
- 'Cookanalla' (JE08) – a Grassland Earless Dragon survey is needed in conjunction with a survey to identify habitat that would support this species. Given the condition of the site, it may be appropriate to undertake surveys when the site has recovered, at least to some degree, from its current threatening processes. This site appears to lend itself to a land use that integrates conservation values with development. If areas of grassland are developed an offset should be required.
- AMTECH (JE09) – reassess the site's ecological values as these may have changed. If this site no longer meets criteria for its current classification as a Category 2: Complementary Conservation Site and changes to Category 3: Landscape and Urban Sites, its development potential could be realised. If areas of grassland are developed an offset should be required.
- Kaleen East Paddocks (BE09) – reassess the site's ecological values, as they were not obvious at the time of inspection. If these values still exist and development were to occur, given the likelihood that there is only a small area of Natural Temperate Grassland remaining, this may be able to be integrated with any future developments.
- Lawson Commonwealth – East (BE08(b)) – Given the overall context of this site it appears to lend itself to a land use that integrates conservation values with development. An offset should be required if areas of grassland are developed.
- Constitution Avenue, Reid (CC02) – If a decision is made to develop the Natural Temperate Grassland area, an offset should be required.

Findings that informed Recommendation 27

During the investigation, the Commissioner's Office found it difficult to identify the location of lowland native grassland sites relative to planning zones that guide land use. To help the community and developers gain information on grassland sites relative to planning zones it is recommended that a map of the location of lowland native grassland sites relative to planning zones be published.

Recommendation 27: Publish a map that shows the location of lowland native grassland sites relative to planning zones. This should be readily available through the ACT Planning and Land Authority and the Department of Territory and Municipal Services.

6 Corridors and connectivity

It is important to consider corridors and connectivity, especially for wildlife movement, at a broad landscape level and within or between sites. Local connectivity within sites or between adjacent sites is important for flora generally, and less mobile fauna species, such as the Grassland Earless Dragon, Striped Legless Lizard and Golden Sun Moth, specifically for:

- maintaining genetic diversity within populations
- repopulating an area that may have been subject to population loss through a natural or human-imposed activity, such as a burn.[123]

Despite fragmentation and degradation of Natural Temperate Grassland and Yellow-Box Red Gum Grassy Woodland communities, the Majura and Jerrabomberra valleys retain large areas of native grassy ecosystems in varying degrees of condition, including links between grassland and woodland, which provide significant habitat for native species and possibilities for animal movement.[124]

In terms of biodiversity conservation, the ideal approach is to establish a series of conservation reserves (which may include voluntary schemes) that are of sufficient size and biodiversity to maintain a full range of ecological communities (and hence species) on a long-term basis. It is also desirable for such reserves to be located to enable connectivity for animal movement and other interactions between them.[125]

The natural connections between grasslands and adjoining woodlands have mostly been severed, but should be retained where they still exist.

Important grassland sites for connectivity between woodland and grassland are at:

- Mount Ainslie Nature Reserve and Campbell Park (MA05)
- 'Callum Brae' (JE02)
- Jerrabomberra West Reserve (JE03) and woodland to the west
- Gungaderra Nature Reserve (GU02) and Gungahlin Hill
- Aranda Bushland and Caswell Drive (BE10)
- Majura Valley at the Majura Training Area (MA01).

Important grassland sites for connectivity between grasslands are at:

- Campbell Park (MA05) and Majura West (MA06)
- adjacent grassland on either side of the ACT and New South Wales border via Harman Bonshaw North (JE06) and Harman Bonshaw South (JE07), Jerrabomberra East Reserve (JE05), Woods Lane (JE06), and Queanbeyan Nature Reserve (Letchworth, New South

[123] David Hogg Pty Ltd, Eastern Broadacre Planning Study, Assessment of Ecological Opportunities and Constraints, June 2008.

[124] Report from Parks Conservation and Lands to the ACT Commissioner for Sustainability and the Environment for the Inquiry into the Management of Lowland Native Grasslands, Parks Conservation and Lands, August 2008.

[125] David Hogg Pty Ltd Eastern Broadacre Planning Study, Assessment of Ecological Opportunities and Constraints, June 2008.

Wales)

- adjacent grassland between the Canberra International Airport (MA03) the Majura Training Area (MA01) and 'Malcolm Vale' (MA04).

Development that potentially affects lowland native grassland is either underway or planned for the ACT (*see* Section 5). This development has the potential to sever corridor and connectivity between grasslands and woodlands and/or other adjacent habitats. Many of the recommendations presented in this report reinforce the importance of connectivity. However, efforts to retain connectivity could be assisted if information on the location of lowland native grassland, in particular Natural Temperate Grassland, were readily available.

7 Adaptive management

One of the key features of the lowland native grassland is the habitat it provides for a range of threatened fauna and flora. To restore habitat for fauna, an essential management objective is to maintain or improve the diversity of its structure and native species composition. The long-term sustainability of lowland native grassland requires an adaptive management[126] regime to maintain, improve and restore their ecological condition and habitat quality.[127]

Adaptive management allows for the testing of management practices on site to determine if they are achieving the desired outcome, and adapting them as required. It requires that clearly defined objectives be developed, based on current knowledge of the vegetation community, associated species and their responses to management. It is critical that management goals and on-ground management be subject to ongoing review based on analysis of monitoring results and reporting on management practices, then review of information and making changes as necessary.[128]

This requires that lowland native grassland sites be subject to regular inspections and monitoring programs to ensure threats, such as weeds and overgrazing, are identified quickly enough to prevent damage to sites and before the threatening process reaches a critical stage. Therefore, an annual monitoring program, involving site inspections and photographic recordings, should be developed and maintained to support an adaptive management approach.

Given the multiple jurisdictions and managers of the grassland sites and the desirability of monitoring each site for informing management decisions, the most effective mechanism for this to occur would be to convene a meeting of grassland and landscape ecologists to develop a best-practice monitoring program to be applied at selected sites to monitor impacts and implement adaptive management.

Only 40% of the Territory's lowland native grassland sites are in good condition. This percentage may have been higher if an adaptive management approach had been used to manage all sites. An adaptive management approach is designed to improve environmental management by learning from results. It uses management actions as the primary tool for learning about the system being managed. An adaptive management approach focuses on achieving field results through, among other things, regular site inspections and monitoring (this could include photographic recordings), using research findings to inform management practices, undertaking controlled and monitored experiments, such as, reintroducing targeted species (plants and animals).

An adaptive management approach relies on regular site inspections and routine monitoring, something that was not being undertaken for many of the Territory's sites.

[126] Adaptive management is an approach designed to improve environmental management by learning from management outcomes. Adaptive management uses management itself as the primary tool for learning about the system being managed through an interactive learning process where the decision-making framework is aimed at reducing uncertainty. Knowledge gained through this process is then feed back into the management strategy in order to determine future courses of action and improve future management. Source: Carl Walters Adaptive Management of Renewable Resources, 1986.

[127] Action Plan No. 28, page 74.

[128] Action Plan No. 28, page 71.

Without regular site inspections and monitoring, threatening processes can go undetected until damage becomes obvious, at which stage the effort and resources needed to restore a site may be significant.

Recommendation 28: Use adaptive management to guide land management so that sites in good condition (40%) are maintained, and those in a critical condition (20%) or approaching a critical condition (40%) are restored.

7.1 Reassess some lowland native grassland sites in the ACT

From submissions received and discussions held with relevant land managers, there is a need for some sites to be reassessed to determine if they should be reclassified or if additional sites should be added to those identified as endangered Natural Temperate Grassland and as lowland native grassland sites.

The North Belconnen Landcare Group has nominated an area near the Evatt Footbridge as a lowland native grassland site. This site needs to be assessed before it is considered for designation as lowland native grassland.

During the investigation it was found that the ecological values on some sites may have changed and therefore these sites need to be reassessed to determine their appropriate classification. These sites are Wells Station Road (GU07); Nicholls (GU08); Novar Street, Yarralumla (CC10); Belconnen Pony Club (GU06); Lawson Commonwealth – East (BE08(b)); and Mitchell (GU05).

Recommendation 29: Assess the ecological values of Evatt Footbridge; Wells Station Road (GU07); Nicholls (GU08); Novar Street, Yarralumla (CC10); Belconnen Pony Club (GU06),; Lawson Commonwealth – East (BE08(b)); and Mitchell (GU05).

8 Communication between stakeholders

We are fortunate in the ACT to have an active and engaged community with 38% of the (18 years and older) population volunteering.[129] This volunteering extends to work being undertaken to protect and conserve lowland native grassland sites and communities in the ACT. Volunteer groups in the Territory include:

- Friends of Grasslands
- Limestone Plains Group
- Bush on the Boundary Reference Group
- Friends of Aranda Bushland
- Ginninderra Catchment Group
- North Belconnen Landcare Group.

The Friends of Grasslands community group is dedicated to conservation of native temperate grassy ecosystems, particularly the endangered Natural Temperate Grasslands. It has over 200 members and educates, advocates and advises on matters to do with conservation of grassy ecosystems, and carries out surveys and other on-ground works.

The Limestone Plains Group is an alliance of ACT scientists and nature conservation groups advocating responsible and ecologically informed management of grassy ecosystems in the ACT and region.

The Bush on the Boundary Reference Group is currently specifically focused on issues of conservation in the Gungahlin area. Other Parkcare, Landcare and Friends groups tend to be focused on undertaking management and conservation actions at specific sites, and in this, are frequently supported by ACT Government personnel.

Conservation of our lowland native grassland, along with the entire natural environment in the ACT is both a government and community responsibility, including private landholders. Increasing the awareness and involvement of landholders and the wider community in the conversation of the lowland native grassland and biodiversity in general is a major challenge. Building upon the existing networks and arrangements for participation in collaborative and cooperative arrangements seems to be the most effective approach to conservation in the Territory. The building of partnerships between government and community, with resources and support as appropriate, will play an increasingly important role in biodiversity conservation in the ACT.[130]

Voluntary work should be actively encouraged for the ongoing management and conservation of the lowland native grassland sites. For example, community group members and other individuals might be able to assist in research, monitoring and reporting programs, possibly through a community partnership approach.

Many stakeholders, researchers and experts were concerned about not having the opportunity to meet with each other and land managers, as a group, to share information.

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[129] State of the Environment Report 2007–08 ACT, Overview and Recommendations Paper, page 6.

[130] ACT Nature Conservation Strategy, 1997.

This could be overcome by conducting an annual community and stakeholder forum to, among other things coordinate research, monitoring and data collection, and raise awareness. The Commissioner's Office would be willing to convene the initial forum.

Recommendation 30: Conduct an annual community and stakeholder lowland native grassland forum to, among other things, coordinate research, monitoring and data collection, and raise awareness.

There is a wealth of information and expertise in the Capital region on lowland native grassland, but it is dispersed and therefore difficult to access. This difficulty could be addressed by establishing an accessible central register of information on lowland native grassland that includes current research and studies. This could be made available through a website.

Recommendation 31: Establish an accessible central register of information and expertise on lowland native grassland.

8.1 Indigenous stakeholders

During this investigation, some members of the Indigenous community meet with the Commissioner and her staff and highlighted the significance of the grassland sites to the Aboriginal culture, in particular the lowland native grassland sites of Crace and Lawson. Mr Shane Mortimer, of the Ngambri people, expressed his views, which are included in this report as Appendix 9.

8.2 Awareness

A gap in the long-term conservation of the lowland native grassland is that of community awareness. The ACT community needs to be made aware of the values of the lowland native grassland and other natural assets in the Territory to ensure their long-term survival.

The Australian Centre for Christianity and Culture, Barton (CC04) lessees are very aware of the value of their grassland and have been actively managing their site. The ecological values of the site are well respected by the lessees, who have taken significant effort to ensure the grassland remains in good condition, and that any activities on the site do not compromise the grassland. Parks Conservation and Lands staff within the Department of Territory and Municipal Services have worked closely over the past 15 years with the lessees to ensure the values are retained, and a good relationship has developed between the lessees and this agency's staff.

Australian Centre for Christianity and Culture staff and managers have welcomed opportunities for community groups and individuals from neighbouring government agencies to visit the site, to learn more about the endangered Natural Temperate Grassland community and associated flora and fauna. Such groups and individuals have provided input on the management and conservation values on the site, including the first record of the endangered Golden Sun Moth found on the site. Friends of Grasslands were represented on a management group that met for some years. Parks Conservation and Lands staff have been invited to speak to about the ecological values of the site at public occasions. The site managers have incorporated local grassland species into the biblical gardens that have been established on the periphery of the grassland site and the grassland site itself is an integral part of the design and use of the site.

The position of the site in central Canberra, the ease of access, the unique blend of cultural, environmental and religious values represented and the beauty of the site overlooking the lake and hills to the north and east make it a prime site for enhancing visitation and increasing community awareness.

While in some spheres, community awareness of the importance of the ecological value of lowland native grassland and the species it supports has increased significantly over the past 15 years, awareness within the general public still appears limited. Awareness could be increased, for example, by:

- placing signage with interpretative material at key sites, such as Canberra International Airport (MA03); St John's Church, Reid (CC03); Australian Centre for Christianity and Culture, Barton (CC04); 'Callum Brae' (JE02); Jerrabomberra West Reserve (JE03); Jerrabomberra East Reserve (JE05); Mulanggari Nature Reserve (GU01); Gungaderra Nature Reserve (GU02); Crace Nature Reserve (GU03); North Mitchell (GU04); and Dunlop Nature Reserve (BE02)
- promoting sites as part of the Territory's Tracks and Trials Heritage Interpretative Tour
- encouraging use of lowland native grassland in restoration and rehabilitation projects following development activities such as new suburbs and road construction
- encouraging use of native grasslands to replace lawns and gardens in private and public places, which could lead to lower ongoing maintenance costs and reduced water use
- adopting a patron for Natural Temperate Grassland and endangered grassland species.

Recommendation 32: Increase community awareness of the importance of lowland native grassland, in particular Natural Temperate Grassland and the endangered grassland species.

Appendixes

Appendix 1: Report on Belconnen Naval Transmission Station Site as part of the Investigation into ACT Lowlands Grasslands by Dr Maxine Cooper Commissioner for Sustainability and the Environment, 26 February 2008

Report on
Belconnen Naval Transmission Station (BNTS) Site as part of the Investigations into ACT Lowlands Grasslands
by
Dr Maxine Cooper
Commissioner for Sustainability and the Environment.

26 February 2008

Ginninderra Peppercress
(Lepidium ginninderrense)

Golden Sun Moth

(Synemon plana)

Perunga Grasshopper

(Perunga ochracea)

Belconnen Naval Transmitting Station (BNTS) January 2008
Natural Temperate Grassland

OFFICE OF THE COMMISSIONER
FOR SUSTAINABILITY AND THE ENVIRONMENT ACT

ABN: 14 526 086 507

Jon Stanhope MLA
Minister for the Environment, Water and Climate Change
GPO Box 1020
Canberra ACT 2601

26 February 2008

Dear Chief Minister

On 15 November 2007 you directed pursuant to section 12(1)(b) of the *Commissioner for the Environment Act 1993* (the Act) that I conduct an investigation into the lowland native grasslands. The first part of my investigation has been focused on the native grassland at the Belconnen Naval Transmission Station (BNTS) as it required urgent attention.

Pursuant to section 21(d) of the Act I provide you with a copy of my report on BNTS.

I intend to now continue with investigations into the other sites of lowland native grassland and will provide you with a report in due course.

Yours sincerely

M. Cooper.

Dr Maxine Cooper
Commissioner

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Summary of Commissioner's Recommendations

Recommendation 1 - Urgent action is to be taken to restore the ecological condition of the Grassland, and provide opportunities for the Perunga Grasshopper, Golden Sun Moth and Ginninderra Peppercress to survive and thrive at BNTS.

Recommendation 2 – Kangaroos are to be removed immediately from BNTS to achieve a stocking rate of 1 kangaroo per hectare or less. This is to be done by the land manager, preferably before the end of April 2008, to prevent impacts on pasture biomass occurring during the dormant 2008 winter season.

Recommendation 3 – Kangaroo population numbers are to be maintained at the targeted level for the foreseeable future using fertility-controlled kangaroos only. A program to maintain this situation is to be implemented as needed. (This recommendation is made on the assumption that all remaining kangaroos at BNTS will be part of fertility control research programs.)

Recommendation 4 – Further reductions in the number of kangaroos at BNTS (i.e. even below the proposed stocking rate of 1 kangaroo per hectare) is to occur if recovery of the grassland does not improve over the next growing season even if research projects are compromised.

Recommendation 5 – Kangaroos are to be removed from BNTS by the most humane method suitable for that site having regard to advice from the AFP that firearms are not to be used at BNTS. (The Expert Panel has recommended sedating by darting followed by euthanasia by lethal injection.)

Recommendation 6 - The policy of the Conservator of Flora and Fauna, to the effect that translocation of eastern grey kangaroos is not an appropriate management technique, is to remain unchanged and that this policy position be confirmed to the Department of Defence immediately.

Recommendation 7 - The interim grassland management plan and interim kangaroo management plan for BNTS are to be completed by the end of August 2008, by the land manager, in consultation with key stakeholders. These plans are to adopt adaptive management principles and be based on a stocking rate of 1 kangaroo per hectare or less prior to the 2008 winter.

Recommendation 8 - Conditions at BNTS are to be reported on a quarterly basis to all relevant agencies and to the Commissioner's Office. The Commissioner is to establish an independent group to assist her evaluate progress and report on this in her annual report.

Recommendation 9 - A long-term grassland management plan covering BNTS is to be developed prior to the abutting Lawson lands being developed for residential purposes. This plan should incorporate clear management objectives and be based on an adaptive management approach to protect the Grassland, Perunga Grasshopper, Golden Sun Moth and Ginninderra Peppercress at the BNTS. (The interim grassland management plan and interim kangaroo management plan (Recommendation 7) should be incorporated into the long-term plan. This long-term plan could cover all ACT natural temperate grassland areas.)

Recommendation 10 - The Territory is to ensure that legal measures are implemented to protect and preserve the high conservation value of the Grassland and its threatened species when the land at BNTS is transferred from the Commonwealth to another entity. (This recommendation is made on the assumption that Territory laws will fully prevail post the transfer.)

Recommendation 11 - The review of the Memorandum of Understanding between the Department of Defence and ACT Government (TAMS) is to be completed by August 2008.

Introduction

On 15 November 2007 the Minister for the Environment, Water and Climate Change, Jon Stanhope, pursuant to section 12(1)(b) of the *Commissioner for the Environment Act 1993*, directed that I undertake an Investigation into the lowland native grasslands. A copy of the Terms of Reference for the Investigation is at **Attachment A**.

On 21 November 2007 a meeting was held with key stakeholders for a roundtable discussion concerning relevant matters relating to the Investigation. Some stakeholders sought clarification regarding the scope of the Investigation particularly as to whether it would include threatened species.

On 29 November 2007 the Minister advised that:

> *Investigation of Lowland Native Grasslands their associated threatened communities and species, as well as threats to, and identification of measures for protecting these, and other species are an inherent part of the Terms of Reference.*

Following receipt of this advice from the Minister, a Commissioner's comment was attached to the Terms of Reference. A copy of this document is at **Attachment B**.

A media release, from the Commissioner's office, advising of the Investigation and inviting submissions was issued on 30 November 2007. A copy of the media release is at **Attachment C**.

On 1 December 2007 an advertisement was placed in The Canberra Times that also advised of the Investigation and invited submissions. A copy of the advertisement is at **Attachment D**.

Both the press release and the advertisement advised that the time for lodging submissions relating to the Belconnen Defence site otherwise known as the Belconnen Naval Transmitting Station (BNTS) closed on 14 December 2007 and that the closing date for all other submissions was 25 January 2008. Early submissions on the BNTS site were required because the secure area within the BNTS appeared to require urgent attention. Accordingly, the first part of the Investigation focuses on this site.

Public submissions were received from a total of 12 community organisations and individuals in respect of the BNTS site although some of these submissions also dealt with issues associated with other sites. A list of these submissions is at **Attachment E**.

For the purposes of the Investigation a number of meetings with officers in the Department of Defence (Defence) including with the Secretary of that Department were held. Defence provided a high level of assistance and co-operation in respect of the Investigation. For example, the Department of Defence made available a number of documents relating to the natural temperate grassland within the BNTS and associated matters. In addition, the Department of Defence provided access to the secure area within the BNTS on a number of occasions so that the state of the natural temperate grassland could be assessed.

Officers of the department of Territories and Municipal Services (TAMS) provided information relevant to the Investigation and were also very helpful.

Belconnen Naval Transmission Station (BNTS)

BNTS is within the suburb of Lawson and occupies approximately 143 hectares of the northern portion of that suburb (**Map 1**). The existing suburbs of McKellar, Giralang and Kaleen and undeveloped Territory land to the South surround the site. The BNTS land has been declared National Land pursuant to section 27 (1) of the Commonwealth *Australian Capital Territory (Planning and Land Management) Act 1988* and is under the control of the Commonwealth Department of Defence.

The secure area of BNTS occupies approximately 115 hectares and it has a security fence running along its perimeter. The secure area of BNTS contains the majority of the site's natural temperate grassland (endangered ecological community under Territory and Commonwealth legislation) with some smaller areas outside the security fence on abutting Defence land. Within this grassland can be found the golden sun moth (endangered under Territory and Commonwealth legislation), ginninderra peppercress (endangered under Territory legislation and vulnerable and critical habitat under Commonwealth legislation) and perunga grasshopper (vulnerable under Territory legislation).

Natural Temperate Grassland

Natural temperate grassland is one of the ACT's most threatened ecosystems. It is estimated that 20,000 ha of natural temperate grasslands occurred in the ACT prior to European settlement. Only approximately 5% (1,000 hectares) of this grassland remains today. Nationally, less than 1% of this community remains[1].

Natural temperate grassland is a native ecological community that is dominated by native species of perennial tussock grasses. The dominant grasses are Themeda triandra, Austrodanthonia species, Austrostipa species, Bothriochloa macra and Poa species. The upper canopy stratum generally varies in height from mid-high (0.25 - 0.5 m) to tall (0.5 – 1.0 m). There is also a diversity of native herbaceous plants (forbs), which may comprise up to 70% of species present. The community is naturally treeless or has less than 10% projective foliage cover of trees, shrubs and sedges in its tallest stratum. In the ACT it occurs where tree growth is limited by cold air drainage, generally below 625 m[1].

Under the ACT *Nature Conservation Act 1980* the Minister for the Environment, on the recommendation of the Flora and Fauna Committee, has declared that the natural temperate grassland is an endangered community. The grassland is also listed as an endangered ecological community under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPCB).

The natural temperate grassland at BNTS has a botanical significance rating of 2[2]. This means that the natural temperate grassland at BNTS has high botanical significance[3]. There are only three sites in the ACT, which contain natural temperate grassland, which has a high botanical significance rating and which are over 50 ha in size[4]. BNTS is one of these three sites[5].

[1] ACT Government, 2005 *A vision splendid of the grassy plains extended: ACT lowland native grassland conservation strategy*. Action Plan No. 28 (Arts, Heritage and Environment, Canberra), paragraph 2.1.4
[2] ibid paragraph 3.4.6
[3] ibid see table 3.1 and paragraph 3.4.6
[4] ibid paragraph 3.4.6
[5] the other two sites are the Majura Training Area and Mulanggari Nature Reserve

Map 1 – BTNS Lawson

Threatened Species

At BNTS the natural temperate grassland is the habitat of the perunga grasshopper (which the Minister, on the recommendation of the Flora and Fauna Committee, has declared to be a vulnerable species), the golden sun moth and the ginninderra peppercress (both of which the Minister, on the recommendation of the Flora and Fauna Committee, has declared to be endangered species). Another vulnerable species, the striped legless lizard, has been found outside the secure area; however, it was most likely present in the secure area at BNTS in former years.

Under the EPBC the golden sun moth is listed as critically endangered and the ginninderra peppercress and striped legless lizard are listed as vulnerable.

Eastern Grey Kangaroos

Within the secure area of BNTS eastern grey kangaroos (kangaroos) are contained. As at 10 December 2007 there were approximately 588 kangaroos within the secure area.

Approximately 60 female kangaroos in this population are tagged and are being used for fertility research purposes. Of these 60 kangaroos, 40 have been subject to trial fertility control measures and the remaining 20 have been used as controls.

Issues

Within the context of the terms of reference for the investigation **(Attachments A and B)** the six critical questions in relation to the BNTS site appear to be:

1. *Should the natural temperate grassland and the threatened species within the grassland at BNTS be conserved?*
2. *What is the current state of the natural temperate grassland at BNTS?*
3. *If the current state of the natural temperate grassland at BNTS is less than optimal, what is the cause?*
4. *What action is necessary to conserve the natural temperate grassland and threatened species that have the grassland as their habitat?*
5. *If action to conserve the natural temperate grassland requires removal of some or all of the kangaroos, what is the most humane method of removing the kangaroos within the constraints of the BNTS site?*
6. *How should the natural temperate grassland be managed in the future so that it and the threatened species are conserved?*

Expert Panel

To assist in resolving the six critical questions related to BNTS, as outlined above, an interdisciplinary approach was considered desirable. To this end a panel of experts from different disciplines was formed. The expert panel consisted of:

- a plant ecologist who could advise me on the current state of the natural temperate grassland and threatened species that have grassland as their habitat (Dr Sue McIntyre);
- an expert in relation to kangaroos (Professor David Morgan);
- an expert in relation to animal welfare issues (Michael Linke); and
- a veterinarian experienced in animal research and animal ethics to provide practical advice in relation to animal management (Dr Andrew Braid).

A copy of the curriculum vitae for each of these experts is at **Attachment F**.

The expert panel met as a group on 25 January 2008 and on that day inspected the natural temperate grassland at BNTS. The expert panel was provided with a copy of all the submissions received in relation to the Investigation together with a number of other documents relevant to the issues identified above. The expert panel was requested to consider the six issues identified above and provide an interdisciplinary expert report.

Discussion and Commissioner's Recommendations

On 19 February 2008 the expert panel submitted its report which is at **Attachment G**. The expert panel's report, submissions listed at **Attachment E**, and material provided by the Department of Defence and Territory and Municipal Services have all been carefully considered in developing the recommendations presented in this report.

In forming my recommendations the intent of all the recommendations made by the expert panel is respected as has been the advice received from the ACT's Conservator of Flora and Fauna, Territory and Municipal Services (TAMS) **(Attachment H)**.

1. Should the natural temperate grassland and the threatened species within the grassland at BNTS be conserved?

Reasons for conserving the natural temperate grasslands and the threatened species within the grassland at BNTS are presented in the expert panel's report **(Attachment G, pages 1 and 2)**. Many of the submissions made to his investigation argued the importance of conserving the grassland at BNTS.

As previously mentioned in this report (page 8), the natural temperate grassland is one of the ACT's most threatened ecosystems with only 1,000 hectares remaining. The grassland at BNTS (approximately115 hectares) accounts for 12% of the remaining grassland and importantly this is also considered to be of high botanical significance. This site is important due to the grassland and also the presence of threatened species. Species, by their very categorisation as threatened are ones that are offered legislative protection. Accordingly, the answer to question 1 is a categorical yes and is reflected in the first recommendation on page 13 of this report.

2. What is the current state of the natural temperate grassland at BNTS?

The expert panel undertook a field assessment of the site on the 25 January 2008 and concluded that despite recent rains the condition of the native temperate grassland over much of BNTS is still poor. Their analysis of the site is presented in some detail in their report **(Attachment G, pages 4 to 7)**. I also visited the site with the panel and concur with their analysis.

The affect of over-grazing by kangaroos is well illustrated by photographs in the expert panel's report. These are reproduced on the following pages.

Figure 1. Kangaroo enclosure on right showing response to resting over spring/summer 2007-8. Area on the left continues to be grazed. In the centre of the picture is an eroded area with scalding between the tussocks. Note the growth response of this patch is limited even with grazing removal. This is due to the condition of the soil restricting rainfall infiltration and the phenomenon that short-growing, low productivity species are most persistent in eroded areas (January 2008).

Figure 2. Historical grazing pressure at the BNTS has resulted in dominance by low-growing species. Combined with continuing grazing pressure, these small plants have failed to produce good grass cover despite favourable growing conditions (January 2008).

Figure 3. Evidence of soil erosion: bare scalded areas between tussocks, individual tussocks remain raised while surrounding soil has washed away, leaving a lowered soil surface (January 2008).

Given the importance and condition of BNTS the expert panel recommended that urgent action be taken to protect the grassland and threatened species.

The expert panel's recommendation regarding this issue **(Attachment G, page 8)** is fully supported and is adopted as my first recommendation.

Recommendation 1 - Urgent action is to be taken to restore the ecological condition of the Grassland, and provide opportunities for the Perunga Grasshopper, Golden Sun Moth and Ginninderra Peppercress to survive and thrive at BNTS.

3. If the current state of the natural temperate grassland at BNTS is less than optimal, what is the cause?

The expert panel concluded that the cause of this is grazing pressure by eastern grey kangaroos **(Attachment G, pages 7 and 8).** They concluded that the *current dense kangaroo population is preventing recovery of the Grassland by impeding biomass accumulation, preventing re-colonisation by less grazing tolerant, more productive Grassland plants and preventing the re-establishment of a soil crust of cryptograms (mosses, algae and lichens) on the bare ground between the tussocks…As the current growing season tapers into autumn then winter, the impact of kangaroos on the Grassland is expected to increase substantially* **(Attachment G, page 8).**

4. What action is necessary to conserve the natural temperate grassland and threatened species that have the grassland as their habitat?

The expert panel recommended that there be …*immediate removal of all kangaroos from the BNTS and that this removal be completed before impacts on pasture biomass occur during the dormant winter growing season* **(Attachment G, page 9)**.

The ACT's Conservator of Flora and Fauna (TAMS), has advised that complete removal of kangaroos is not considered necessary to facilitate grassland recovery, particularly if an adaptive management approach is used. This approach would involve the number of kangaroos being adjusted according to prevailing conditions. The Conservator also indicated that the site is likely to recover if kangaroo numbers were at a level of approximately 1 per hectare **(Attachment H, page 4)**. Currently the density of kangaroos is approximately 5 per hectare (588 kangaroos).

The Conservator highlighted the role of some kangaroos at BNTS regarding fertility control research. He argues that the BTNS site, particularly by being enclosed, offers opportunities not readily available at other sites **(Attachment H, page 2)**. Research on kangaroo fertility is critical if kangaroo populations are to be managed so that ecological systems are protected concurrently with achieving a high level of animal welfare. The results of the research may provide all land managers with alternatives for managing kangaroo populations.

The option of accommodating research kangaroos on land immediately adjacent to BNTS was explored. These animals could have then been re-introduced to BNTS when the grasslands had recovered. As mentioned above, the Conservator did not consider it necessary to remove all kangaroos and was also of the view that such an approach could compromise research programs **(Attachment H, page 5).**

Taking into account the intent of the expert panel's recommendation and the information from the Conservator, the following recommendations are made:

Recommendation 2 – Kangaroos are to be removed immediately from BNTS to achieve a stocking rate of 1 kangaroo per hectare or less. This is to be done by the land manager, preferably before the end of April 2008, to prevent impacts on pasture biomass occurring during the dormant 2008 winter season.

Recommendation 3 – Kangaroo population numbers are to be maintained at the targeted level for the foreseeable future using fertility-controlled kangaroos only. A program to maintain this situation is to be implemented as needed. (This recommendation is made on the assumption that all remaining kangaroos at BNTS will be part of fertility control research programs.)

Recommendation 4 – Further reductions in the number of kangaroos at BNTS (i.e. even below the proposed sustainable stocking rate of 1 kangaroo per hectare) is to occur if recovery of the grassland does not improve over the next growing season even if research projects are compromised.

The expert panel made a recommendation … *that all kangaroos re-introduced or dispersing into the BNTS must be subject to known and established fertility control measures and be incapable of breeding* **(Attachment G, page 12)**. This only applies if all kangaroos were to be removed from BNTS. However if the site were to accommodate kangaroos other than those part of a research program, I would agree that those animals must be subject to known and established fertility control measures and be incapable of breeding.

5. If action to conserve the natural temperate grassland requires removal of some or all of the kangaroos, what is the most humane method of removing the kangaroos within the constraints of the BNTS site?

Submissions from the community indicated that this issue was of great concern to several groups. Accordingly, the expert panel's membership was biased towards people with animal welfare expertise.

The expert panel considered non-lethal and lethal methods **(Attachment G, pages 9 to 11)**. They found that shooting is the most humane method. However, the AFP will not allow this method to be used at BNTS due to public safety concerns. The expert panel therefore recommended that the kangaroos be removed from BNTS by sedating by darting followed by euthanasia by lethal injection. The Department of Defence (Defence) has advised that their contractor will be required to develop a specific method for capture darting. As part of this method, the contractor will be required to address animal welfare concerns including stopping work immediately if the kangaroos become stressed and there is to be a review of procedures if any kangaroos are injured during any stage of the procedure. I am also advised that there will be supervision by a qualified and experienced veterinarian at all times.

The expert panel also considered the alternative option of moving the kangaroos. The expert panel rejected this option because they did not consider that dart capture followed by release into the wild to be a better option.

In light of the opinion of the expert panel that dart capture followed by release into the wild is not a preferred option, it would therefore not be appropriate for any export licence to be granted to the Department of Defence.

Furthermore, it is understood that the Conservator of Flora and Fauna does not intend issuing translocation licences for the movement of kangaroos and that this is consistent with the policies stated in the first and third Kangaroo Advisory Committee reports. The Conservator has advised that the policy stated in these reports is as follows:

> First Report: that translocation is not an appropriate management strategy for free ranging kangaroos in the ACT; and
> Third Report: that although translocation can play a role in the conservation of threatened fauna, it is neither a humane nor an appropriate management technique for abundant species like eastern grey kangaroos in the ACT.

From discussions with officers in Defence it is understood that the option of moving the kangaroos to New South Wales is being explored. It would seem that this could not occur unless the Conservator of Flora and Fauna granted an export licence to the Department of Defence (see sections 48 and 104 of the Nature Conservation Act).

The panel's recommendation and the Conservator's policy regarding this issue **(Attachment G, page 11)** are supported.

Recommendation 5 – Kangaroos are to be removed from BNTS by the most humane method suitable for that site having regard to advice from the AFP that firearms are not to be used at BNTS. (The Expert Panel has recommended sedating by darting followed by euthanasia by lethal injection.)

Recommendation 6 - The policy of the Conservator of Flora and Fauna, to the effect that translocation of eastern grey kangaroos is not an appropriate management technique, is to remain unchanged and that this policy position be confirmed to the Department of Defence immediately.

The above policy includes the movement of joeys. However, I understand that a case can be, and in the past has been, put forward for exemption in exceptional circumstances. I therefore propose that the Conservator, on a case-by-case basis, consider any requests for exemptions.

6. How should the natural temperate grassland be managed in the future so that it and the threatened species are conserved?

From meetings with officers in Defence and TAMS, it is understood that Defence is currently developing a new management plan in consultation with TAMS, to protect the natural temperate grassland and threatened species at BNTS (grassland management plan). It is also understood that Defence, in consultation with TAMS, is also developing a kangaroo management plan for BNTS. The management plan will be designed to provide a management strategy for the on-going management of the key natural values, in particular the natural temperate grassland and the threatened species. The kangaroo management plan will be integrated with the grassland management plan to ensure that on-going management of the natural values are sustainable and complementary.

It is also understood that Defence plans to divest itself of their 143 hectares of land at Lawson, including BNTS, around June 2009, and that the grassland and kangaroo management plans currently being developed are focused on assisting Defence in their land management activities primarily until that time. It is understood that these plans will not address issues such as community access or give guidance on the appropriate forms of abutting urban development. As the Lawson site is proposed for urban development in the short to medium term it will be important that a long-term management plan (incorporating a range of issue including kangaroo management and research) be developed as well as the shorter-term plans currently being prepared by Defence. This longer-term plan could cover all temperate grassland areas.

The expert panel has recommended that an adaptive management approach based on clear management objectives, expressed in a long-term management plan, be taken to protect the natural temperate grassland, perunga grasshopper, and golden sun moth and ginninderra peppercress at the BNTS. This plan would therefore be an extension of the plans that are currently being developed by Defence.

I strongly support the development of the grassland management plan and the kangaroo management plan for BNTS currently being prepared by Defence. These management plans are essential for ensuring that a holistic approach is taken to managing the kangaroos and conserving the natural temperate grassland and threatened species within the secure area at BNTS. However, they should be considered as interim plans and incorporated into a long-term management plan that explicitly addresses issues such as the role of BNTS in the long-term with respect to kangaroo research, community access etc. This should be done prior to the development of the Lawson site so that there is a clear understanding of the role and purpose of BNTS and the opportunities available to the community to support the protection of BNTS. Accordingly, the following recommendations are made.

Recommendation 7 - The interim grassland management plan and interim kangaroo management plan for BNTS are to be completed by the end of August 2008, by the land manager, in consultation with key stakeholders. These plans are to adopt adaptive management principles and be based on a stocking rate of 1 kangaroo per hectare or less prior to the 2008 winter.

Recommendation 8 - Conditions at BNTS are to be reported on a quarterly basis to all relevant agencies and to the Commissioner's Office. The Commissioner is to establish an independent group to assist her evaluate progress and report on this in her annual report.

If Recommendation 8 is adopted the members of the expert panel could be part of the independent group.

Recommendation 9 - A long-term grassland management plan covering BNTS is to be developed prior to the abutting Lawson lands being developed for residential purposes. This plan should incorporate clear management objectives and be based on an adaptive management approach to protect the Grassland, Perunga Grasshopper, Golden Sun Moth and Ginninderra Peppercress at the BNTS. (The interim grassland management plan and interim kangaroo management plan (Recommendation 7) should be incorporated into the long-term plan. This long-term plan could cover all ACT natural temperate grassland areas.)

Recommendation 9 respects the expert panel's recommendation on this issue **(Attachment G, page 11)**. The long-term plan may require a cooperative effort between the current land manager and a future land manager given that BNTS may be under a different land manager as of mid-2009.

Given the importance of BNTS, the expert panel wished BNTS to be given a high level of legal protection **(Attachment G, page 13)**. The panel understood that BNTS is to be transferred to the Territory. While this maybe the case I have worded my recommendation to accommodate a transfer to another entity.

Recommendation 10 - The Territory is to ensure that legal measures are implemented to protect and preserve the high conservation value of the Grassland and its threatened species when the land at BNTS is transferred from the Commonwealth to another entity. (This recommendation is made on the assumption that Territory laws will fully prevail post the transfer.)

Memorandum of understanding

In September 1998 a memorandum of understanding between the Department of Defence, the then Commonwealth Department of Environment and the then ACT Department of Urban Services (the Memorandum of Understanding) was signed. The Memorandum of Understanding appears not to have been terminated and therefore is still in operation.

Action Plan No. 28 called *A Vision Splendid of the Grassy Plains Extended*, made under the Nature Conservation Act, outlines conservation goals, objectives and actions for the natural temperate grassland and grassland dependent species including the threatened species of golden sun moth, ginninderra peppercress, perunga grasshopper and striped legless lizard.

The Action Plan provides for the Commonwealth and the responsible ACT Department (namely TAMS) to keep the Memorandum of Understanding under review[6]. I understand from meetings with officers in Defence and TAMS that steps are currently being taken to review the Memorandum of Understanding.

I strongly support a review of the Memorandum of Understanding and encourage an emphasis on the coordination and sharing of research activities, monitoring results and evaluations. It may also be beneficial to ensure that senior management in both organisations are routinely briefed with the same information on site conditions, research, progress etc.

An up-to-date Memorandum of Understanding is essential for ensuring that in the future there is effective communication, cooperation and concerted action by the Department of Defence and TAMS to conserve the natural temperate grassland and the threatened species that depend upon that grassland at BNTS.

Recommendation 11 - The review of the Memorandum of Understanding between the Department of Defence and ACT Government (TAMS) is to be completed by August 2008.

[6] ACT Government, 2005 *A vision splendid of the grassy plains extended: ACT lowland native grassland conservation strategy*. Action Plan No. 28 (Arts, Heritage and Environment, Canberra), Table 4.1 under the heading Management

Attachment A

ACT LOWLAND GRASSLANDS
INQUIRY BY THE COMMISSIONER FOR SUSTAINABILITY AND THE ENVIRONMENT
TERMS OF REFERENCE

The ACT Government has prepared a number of significant strategies for the conservation of grasslands and woodland. The Lowland Native Grassland Conservation Strategy and the Lowland Woodland Conservation Strategy along with the Aquatic Species and Riparian Zone Conservation Strategy, provide a strong framework for planning and management of the key threatened ecological communities in the ACT and species that are dependent upon them.

In recent months the ACT Government has become extremely concerned about the deterioration of some of our significant lowland native grasslands, particularly at Majura, Belconnen, Jerrabomberra and Gungahlin.

An inquiry into the situation is required under the following Terms of Reference:

(1) Review existing management arrangements, and if necessary, identify comprehensive conservation management principles and immediate actions to ensure the protection and long-term sustainability of native lowland grasslands and their vulnerable ecosystems.

(2) Identify the causes of the deterioration of lowland native grasslands. In doing this, the impact of eastern grey kangaroos, both in the long and short term, is to be explicitly addressed.

(3) Identify any impediments to implementing short and long-term management practice for conservation of lowland grasslands within the ACT. In doing this, identify any deficiencies (including development controls, data collection, monitoring and reporting programs) which need to be remedied to further protect native lowland grasslands, their vulnerable ecosystems and associated fauna adequately.

(4) Identify ways for ensuring effective communication with stakeholders, whose actions potentially, indirectly or directly affect threatened grasslands.

(5) Determine whether any policy/legislative changes are needed for the protection of threatened lowland native grasslands.

The Commissioner is to consult with all relevant experts and key stakeholders, including the Department of Territory and Municipal Services, to canvas measures needed to ensure the long term sustainability of native lowland grasslands.

Attachment B

ACT LOWLAND NATIVE GRASSLANDS
INQUIRY BY THE COMMISSIONER FOR SUSTAINABILITY AND THE ENVIRONMENT
TERMS OF REFERENCE

The ACT Government has prepared a number of significant strategies for the conservation of grasslands and woodland. The Lowland Native Grassland Conservation Strategy and the Lowland Woodland Conservation Strategy along with the Aquatic Species and Riparian Zone Conservation Strategy, provide a strong framework for planning and management of the key threatened ecological communities in the ACT and species that are dependent upon them.

In recent months the ACT Government has become extremely concerned about the deterioration of some of our significant lowland native grasslands, particularly at Majura, Belconnen, Jerrabomberra and Gungahlin.

An inquiry into the situation is required under the following Terms of Reference:

(6) Review existing management arrangements, and if necessary, identify comprehensive conservation management principles and immediate actions to ensure the protection and long-term sustainability of native lowland grasslands and their vulnerable ecosystems.

(7) Identify the causes of the deterioration of lowland native grasslands. In doing this, the impact of eastern grey kangaroos, both in the long and short term, is to be explicitly addressed.

(8) Identify any impediments to implementing short and long-term management practice for conservation of lowland grasslands within the ACT. In doing this, identify any deficiencies (including development controls, data collection, monitoring and reporting programs) which need to be remedied to further protect native lowland grasslands, their vulnerable ecosystems and associated fauna adequately.

(9) Identify ways for ensuring effective communication with stakeholders, whose actions potentially, indirectly or directly affect threatened grasslands.

(10) Determine whether any policy/legislative changes are needed for the protection of threatened lowland native grasslands.

The Commissioner is to consult with all relevant experts and key stakeholders, including the Department of Territory and Municipal Services, to canvas measures needed to ensure the long term sustainability of native lowland grasslands.

Commissioner's comment. Following release of the above terms of reference some stakeholders sought clarity regarding scope of the inquiry/investigation, in particular the inclusion of the Grassland Earless Dragon, the Striped Legless Lizard and the Golden Sun Moth. I have been advised by the Minister, letter dated 29 November, that the *investigation of Lowland Native Grasslands includes their associated threatened communities and species, as well as threats to, and identification of measures for protecting these, and other species are an inherent part of the Terms of Reference.* Accordingly the specific species mentioned above are included.

Attachment C

OFFICE OF THE COMMISSIONER
FOR SUSTAINABILITY AND THE ENVIRONMENT

30 November 2007

MEDIA RELEASE

The ACT Commissioner for Sustainability and the Environment Dr Maxine Cooper today invited public submissions to an important investigation into the ACT's Lowland Native Grasslands.

"The ACT Lowland Native Grasslands Investigation is important examination of a significant environmental feature of our Territory. Accordingly, I invite and encourage members of the public, stakeholders and interested parties to make submissions," Dr Cooper said.

The Office of the Commissioner for Sustainability and the Environment is undertaking the investigation at the direction of Chief Minister and Minister for the Environment, Water and Climate Change, Jon Stanhope.

"ACT's Lowland Native Grasslands are of regional and national significance and our current investigation will help inform efforts to appropriately monitor and protect them for future generations," Dr Cooper said.

People who would like to make submissions should look at the Terms of Reference on the Commissioner's website at: http://www.envcomm.act.gov.au

Submissions relating to the Belconnen Defence site need to be lodged by close of business on Friday 14 December 2007.

All other Submissions should be lodged by close of business Friday 25 January 2008. All submissions will be made public unless otherwise requested in writing. Anyone who has already submitted information, should advise the Commissioners Office if they do not want that information to be made public.

For further information or questions about submissions or deadlines contact:

The Office of the Commissioner for Sustainability and the Environment
Phone: (02) 6207 2626
Fax: (02) 6207 2630
Email: EnvComm@act.gov.au
Post: PO Box 356
Dickson ACT 2602

Attachment D

INVESTIGATION INTO
ACT LOWLAND NATIVE GRASSLANDS

The ACT Commissioner for Sustainability and the Environment, Dr Maxine Cooper, is inviting public submissions to an important investigation into the ACT's Lowland Native Grasslands.

The Office of the Commissioner for Sustainability and the Environment is undertaking the investigation at the direction of Chief Minister and Minister for the Environment, Water and Climate Change, Mr Jon Stanhope.

People who would like to make submissions should look at the Terms of Reference on the Commissioner's website at: http://www.envcomm.act.gov.au

Submissions relating to the Belconnen Defence site need to be lodged by close of business on Friday 14 December 2007.

All other Submissions should be lodged by close of business Friday 25 January 2008. All submissions will be made public unless otherwise requested in writing. Anyone who has already submitted information, should advise the Commissioner's Office if they do not want that information to be made public.

For further information or questions about submissions or deadlines contact:

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Fax: (02) 6207 2630
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Post: PO Box 356
Dickson ACT 2602

Attachment E

Public Submissions

Philip Machin – 4 November 2007

Arthur Georges – 27 November 2007

Rosemary Blemings – 28 November 2007

Wildlife Carers Group - 27 November 2007, 5 December 2007 and 6 December 2007

Australian Society for Kangaroos – 13 December 2007

Friends of Grasslands – 29 October 2007, 29 November 2007 and 3 December 2007

Limestone Plains Group – 8 October 2007, 16 October 2007 and 14 December 2007

RSPCA ACT and RSPCA Australia – 14 December 2007

Wildcare – 14 December 2007

Animal Liberation ACT – 30 October 2007 and 14 December 2007

Frankie Seymour – 14 December 2007

Ginninderra Catchment Group and Bush on the Boundary Reference Group – 13 December 2007

Short Curriculum Vitae *Expert Panel, 2008*

***Associate Professor* David Grantley Morgan AM**

Department of Zoology, University of Melbourne

Summary Profile

Professor Morgan joined the staff of the Zoology Department at the University of Melbourne in 1993, after over 30 years of work in science education for the Victorian Education Department, Melbourne State College, Melbourne College of Advanced Education and the University of Melbourne's Institute of Education, including many years as Biology Department Head. From the early 1960's to the late 1980's he also directed the (national) School Biology Project for the Australian Academy of Science, for which he was awarded Membership of the Order of Australia (AM). Since 2003 he has been Principal Fellow within the Zoology Department.

Since joining the Zoology Department, his teaching and research have focussed on terrestrial ecology, population census methods for birds and mammals, population ecology, modelling and management, and environmental management, in which he currently teaches. This has included research on kangaroos.

Studies on Kangaroos

Population studies on the western grey and red kangaroo began in national parks in the Victorian Mallee during the 1970's, involving both modelling and management, and have continued to the present day in conjunction with Parks Victoria as well as with its predecessors. He has also monitored eastern grey kangaroo populations in the Puckapunyal Military Area in Victoria since the early 1980's. He is a long-term member of the Victorian Kangaroo Technical Advisory Committee, which addresses and advises on management issues involving over-abundant kangaroos on public land in Victoria. PhD and Honours students under his supervision have carried out research on population estimation methods, diel movement patterns in eastern grey kangaroos, dietary choice in western grey and red kangaroos, and on the relationships between kangaroo diet, population density and vegetation change,

Acting in most cases on behalf of the University of Melbourne, he has carried out a variety of research consultancies on Australian fauna and flora for various Australian government departments and agencies, including the Commonwealth Bureau of Rural Resources, the Australian Fisheries Council, the Department of Defence, the Victorian Department of Conservation and Natural Resources, and the New South Wales Department of Land and Water Conservation. This has included work on feral pigs and southern bluefin tuna, and on other grazing mammals such as wallabies and koalas.

Publications

He has been sole author of well over a hundred technical reports and research papers in ecological fields, and part-author of a number of others. He has addressed various conferences, the most recent being the 2006 Symposium of the Australian Mammal Society. He has also spoken and published extensively in science education. His most recent publication on kangaroos — *Managing a Kangaroo Population by Simulating Predation* — is currently in press.

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Parkville
Victoria 3052
Australia

— February 2008

February 2008

Contact Details and Curriculum Vitae

personal details:	
name:	Andrew Leslie Braid
address:	P.O. Box 6190, O'CONNOR. ACT 2602
telephone:	(02) 6257 2623 (home) (02) 6241 4002 (Kaleen Veterinary Hospital: Monday, Tuesday) (02) 6242 1638 (CSIRO Sustainable Ecosystems: Wednesday, Thursday, Friday)
email:	Andrew.Braid@csiro.au
facsimile:	(02) 6257 2623 (home), 6242 1555 (CSE)
place of birth:	Melbourne
nationality:	Australian
education:	The University of Melbourne Bachelor of Veterinary Science

employment history

1993–2008 (current):

CSIRO Sustainable Ecosystems (formerly Wildlife and Ecology): half-time position.
Divisional veterinarian, manager of animal facilities and supervisor of animal care staff:

- Provide veterinary advice in research procedures and animal care.
- Undertake surgical procedures for research teams working in the Pest Animal Control CRC on biocontrol of the vertebrate pests species: mouse, rabbit and fox.
- Manage of the animal facilities, including supervision of the animal care staff, maintenance of the animal holding facilities and financial management.

Note: This position has been significantly reduced since the closure of the CSE animal house in July 2005.

Executive Officer of the Sustainable Ecosystems Animal Ethics Committee (SEAEC):

- Undertake all secretarial duties associated with the activities of the Committee – minutes, reports, memos, records etc.
- Provide advice and reference material for the members of the Committee
- Provide advice and training to CSE researchers on the requirements of the Code and SEAEC.
- Act on behalf of the Division on all matters relating to animal welfare and the use of animals in research.

Member of CSE's Agricultural Landscapes Program: Provide input into the integration of livestock production systems into environmental conservation practices in agriculture. During 2007 joined the Divisional Biofuels team, specifically considering the use of biofuel co-products as livestock feed.

Additional activities associated with animal welfare and ethics

- Category A member of SEAEC, 1993 -2004
- Member of the NSW Animal Research Review Panel's, Wildlife Advisory Group, 1994 to 1998. This group developed Section 5 of the Code, Wildlife Studies, which was introduced in the 6th edition, 1997
- Member of the review team for the External Review of the Animal Ethics Committee of the Australian National University, 2002 and 2007
- Represented CSE at the RSPCA Australia/AWC/VPC joint workshop Towards Humane Vertebrate Pest Control – development of a national research, development and education strategy – August 2003
- Adviser on veterinary and animal welfare matters for the Australian Wool Innovation Ltd research project 'Development of Baits with Enhanced Canid Specificity' 2003-2005
- Appointed to the ACT Animal Welfare Advisory Committee, December 2005 as the representative of organisations using animals in research in the ACT.
- Consultancy with the Invasive Animals CRC for the Vertebrate Pest Committee to initiate national adoption of agreed Codes of Practice and Standard Operating Procedures for Humane Vertebrate Pest Control, 2006 – 2007.
- Attended: ANZCCART Conferences and Workshops, NSW ARRP Meeting of Chairs of AECs, RSPCA's annual Scientific Conferences in Canberra.

1988–2008 (current):

Kaleen Veterinary Hospital, ACT:
Veterinarian in charge of the veterinary practice two days per week, undertaking consultations and surgery as required.

1975–1988:

Principal, Kiama Veterinary Clinic, Kiama. NSW:
The practice was based on dairy work in the Jamberoo Valley and around Kiama, Albion Park and West Dapto, NSW, servicing up to 80 dairy farms. Emphasis was in veterinary preventive medicine and its integration with farm management procedures and economics. The practice provided a herd health program which was based on computer records of dairy herds and regular

visits for examination and treatment of animals not meeting production criteria. The practice also provided an artificial insemination service. In addition to the dairy work, there was a veterinary service for companion animals, horses and racing greyhounds and the practice oversaw the health and welfare of a variety of exotic animals at a local resting park owned by Sole Bros Circus. During this time the practice was expanded to three veterinarians.

publications:

NSW Animal Research Review Panel (1996) *Guidelines for wildlife interaction studies*.
NSW Animal Research Review Panel (1996) *Guidelines for the use of feral animals in research.*
Robinson, AJ, Muller, WJ, Braid, A, Kerr, PJ (1998) The use of buprenorphine in laboratory rabbits infected with myxoma virus, *Laboratory Animals*.
Gerhard H. Reubel, Jenny Pekin, Daryl Venables, John Wright, Steven Zabar, Katrina Leslie, Terry L.W. Rothwell, Lyn A. Hinds, Andrew Braid. Experimental infection of European red foxes (*Vulpes vulpes*) with canine herpesvirus. *Veterinary Microbiology* 83 (2001) 217-233
Hardy, CM., Braid AL. Vaccines for immunological control of fertility in animals. *Rev. sci. tech. Off. Int. Epiz., 2007,* **26** (2) 461-470
Braid AL., *Biofuel Co-products as Livestock Feed.* RIRDC Publications No 07/175, November 2007

Curriculum vitae: Sue McINTYRE

Academic Qualifications

1980 BSc (Honours, First Class), Botany Department, University of Melbourne
1987 PhD, Botany Department, University of Melbourne
Thesis topic 'Population Studies of *Diplachne fusca* in Relation to the Weed Flora of Rice Weed in New South Wales"

Main Research Interests

Grassland ecology, conservation biology, plant functional types in relation to disturbances, landscape planning, integration of natural resource conservation and production in rural lands.

Present Appointment

2003- present Senior Principal Research Scientist, CSIRO Sustainable Ecosystems, Canberra

Previous Appointments

1997-2003 Principal Research Scientist, CSIRO Sustainable Ecosystems, Brisbane
1993-1997 Senior Research Scientist, CSIRO Tropical Agriculture, Brisbane.
1989-1993 Research Fellow, University of New England, Armidale.
1976-1989 Tutor, Dept. of Ecosystem Management/ Dept. of Agronomy and Soil Science.
1982-1985 Experimental Officer, CSIRO Centre for Irrigation Research, Griffith NSW.

Awards

1990-3 Australian Postdoctoral Research Fellowship (Australian Research Council)
1988-9 Australian Wool Corporation Research Fellowship.
1987 Melbourne University Writing-up Award.
1985-6 Melbourne University Post-graduate Scholarship.

Student Supervision

Skinner, A. (2005 -) PhD. Charles Sturt University
Mokany, K (2004 - 07) Ph.D. Australian National University
Martin, T.G (2001- 05) Ph D. University of Queensland
Reseigh, J. (2000-2004) Ph.D. University of New England.
Dorrough, J. (1997-01) Ph.D. Australian National University.
Best, K. (1997) BSc (Hons). University of Queensland.
Chalmers, A. (1992-96). Ph.D. University of New England.
Trémont, R. (1992). M. Litt.: University of New England.

Externally-funded projects conducted since 1995 (as principal investigator)

2007 - 2008	*"Active management and enhancement of endangered temperate woodlands"* National Heritage Trust
2005-2007	*"Linking management to the ecosystem services provided by understorey vegetation in grassy woodlands"* Environmental Trust of NSW
2004 - 2006	*"Land use change, plant functional types and ecosystem services*" French-Australian Science and Technology (FAST) Programme (with S. Lavorel)
2001 - 2004	*'Weed functional groups'* Weed Management CRC
2001-2004	LWA *'A National Framework for Landscape Classification'*
2000-2003	LWA *'Improved Vegetation Planning for Rural Landscapes'*
1997-2001	MLA, LWRRDC & EA '*Incorporation of practical measures to assist conservation of biodiversity within sustainable beef production in northern Australia'*
1997-2000	LWRRDC '*Applying management principles on variegated landscapes: identifying production/conservation trade-offs'* (with N. MacLeod).
1996-1997	Bilateral Science and Technology Collaboration Scheme 'Effects of human disturbance on grasslands'
1996-1997	LWRRDC '*Diversity and sustainability in rangeland livestock production system'*

Scientific and advisory committees

2007 – present	Board Director, Bush Heritage Australia
2007 – present	Member Conservation Committee, Bush Heritage Australia
2001 - present	Editorial Board, Pacific Conservation Biology
2006 - 2007	Associate Editor, *Journal of Vegetation Science*
2000 - 2003	Management Committee, LWRDDC Phase II Remnant Vegetation Management Program
1999 - 2006	Editorial Advisory Committee, Australian Journal of Botany.
1997 - 2001	Global Change and Terrestrial Ecosystems, Leader Task 2.2.1 (Responses of Vegetation to Land Use and Disturbance)
1997 - 2001	Global Change and Terrestrial Ecosystems, Leader Task 2.2.1
1997 - 2000	Member of the Council for Sustainable Vegetation Management
1995 - 1998	Editor, Australian Journal of Ecology

Publications

104 publications including 60 papers in refereed journals, 10 book chapters and 1 edited book.

Most significant contributions

McIntyre S. & Barrett G. W. (1992). Habitat variegation, an alternative to fragmentation *Conservation Biology*, 6, 146-147.

McIntyre S. and Lavorel S. (1994). Predicting richness of native, rare and exotic plants in response to habitat and disturbance variables across a variegated landscape. *Conservation Biology*, 8, 521-531.

McIntyre S., Lavorel S. and Trémont R. M. (1995). Plant life-history attributes: their relationship to disturbance response in herbaceous vegetation. *Journal of Ecology*, 83, 31-44.

Lavorel, S., McIntyre, S., Landsberg, J. and Forbes, T. D. A. (1997). Plant functional classifications: from general functional groups to specific disturbance response groups. *Trends in Ecology and Evolution,* 12, 474-478.

McIntyre, S. and Hobbs, R. J. (1999) A framework for conceptualizing human impacts on landscapes and its relevance to management and research models. *Conservation Biology*, 13, 1282-92.

McIntyre, S., Díaz, S., Lavorel, S. and Cramer, W. (1999). Plant functional types and disturbance dynamics. *Journal of Vegetation Science*, 10, 604-608.

McIntyre, S., Lavorel, S., Landsberg, J. and Forbes, T. D. (1999). Disturbance response in vegetation - gaining a global perspective on functional traits. *Journal of Vegetation Science,* 10, 621-630.

McIntyre, S, McIvor, J. G & MacLeod, N. D. (2000) Principles for sustainable grazing in eucalypt woodlands: landscape-scale indicators and the search for thresholds. In 'Management for sustainable ecosystems' pp. 92-100, Eds. P. Hale, A. Petrie, D. Moloney and P. Sattler, 'Centre for Conservation Biology, University of Queensland, Brisbane.

McIntyre, S. & Lavorel, S. (2001) Livestock grazing in sub-tropical pastures: steps in the analysis of attribute response and plant functional types. *Journal of Ecology*, 89, 209-226.

McIntyre, S., McIvor, J. G. & Heard, K. M. (2002) (eds) *Managing and conserving grassy woodlands*. CSIRO Publishing, Melbourne.

McIntyre, S. (2003) The Landscape Game: a learning tool for demonstrating landscape design principles. *Ecological Management and Restoration*, 4 103 – 109.

McIntyre, S., Heard, K.M. & Martin, T.G. (2003) The relative importance of cattle grazing in sub-tropical grasslands - does it reduce or enhance plant biodiversity? *Journal of Applied Ecology*, 40, 445-457.

Hobbs, R. J. and McIntyre, S. (2005). Categorizing Australian landscapes as an aid to assessing the generality of landscape management guidelines. *Global Ecology and Biogeography*, 14, 1-15.

McIntyre, S. & Tongway, D. (2005) Grassland structure in native pastures – links to soil surface condition. Ecological Management and Restoration, 6, 43-50.

McIntyre, S. (2005) Biodiversity attributes of different sward structures in grazed grassland. Ecological Management and Restoration, 6, 71-73.

McIvor, J. G., McIntyre, S., Saeli, I. and Hodgkinson, J. J. (2005) Patch dynamics in grazed sub-tropical native pastures in south-east Queensland, Austral Ecology, 30, 445-464.

Hutchinson, M. F., McIntyre, S., Hobbs, R. J., Stein, J. L., Garnett, S. and Kinloch, J. (2005). Integrating a global agro-climatic classification with bioregional boundaries in Australia. Global Ecology and Biogeography, 14, 197-212.

McIntyre, S., Martin, T. G., Heard, K. M. and Kinloch, J. (2005) Plant traits predict impact of invading species: an analysis of herbaceous vegetation in the sub-tropics. Australian Journal of Botany, 53, 757–770.

Martin, T. G., McIntyre S., Catterall. C. P. and Possingham, H. P. (2006) Is landscape context important for riparian conservation? Birds in grassy woodland. Conservation Biology, 127, 201-214.

Díaz, S., Lavorel S., McIntyre, S., Falczuk, V., Casanoves, F., Milchunas, D. G., Skarpe, C, Rusch, G., Sternberg, M., Noy-Meir, I., Landsberg, J., Wei, Zhang, Clark, H. and Campbell, B. D. (2007) Grazing and plant traits – a global synthesis. Global Change Biology, 13, 313–341.

McIntyre, S. & Lavorel, S. (2007) A conceptual model of land use effects on the structure and function of herbaceous vegetation in the Australian temperate zone. Agriculture, Ecosystems and Environment, 119, 11-21.

Lavorel, S., Grigulis, K., McIntyre, S., Garden, D., Williams, N., Dorrough, J., Berman, S., Bonis, A., Quétier, F., Thébault, A. (2008) Assessing functional diversity in the field – methodology matters! Functional Ecology, 22, 134-147.

Michael Linke is 42 years old and has been with RSPCA since June 2005. Michael has had extensive leadership and management experience and he is using this experience to forge a new future for RSPCA ACT.

1984 to 1999	Various roles Australian Taxation Office	Michael spent 15 years with the ATO going from the ASO1 level to the EL2 level. Highlights include: Site Manager, Penrith Office of Large Business and International Taxation Site Manager, Canberra, Child Support Agency. Michael was heavily involved in the tax file number development as well as development of the Tax Pack and revised superannuation legislation. During his time with the ATO Michael also gained a Taxation Law Degree from the University of NSW and won a public service medal.
1999 to 2005	Regional Manager Royal Blind Society (now known as Vision Australia)	Michael was appointed to this position as a result of his leadership skills as well as volunteer work within the blindness and vision impaired community, both in Sydney and in Canberra. As regional manager Michael was responsible for the ACT, the Capital Region and most of south western NSW. Michael lead a team of 18 staff and 3,000 volunteers across three sites and nine low vision clinics. Michael was instrumental in renewing funding streams for the ACT branch of RBS as well as delivering new services to the region, including: ♦ Revised low clinic services and models ♦ Audio Description Services, which won a Prime Ministers Partnership award with Canberra Theatre. Michael has also been heavily involved in sporting choices and options for young vision impaired and blind people. He volunteers his time to assist sports development and also speaks to children at local schools.
2005 to Present	CEO RSPCA ACT	Since taking on the role of CEO at RSPCA Michael has forged a new culture, one of optimism for both people and animals at RSPCA. He has delivered new services, expanded funding opportunities and tripled the number of members in just 24 months. In this time Michael has also studied with the Humane Society of the United States and gained Certificates in Volunteering and Board Management and Governance of Animal Shelters. Michael also represents RSPCA ACT on the Queanbeyan Companion Animal Advisory Committee and is an RSPCA Australia Council Member.

1980 to 2005	Sporting Achievements	Michael has represented NSW, ACT, SA and Australia in cricket for the blind and vision impaired. Michael was the youngest player ever to be selected for the Australian side, aged 16. Michael has toured India, New Zealand, South Africa, and England as an Australian player with the highlight being scoring a century in the World Cup in India in 1996. Michael scored 124 from 86 balls. Michael won the Cricket Australia Festival of Cricket Award in 2006 for services to cricket for the blind and vision impaired. Michael won two gold medals and a silver medal at the 2005 World Championships of Ten Pin Bowling for bowlers with a vision impairment in Orlando Florida. Michael was also crowned world champion at this event.

Final Expert Report – 19 February 2008

Background

The Commissioner for Sustainability and the Environment sought our expert opinion regarding a number of matters relating to her investigation into the natural temperate grassland (the Grassland) and threatened species within the secure area at the Belconnen Naval Transmission Station at Lawson (BNTS). References to the BNTS in this report refer only to the secure area unless otherwise stated.

We were provided with numerous documents relating to issues associated with the Grassland and threatened species. A list of these documents is at **(Attachment A)**.

On 25 January 2008 we inspected the Grassland at BNTS and as a panel met to discuss matters associated with their protection. Our recommendations in this regard are set out in this report which we provide to the Commissioner to assist her with her investigation.

Secretariat assistance in respect of preparation of our report was provided by the Office of the Commissioner.

Why the Grasslands are Important

Under the *Nature Conservation Act 1980* (the Act) the Minister for the Environment, on the recommendation of the Flora and Fauna Committee, has declared that the Grassland is an endangered community. The Grassland is described as a naturally occurring grassland of the temperate zone, dominated by native perennial tussock grasses, with associated native herbs and native fauna. The Grassland is also listed as an endangered ecological community under the *Environment Protection and Biodiversity Conservation Act 1999* (the Commonwealth Act).

At BNTS the Grassland is the habitat of the Perunga Grasshopper (which the Minister, on the recommendation of the Flora and Fauna Committee, has declared to be a vulnerable species), the Golden Sun Moth and the Ginninderra Peppercress (both of which the Minister, on the recommendation of the Flora and Fauna Committee, has declared to be endangered species). Another vulnerable species, the Striped Legless Lizard, occurs immediately outside the secure area and was most likely present there in former years.

In order for these declarations to be made under the Act various criteria had to be satisfied (see Disallowable Instrument 99 of 1995). An endangered community is either a community presumed extinct or a community subject to current and continuing threats or other processes likely to lead to premature extinction as demonstrated by one or more matters.

An endangered species must meet one of three criteria: first, the species is known or suspected to occur in the ACT region and is already recognized as endangered or presumed extinct in an authoritative international or national listing or second, the species is observed, estimated, inferred or suspected to be at risk of premature extinction in the ACT region in the near future as demonstrated by one or more matters or thirdly, the species is presumed extinct in the ACT region.

A vulnerable species is either a species known or suspected to occur in the ACT region and is already recognized as vulnerable in an authoritative international or national listing or the species is observed, estimated, inferred or suspected to be at risk of premature extinction in the ACT region in the medium-term future, as demonstrated by one or more matters.

Under the Commonwealth Act the Golden Sun Moth is listed as critically endangered and the Ginninderra peppercress and Striped Legless Lizard are listed as vulnerable.

The Nature Conservation Strategy made under the Act (Disallowable Instrument 263 of 1997) provides under the heading *Conservation of Threatened Species and Communities* that the *Objective* is to enable species and communities that are threatened with extinction to survive and thrive in their natural habitats. This objective applies with equal force to the Grassland, Perunga Grasshopper, Golden Sun Moth and Ginninderra Peppercress.

The Act provides for the preparation of action plans which are to include proposals to ensure, as far as is practicable, the identification, protection and survival of the species, or the ecological community which is the subject of a declaration. Action Plan 28 called *A Vision Splendid of the Grassy Plains Extended* (Disallowable Instrument 84 of 2005) provides the following protection goal for the Grassland:

> Conserve in perpetuity all remaining core conservation sites and other viable areas of the natural temperate grassland ecological community in the ACT.

In relation to the Grassland flora and fauna the Action Plan has the following protection goal:

> Conserve in perpetuity, viable, wild populations of all native grassland flora and fauna species in the ACT, and support local, regional and national efforts towards conservation of these species.

Background to the Grassland at BNTS

The Grassland at BNTS has a botanical significance rating of 2 (see paragraph 3.4.6 of the Action Plan). This means that the Grassland has high botanical significance (see table 3.1 of the Action Plan).

The Grassland at BNTS is the only known site of the Ginninderra Peppercress.

The BNTS site has a kangaroo population held captive by the security fence. The security fence prevents most emigration and protects the population from disturbance, accidents and any potential predation (e.g. from domestic dogs). This has contributed to a rapid growth in the enclosed kangaroo population to some 588 kangaroos at the last count on 10 December 2007, at a density of approximately 5 per ha. Approximately 60 female kangaroos in this population are tagged and are being used for fertility research purposes. Of these 60 kangaroos, 40 have been subject to trial fertility control measures and the remaining 20 have been used as controls. None of the research kangaroos are subject to permanent fertility control.

The reference condition for the current state of the Grassland at BNTS is that of pre-European settlement. While much of its character has to be inferred, this is an important point of reference, as the various plants and animals in the Grassland would be adapted to the conditions prevailing then.

> In the absence of local data on the pre-European settlement condition its nature can be inferred from historical records, remnant populations still at the site, and from similar but less modified systems elsewhere. Kangaroos are likely to have been in relatively low numbers at that time, being prey for dingoes and for local people with a hunter gatherer mode of life; this predation is no longer present.
>
> Following settlement, the Grassland was used for pastoral purposes, being grazed by sheep and cattle. The woodland areas on higher ground were partly cleared, and many non-indigenous species were introduced, some becoming weeds. After the removal of sheep, the combination of Grassland and woodland patches on the site, together with the almost complete absence of predators, favoured rapid growth of the eastern grey kangaroo population. What is now on the site is thus a consequence of its pre-European state and its subsequent history.

The current state of the Grasslands at BNTS

Important ecological processes associated with the reference condition of the Grassland that no longer persist today are: dingo and aboriginal predation of native herbivores, a fire regime, and small-scale soil disturbances associated with small mammal digging. While the pre-European settlement conditions cannot be fully restored, current management practises need to take into account the conditions under which the various plants and animals in the Grassland may have evolved. On-going management will always be required to substitute for the elements and processes that are now missing from the system. As far as possible, these should seek to preserve and restore the composition, structure and function of the Grassland as it was prior to European settlement.

A key element of the pre-European settlement condition of the Grassland is that it would have conserved vital resources: to some extent water, but particularly nutrients and organic matter. If soil, nutrients and organic matter are washed out of the landscape as dissolved nutrients, soil particles and loose plant litter, the ecosystem as a whole is actively eroding and not functioning as a stable entity.

While the recent good rain has provided an opportunity for many plants in the Grassland community to grow and flower (Fig. 1), the condition of the Grassland over much of the BNTS is still poor (Fig. 2). Total biomass is still relatively low over much of the area. Unlike its pre-European condition, the ground between the grass tussocks is no longer stabilized by the presence of plant litter, mosses or lichens, allowing for rapid rainfall runoff and creating conditions for further soil loss. Evidence of soil erosion at the site includes the presence of scalds, sheeting, small gullies and terracettes. There are also extensive areas where pedestals are present. These are soil columns associated with persistent plant bases remaining after the surrounding soil has eroded away (Fig 3). Together these signs indicate that the natural resource base of the Grassland has been and continues to be damaged and the productive potential of the Grassland is in decline.

Figure 1.
Kangaroo enclosure on right showing response to resting over spring/summer 2007-8. Area on the left continues to be grazed. In the centre of the picture is an eroded area with scalding between the tussocks. Note the growth response of this patch is limited even with grazing removal. This is due to the condition of the soil restricting rainfall infiltration and the phenomenon that short-growing, low productivity species are most persistent in eroded areas (January 2008).

Figure 2. Historical grazing pressure at the BNTS has resulted in dominance by low-growing species. Combined with continuing grazing pressure, these small plants have failed to produce good grass cover despite favourable growing conditions (January 2008).

Figure 3. Evidence of soil erosion: bare scalded areas between tussocks, individual tussocks remain raised while surrounding soil has washed away, leaving a lowered soil surface (January 2008).

The sustainable management of a grassland requires that sufficient plant material (biomass) be present to provide habitat for the range of species associated with it. Biomass provides the primary food source for herbivores, including large grazers and invertebrates, which in turn provide a food source for other organisms in the grassland food web. In addition, the physical presence of the grass sward provides the means of protection of soil and the physical structure necessary for the shelter, foraging and breeding requirements of all Grassland species.

Except when grazing is very heavy and relatively non-selective (such as is currently the case in BNTS), large herbivores tend to create a mosaic of different types of patches in pastures which reflects variation in grazing pressure across the landscape. Plant species composition varies under these different grazing pressures because plants (including native plants) exhibit a range of grazing tolerances.

The animals living in the grass sward also vary in their requirements, and variation in Grassland structure thus provides a means by which the maximum number of species can persist. For example, the need for large tussocks with accompanying thick litter might be associated with the provision of shelter (e.g. for lizards, insects), structure for foraging (e.g. the use of tall flowering stems to attach spider webs) or for food supply (e.g. thick litter providing a damp organic layer for invertebrates). A short grass sward may be essential to provide open foraging areas or particular food plants for some fauna.

Grassland structure is therefore intimately associated with the grazing effects of large herbivores. Little or no grazing allows for the accumulation of biomass and selects for tall-growing grazing-intolerant plant species (e.g. *Themeda triandra,* a major component of Striped Legless Lizard habitats). Moderate grazing allows the herbivores to graze selectively and, in native grasslands, this creates patchiness - areas of both tall and short grass swards.

Heavy grazing pressure results in non-selective grazing - the herbivores eat virtually all plants on offer and the resulting grass sward is very short and lawn-like. Plants selected for under heavy grazing pressure (e.g. *Austrodanthonia carphoides*, *Chloris truncata*) are grazing tolerant and short-growing (even when ungrazed).

The relative amounts of different patch structures is an important consideration in the sustainable management of the Grassland. The high priority for soil protection means that tall and medium height patches are essential over the majority of the Grassland area. In commercially grazed native pastures, the maximum recommended area of short patches (lawn areas grazed non-selectively) is one third of the grassland area. The short patch structure observed at BNTS exceeds this threshold and tall species such are *Themeda* are highly restricted on the site.

Ginninderra Peppercress, Perunga Grasshopper, Golden Sun Moth

The requirements of these three species are poorly understood at this time. The Ginninderra Peppercress appears to have some soil disturbance and/or bare ground requirement. Disturbance-dependent plants are not necessarily tolerant of severe defoliation, even though they may benefit from the open habitat created by high levels of grazing. In the future, it will be important to investigate the effects of different disturbance and grazing combinations on the reproduction and recruitment of Ginninderra Peppercress.

The Perunga Grasshopper shelters in grass tussocks and appears to be associated with *Chrysocephalum apiculatum*. In the case of both these resources, extreme grazing pressure such as occurs at BNTS is likely to be detrimental to the persistence of the Perunga Grasshopper.

The *Austrodanthonia* species that the Golden Sun Moth associates with are quite grazing tolerant and in some cases probably grazing-dependent as well. However, the geographic range of the plants far exceeds the geographical range of the moth, so there are some significant unknown factors controlling the moth's distribution. While grazing is clearly associated with the moth's habitat, it is most unlikely that extreme grazing pressure that results in soil erosion is a vital element of the moth's habitat requirements. Experimental investigations into the active management requirements of these threatened insect species is also needed.

While the three threatened species above have some considerable tolerance of grazing, we have insufficient knowledge to know what will allow them to thrive.

The cause of the current state of the Grassland at BNTS

In relation to the reference pre-European state of the Grassland, it is quite clear that the Grassland has lost condition, as evidenced from the soil erosion indicators described above and the relative paucity of tall tussock species such as *Themeda triandra*. The cause of this is grazing pressure. The lack of burning is not currently an issue for the site due to the low level of biomass. If biomass is allowed to build up, the re-introduction of fire could be an appropriate management practice to trial at the site.

It is likely that much of the poor condition of the Grassland in terms of soil condition and Grassland community composition (e.g. the presence of exotic species, loss of tall tussock structure) was brought about through pastoral management practices.

Following the removal of domestic livestock during the 1990's, the BNTS site has been under a post-pastoral regime that has not allowed recovery of the Grassland but has contributed to its continuing deterioration. Severe drought may also have been a factor. Sustainable management involves the adjustment of grazing pressure to match the variation in plant productivity associated with varying rainfall. With appropriate limits to grazing pressure, a Grassland should be able to survive droughts with minimal loss of condition.

The current dense kangaroo population is preventing the recovery of the Grassland by impeding biomass accumulation, preventing re-colonization by less grazing tolerant, more productive Grassland plants and preventing the re-establishment of a soil crust of cryptogams (mosses, algae and lichens) on the bare ground between the grass tussocks.

As the current growing season tapers into autumn then winter, the impact of kangaroos on the Grassland is expected to increase substantially. The summer rain in 2007-8 will allow current pouch young to survive and more breeding is anticipated in Nov-Feb 2008-09. It is therefore to be expected that grazing pressure on the Grassland will rise dramatically in winter and early spring 2008 and the ecological condition of the Grassland will further decline due to low levels of biomass accumulation that are currently being observed. Thus in the foreseeable future, without any intervention, there will be more bare ground, more erosion, and more pressure on the entire Grassland ecosystem, including the threatened species.

Recommendation No. 1.

> **We recommend that urgent action be taken to restore the ecological condition of the Grassland, and provide opportunities for the Perunga Grasshopper, Golden Sun Moth and Ginninderra Peppercress to survive and thrive at BNTS.**

Supplementary feeding of kangaroos

We have considered whether supplementary feeding of the kangaroos would ensure the protection and long-term sustainability at BNTS of the Grassland and threatened species. In our opinion supplementary feeding would not stop overgrazing of the Grassland by the kangaroos. Kangaroos will continue to preferentially graze the Grassland even when supplementary feed is provided.

The main effects of supplementary feeding will be to maintain the condition of kangaroos at times of potential physiological stress, reducing mortality of malnourished, weak individuals, and facilitating the survival of young. Supplementary feeding is therefore likely to result in an even greater kangaroo population and increased pressure on the Grassland.

Urgent Action to be taken to protect the Grassland

If the Grassland were to be managed as a commercial pasture, complete resting or spelling would be recommended on the basis of its current condition. Under the more conservative criteria that should be applied to land managed for nature conservation, immediate and prolonged resting or spelling would certainly be required.

The Grassland should be rested for at least two growing seasons by the complete removal of all of the kangaroos. Grassland soil and plant condition at the time of removing the kangaroos should be recorded and recovery monitored after two growing seasons. Weed control should be ongoing into the future.

Panel Recommendation No. 2.

> **We recommend the immediate removal of all kangaroos from the BNTS and that this removal be completed before impacts on pasture biomass occur during the dormant winter growing season.**

Removal of the Kangaroos

We have considered how the approximately 588 kangaroos at BNTS should be removed. We have considered both lethal and nonlethal methods. Our focus is on recommending the most humane method of removal.

Non-lethal methods

Move the kangaroos

The only identifiable nonlethal method of removing the kangaroos from BNTS is to physically move the kangaroos to another site. For the 60 kangaroos subject to research at BNTS this may be appropriate, provided that another site suitable for holding captive kangaroos for research purposes can be located. However, for the other kangaroos currently captive at the BNTS site, we do not consider dart-capture followed by release into the wild to be a humane option for the reasons set out below.

Firstly, it is against current ACT Government policy. This policy has been in place for some time and is backed by sensible and robust investigation and research.

Secondly, to move the kangaroos would present tremendous animal welfare concerns. Given that the kangaroos are wary of human intervention, as observed on our site visit, human intervention could lead to a high percentage of kangaroos suffering from capture myopathy (or shock), which is a reaction to human intervention not fully understood at this juncture.

Thirdly, subsequent release of the kangaroos also presents welfare concerns, as animals will often recover in a state of confusion and risk injury to themselves, other kangaroos and potentially operators. Once released into the wild any injured kangaroos cannot be readily located and euthanased.

In addition to the animal welfare concerns are issues associated with locating a suitable release site. There is an abundance of eastern grey kangaroos in the ACT and NSW. A large scale move of most or all of the kangaroos at the BNTS would not only place pressure on the population being translocated but would also impact the area or areas to which they are introduced, affecting food supply and social interactions in both existing and introduced populations. Large numbers of kangaroos could be expected to die as a consequence.

Lethal methods

There are two identifiable lethal methods of removing the kangaroos, namely, shooting or euthanasia by lethal injection.

Shooting

Shooting is universally accepted as the most humane lethal method of removing kangaroos. This is also the currently acceptable method detailed in kangaroo management codes of practice across Australia. The advantages of shooting, over other methods of lethal removal, is that it can target particular animals, is quick and is humane in the hands of properly trained and skilful marksman.

We have been informed that the Australian Federal Police has recommended that firearms not be used to remove kangaroos at the BNTS because of public safety concerns. Therefore, shooting is not an option at BNTS.

Euthanasia by lethal injection

Euthanasia by lethal injection requires darting to tranquillise the kangaroo, then the administration of a lethal injection. Although not our preferred option, in the absence of the use of firearms it is the next best method of lethal removal if carried out by trained marksman and appropriate immediate veterinary intervention is available.

Generally kangaroos are herded into a pen, darted with a tranquilliser and then once they have become immobilised are subject to euthanasia by lethal injection. This process causes stress to kangaroos and there may be an injury rate of between 5% and 15%. These injuries are caused as kangaroos become agitated during herding and try to flee, a typically natural response to being forced into an unnatural situation. Kangaroos can also be injured at the time of tranquillisation because they often become agitated before the effect of the tranquilliser brings them down. The level of injuries and associated stress may be reduced by using a more passive means of approaching and tranquillising kangaroos, for example, free range darting, but it is very unlikely that the use of this method would lead to the capture and euthanasia of all the kangaroos at the BNTS site. However, the method adopted will be dependent upon the conditions of the site and the operator engaged by the Department of Defence to dart and euthanase the kangaroos.

Panel Recommendation No. 3.

> **We recommend that the removal of the kangaroos from BNTS be by the most humane method suitable for the BNTS site. Having regard to advice from the AFP that firearms are not to be used at BNTS, we recommend euthanasia by lethal injection.**

Future Management of the Grasslands at BNTS

Nature Conservation Strategy and Action Plan

Future management of the BNTS site must ensure that the Grassland, Perunga Grasshopper, Golden Sun Moth and Ginninderra Peppercress survive and thrive in accordance with the objective found in the Nature Conservation Strategy.

Table 4.1 of the action plan provides for various actions to be taken to conserve the Grassland and threatened species. These actions include monitoring, research, a memorandum of understanding with the Commonwealth and management plans.

There is clearly a need for a planned adaptive management approach at BNTS, within a research framework, whereby problems can be identified early and the above actions can be implemented in a timely manner.

Panel Recommendation No. 4.

> **We recommend that an adaptive management approach based on clear management objectives, expressed in a management plan, be taken to protect the Grassland, Perunga Grasshopper, Golden Sun Moth and Ginninderra Peppercress at the BNTS.**

Re introduction of grazing

The Grassland should be rested for at least two growing seasons. Re-introduction of kangaroo grazing should be according to a carefully managed regime based on measures of improved soil condition, and requirements of the grassland overall.

Kangaroos used for grazing in the future at BNTS must be a non-breeding population. Any kangaroos penetrating the secure area through the security fence will need to be identified and the rate of return monitored. Permanent fertility control measures will need to be carried out in respect of those kangaroos. BNTS in the future may be a suitable site for the rehabilitation of injured kangaroos; however, such kangaroos will also need to be made infertile.

When kangaroos are used for future grazing at BNTS, having those kangaroos subject to permanent fertility control will ensure that the rate of recovery of the kangaroo population can be controlled and will not be able to outstrip the recovery rate of the grassland ecosystem. Careful management of the reintroduction of kangaroos should provide the capacity for ongoing non-lethal control of grazing pressure at this site.

Various methods of fertility control have been under development for some years but, at the current state of knowledge, surgical methods are the only ones that are permanent and do not require multiple interventions. This should involve all kangaroos of both sexes: males by vasectomy and females by tubal ligation possibly carried out using laparoscopy.

As grazing is re-introduced, it may be appropriate to establish some internal kangaroo-proof fences to experimentally test the response of eroded areas, different patch types and threatened species to different grazing pressures. As described above, the total number of kangaroos maintained in the future at BNTS would need to be responsive to grazing pressure overall. The use of internal fences (most likely exclosures) could be used to explore the response of the various Grassland elements to different grazing regimes, consistent with an adaptive management approach.

Panel Recommendation No. 5.

> **We recommend that all kangaroos re-introduced or dispersing into the BNTS must be subject to known and established fertility control measures and be incapable of breeding.**

Nature conservation reserve

We are aware that there is a proposal that the land at the BNTS be transferred from the Commonwealth to the Territory. We understand that the Territory has agreed in principle to designating a part of the site as a nature reserve.

Panel Recommendation No. 6.

> **We recommend that when the land at BNTS is transferred to the Territory that legal measures be taken to protect and preserve the high conservation value of the Grassland and its threatened species.**

Dr Andrew Braid
Michael Linke
Dr Sue McIntyre
Professor David Morgan

ATTACHMENT A

Documents Provided to the Expert Panel

Public submissions received by the Commissioner for Sustainability and the Environment in relation to her investigation into the natural temperate grassland and threatened species at BNTS:

- Philip Machin – 4 November 2007
- Arthur Georges – 27 November 2007
- Rosemary Blemings – 28 November 2007
- Wildlife Carers Group - 27 November 2007, 5 December 2007 and 6 December 2007
- Australian Society for Kangaroos – 13 December 2007
- Friends of Grasslands – 29 October 2007, 29 November 2007 and 3 December 2007
- Limestone Plains Group - 8 October 2007, 16 October 2007 and 14 December 2007
- RSPCS ACT and RSPCA Australia - 14 December 2007
- Wildcare – 14 December 2007
- Animal Liberation ACT - 30 October 2007 and 14 December 2007
- Frankie Seymour – 14 December 2007
- Ginninderra Catchment Group and Bush on the Boundary Reference Group – 13 December 2007

Material from Commonwealth Department of Environment, Water, Heritage and the Arts Web Site:

- Natural Temperate Grassland of the Southern Tablelands of NSW and the Australian Capital Territory
  - *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) Status and Documents
  - Advice to the Minister for the Environment and Heritage from the Endangered Species Scientific Subcommittee (ESSS) on a proposal to add an ecological community to Schedule 2 of the *Endangered Species Protection Act 1992* (ESP Act)
- Lepidium Ginninderrense - Ginninderra Peppercress
  - EPBC Act Status and Documents
  - Listed Critical Habitat
  - Advice from the Minister for the Environment and Heritage from the Threatened Species Scientific Committee (TSSC) on Amendments to the list of Threatened Species under the EPBC Act 28 February 2005.
  - National Recovery Plan under the EPBC Act, based on an Action Plan (Action Plan No. 25) prepared for the species under the *Nature Conservation Act 1980* (ACT)
- Synemon plana - Golden Sun Moth
  - EPBC Act Status and Documents
  - Advice to the Minister for the Environment and Heritage from the TSSC on Amendments to the list of Threatened Species under the EPBC Act
- Delma impar - Striped Legless Lizard
  - EPBC Act Status and Documents
  - National Recovery plan for the Stripped Legless Lizard (Delma impar) 1999-2003

Kangaroo Advisory Committee Reports:

- Living with Eastern Grey Kangaroos in the ACT – Rural Lands First report to the Minister for the Environment, Land and Planning – February 1996
- Kangaroos in captivity in the ACT Second report to the Minister for the Environment, Land and Planning – August 1996
- Living with Eastern Grey Kangaroos in the ACT – Public Land Third report to the Minister for the Environment, Land and Planning – October 1997

Material from TAMS:

- Answers to Questions relating to the Investigation at BNTS site – 17 December 2007, 11 February 2008 and 14 February 2008.
- Material from Website – Why reduce eastern grey kangaroo populations at Majura Training Area and Belconnen Naval Transmitting Station in the ACT – A pictorial guide to the Kangaroo culling issue
- Material from Website - Kangaroo Culling on Defence lands - Fact Sheet
- Don Fletcher, Managing Eastern Grey Kangaroos Macropus giganteus in the ACT: reducing the overabundance in Pest or Guest: the zoology of overabundance, edited by Daniel Lunney, Peggy Eby, Pat Hutchings and Shelley Burgin, 2007
- Don Fletcher, extract from thesis Population Dynamics of Eastern Grey Kangaroos in Temperate Grasslands, 2006
- Minute from the Chief Police Officer Andy Hughes of the Australian Federal Police to the Minister for Police and Emergency Services re: Application for Kangaroo cull – Department of Defence – 21 May 2007
- Minutes from Leanne Close, Deputy Chief Police Officer, ACT Policing, AFP to Russell Watkinson TAMS dated 21 May 2007 and 31 May 2007
- e-mail from David Jones AFP to Monika Boogs dated 24 May 2007
- Minutes from Hamish McNulty, TAMS, 29 January 2008 and 14 February 2008
- Minute from Sharon Lane, TAMS, dated 31 January 2008
- Memorandum of Understanding, 7 September 1998

Confidential Material from Department of Defence:

- Comprising habitat surveys, threatened species surveys, various management documents in relation to the grassland, threatened species and kangaroos and other related documents.

Legislation and associated documents:

- *Nature Conservation Act 1980*
- *Nature Conservation Regulation 1982*
- *Nature Conservation (Criteria for Declaring Endangered Species) Determination 1995*
- *Nature Conservation (Licensing Criteria) Determination 2001*
- *Nature Conservation (Special Protection Status) Declaration 2005 (No.1)*
- *Nature Conservation (Species and Ecological Communities) Declaration 2005 (No.1)*
- *Nature Conservation (The ACT Nature Conservation Strategy) Approval 1997*
- *Nature Conservation (Threatened Ecological Communities and Species) Action Plan 2007 (No.1)*
- *Nature Conservation Criteria Determination 2001*
- *Nature Conservation Declaration of Protected and Exempt Flora and Fauna 2002 (No.2)*
- *Animal Welfare Act 1992*

- *Animal Welfare Regulation 2001*
- Code of Practice for the Humane Destruction of Kangaroos in the ACT
- Extracts from EPBC Act

Other Documents:

- Aerial and other maps of Lawson site
- Terms of Reference for the Investigation
- Humaneness and Pest Animal Control – Trudy Sharp and Glen Saunders Vertebrate Pest Research Unit – Report 2 October 2007 – NSW Department of Primary Industries

Attachment H

ENVIRONMENT AND RECREATION

Dr Maxine Cooper
Commissioner for Sustainability and the Environment

Dear Dr Cooper

Questions sent to Sharon Lane by Pamela Mathie on 7th, 8th and 12th February 2008

This letter attempts to clarify the position of the Department, in regard to both kangaroo fertility control research, and the Belconnen Naval Transmitter Station (BNTS) and in doing so, respond to your detailed questions. It also addresses the application from the Invasive Animals Co-operative Research Centre (IACRC) to join the project in order to trial the GonaCon® vaccine.

Fertility Control Research

Since 1998 the ACT has committed resources to an attempt to develop an effective means of controlling the fertility of free ranging populations of eastern grey kangaroos. To develop effective fertility control is no easy task, and requires a long-term commitment. In Australia, there are four research groups working on kangaroo fertility control, based in four universities and CSIRO. The control of kangaroo populations is important for (a) conservation of threatened grassland and woodlands, (b) for community safety particularly in relation to car collisions with kangaroos, and (c) controlling impacts on rural production.

The ACT has linked itself to those researchers whose fertility control products are intended ultimately for delivery in food. A non-lethal, oral contraceptive (i.e. a food-based delivery method) for controlling kangaroo densities is highly desirable because (a) the main kangaroo control method used at present, shooting, is unsafe in many urban areas, (b) non-lethal solutions are more socially acceptable, (c) oral delivery will be the most cost-effective method, and (d) oral delivery is likely to be the only feasible method for controlling population growth of wild, free-ranging kangaroos. Fertility control products which require each kangaroo to be darted (eg implants) are unlikely to be cost-effective for controlling free-ranging populations. The delivery of effective fertility control in food is the ultimate goal.

For the future benefit of the ACT, I am keen that the most promising of fertility control products currently available should be trialled in eastern grey kangaroos, including, but not limited to, the Zona Pellucida (ZP) vaccine currently on trial at BNTS. The most promising product appears to us to be the GonaCon® GnRH vaccine which has recently been allowed into Australia from the USA for research by the IACRC. To trial that product, and also continue the current research on ZP vaccines, I advise you that an additional 40 female kangaroos would be required.

In your email on the 7th you refer to discussion with Ms Lane of three phases of the current fertility control research project in which Parks, Conservation and Lands (PCL) is engaged. These conceptual phases are not formally documented but were explained as follows to enable you to understand the nature of the work being conducted and planned:

Macarthur House • 12 Wattle Street Lyneham ACT 2602
GPO Box 158 Canberra ACT 2601 • Telephone (02) 6207 7624 • Facsimile (02) 6207 5527

Phase 1: developing and trialling a successful fertility control substance such as that currently being applied at BNTS, or a more robust version now undergoing laboratory trials;
Phase 2: research into feeding preferences of kangaroos to design a bait for delivering a vaccine in food; and
Phase 3: testing the population level effect of the vaccine in food.

Phase one has been underway since 1998 and is continuing. Phase two has commenced. Both phase one and two are active at BNTS.

The Importance of BNTS for Kangaroo Research
In order to facilitate research on eastern grey kangaroos, including research on fertility control, access to a site such as BNTS is invaluable to the ACT. The BNTS site is exceptional for fertility control research because of its convenient size, open grassland vegetation, 'people-proof' security fence, and urban location. A site like this is essential for the first 'real' deployment of fertility control vaccine in food, when it is developed. For example, the quarantine approval of one of the vaccines, at this pre-registration stage, requires a securely fenced site. Research institutions which the ACT may partner in the quest for effective fertility control products and methods, such as the Marsupial Research Laboratory at the University of Newcastle, and the Invasive Animals CRC (IACRC), do not have ready access to extensive tracts of land, and depend on agencies such as ours and Defence, to facilitate access to kangaroo populations and sites such as BNTS.

If BNTS is transferred to the ACT Government, it is expected that the 100 hectares of Natural Temperate Grassland will be reserved for nature conservation. In accordance with legislation, all of the ACT's conservation areas are available for research purposes (as well as conservation, education and recreation) and I expect that the Department will continue to conduct kangaroo and grassland research on the site.

Research Animals at BNTS
At BNTS, PCL currently has three treatment groups, each of twenty females (all ear-tagged) as well as seven males, comprising 67 kangaroos tagged. The tagged males are relevant only to the pellet feeding experiments and can be disregarded for purposes of the following explanation. Additional untagged male kangaroos 'participate' in the project by mating with the tagged females. The tagged animals and the unknown number of males are part of a collaborative research project by the University of Newcastle, Defence, a private biotechnology company in New Zealand, and Parks Conservation and Lands (PCL). The current agreement with the University expires at the end of this year. However, the University is in the process of sourcing additional funding to continue the research.

Previous advice provided by Ms Sharon Lane suggested that a minimum number of 56 kangaroos would be required to continue the fertility control project with the Marsupial Research Laboratory, plus 30 more to add the two GonaCon treatments, which would be highly desirable from an ACT Government perspective. These numbers had been estimated at short notice by Dr Fletcher. However, further consideration and consultation has resulted in some modification to that advice, as follows.

Discussion with Dr Lyn Hinds, one of the leading fertility control researchers, has caused PCL to reconsider. Dr Fletcher had based his calculation on an estimated 'absolute minimum' number of 15 females in each treatment group but Dr Hinds argued persuasively that to start with this number is accepting too high a level of risk, and that the size of each treatment group should continue to be twenty. In either case, the number of males should be at least 20% of the number of females. Therefore the number of kangaroos needed, is the number of experimental treatments (5) (including an experimental 'control' or untreated group), plus 20% males i.e. 20 males. Five treatments x 20 plus 20% = 120.

The minimum number of kangaroos per treatment depends on the likelihood of animals being lost from the experiment, which depends on site characteristics such as the quality of fencing, vegetation type, fox abundance, and level of public interference. Dr Fletcher's estimate was that 15 females per treatment was acceptable, based on his experience at BNTS in 2005-2007 where few losses have been experienced. (He also assumed a lower number of males, 16 rather than 20, assuming they were hand picked, and replaced at intervals.) However, Dr Fletcher acknowledges that there have been higher losses from the enclosures at Tidbinbilla (due to escapes etc), and that a higher rate of loss appears to be typical of this type of research. Dr Hinds would prefer to see research of this type of research start with groups of twenty females as a buffer against losses.

Therefore, to allow the current research program to continue and to support the very promising IACRC work (which I believe to be extremely valuable), our current advice is that all of the tagged females at BNTS (60) should be retained to successfully continue the current project, plus an additional forty females to test the GonaCon vaccine, plus twenty males, i.e 120 kangaroos on the site. All of these kangaroos would presumably be captured as a by-product of the population reduction operation (which involves capture-darting).

Uni Newcastle/ PCL/ Defence project

- 20 untreated experimental 'control' females (already tagged)
- 20 females that have had an initial vaccination by injection (already tagged)
- 20 females that have had an initial vaccination by mouth (already tagged)
- 12 males (7 already tagged)

IACRC/PCL project

- 20 females (to be given one injection of GonaCon vaccine)
- 20 females (to be given one injection and a subsequent injection of GonaCon vaccine)
- Additional 8 males

The IACRC project would use the same 20 untreated experimental 'control' females as the University of Newcastle project.

Both projects would continue for three years. The duration of infertility is an extremely important determinant of effectiveness and is expected to be about three years for both vaccines, but this has never been assessed.

Stocking Rates for Kangaroos at BNTS
I understand that your independent panel has advised that all of the kangaroos should be taken off the site for two years.

I have obtained advice from applied ecologists in my department who have been recognised for their expertise in grassland ecology, (Dr Don Fletcher, expert in dynamics of eastern grey kangaroo populations and their food supplies, and Ms Sarah Sharp, expert in conservation of native temperate grasslands and woodlands). Both scientists frequently interact with managers, and are accustomed to the need to accommodate multiple objectives. They have advised me that a significant reduction in kangaroo density is essential to prevent severe damage to the pasture predicted in future, and to allow the grassland vegetation to recover from the damage incurred to date from the drought and over-grazing by kangaroos. Dr Fletcher and Ms Sharp agree that the reduction in grazing pressure that will be brought about by reducing the kangaroo density from the current level of approximately five kangaroos per hectare, to approximately one kangaroo per hectare, will have clear benefits for the grassland, and is likely to provide an acceptable management regime with which to move forward. They recommend for the long term an adaptive management approach in which the number of kangaroos is adjusted up or down based on measurements in the herbage mass and vegetation condition. Both scientists acknowledge the importance of reducing the number of kangaroos below the number required for fertility control research, if that is proved necessary, but the value of the fertility control research is high, and it should be protected if possible.

Previous correspondence to your office provided by Ms Sharon Lane (31 January), commented that the recommendation to totally destock the site is contrary to our understanding of current scientific knowledge. Dr Graeme Coulson (2001) has concluded that about 1 kangaroo per ha is a sustainable level. An independently derived empirical model by Dr Fletcher supports Dr Coulson's conclusion. Clearly, the current population of approximately 590 kangaroos far exceeds the recommended carrying capacity of the site (which at approximately 1 per ha is approximately 116 kangaroos). There will be a great improvement if the population is reduced to the estimated sustainable population level.

In relation to any growth in the kangaroo population on the site, over and above the number of animals being used for research, the population would be controlled by the removal and euthanasia of pouch young as is standard practice for the management of research animals. This will be undertaken by capture darting and euthanasia.

Fencing Proposal

You requested information on the cost of fencing to enclose a number of kangaroos as an alternative to the current site. The existing fence at BNTS would be expensive to replace, and not surprisingly, the cost estimate we provided for a smaller alternative was in the hundreds of thousands of dollars.

Your response (in the email of 7 February) was to suggest that the research kangaroos could be moved to a much smaller area where they were confined at the same density as currently applies at BNTS. Our previous advice was that about one kangaroo per hectare is an acceptable stocking rate. Anything well above this stocking rate would change the nature of research from trials on a free-ranging population to trials on penned animals fed on pellets. We have not costed the management of the 'small pen' alternative in which the kangaroos were confined at high density and fed artificially.

Research on a new fertility control needs to demonstrate that any effect is from the medication. Either translocation or close confinement have the potential to disrupt breeding and are therefore a threat to the research, or a source of delay. Continuing the research on the existing site as it is currently set up, would result in the best outcome for the research projects and allow the research to continue without delays or interruption.

Additionally, any research undertaken in a penned environment requires the cost of the food (standard macropod pellets) and staffing to be added, which would be likely to offset the cost of fencing the larger area.

In regard to your supplementary email of 12 January, asking how quickly a fence could be built at BNTS around kangaroo research enclosures of 11 ha and 56 ha, if the enclosures were inside the BNTS fence there would need to be consideration of the impact on the grassland of supporting a high density of kangaroos in the enclosure for a sustained period, by artificial feeding. Also in that case, the Department of Defence should be approached for information about the time required for their approval and budgeting processes. If the enclosures were outside the BNTS fence, we might need approval from the ACT Planning Authority, and our experience is that this could take some time. Fencing contractors indicate that when the time came, the fence could be built in a matter of weeks, depending on details of its specification, materials, alignment, etc.

Kangaroos Outside the BNTS Enclosure
In your email of the 8th January you enquired about the management of kangaroos outside of the BNTS enclosure. The area outside the enclosure does not contain an endangered ecological community and therefore the long-term ramification of grazing pressures is not an ecological issue of concern. The fate of these animals when suburban development proceeds will be similar to kangaroos in other areas of Canberra (such as Gungahlin) where suburban development has been extensive, ie. the constant disturbance of people and machinery will cause the kangaroos to disperse into other areas.

Currently, Parks Conservation and Lands are preparing an ACT Kangaroo Management Plan to define policies and actions for the management of kangaroos throughout the Territory. The issue of controlling and managing kangaroo populations in the urban area and kangaroo fertility control research will be a central theme of this plan.

Recommendations
I fully agree that the grassland at the BNTS needs to be given a rest from the excessively heavy grazing regime inflicted by excessive number of kangaroos on the site. The government has been pressing for this outcome for some time now. It may well be that in an ideal situation, for example a sheep-grazing property, that all the stock be removed. In the case of BNTS, however, I propose that an alternative approach is justifiable for the following reasons:

a) kangaroos on the site are important to the collaborative research program and in the interests of that program continuing uninterrupted and allowing a supporting trial to be undertaken, a sustainable number of kangaroos should be retained;
b) the site has a long history of grazing (before kangaroos it was grazed by domestic livestock) and therefore the grasslands and associated species that persist there are accustomed to grazing and need some form of biomass control (grazing, slashing and/or burning) to retain their ecological function;

c) reducing the kangaroo density approximately 4-fold would significantly reduce the effects of grazing on biomass and thus should allow for significant recovery of the grassland;
d) allowing a sustainable stocking rate to be retained on the site provides the opportunity to monitor the effects of destocking and hence allow for adaptive management to proceed;
e) allowing a sustainable number of kangaroos to remain on the site will negate the need to reintroduce kangaroos later;
f) allowing the continued use of BNTS would avoid the costly and difficult exercise of setting up a similar research facility elsewhere in the ACT; and
g) if the BNTS site was to be unavailable for kangaroo fertility research, I expect that the research projects (current and proposed) will be delayed or put at risk, compromising our attempt to progress evidence-based kangaroo management..

Thank you for your emails in relation to the above matters. I trust that this information is of assistance to your inquiry.

Yours sincerely

Hamish McNulty

Hamish McNulty
Conservator of Flora and Fauna
Executive Director, Environment and Recreation

Date 14/2/08

Appendix 2: Addendum Report to the Report on Belconnen Naval Transmission Station Site as part of the Investigation into ACT Lowlands Grasslands by Dr Maxine Cooper Commissioner for Sustainability and the Environment, 28 March 2008

ADDENDUM REPORT TO THE REPORT ON BELCONNEN NAVAL TRANMISSION STATION (BNTS) SITE AS PART OF THE INVESTIGATION INTO ACT LOWLAND NATIVE GRASSLANDS

From
Dr Maxine Cooper
Commissioner for Sustainability and the Environment
28 March 2008

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Introduction

On 17 March 2008 the Office of the Chief Minister, Minister for the Environment, Water and Climate Change requested further advice following the submission of my report on the Belconnen Naval Transmission Station (BNTS) site as part of the investigation into ACT Lowland Native Grasslands (http://www.envcomm.act.gov.au/investigation). The Office of the Chief Minister requested that further advice be provided with respect to firstly, the findings by Defence's expert panel and secondly, a possible scientific trial of translocation involving kangaroos from BNTS. This document provides this additional information and is an addendum to my earlier report.

Background

In order to address the above request, on 20 March 2008, I and Major General Liz Cosson, Department of Defence, co-chaired a meeting of the experts engaged by my Office, namely Dr Andrew Braid (CSIRO Veterinarian), Associate Professor David Morgan (Department of Zoology, University of Melbourne), Mr Michael Linke (CEO, ACT RSPCA); and the experts engaged by the Department of Defence, namely Dr Hal Cogger (John Evans Memorial Fellow, Australian Museum), Dr Graeme Coulson (Senior Lecturer in Zoology, University of Melbourne) and Dr George Wilson (Consultant and Director, Australian Wildlife Services). Dr Sue McIntyre (CSIRO Senior Principal Research Scientist) is a member of both panels and was present. Also present were Mr Nick Warner, Secretary of Defence; Mr Hamish McNulty, Conservator of Flora and Fauna (Department of Territory and Municipal Services, ACT Government); Dr David Robertson, Defence contractor for the BNTS work and ecologist, Cumberland Ecology; and Defence staff and a staff member from the Commissioner's Office. The matters agreed to by the experts are at **Attachment A**. In addition to this meeting, a meeting was held with Dr Lyn Hinds, Senior Principal Research Scientist, CSIRO on 18 March 2008. Dr Hinds is an eminent marsupial research scientist. Wildcare members, on 19 March 2008, also met with me and discussed their translocation proposal that was based on material submitted to Defence in June 2007. A copy of this document was provided to me on 19 March 2008 and Wildcare granted permission for it to be distributed. On 28 March 2008, Wildcare advised that it was not to be made public.

Wildcare's proposal was given to my expert panel before the meeting on 20 March 2008 and Defence made copies available at the meeting of the experts. NSW, Parks and Wildlife Group, Department of Environment and Climate Change (DECC) were contacted to verify aspects of the Wildcare proposal and that Department's response is at **Attachment B**.

Consideration of relevant matters

At the meeting with Dr Hinds, current research was discussed, as was research for future projects, including translocation. Dr Hinds is of the view that overall the most productive approach would be to focus on fertility control research.

On 26 March 2008, DECC clarified some issues in respect of the Wildcare proposal (see **Attachment B**). DECC stated, among other things, that:

- *The Department has not offered to be part of a relocation team. The Department had offered to provide assistance of a technical and advisory nature should a translocation go ahead but has specifically stated that we are not able to second staff to such a subject.*

- *The Department's position is that we are prepared to consider a proposal, however we would normally only consider translocation where it was essential for the survival of a species, which doesn't appear to be the case in this situation. We have previously provided the Commissioner advice* (**Attachment C**) *about the information requirements necessary for us to consider such a proposal. The Department has not received any proposal for translocation of these kangaroos and so we cannot say whether or not we would support a specific proposal.*

The experts have summarized the matters on which they agree based on the joint meeting on 20 March 2008 and in the context of their earlier reports (**Attachment A**). Their summary is presented on pages 4-5 of this document. Importantly there is unanimous agreement that euthanasia should be pursued over translocation. From the meeting on 20 March 2008 it is understood that this has always been the preferred position of all experts (refer to point 6 of the combined experts summary at **Attachment A** and on pages 4 and 5 of this document). The Defence Panel did recommend euthanasia and translocation to reduce the population of kangaroos at BNTS, as mentioned in point 6, however, this was done to acknowledge that the Department of Defence may have overriding reasons for translocation to be their preferred option. The Defence Panel put stringent conditions, on translocation and expected that all of their recommendations would have been implemented by December 2007. The conditions relating to translocation have not been met and the Defence Expert Panel members believe that now only euthanasia should be perused.

On 26 March 2008, the Department of Defence, advised that … *based on its panel of independent expert advice in August 2007, Defence continues to pursue an opportunity to translocate as many kangaroos as possible from BNTS, including undertaking a translocation research project.*

Matters agreed to by the experts

The matters agreed to by the experts from the two expert panels that were present at the meeting on the 20 March 2008 (**Attachment A**) are:

1. The natural temperate grasslands and the threatened species within the grassland at BNTS should be preserved and urgent action needs to occur.

2. The current condition of the grassland is poor.

3. The main cause of the current poor condition of the grassland is heavy grazing pressure by the eastern grey kangaroos (the kangaroos). The situation is compounded by the drought.

4. The current density of kangaroos is preventing recovery of the grassland and threatening its long term sustainability.

5. Kangaroo numbers at BNTS (within the fenced area) should be dramatically reduced before the onset of winter 2008 in order to protect the grassland. In August 2007, the Defence panel recommended in effect the removal of all but 100 kangaroos and were under the impression that their recommendations would be implemented by December 2007. In February 2008 the Commissioner's panel recommended the removal of all kangaroos by winter 2008. [The ACT Conservator of Flora and Fauna advised, in February 2008, that not all kangaroos needed to be removed if an adaptive management approach were adopted (where kangaroo density is adjusted relative to the grassland's response to kangaroo grazing) and that an appropriate stocking rate would be 1 kangaroo per hectare (approximately 100 to 120 kangaroos). The Commissioner considered all this advice and in February 2008 recommended an adaptive management approach with an initial density of 1 kangaroo per hectare or less. It is noted that currently approximately 60 female kangaroos at BNTS are tagged and are being used for fertility research purposes.]

6. The most humane method of removing the kangaroos from BNTS would be through shooting. However, the Australian Federal Police will not agree to the use of firearms because of public safety concerns. In the absence of the use of firearms, the next best method for the humane removal of the kangaroos is by sedation by darting followed by euthanasia by lethal injection. [All experts have consistently supported euthanasia over translocation including the members of the Defence Panel who, as reflected in their August 2007 report, also acknowledged that there might be overriding reasons for translocation to be the preferred option of the Department of Defence. In doing this the Defence Panel put stringent conditions on translocation and were of the understanding that if these could be met, they would have been implemented by December 2007. These conditions have not been met and the Defence Expert Panel members believe that now only euthanasia should be pursued.]

7. No expert requested or supported a specific research project involving the translocation of kangaroos at BNTS[1], nor any allocation of funds for such a study. Such research would be expensive and an inappropriate use of research funds when there is such a need for research on a wide variety of threatened species and communities, including those at BNTS.

8. No release sites have been nominated. The panels are not aware of suitable release sites that address animal welfare issues for translocated and resident animals nor do they believe one can be found. A permit to release into New South Wales would be likely to draw opposition from nearby land holders.

9. All kangaroos remaining at BNTS are therefore to be part of long-term fertility control research with numbers not to exceed more than 1 per hectare subject to an adaptive management approach within the constraints on kangaroo numbers required for fertility control research. Best practice for this site in the view of expert panel members would be for it to be planned and managed as a model urban grassland ecosystem where all threatened species are protected and conserved. The long-term future of the site needs clarification, including the role of the perimeter fencing and the internal fencing.

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[1] While it was agreed that translocation of kangaroos from BNTS should not be undertaken on animal welfare grounds alone, there was some discussion of other issues as well, including the shortage of suitable reception sites, the time involved in securing the necessary approvals and the uncertain fate of translocated kangaroos.

Conclusion

As the matters agreed to by the experts reinforce the recommendations made by me on 26 February 2008, my recommendations stand. For ease of reference, a copy of my recommendations is at **Attachment D**. A copy of the full report is at our website: http://www.envcomm.act.gov.au/investigation. With respect to using kangaroos from BNTS in a translocation scientific research project, as stated by the experts at point 7 on page 5 of this document, such a project was not identified by them. Accordingly, it is recommended that scientific research in relation to the kangaroos at BNTS focus on fertility control. The kangaroos remaining on that site will be involved in this research. If additional funds were available for research they could be directed to enhancing the current research being undertaken so as to try and realize results more quickly and/or be invested in research on threatened grassland species.

The Canberra Region has the opportunity to use the BNTS site as a demonstration of best practice urban ecosystem management whereby the threatened grassland (of which there is less than 1% remaining of the original grassland intact nationally) and all of its associated flora and fauna (including eastern grey kangaroos and threatened species) exist for future generations. It is very concerning that the needed action has not been taken to maintain the very important values of the BNTS grassland and the threatened species it supports so as to realize this opportunity.

Attachment A

Belconnen Naval Transmission Station, ACT - matters agreed by members of the two expert panels

In August 2007 a panel of experts being Dr Sue McIntyre, Dr Hal Cogger, Dr Graeme Coulson and Dr George Wilson provided a report to the Department of Defence concerning the above site.

In February 2008 a panel of experts being Dr Sue McIntyre, Dr Andrew Braid, Mr Michael Linke and Associate Professor David Morgan also provided a report to the Commissioner for Sustainability and the Environment on the above site.

On 20 March 2008 a meeting with all these experts was convened in order to provide the Commissioner for Sustainability and the Environment with advice.

Based on the respective reports of each panel of experts and the meeting on 20 March 2008 all the experts agree on the following:

1. The natural temperate grasslands and the threatened species within the grassland at BNTS should be preserved and urgent action needs to occur.

2. The current condition of the grassland is poor.

3. The main cause of the current poor condition of the grassland is heavy grazing pressure by the eastern grey kangaroos (the kangaroos). The situation is compounded by the drought.

4. The current density of kangaroos is preventing recovery of the grassland and threatening its long term sustainability.

5. Kangaroo numbers at BNTS (within the fenced area) should be dramatically reduced before the onset of winter 2008 in order to protect the grassland. In August 2007, the Defence panel recommended in effect the removal of all but 100 kangaroos and were under the impression that their recommendations would be implemented by December 2007. In February 2008 the Commissioner's panel recommended the removal of all kangaroos by winter 2008. [The ACT Conservator of Flora and Fauna advised, in February 2008, that not

all kangaroos needed to be removed if an adaptive management approach were adopted (where kangaroo density is adjusted relative to the grassland's response to kangaroo grazing) and that an appropriate stocking rate would be 1 kangaroo per hectare (approximately 100 to 120 kangaroos). The Commissioner considered all this advice and in February 2008 recommended an adaptive management approach with an initial density of 1 kangaroo per hectare or less. It is noted that currently approximately 60 female kangaroos at BNTS are tagged and are being used for fertility research purposes.]

6. The most humane method of removing the kangaroos from BNTS would be through shooting. However, the Australian Federal Police will not agree to the use of firearms because of public safety concerns. In the absence of the use of firearms, the next best method for the humane removal of the kangaroos is by sedation by darting followed by euthanasia by lethal injection. [All experts have consistently supported euthanasia over translocation including the members of the Defence Panel who, as reflected in their August 2007 report, also acknowledged that there might be overriding reasons for translocation to be the preferred option of the Department of Defence. In doing this the Defence Panel put stringent conditions on translocation and were of the understanding that if these could be met, they would have been implemented by December 2007. These conditions have not been met and the Defence Expert Panel members believe that now only euthanasia should be pursued.]

7. No expert requested or supported a specific research project involving the translocation of kangaroos at BNTS[2], nor any allocation of funds for such a study. Such research would be expensive and an inappropriate use of research funds when there is such a need for research on a wide variety of threatened species and communities, including those at BNTS.

8. No release sites have been nominated. The panels are not aware of suitable release sites that address animal welfare issues for translocated and resident animals nor do they believe one can be found. A permit to release into New South Wales would be likely to draw opposition from nearby land holders.

[2] While it was agreed that translocation of kangaroos from BNTS should not be undertaken on animal welfare grounds alone, there was some discussion of other issues as well, including the shortage of suitable reception sites, the time involved in securing the necessary approvals and the uncertain fate of translocated kangaroos.

9. All kangaroos remaining at BNTS are therefore to be part of long-term fertility control research with numbers not to exceed more than 1 per hectare subject to an adaptive management approach within the constraints on kangaroo numbers required for fertility control research. Best practice for this site in the view of expert panel members would be for it to be planned and managed as a model urban grassland ecosystem where all threatened species are protected and conserved. The long-term future of the site needs clarification, including the role of the perimeter fencing and the internal fencing.

Dr Sue McIntyre, Dr Hal Cogger, Dr Graeme Coulson, Dr George Wilson, Dr Andrew Braid, Mr Michael Linke and Associate Professor David Morgan.

27 March 2008

From: Henchman Alistair
Sent: Wednesday, 26 March 2008 10:08 AM
To: 'pamela.mathic@act.gov.au'
Cc: Corbyn Lisa
Subject: kangaroos at Belconnen Naval Transmitting Station

Pamela

Following is the response of the NSW Department of Environment and Climate Change to the particular references made in the Wildcare proposal for managing kangaroos at the site.

P 7
NSW NPWS staff are listed as being part of the relocation team.
The Department has not offered to be part of a relocation team. The Department had offered to provide assistance of a technical and advisory nature should a translocation go ahead but has specifically stated that we are not able to second staff to such a project.

P 22
"it is not the case that the responsible authority in NSW would not support the importation of eastern grey kangaroos."
The Department's position is that we are prepared to consider a proposal, however we would normally only consider translocation where it was essential for the survival of a species, which doesn't appear to be the case in this situation. We have previously provided the Commissioner advice about the information requirements necessary for us to consider such a proposal. The Department has not received any proposal for translocation of these kangaroos and so we cannot say whether or not we would support a specific proposal.

NPWS have offered to second staff to be involved in the relocation
No such offer has been made - in fact the Department advised Defence in June 2007 that we would be unable to second staff to the project.

P 23
"We have been advised that there is no policy obstacle to such a translocation"
We have advised Defence that the Department does not have or administer any policies or laws that prevent the implementation of a carefully considered translocation proposal.

P 39
Experts consulted
The members of the senior executive of the Department are not experts in animal relocations and their advice was limited to the policy and resourcing matters mentioned above as well as advice about the information requirements for any application. The Endangered Species Unit staff member listed has experience in managing threatened species but not specific experience in relocation of species.

Please let me know if you require any further information.

Alistair Henchman, Director Southern
Parks and Wildlife Group, Department of Environment and Climate Change
PO Box 733 Queanbeyan NSW 2620
ph 02 6298 0322 fax 02 6299 6858 mob 0408 20 91 90
alistair.henchman@environment.nsw.gov.au

Our reference : ED08/78
Contact : Alistair Henchman (02) 6298 0322

RECEIVED
12 FEB 2008
OCSE

Dr Maxine Cooper
Commissioner
Office of the Commissioner for Sustainability and the Environment
PO Box 356
DICKSON ACT 2911

- 7 FEB 2008

Dear ~~Dr Cooper~~ Maxine

I am writing in response to your letter of 16 January 2008, seeking advice on the regulatory framework and likely information the NSW Government would require from a proponent, to enable it to consider a proposal to translocate up to 450 eastern grey kangaroos from the ACT to NSW.

As you would appreciate, it is difficult to provide comprehensive answers to your questions in the absence of a formal translocation proposal or identification of preferred release sites. In addition, a future proposal may require consideration under NSW legislation which is not administered by the Department of Environment and Climate Change (DECC) such as the *Environment, Protection and Biodiversity Conservation Act 1999*, *Prevention of Cruelty to Animals Act 1979* and the *Environmental Planning and Assessment Act 1979*.

My response is restricted to matters relating to the NSW *National Parks and Wildlife Act 1974* (NPW Act) and the *Threatened Species Conservation Act 1995* (TSC Act):

The translocation of protected species in NSW, such as eastern grey kangaroos is likely to trigger the provisions of the NPW Act identified below:

- All actions likely to harm a protected species may require a licence under s120 of the NPW Act. Harm in the context of a translocation proposal are those actions that include pursue, capture, trap, injure or kill.
- It is an offence to "liberate" a fauna species in NSW without a licence issued under s127 of the NPW Act. This would apply to the release of the captured kangaroos in NSW.
- In order to import fauna into NSW, a licence will be required under s126 of the NPW Act. The DECC would require an approved export permit from the other jurisdiction, before approving the import of fauna.
- In addition, a Scientific Licence under s132c of the NPW Act may be required should the proposal contain actions to research the impacts of translocation on the individual kangaroos or the environment into which the animals will be released. It is possible that DECC, as part of a future approval, would require the proponent to implement a program of research.

The granting of a Scientific Licence is subject to approval from the relevant NSW Animal Care and Ethics Committee (ACEC). The appropriate ACEC to approach is dependent on which organisation will undertake the research.

The Department of Environment and Conservation NSW is now known as the Department of Environment and Climate Change NSW

PO Box A290 Sydney South NSW 1232
59-61 Goulburn St Sydney NSW 2000
Tel: (02) 9995 5000 Fax: (02) 9995 5999
TTY (02) 9211 4723
ABN 30 841 387 271
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Department of Environment & Climate Change NSW

The proposal will also need to be assessed under s91 of the TSC Act to determine the likely impacts of the translocation and resulting grazing upon any threatened species, population or ecological community or their habitat. The proposal will therefore require detailed consideration of potential impacts. The TSC Act makes additional provision for the preparation of a Species Impact Statement should the proposal significantly affect the threatened species, population, ecological community or their habitat. A licence under this section would be required should it be deemed that the release of the kangaroos would have a significant effect.

The likelihood of kangaroos resulting in a significant impact would in part be dependant upon the carrying capacity of the site in which they are to be released and the vegetation types present. It is presumed that a significant impact would only result if the grazing was unsustainable and prolonged. Consideration under the Commonwealth's *Environmental Protection and Biodiversity Conservation Act 1999* may also be necessary should the site contain species or communities listed under that Act.

The ecological impacts of the proposal on non-threatened species, particularly the impacts on any resident populations of kangaroos would need to be thoroughly considered.

Such a proposal would also need to comprehensively address all the relevant animal welfare issues. As you would understand, ensuring animal welfare is essential. DECC may thus require documented RSPCA approval of all facets of the proposal including best practice capture, handling, sterilisation and release protocols for the kangaroos including any conditions placed on that approval. These protocols may be referred to the NSW Animal Welfare Advisory Committee for comment.

Given the size and scale of the proposal, DECC would likely request additional information relevant to the location, impacts to, and future management and monitoring of release sites, their proximity to parks, neighbouring properties and commercial kangaroo culling areas. Written approval from the relevant owner of the release sites will need to form part of the translocation proposal.

DECC has a policy for the translocation of threatened fauna which provides initial guidance on the matters to be covered by a translocation proposal (Attached). Any approval by DECC to proceed with a translocation program would be dependent on the provision of a fully costed and funded implementation and long term monitoring program. The DECC translocation policy also requires the proponent to seek the endorsement of partner organisations and other stakeholders where appropriate.

With respect to your request for indicative timeframes for DECC to assess such a proposal. I understand that other translocation proposals requiring DECC approval have involved much smaller numbers of animals. A proposal of this kind would be unique in size and scale and likely involve the input of other stakeholders. An indicative timeframe would be in the order of three to six months from receipt of a translocation proposal and licence application which meets all of the above requirements including the RSPCA approval.

If you have any queries regarding this matter, please do not hesitate to contact me or have your staff contact Alistair Henchman on (02) 6298 0322.

Yours sincerely

Lisa Corbyn

LISA CORBYN
Director General

Attachment D

Summary of Commissioner's Recommendations

Recommendation 1: Urgent action is to be taken to restore the ecological condition of the Grassland, and provide opportunities for the Perunga Grasshopper, Golden Sun Moth and Ginninderra Peppercress to survive and thrive at BNTS.

Recommendation 2: Kangaroos are to be removed immediately from BNTS to achieve a stocking rate of 1 kangaroo per hectare or less. This is to be done by the land manager, preferably before the end of April 2008, to prevent impacts on pasture biomass occurring during the dormant 2008 winter season.

Recommendation 3: Kangaroo population numbers are to be maintained at the targeted level for the foreseeable future using fertility-controlled kangaroos only. A program to maintain this situation is to be implemented as needed. (This recommendation is made on the assumption that all remaining kangaroos at BNTS will be part of fertility control research programs.)

Recommendation 4: Further reductions in the number of kangaroos at BNTS (i.e. even below the proposed stocking rate of 1 kangaroo per hectare) is to occur if recovery of the grassland does not improve over the next growing season even if research projects are compromised.

Recommendation 5: Kangaroos are to be removed from BNTS by the most humane method suitable for that site having regard to advice from the AFP that firearms are not to be used at BNTS. (The Expert Panel has recommended sedating by darting followed by euthanasia by lethal injection.)

Recommendation 6: The policy of the Conservator of Flora and Fauna, to the effect that translocation of eastern grey kangaroos is not an appropriate management technique, is to remain unchanged and that this policy position be confirmed to the Department of Defence immediately.

Recommendation 7: The interim grassland management plan and interim kangaroo management plan for BNTS are to be completed by the end of August 2008, by the land manager, in consultation with key stakeholders. These plans are to adopt adaptive management principles and be based on a stocking rate of 1 kangaroo per hectare or less prior to the 2008 winter.

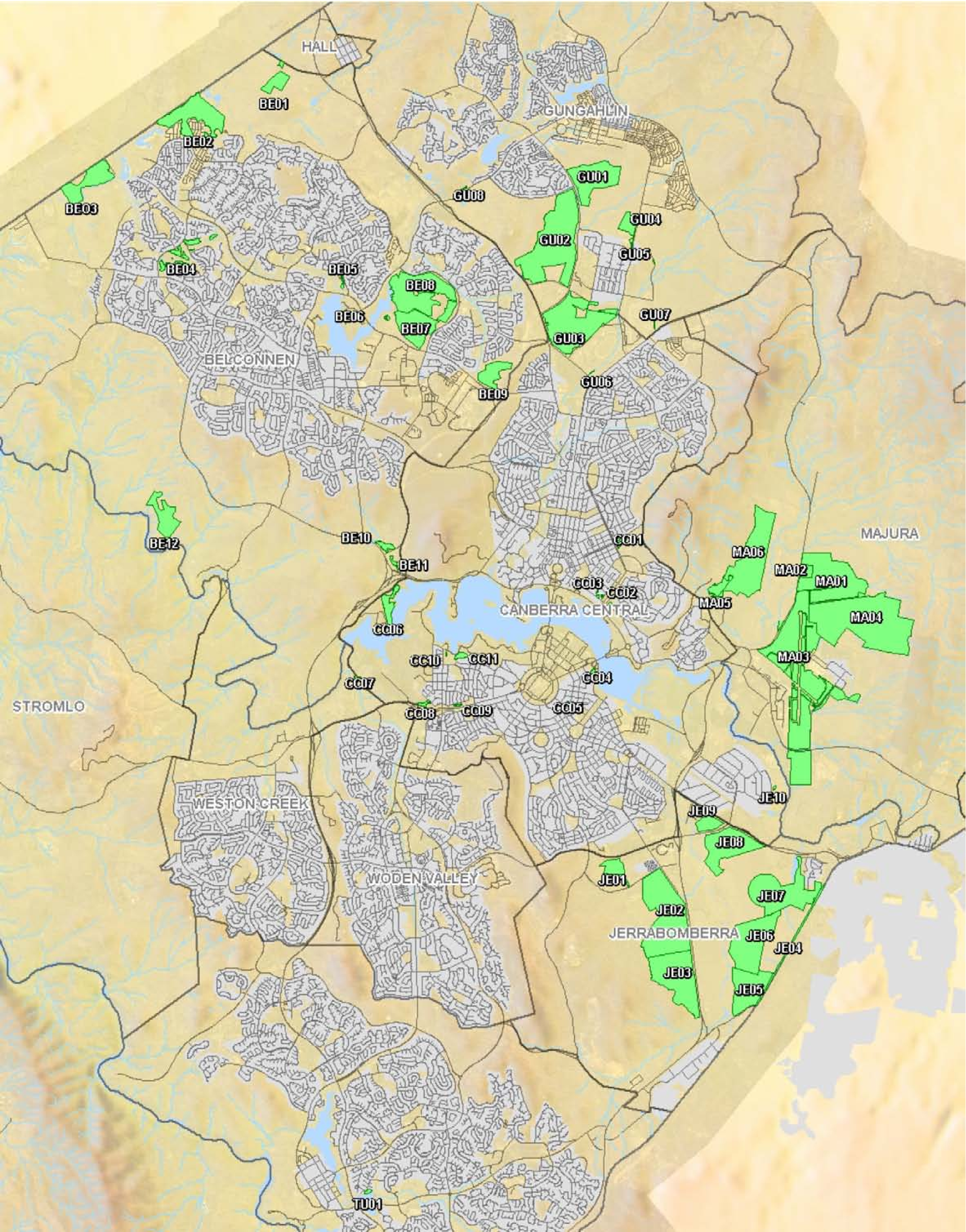
Recommendation 8: Conditions at BNTS are to be reported on a quarterly basis to all relevant agencies and to the Commissioner's Office. The Commissioner is to establish an independent group to assist her evaluate progress and report on this in her annual report.

Recommendation 9: A long-term grassland management plan covering BNTS is to be developed prior to the abutting Lawson lands being developed for residential purposes. This plan should incorporate clear management objectives and be based on an adaptive management approach to protect the Grassland, Perunga Grasshopper, Golden Sun Moth and Ginninderra Peppercress at the BNTS. (The interim grassland management plan and interim kangaroo management plan (Recommendation 7) should be incorporated into the long-term plan. This long-term plan could cover all ACT natural temperate grassland areas.)

Recommendation 10: The Territory is to ensure that legal measures are implemented to protect and preserve the high conservation value of the Grassland and its threatened species when the land at BNTS is transferred from the Commonwealth to another entity. (This recommendation is made on the assumption that Territory laws will fully prevail post the transfer.)

Recommendation 11: The review of the Memorandum of Understanding between the Department of Defence and ACT Government (TAMS) is to be completed by August 2008.

Appendix 3: Map of lowland native grassland sites in the ACT



HALL
BE01
GUNGAHLIN
BE02
BE03
GU01
GU08
GU04
GU02
GU05
BE04
BE05
BE08
BE06
BE07
GU07
GU03
BELCONNEN
GU06
BE09
MAJURA
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CC01
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BE11
MA02
MA01
CC03
CC02
MA05
CANBERRA CENTRAL
MA04
CC06
CC10
CC11
MA03
CC04
CC07
STROMLO
CC08
CC09
CC05
WESTON CREEK
JE10
JE09
JE08
JE01
WODEN VALLEY
JE07
JE02
JERRABOMBERRA
JE06
JE04
JE03
JE05
TU01

Key to map

Name of site	Site no.
Majura Valley	
Majura Training Area	MA01
Air Services Beacon	MA02
Canberra International Airport	MA03
'Malcolm Vale'	MA04
Campbell Park	MA05
Majura West	MA06
Jerrabomberra Valley	
'Mugga Mugga' Homestead	JE01
'Callum Brae'	JE02
Jerrabomberra West Reserve	JE03
Woods Lane	JE04
Jerrabomberra East Reserve	JE05
Harman Bonshaw South	JE06
Harman Bonshaw North	JE07
'Cookanalla'	JE08
AMTECH	JE09
Tennant Street, Fyshwick	JE10
Gungahlin	
Mulanggari Nature Reserve	GU01
Gungaderra Nature Reserve	GU02
Crace Nature Reserve	GU03
North Mitchell	GU04
Mitchell	GU05
Canberra Riding Club	GU06
Wells Station Road	GU07
Nicholls	GU08

Name of site	Site no.
Belconnen	
Ginninderra Experimental Station	BE01
Dunlop Nature Reserve	BE02
'Jarramlee'	BE03
Umbagong Park South, Florey	BE04(a)
Umbagong Park North, Florey	BE04(b)
Evatt Powerlines	BE05
Lake Ginninderra	BE06
Lawson Territory	BE07
Lawson Commonwealth – Belconnen Naval Transmission Station	BE08(a)
Lawson Commonwealth – East	BE08(b)
Kaleen east paddocks	BE09
Caswell Drive	BE10
Glenloch Interchange	BE11
Kama South	BE12
Central Canberra/Tuggeranong	
CSIRO Headquarters, Campbell	CC01
Constitution Avenue, Reid	CC02
St John's Church, Reid	CC03
Australian Centre for Christianity and Culture, Barton	CC04
York Park, Barton	CC05
Yarramundi Reach	CC06
Lady Denman Drive, Yarralumla	CC07
Dudley Street, Yarralumla	CC08
Guilfoyle Street, Yarralumla	CC09
Novar Street, Yarralumla	CC10
Black Street, Yarralumla	CC11
Isabella Pond, Monash	TU01

Appendix 4: Summary for lowland native grassland sites in the ACT

Introduction

This appendix is a summary of each of the 49 lowland native grassland sites in the ACT. Comments with respect to 'Current Threatening Process' and 'Actions' are based on information Dr Ken Hodgkinson provided in his independent assessment of sites, discussions with officers of Australian Government agencies, and also with those officers from the ACT Department of Territory and Municipal Services who were involved in a roundtable discussion held on 10 October 2008.

Under Current Threatening Process the condition of each site is presented as good (**G**), approaching a critical (**AC**) threshold, or in a critical (**C**) condition. All lowland native grassland sites need ongoing adaptive management, including those sites considered to be in good (**G**) condition, in order to maintain an optimum vegetation cover that provides habitat and maintains species diversity, and to control threats including weeds and physical disturbance. Sites identified as being in a critical (**C**) condition or approaching a critical (**AC**) threshold need immediate action.

The information on the condition of a site is relevant at the time of the assessment and therefore may change with changing conditions.

In the report, *Table 5: Site assessment for threatening processes and condition for lowland native grasslands sites in the ACT* is based on the information in this appendix. The location of each site is shown in Appendix 3.

Majura Valley

Majura Training Area (MA01)

Conservation Category 1: Core Conservation Site.

Size: 126.6 hectares of lowland native grassland (113.7 hectares Natural Temperate Grassland) contiguous with grassland within the Air Services Beacon (MA02), the Canberra International Airport (MA03), 'Malcolm Vale' (MA04) and with extensive areas of woodland and forest within the training area to the east.

Comments: National Land. This site contains populations of Button Wrinklewort, Grassland Earless Dragon, Golden Sun Moth, Perunga Grasshopper and Striped Legless Lizard. A fence was erected in 2008 to exclude kangaroos and reduce the extreme pressure of their grazing on the grassland; however, this has transferred the pressure to the surrounding endangered Yellow Box–Red Gum Grassy Woodland, which will be to the detriment of this ecosystem. The site is one of only a few that has a large contiguous link between the natural grassland and woodland upslope. The site has not yet recovered from the extreme grazing pressure from kangaroos.

A potential northern access road (*see* Canberra International Airport below) may affect this site, depending on the location of the road. Consideration is also being given to a potential east-west Kowen link road that may affect this site. In the current proposals for the Majura Parkway this link is not included and it is strongly recommended that the ACT Government commit to ensuring that any future east-west roads do not severe or adversely affect the Grassland Earless Dragon or the Natural Temperate Grassland areas on this site.

The ACT Government, the Department of Defence and the Department of the Environment, Water, Heritage and the Arts (formerly Department of the Environment) signed a memorandum of understanding on 7 September 1998. It appears that this memorandum of understanding was reviewed and revised schedules prepared in October 2001.

Current Threatening Processes: Parts of this site were at a critical (**C**) threshold due to overgrazing by kangaroos. A kangaroo management fence was erected and the site is recovering. Minor ongoing management of weeds is needed.

Action: Allow for recovery of grassland vegetation following kangaroo removal. Reduce kangaroo grazing pressure on unfenced Majura Training Area (containing Yellow Box–Red Gum Grassy Woodland) and abutting areas.

Review and update the existing memorandum of understanding and ensure it is implemented. Retain all Natural Temperate Grassland and ensure connectivity with other lowland native grassland areas so species such as the Grassland Earless Dragon have the opportunity to thrive. Any future roads (or other developments) should therefore be located outside the Natural Temperate Grassland area and continuity should be retained between this area and other lowland grassland communities.

Air Services Beacon (MA02)

Conservation Category 1: Core Conservation Site.

Size: 10.7 hectares Natural Temperate Grassland surrounded on three sides by the Majura Training Area (MA01).

Comments: National Land. This site contains populations of Grassland Earless Dragon, Golden Sun Moth, Perunga Grasshopper and Striped Legless Lizard.

Current Threatening Process: Nil. This site is in good (**G**) condition. Recent kangaroo grazing has reduced the previously heavy grass canopy cover (the kangaroos have now been removed as a result of the exclusion fence around the Majura Training Area). Given the importance of this site, it would be appropriate to develop a memorandum of understanding between the ACT Government and relevant Australian Government agencies, focused on fostering an overt cooperative approach to protecting the grassland.

Action: Develop a memorandum of understanding with Air Services Australia and ensure it is implemented.

Canberra International Airport (MA03)

Conservation Category 1: Core Conservation Site.

Size: 203.6 hectares of lowland native grassland (73.6 hectares Natural Temperate Grassland) and is contiguous with lowland native grassland at Majura Training Area (MA01) and 'Malcolm Vale' (MA04).

Comments: National Land. The site provides habitat for the Grassland Earless Dragon, Golden Sun Moth and Perunga Grasshopper.

Current Threatening Process: This site is in good (**G**) condition. Some weed invasion is being controlled. A potential northern access road could fragment the currently contiguous

Natural Temperate Grassland area. There has been a steady loss of areas of core habitat for Grassland Earless Dragon to development of taxiways and extension of runways, and erection of the Brand Depot complex.

Given the importance of this site, it would be appropriate to develop a memorandum of understanding between the ACT Government and the Canberra International Airport, focused on fostering an overt cooperative approach to protecting the grassland, particularly the Natural Temperate Grassland and identified threatened species habitat.

Action: ACT Government to have discussions with the Australian Government and the Canberra Airport Group for a more optimal location for the proposed northern access road to prevent fragmentation of the Natural Temperate Grassland. Develop a memorandum of understanding with the Canberra Airport Group and ensure it is implemented.

'Malcolm Vale' (MA04)

Conservation Category 2: Complementary Conservation Site.

Size: 155.4 hectares native pasture that is contiguous with the Majura Training Area (MA01) and the Canberra International Airport (MA03).

Comments: National Land. This site provides habitat for the Grassland Earless Dragon.

Current Threatening Process: At a critical (**C**) threshold from overgrazing by kangaroos and weed invasion. Part of the site could be affected by a potential northern access road and could also be affected by a potential east-west Kowen road; *see also* Majura Training Area (MA01).

The ACT Government, the Department of Defence and the Department of the Environment, Water, Heritage and the Arts (formerly the Department of the Environment) signed a memorandum of understanding on 7 September 1998.

Action: Reduce grazing pressure and control weeds. Review and update existing memorandum of understanding and ensure it is implemented.

Campbell Park (MA05)

Conservation Category 1: Core Conservation Site.

Size: 11.7 hectares Natural Temperate Grassland. Contiguous with native pasture to the east and north (Majura West) and with woodland to the east (Mount Ainslie Nature Reserve).

Comments: National Land. This site is habitat for the Button Wrinklewort, Grassland Earless Dragon, Striped Legless Lizard, Golden Sun Moth and Perunga Grasshopper.

The ACT Government, the Department of Defence and the Department of the Environment, Water, Heritage and the Arts (formerly the Department of the Environment) signed a memorandum of understanding on 7 September 1998. There was no evidence that the memorandum of understanding was implemented over the past years, however, staff advise that there is cooperation between the agencies.

Current Threatening Process: Nil. This site is in good (**G**) condition. However, if the threatening processes, particularly grazing, that adversely affect the adjoining lands are not controlled, they may adversely affect this site. Given the importance of this site for the Grassland Earless Dragon, if these threatening processes are not effectively controlled, strategically placed kangaroo management fencing should be erected on this site and on parts of Majura West (MA06). There is either an existing or disused rubbish tip on this site. Some ecologists were of the opinion that its use should cease and it should be rehabilitated. Information regarding whether the tip was still used could not be secured. The Department of Defence was made aware of this issue.

Action: Ensure adequate groundcover is maintained and weeds controlled. Given the importance of this site for the Grassland Earless Dragon, if these threatening processes are not effectively controlled, strategically placed kangaroo management fencing should be erected on this site and on parts of Majura West (MA06). Review and update the existing memorandum of understanding and ensure it is implemented.

Majura West (MA06)

Conservation Category 1: Core Conservation Site.

Size: 133.3 hectares native pasture. This site is contiguous with the Campbell Park (MA05) grasslands and with woodland within the Mount Ainslie Nature Reserve.

Comments: Territory Land. This site contains populations of the Grassland Earless Dragon. The area is subject to an agistment licence.

Current Threatening Process: At a critical (**C**) threshold from overgrazing by kangaroos, rabbits and stock.

Action: Reduce grazing pressure. If stock are removed and the grassland does not respond, and kangaroo numbers are not reduced, strategically placed kangaroo management fencing should be used on this site and at Campbell Park (MA05) to protect the habitat of the Grassland Earless Dragon.

Jerrabomberra Valley

Mugga Mugga Homestead (JE01)

Conservation Category 2: Complementary Conservation Site.

Size: 15.1 hectares Natural Temperate Grassland with adjacent native woodland and grassland separated by roads and neighbouring an olive grove to the south.

Comments: Territory Land. The site is part of the historical homestead of Mugga Mugga managed by ACT Historical Places. Parks Conservation and Lands within the Department of Territory and Municipal Services has provided conservation objectives and a management action spreadsheet.

Current Threatening Process: Nil. This site is in good (**G**) condition.

Action: Ensure periodic stock rotation to allow for natural regeneration.

'Callum Brae' (JE02)

Conservation Category 1: Core Conservation Site.

Size: 162.7 hectares native pasture, contiguous with woodland to the west (Callum Brae Nature Reserve) with native pasture and Natural Temperate Grassland to the south (West Jerrabomberra Nature Reserve).

Comments: Territory Land. Part of the site is managed under a rural lease with a Land Management Agreement. The site contains Grassland Earless Dragon, Golden Sun Moth and Perunga Grasshopper, and is an important area for maintaining habitat connectivity with the West Jerrabomberra Nature Reserve. In 2004 the Conservator of Flora and Fauna placed Conservator's Directions over part of this site under section 60 of the *Nature Conservation Act 1980* (ACT) for the protection of grassland sites and threatened species on this leasehold land. These Directions were superseded by a land management agreement.

Current Threatening Process: Nil. This site is in good (**G**) condition.

Action: Monitor canopy cover.

Jerrabomberra West Reserve (JE03)

Conservation Category 1: Core Conservation Site.

Size: 116.9 hectares lowland native grassland (115.2 hectares Natural Temperate Grassland) that is contiguous with Callum Brae (JE02) to the north and woodland to the east.

Comments: Territory Land. This site contains Golden Sun Moth, Grassland Earless Dragon and Pink-tailed Worm Lizard (*Aprasia parapulchella*). The reserve was gazetted in March 2008. The Department of Territory and Municipal Services has undertaken extensive weed control in the site. Management is guided by a management actions spreadsheet. The site has on its eastern boundary a 3-hectare lease by the Model Aircraft Club.

Current Threatening Process: Nil. This site is in good (**G**) condition, although Model Aircraft Club ingress into the reserve is a potential issue.

Action: Weed control, monitor kangaroo population and canopy cover.

Woods Lane (JE04)

Conservation Category 2: Complementary Conservation Site.

Size: 10.3 hectares of Natural Temperate Grassland. Part of a habitat corridor between the Letchworth lowland native grassland and the Queanbeyan Nature Reserve to the east in New South Wales, separated by the railway line and the proposed Jerrabomberra East Reserve (JE05) to the west.

Comments: Territory Land. Button Wrinklewort occurs in the lane, and is part of a larger population extending from Letchworth and the Queanbeyan Nature Reserve to the east and HMAS Harman to the west. The Department of Territory and Municipal Services maintains the roadside. The southern area is disturbed, as a result of vehicular traffic and dumping some years ago. There are no site-specific requirements governing management of this grassland site, other than general mowing guidelines. Conservation signs have been erected and the areas with the Button Wrinklewort are not mown intensively.

Current Threatening Process: Nil. This site is in good (**G**) condition.

Action: Prioritise site for resurvey, and review boundaries of the lowland native grassland in the roadside. Take measures to prevent further physical disturbance.

Jerrabomberra East Reserve (JE05) (proposed)

Conservation Category 1: Core Conservation Site.

Size: 72 hectares lowland native grassland (62 hectares Natural Temperate Grassland). The site is contiguous with other lowland native grassland in Harman Bonshaw, the Alexander Maconochie Prison site and Woods Lane, which forms a corridor with grasslands in New South Wales.

Comments: Territory Land. The proposed nature reserve contains the endangered Grassland Earless Dragon, Golden Sun Moth and the vulnerable Perunga Grasshopper. It is expected that this reserve will be created in the near future through a variation to the Territory Plan. In 2004 the Conservator of Flora and Fauna has placed Conservator's Directions over part of the site under section 60 of the *Nature Conservation Act 1980* (ACT) for the protection of grassland sites and threatened species on this leasehold land. These Directions were superseded by a land management agreement.

Current Threatening Process: This site is approaching a critical threshold (**AC**) due to overgrazing by kangaroos.

Action: Ensure grazing pressure by kangaroos is reduced.

Harman Bonshaw South (JE06)

Conservation Category 1: Core Conservation Site.

Size: 105.7 hectares native pasture that is contiguous with Harman Bonshaw North and the proposed East Jerrabomberra Nature Reserve.

Comments: National and Territory Land. In 2004 the Conservator of Flora and Fauna has placed Conservator's Directions over part of the site under section 60 of the *Nature Conservation Act 1980* (ACT) for the protection of grassland sites and threatened species on this leasehold land. These Directions were superseded by a land management agreement.

The site is habitat for the Grassland Earless Dragon. The ACT Government, the Department of Defence and the Department of the Environment, Water, Heritage and the Arts (formerly Department of the Environment) signed a memorandum of understanding on 7 September 1998.

Current Threatening Process: Approaching a critical (**AC**) threshold in terms of weed invasion (Serrated Tussock, Chilean Needlegrass, thistles, St John's Wort).

Action: Undertake weed control. Review and update existing memorandum of understanding and ensure it is implemented.

Harman Bonshaw North (JE07)

Conservation Category 1: Core Conservation Site.

Size: 114.6 hectares lowland native grassland (46.3 hectares Natural Temperate Grassland) that is contiguous with Harman Bonshaw South and the proposed East Jerrabomberra Nature Reserve.

Comments: National and Territory Land. The site is habitat for the Grassland Earless Dragon and the Button Wrinklewort. In 2004 the Conservator of Flora and Fauna has placed Conservator's Directions over part of the site under section 60 of the *Nature Conservation Act 1980* (ACT) for the protection of grassland sites and threatened species on this leasehold land. These Directions were superseded by a land management agreement. The ACT Government, the Department of Defence and the Department of the Environment, Water, Heritage and the Arts (formerly Department of the Environment) signed a memorandum of understanding on 7 September 1998.

Current Threatening Process: Approaching a critical (**AC**) threshold from weeds.

Action: Undertake weed control. Review and update existing memorandum of understanding and ensure it is implemented.

'Cookanalla' (JE08)

Conservation Category 2: Complementary Conservation Site.

Size: 81.5 hectares native pasture that forms a wildlife corridor (particularly important for the Grassland Earless Dragon) with Harman-Bonshaw and further south and east to Tharwa Road.

Comments: Territory Land. The site is habitat for the Grassland Earless Dragon. In 2004 the Conservator of Flora and Fauna has placed Conservator's Directions over part of the site under section 60 of the *Nature Conservation Act 1980* (ACT) for the protection of grassland sites and threatened species on this leasehold land. These Directions were superseded by a land management agreement, which is due for review by August 2009.

Current Threatening Process: Approaching a critical (**AC**) threshold from abundant weeds and thistles that occur densely over the site and a population of Boxthorn is located on the hill. The thistles are symptomatic of persistent high grazing pressure from sheep and rabbits.

Action: Reduce grazing pressure and undertake weed control. Enforce conditions in the Land Management Agreement.

AMTECH (JE09)

Conservation Category 2: Complementary Conservation Site.

Size: 18 hectares Natural Temperate Grassland within a larger area of lowland native grassland and modified grassland. Before the extension of Hindmarsh Drive the site was contiguous with 'Cookanalla' (JE08), but it is now isolated.

Comments: Territory Land. This grassland site is within the Advanced Manufacturing Technology Estate. The western end of the estate was developed in 1993. The Grassland Earless Dragon was formerly found on the site, but a survey in 2007–08 failed to locate any animals.[131] The loss of the Grassland Earless Dragon population may be a result of ongoing drought conditions, as the habitat characteristics remain suitable for the species.[132] The prospect of the area being re-populated naturally under better conditions is not favourable due to the likely barrier effect of Hindmarsh Drive. The site is grazed under licence as required for control of biomass to a level suitable for the Grassland Earless Dragon.

Current Threatening Process: This site is in good (**G**) condition. It is questionable as to whether this site is appropriately classified as its ecological values may have changed.

Action: Prioritise site for reassessment for the Grassland Earless Dragon and vegetation when seasonal conditions improve. Resolve future use of the site.

Tennant Street, Fyshwick (JE10)

Conservation Category 2: Complementary Conservation Site.

Size: 0.3 hectares Natural Temperate Grassland within a matrix of disturbed lowland native grassland that is contiguous with Molonglo River, which contains primarily exotic vegetation.

Comments: Territory Land. The site contains a population of Button Wrinklewort. The site has been identified for retention within a corridor linking Tennant Street and Molonglo River, if the remainder of the site is developed.

Current Threatening Process: This site is in good (**G**) condition. Weeds (Serrated Tussock, Sweet Briar and Barley Grass) are at moderate densities at the site. Grazing from rabbits and kangaroos is a problem but the site is not approaching any critical thresholds.

Action: Ensure site is managed for conservation values within its future use as a low-key recreation area.

Gungahlin

Mulanggari Nature Reserve (GU01)

Conservation Category 1: Core Conservation Site.

Size: 68.5 hectares lowland native grassland (58.6 hectares Natural Temperate Grassland) isolated by roads and urban development.

Comments: Territory Land. The site contains populations of Golden Sun Moth, Perunga Grasshopper and Striped Legless Lizard. Management is guided by a management actions spreadsheet; no current management problems.

Current Threatening Process: Nil. This site is in good (**G**) condition.

Action: Monitor canopy cover and undertake routine weed control. Monitor kangaroo population.

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[131] David Hogg Pty Ltd, Eastern Broadacre Planning Study, Assessment of Ecological Opportunities and Constraints, June 2008.

[132] David Hogg Pty Ltd, Eastern Broadacre Planning Study, Assessment of Ecological Opportunities and Constraints, June 2008.

Gungaderra Nature Reserve (GU02)

Conservation Category 1: Core Conservation Site.

Size: 187.3 hectares lowland native grassland (42 hectares Natural Temperate Grassland) contiguous with Yellow Box–Red Gum Grassy Woodland and forest (Gungahlin Hill), and a small degraded patch of Snow Gum–Candlebark Tablelands Woodland within the reserve.

Comments: Territory Land with populations of Striped Legless Lizard, Keys Matchstick Grasshopper (*Keyacris scurra*) and Perunga Grasshopper. Broadcast Australia has a 99-year lease over about 21 hectares in the Reserve and Print Handicapped Radio of the ACT has a 99-year lease over about 5 hectares. Grazing by livestock occurs under an agistment licence over the site for conservation purposes, guided by a management actions spreadsheet. Under a cooperative arrangement Parks Conservation and Lands also manages the lowland native grassland in the two leases in the same way. Broadcast Australia is implementing good conservation practices, including washing of mowers used to reduce grass growth on the boundaries to minimise weed spread. The perimeter fences around the Broadcast Australia site enclose about 25 kangaroos; the fence has been opened on several occasions to remove the kangaroos. Chilean Needle Grass is widespread adjacent to the buildings, and is in danger of spreading within the grassland.

Current Threatening Process: Nil. This site is in good (**G**) condition.

Action: Monitor canopy cover and undertake routine weed control.

Crace Nature Reserve (GU03)

Conservation Category 1: Core Conservation Site.

Size: 136 hectares lowland native grassland (61.5 hectares Natural Temperate Grassland endangered ecological community) isolated by roads and urban development.

Comments: This is National and Territory Land; there is a rural lease over 30 hectares of the reserve. The site contains Striped Legless Lizard and Button Wrinklewort. Grazing by livestock occurs under an agistment licence over the entire site for conservation purposes, in accordance with a management actions spreadsheet.

The site includes 50 hectares of Commonwealth land used by the Department of Defence. Defence is currently in discussions with the ACT Government about selling the Commonwealth land; it is programmed for disposal in 2008–09.

This site is subject to a memorandum of understanding, a rural lease, and an agistment licence. The ACT Government, the Department of Defence and the Department of the Environment, Water, Heritage and the Arts (formerly the Department of the Environment) signed the memorandum of understanding on 7 September 1998. The rural Land Management Agreement attached to the lease is older than five years and therefore overdue for review. The agistment licence provides for grazing to be undertaken for conservation purposes only, in compliance with licence conditions.

Current Threatening Process: At a critical (**C**) threshold from overgrazing by kangaroos, rabbits and cattle, and from weed invasion. The site contains a high component of Chilean Needle Grass. A rabbit control program was recently implemented.

Action: Reduce grazing pressure by kangaroos, rabbits and cattle. Review the existing memorandum of understanding and ensure it is implemented. Review the Land Management Agreement conditions for the leased portion of the site to incorporate conditions to protect the lowland native grassland.

North Mitchell (GU04)

Conservation Category 2: Complementary Conservation Site.

Size: 16 hectares (14.8 hectares Natural Temperate Grassland) recently isolated site.

Comments: This Territory Land contains a grassland site that supports the vulnerable Striped Legless Lizard. No site-specific requirements are in place for managing this site.

Current Threatening Process: Nil. This site is in good (**G**) condition.

Action: Monitor canopy cover and undertake routine weed control.

Mitchell (GU05)

Conservation Category 3: Landscape and Urban Site.

Size: 1.6 hectares Natural Temperate Grassland, adjacent to a small degraded patch of native pasture, otherwise enclosed by industrial sites within Mitchell.

Comments: This Territory Land, located in the General Industrial zone, contains a grassland site supporting the endangered Golden Sun Moth. The zoning is not compatible with the protection and survival of the Natural Temperate Grassland and the Golden Sun Moth. A decision needs to be made as to whether this site is to be retained, and therefore zoned differently. No site-specific requirements are in place for managing this grassland site.

Current Threatening Process: This site is in good (**G**) condition.

Action: Monitor.

Canberra Riding Club (GU06)

Conservation Category 3: Landscape and Urban Site.

Size: 0.3 hectares degraded Natural Temperate Grassland within a lease of 13.9 hectares.

Comments: Territory Land. The Canberra Riding Club's lease of 13.92 hectares includes 0.3 of a hectare of Natural Temperate Grassland. This grassland site has a botanical significance rating of 4 (the lowest rating for Natural Temperate Grassland), contains no threatened species and is in the lowest conservation category. It is small and isolated from other grassland sites.

Current Threatening Process: Approaching a critical (**AC**) threshold from overgrazing by horses.

Action: Prioritise site for reassessment as its ecological value may have changed.

Wells Station Road (GU07)

Conservation Category 3: Landscape and Urban Site.

Size: 0.2 hectares Natural Temperate Grassland along the old gravel track leading to Wells Station. The surrounding area is identified for residential development.

Comments: Territory Land.

Current Threatening Process: Approaching a critical (**AC**) threshold from weeds including Plantago, African Lovegrass, Chilean Needle Grass and Paspalum, which are in high densities and outcompeting the native plant species.

Action: Prioritise site for reassessment as its ecological value may have changed.

Nicholls (GU08)

Conservation Category 3: Landscape and Urban Site.

Size: 0.3 hectares Natural Temperate Grassland within primarily Phalaris-dominated grassland next to Ginninderra Creek.

Comments: Territory Land.

Current Threatening Process: Approaching a critical (**AC**) threshold from weeds invasion by St John's Wort, Chilean Needle Grass, Paspalum and Phalaris.

Action: Prioritise site for reassessment as its ecological value may have changed.

Belconnen

Ginninderra Experimental Station (BE01)

Conservation Category 2: Complementary Conservation Site.

Size: 19.4 hectares (18.9 hectares Natural Temperate Grassland) contiguous with other areas of native pasture and exotic vegetation.

Comments: This National Land is subject to a memorandum of understanding with the ACT Government, the Australian Government Department of the Environment, Water, Heritage and the Arts and the CSIRO. There was no evidence that the memorandum of understanding was implemented over the past years, however, staff advise that the agencies are cooperating.

Maintenance of lowland native grassland involves minor weed control and ensuring that no stock is permitted on that part of the property when the grass is in seed, as agreed at on-site meetings with the ACT Government.

Current Threatening Process: At critical (**C**) threshold due to grazing pressure by kangaroos.

Action: Reduce the grazing pressure from kangaroos. Review and update the existing memorandum of understanding and ensure it is implemented.

Dunlop Nature Reserve (BE02)

Conservation Category 1: Core Conservation Site.

Size: 120 hectares (82 hectares Natural Temperate Grassland) contiguous with other areas of native pasture, exotic vegetation and Yellow Box–Red Gum Grassy Woodland.

Comments: This is Territory Land and an agistment licence permits grazing by livestock for conservation management purposes and fuel control in accordance with the site management actions spreadsheet. This site is a high priority for fuel mitigation for neighbouring suburbs, so there is a need to balance grazing and fuel loading.

Current Threatening Process: At a critical (**C**) threshold from overgrazing by kangaroos, sheep and rabbits.

Action: Reduce the grazing pressure. Review licence conditions to incorporate conditions that protect these grassland sites.

'Jarramlee' (BE03)

Conservation Category 2: Complementary Conservation Site.

Size: 52 hectares Natural Temperate Grassland contiguous with other areas of native pasture and exotic vegetation.

Comments: Territory Land.

Current Threatening Process: At a critical (**C**) threshold from overgrazing by rabbits, kangaroos and stock.

Action: Reduce grazing pressure.

Umbagong Park South, Florey (BE04(a))

Conservation Category 1: Core Conservation Site.

Size: 2.8 hectares Natural Temperate Grassland contiguous with other areas of native pasture and exotic vegetation, including Umbagong Park North, Florey (BE04(b)).

Comments: This Territory Land has a high diversity of native species. Successfully burned previously, the site has a low weed infestation, with exception of Chilean Needle Grass and African Love Grass on the boundaries.

Current Threatening Process: Approaching a critical (**AC**) threshold from African Lovegrass along the bicycle path and high biomass of Kangaroo Grass.

Action: Reduce canopy cover and consider for inclusion in an ecological burn program.

Umbagong Park North, Florey (BE04(b))

Conservation Category 1: Core Conservation Site.

Size: 12 hectares (6 hectares Natural Temperate Grassland) contiguous with other areas of native pasture and exotic vegetation including Umbagong Park South, Florey (BE04(a)).

Comments: This Territory Land is a low priority site, as it comprises small isolated patches of Natural Temperate Grassland.

Current Threatening Process: Approaching a critical (**AC**) threshold from Chilean Needle Grass and overgrowth of Kangaroo Grass.

Action: Reduce canopy cover, consider for inclusion in an ecological burn program and prevent further incursion of Chilean Needle Grass.

Evatt Powerlines (BE05)

Conservation Category 3: Landscape and Urban Site.

Size: 1.1 hectares Natural Temperate Grassland with other areas of native pasture and exotic vegetation.

Comments: This small area of Territory Land is an ungrazed site that has a high level of usage. Previously part burned. North Belconnen Landcare Group is undertaking a trial for treatment of Chilean Needle Grass.

Current Threatening Process: This site is in good (**G**) condition; there is minor weed invasion from Phalaris and Chilean Needle Grass.

Action: Reduce canopy cover, consider for inclusion in an ecological burn program and prevent further invasion of Chilean Needle Grass.

Lake Ginninderra (BE06)

Conservation Category 2: Complementary Conservation Site.

Size: 1.9 hectares Natural Temperate Grassland, isolated site.

Comments: Territory Land. One small area of Wallaby Grass-dominated grassland by the bicycle path supports a population of Golden Sun Moth. This area is mown. The rest of the grassland has been previously burned.

Current Threatening Process: This site is in good (**G**) condition. Some physical disturbance in the form of erosion associated with an informal track from the bicycle path to the top of the hill.

Action: Prevent access to the informal track and revegetate.

Lawson Territory (BE07)

Conservation Category 3: Landscape and Urban Site.

Size: 59.2 hectares lowland native grassland (3.3 hectares Natural Temperate Grassland) contiguous with the Belconnen Naval Transmission Station.

Comments: This Territory Land is the only grassland site that is in a residential zone identified for development. The site is grazed under an agistment licence and is habitat for the Golden Sun Moth.

Current Threatening Process: Approaching a critical (**AC**) threshold from weed invasion from Serrated Tussock and thistles and overgrazing from stock.

Action: Control weeds along the northern boundary so they do not adversely affect Lawson Commonwealth – Belconnen Naval Transmission Station (BE08(a)). While overgrazed it is not recommended that this be addressed as the land is to be redeveloped for residential purposes. In future planning, ensure a sufficient buffer between the reserve and the suburb to support long-term survival of the Golden Sun Moth.

Lawson Commonwealth – Belconnen Naval Transmission Station (BE08(a))

Conservation Category 1: Core Conservation Site.

Size: 94 hectares Natural Temperate Grassland, contiguous with Lawson Territory (BE07).

Comments: This National Land is subject to a memorandum of understanding between the ACT Government, the Australian Government Department of the Environment, Water, Heritage and the Arts and the Department of Defence. The site is enclosed by a high-security fence and consists of grassland supporting populations of Golden Sun Moth, Ginninderra Peppercress and the Perunga Grasshopper. The Commissioner, in a separate report,[133] made recommendations for this site (*see* Appendixes 1 and 2).

Current Threatening Process: At a critical (**C**) threshold from overgrazing by kangaroos.

Action: Implement the Commissioner's recommendations for this site.

Lawson Commonwealth – East (BE08(b))

Conservation Category 1: Core Conservation Site.

Size: 26.3 hectares Natural Temperate Grassland.

Comments: This National Land is to the east of the fenced transmitting station, adjacent to Baldwin Drive. This grassland supports a population of the Striped Legless Lizard. The site is subject to a memorandum of understanding between the ACT Government, the Australian Government Department of the Environment, Water, Heritage and the Arts, and the Department of Defence. The boundaries of the grassland area were unclear.

Current Threatening Process: Nil. This site is in good (**G**) condition.

Action: Given the overall context of this site, it seems to lend itself to a land use that integrates conservation values with development. An offset should be required if areas of grassland are developed.

Kaleen East Paddocks (BE09)

Conservation Category 3: Landscape and Urban Site.

Size: 28.2 hectares lowland native grassland (including 4 hectares Natural Temperate Grassland) contiguous with other areas of degraded native pasture and exotic vegetation.

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[133] Dr Maxine Cooper, 26 February 2008, *Report on Belconnen Naval Transmission Station Site as part of the Investigations into ACT Lowland Grasslands*, Commissioner for Sustainability and the Environment (*see* Appendix 1).

Comments: This Territory Land is a grassland site that is part of a horse holding paddock, and is fenced off separately. Site management is governed by a contract between the Territory and Capital Weed Control Pty Limited. Under the contract Capital Weed Control provides services for complete management of the paddock, which includes:

- sustainable agricultural management including protection of areas of significant conservation values, as identified by the Territory
- weed and pest control.

The contract provides that the Territory measure Capital Weed Control's performance against, among other things, the extent to which management of areas identified as being of significant conservation value are maintained in accordance with management plans developed by Parks Conservation and Lands. Capital Weed Control, in consultation with Parks Conservation and Lands, prepared a site-specific management statement for this site.

An integrated land management issue was evident at this site. While weed growth was carefully controlled in the horse paddock, in the abutting roadside one of the main sources of weeds was an exceptionally large Firethorn bush that is clearly the source of this weed in the horse paddock. Parks Conservation and Lands was notified and subsequently treated the bush.

Current Threatening Process: Nil. This site is in good (**G**) condition; there are minor weeds including Serrated Tussock and woody shrubs.

Action: Control weeds maintain optimal canopy cover. Foster integrated land management practices across the various areas within Parks Conservation and Lands. Prioritise for reassessment of the site's ecological values as they were not obvious at the time of inspection.

Caswell Drive (BE10)

Conservation Category 1: Core Conservation Site.

Size: 4.8 hectares of Natural Temperate Grassland contiguous with other areas of native pasture, Snow-Gum Woodland, Yellow Box–Red Gum Grassy Woodland and forest.

Comments: This small site, located between Caswell Drive and William Hovell Drive, is contiguous with the Aranda Bushland. Kangaroos are a major issue on the site. As a result, this is a hotspot for motor vehicle accidents involving kangaroos.

Current Threatening Process: At a critical (**C**) threshold from overgrazing by kangaroos.

Action: Reduce the number of kangaroos and control rabbits. Given the size and location of this site it may be necessary to reduce the number of kangaroos on land in the vicinity, rather than concentrating only on this site.

Glenloch Interchange (BE11)

Conservation Category 1: Core Conservation Site.

Size: 2.2 hectares of Natural Temperate Grassland site that contains a small remnant Snow Gum–Candlebark Tableland Woodland, otherwise isolated by roads.

Comments: This small site is benefiting from the new road as it is isolated from Black Mountain and Aranda Bushland and therefore currently protected from high grazing pressure from kangaroos.

Current Threatening Process: Nil. This site is in good (**G**) condition.

Action: Monitor for increases in canopy cover and weed invasion; consider for inclusion in an ecological burn program.

Kama South (BE12)

Conservation Category 1: Core Conservation Site.

Size: 38.5 hectares Natural Temperate Grassland endangered ecological community, contiguous with areas of Yellow Box–Red Gum Grassy Woodland.

Comments: This is a recently identified site and is proposed for reservation. The Molonglo Valley has not previously been identified as an area that supported natural grassland, but recent investigations have found that before European settlement such grassland would have occurred extensively along the southern side of the river. Only 38.5 hectares remains of a much larger area that would have been present before European settlement. There are isolated weedy areas of Serrated Tussock, thistles and St John's Wort. It is currently used as an agistment area, with grazing being undertaken for conservation purposes only.

Current Threatening Process: Nil. This site is in good (**G**) condition.

Action: Monitor for increases in canopy cover and weed invasion; consider for inclusion in an ecological burn program.

Evatt Footbridge

Conservation Category: Yet to be assessed – included following a submission from the North Belconnen Landcare Group.

Size: less than 1 hectare, contiguous with other areas of native pasture and exotic vegetation.

Comments: This site has been fenced off to exclude it from mowing and is weeded and 'managed' by the North Belconnen Landcare Group.

Current Threatening Process: Nil.

Action: Assess site for inclusion as a lowland native grassland site.

Central Canberra/Tuggeranong

CSIRO Headquarters (CC01)

Conservation Category 2: Complementary Conservation Site.

Size: 3 hectares Natural Temperate Grassland, isolated from other patches of native grassland.

Comments: This grassland site includes both National and Territory Land. The grassland site contains the endangered Golden Sun Moth. The National Land is managed by the

CSIRO and there is a memorandum of understanding between the ACT Government, the Australian Government Department of the Environment, Water, Heritage and the Arts and the CSIRO, which was signed on 7 September 1998.

A management plan, prepared by CSIRO, ensures no mowing occurs within the grassland area. Kangaroos are migrating from Mount Ainslie so are difficult to control.

Current Threatening Process: At a critical (**C**) threshold from overgrazing by kangaroos. The steep slope predisposes this site to active and serious soil erosion, especially from the informal pedestrian and vehicular tracks that cross the site.

Action: While there is a need to reduce grazing pressure by kangaroos, given the urban context, this is likely to be best achieved by reducing numbers strategically across the region. There is also a need to control pedestrian and vehicular access to prevent erosion. Review existing memorandum of understanding and ensure it is implemented.

Constitution Avenue, Reid (CC02)

Conservation Category 2: Complementary Conservation Site.

Size: 0.7 hectares Natural Temperate Grassland contiguous with other areas of exotic grassland.

Comments: The grassland site is vacant unleased Territory Land; the entire site is a Designated Area and contains the endangered Golden Sun Moth.

Current Threatening Process: Approaching a critical (**AC**) threshold from high grass cover. Chilean Needle Grass surrounds the area of Natural Temperate Grassland but a physical mulch barrier is impeding invasion into the grassland.

Action: Consider for inclusion in an ecological burn program.

St John's Church, Reid (CC03)

Conservation Category 2: Complementary Conservation Site.

Size: 0.9 hectares Natural Temperate Grassland, isolated.

Comments: This very small site provides habitat for the Golden Sun Moth. The church community is actively trying to protect the grassland and Golden Sun Moth. They propose to erect interpretative signage about the grassland.

Current Threatening Process: Nil. This site is in good (**G**) condition; there is some minor weed invasion by Chilean Needle Grass, Paspalum and African Lovegrass and extension of a car park.

Action: Parks Conservation and Lands help the lessee prepare a long-term conservation management strategy to guide implementation of conservation management strategy.

Australia Centre for Christianity and Culture, Barton (CC04)

Conservation Category 1: Core Conservation Site.

Size: 1.9 hectares Natural Temperate Grassland, isolated.

Comments: This site covers National and some Territory Land and has a botanical significance rating of 1 (the highest and only site in Canberra with this rating), and provides habitat for the Button Wrinklewort and Golden Sun Moth. This site consists of two leases occupied by the Australian Centre for Christianity and Culture and St Mark's National Theological Centre. Both leases require development of a conservation management plan to protect the Natural Temperate Grassland. Parks Conservation and Lands, in consultation with the lessees, has developed a draft Conservation Management Plan and Specifications for the site.[134]

Current Threatening Process: Approaching a critical (**AC**) threshold from canopy closure and associated loss of forbs.

Action: Undertake ecological burn in 2009 (the site is scheduled in the Bushfire Operational Plan 2008–09 for a conservation burn in autumn 2009). Develop a memorandum of understanding for the National component of this site and ensure it is implemented. The lessee should finalise the draft Conservation Management Plan and Specifications in consultation with the Department of Territory and Municipal Services and the National Capital Authority.

York Park, Barton (CC05)

Conservation Category 2: Complementary Conservation Site.

Size: 0.4 hectares of Natural Temperate Grassland, isolated.

Comments: This site is National Land managed by the Australian Government Department of Finance. The grassland site contains a population of Golden Sun Moth. The Department of Finance has a draft maintenance plan dated December 2007 that deals with weed management, biomass management and other associated matters relating to the site. (The National Capital Authority managed the site previously, and was subject to a memorandum of understanding with the ACT Government. Weeds are being actively managed.)

Current Threatening Process: Approaching a critical (**AC**) threshold from weed invasion, including Chilean Needle Grass, Prickly Lettuce, Plantago, Paspalum, Brome Grass and Cocksfoot.

Action: As this is one of few remaining Natural Temperate Grassland sites within urban Canberra, ensure the site is retained and maintains its ecological integrity in future development planning. Review and update existing memorandum of understanding and ensure it is implemented.

Yarramundi Reach (CC06)

Conservation Category 2: Complementary Conservation Site.

Size: 21.1 hectares of Natural Temperate Grassland contiguous with other areas of primarily exotic vegetation.

Comments: This site is National Land and provides habitat for the Golden Sun Moth and the Striped Legless Lizard. In the 1980s it was recognised as one of the most diverse and

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[134] Pers. comm., Sarah Sharp, Parks Conservation and Lands.

'important' grasslands in the Territory, but has become increasingly invaded by weeds, particularly Chilean Needle Grass, significantly reducing the area of Natural Temperate Grassland remaining. Most of the site was burnt in December 2001 in a wildfire. The ACT Government, the Australian Government Department of the Environment, Water, Heritage and the Arts and the National Capital Authority signed a memorandum of understanding on 7 September 1998.

Current Threatening Process: Approaching a critical (**AC**) threshold from weeds, especially Chilean Needle Grass actively spreading over much of the site, and along the lower bicycle path verges.

Action: Control invasions of weeds and consider including in an ecological burn program. Review existing memorandum of understanding and ensure it is implemented.

Lady Denman Drive (CC07)

Conservation Category 2: Complementary Conservation Site.

Size: Several patches of grassland, totalling 0.4 hectares Natural Temperate Grassland within a roadside of primarily exotic vegetation.

Comments: This site is part National Land and provides habitat for the Golden Sun Moth. The ACT Government, the Australian Government Department of the Environment, Water, Heritage and the Arts and the National Capital Authority signed a memorandum of understanding 7 September 1998.

Current Threatening Process: Approaching a critical (**AC**) threshold from too close and too frequent mowing and weed invasion, especially Chilean Needle Grass.

Action: Review mowing practices and control weeds. Review existing memorandum of understanding and ensure it is implemented.

Dudley Street, Yarralumla (CC08)

Conservation Category 2: Complementary Conservation Site.

Size: 2.2 hectares including 1.5 hectares Natural Temperate Grassland surrounded by weedy exotic grassland.

Comments: This Territory Land contains the Golden Sun Moth. The northern portion of the site is mown regularly; the southern portion is seldom mown, and occasionally burnt. Part of the site was burnt in spring 2008 to reduce overgrowth of Kangaroo Grass.

Current Threatening Process: Approaching a critical (**AC**) threshold from Chilean Needle Grass and mowing, which is too close and too frequent.

Action: Review mowing regime.

Guilfoyle Street, Yarralumla (CC09)

Conservation Category 2: Complementary Conservation Site.

Size: 0.8 hectares Natural Temperate Grassland within a 2-hectare site of disturbed native pasture.

Comments: This Territory Land contains a single Button Wrinklewort plant. The site is identified for potential development of an embassy.

Current Threatening Process: Approaching a critical (**AC**) threshold from close and frequent mowing, which is threatening survival of native grasses and forbs, preventing plant regeneration and spreading Chilean Needle Grass throughout the site.

Action: Modify mowing practices. Determine the long-term use of site and if developed ensure development occurs in a way that protects the grassland.

Novar Street, Yarralumla (CC10)

Conservation Category 3: Landscape and Urban Site.

Size: 0.2 hectares Natural Temperate Grassland surrounded by exotic/weedy grassland.

Comments: Territory Land.

Current Threatening Process: Approaching a critical (**AC**) threshold from the close and frequent mowing which is preventing plant regeneration of native grasses and forbs.

Action: Reassess site as its ecological value may have changed.

Black Street, Yarralumla (CC11)

Conservation Category 2: Complementary Conservation Sites.

Size: 3.6 hectares Natural Temperate Grassland surrounded by exotic/weedy grassland.

Comments: This Territory Land supports a population of the Golden Sun Moth. The site was recently mown, after a long period un-mown.

Current Threatening Process: Approaching a critical (**AC**) threshold from close mowing which will threaten survival of Kangaroo Grass and native forbs, preventing plant regeneration.

Action: Review mowing regime.

Isabella Pond, Monash (TU01)

Conservation Category 1: Core Conservation Site.

Size: 1.2 hectares Natural Temperate Grassland surrounded by exotic/weedy grassland.

Comments: This Territory Land contains the only remaining Natural Temperate Grassland site in the Tuggeranong Valley. The site has been previously burnt for ecological purposes, and was burnt in spring 2008 as part of the Bushfire Operational Plan 2008–09.[135]

Current Threatening Process: Nil. This site is in good (**G**) condition.

Action: Monitor canopy cover and species diversity.

[135] Pers. comm., Sarah Sharp, Parks Conservation and Lands.

Appendix 5: Media release

30 November 2007

MEDIA RELEASE

The ACT Commissioner for Sustainability and the Environment Dr Maxine Cooper today invited public submissions to an important investigation into the ACT's lowland native grasslands

'The ACT Lowland Native Grasslands Investigation is important examination of a significant environmental feature of our Territory. Accordingly, I invite and encourage members of the public, stakeholders and interested parties to make submissions,' Dr Cooper said

The Office of the Commissioner for Sustainability and the Environment is undertaking the investigation at the direction of Chief Minister and Minister for the Environment, Water and Climate Change, Jon Stanhope.

'ACT's lowland native grasslands are of regional and national significance and our current investigation will help inform efforts to appropriately monitor and protect them for future generations,' Dr Cooper said.

People who would like to make submissions should look at the Terms of Reference on the Commissioner's website at: http://www.envcomm.act.gov.au

Submissions relating to the Belconnen Defence site need to be lodged by close of business on Friday 14 December 2007.

All other Submissions should be lodged by close of business Friday 25 January 2008. All submissions will be made public unless otherwise requested in writing. Anyone who has already submitted information, should advise the Commissioners Office if they do not want that information to be made public.

For further information or questions about submissions or deadlines contact:

The Office of the Commissioner for Sustainability and the Environment
Phone: (02) 6207 2626
Fax: (02) 6207 2630
Email: EnvComm@act.gov.au
Post: PO Box 356 Dickson ACT 2602

Appendix 6: Advertisement

INVESTIGATION INTO ACT LOWLAND NATIVE GRASSLANDS

The ACT Commissioner for Sustainability and the Environment, Dr Maxine Cooper, is inviting public submissions to an important investigation into the Territory's Lowland Native Grasslands. The Office of the Commissioner for Sustainability and the Environment is undertaking the investigation at the direction of Chief Minister and Minister for the Environment, Water and Climate Change, Mr Jon Stanhope.

People who would like to make submissions should look at the Terms of Reference on the Commissioner's website at: http://www.envcomm.act.gov.au

Submissions relating to the Belconnen Defence site need to be lodged by close of business on Friday 14 December 2007. All other Submissions should be lodged by close of business Friday 25 January 2008. All submissions will be made public unless otherwise requested in writing. Anyone who has already submitted information should advise the Commissioner's Office if they do not want that information to be made public.

For further information or questions about submissions or deadlines contact:

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Phone: (02) 6207 2626
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Email: EnvComm@act.gov.au
Post: PO Box 356 Dickson ACT 2602

Appendix 7: Public submissions received

Philip Machin	4 November 2007
Arthur Georges	27 November 2007
Rosemary Blemings	28 November 2007 and 10 January 2009
Wildlife Carers Group	27 November, 5 December, 6 December 2007, 13 January 2009 and 14 January 2009
Australian Society for Kangaroos	13 December 2007 and 24 January 2008
Friends of Grasslands	29 October, 29 November, 3 December 2007 and 25 January 2008
Limestone Plains Group	8 October, 16 October and 14 December 2007
RSPCA ACT and RSPCA Australia	14 December 2007
Wildcare	14 December 2007 and 31 January 2008
Animal Liberation ACT	30 October 2007, 14 December 2007 and 21 January 2009
Frankie Seymour	14 December 2007
Ginninderra Catchment Group and Bush on the Boundary Reference Group	13 December 2007
ACT Rural Landholders Association	24 January 2008
Jean Geue	25 January 2008 and 14 January 2009
Neil Williams	22 February 2008
North Belconnen Landcare Group	12 January 2009
Parks Conservation and Lands	August 2008

Note:

All submissions, except that received from Wildcare, are publically available.

Appendix 8: Future proofing Natural Temperate Grasslands in urban and peri-urban Canberra, by Dr Kenneth C Hodgkinson, January 2009

Future-proofing Natural Temperate Grasslands in urban and peri-urban Canberra

January 2009

Report to:	**The Commissioner for Sustainability and the Environment, ACT**
Prepared by:	**Dr Kenneth C. Hodgkinson[1]**

[1] Curriculum Vitae is provided as Appendix 1

Terms of Reference

1. Review the:

   (a) Action Plan No 28 *A Vision Splendid of the Grassy Plains Extended* ACT Lowland Native Grassland Conservation Strategy;

   (b) the National Recovery Plan for Natural Temperate Grassland of the Southern Tablelands (New South Wales and ACT): An Endangered Ecological Community, January 2006; and

   (c) the ACT Nature Conservation Strategy;

   and advise whether any conservation management principles in addition to those set out in these documents are required to protect the natural temperate grassland of the ACT.

2. Inspect and take at least one photograph of each natural temperate grassland site in the ACT except for the Belconnen Naval Transmitting Station site.

3. Identify, through a visual inspection, those sites, if any, approaching a critical threshold beyond which unacceptable degradation will occur and identify the causes of the deterioration.

4. Review the existing management arrangements in relation to each grassland site and:

   (a) in relation to each site approaching a critical threshold beyond which unacceptable degradation will occur identify the actions needed to protect the natural temperate grassland on the site in the:

      (i) immediate to short-term; and

      (ii) long term.

   (b) in relation to all other grassland sites identify, for specific individual sites and/or a group of sites, any management changes that are needed to protect the natural temperate grassland on the site or sites in the:

      (i) short term; and

      (ii) long-term.

Introduction

Canberra is the Australian Bush Capital 'city in the country'. A random survey of Canberra residents (ACT Government 2002) showed the five common reasons why residents liked Canberra were; easy to move around, *wide open space/green*, *Bush capital*, fresh unpolluted air and *quiet and peaceful.* In the same survey, the five common concerns of residents about the future of Canberra were; community well-being, *environment*, movement and interaction, employment and education opportunities and *maintaining and enhancing unique sense of place* (aspects relating to nature are in italics).

These and other information from residents were built into one of the 13 guiding principles for the ACT Government in translating sustainability into practical action (ACT Government 2003):

Valuing and protecting ecological integrity and biodiversity: recognise that all life has intrinsic value and that ecological processes and biological diversity are part of the irreplaceable life support systems upon which a sustainable future depends.

Earlier, a strategy for nature conservation in the ACT was developed (ACT Government 1998). In broad terms, the need for reserving important natural areas in the ACT was established, the importance of complementary off-reserve systems was recognised, the task of restoring species and plant communities threatened with extinction was understood, the need to monitor biodiversity was seen to be critical for management and reporting, the threats to biodiversity in the ACT were identified to be pest animals, environmental weeds, changed fire regimes, degradation of aquatic systems and the clearing of natural vegetation, and finally the imperative to involve the community in nature conservation was stated clearly. This foundation document adequately brought together the best-practice that had emerged from Australia's ecological research. The document is comprehensive; it has not been weakened by subsequent scientific theories or research. The strategy does not require revision at this time and can be used with confidence into the near future.

In the following seven years, programs to implement the strategy were developed, including a strategy for conservation of the ecological community recognised as Natural Temperate Grassland (Environment ACT 2005). The strategy was built on the knowledge derived by ecological survey, that before European settlement this grassland occupied 11% of the ACT and that today 1 % of the ACT contains this community and that much of this remaining grassland is degraded and continually threatened by human activity and exotic species. The strategy for conservation of this threatened grassland ecosystem is comprehensive and based on all the scientific knowledge available at the time. In the strategy, remnant sites of the Natural Temperate Grasslands are categorised and appropriate managements outlined. Category 1 sites are core conservation sites because they are of high botanical significance or they are habitat for key threatened species or they are large sites of moderate botanical significance. Category 2 sites are complementary conservation sites of moderate botanical significance or threatened species habitat or medium area sites of high botanical significance. Category 3 sites are landscape and urban sites of low to very low botanical significance or unlikely to support small populations of threatened species. In addition, two principles for general management of these grasslands, whatever their Conservation Category, are advocated; best practice and adaptive. Best practise management is extensively explored in the document but adaptive management is only outlined and as such is insufficient for implementation.

A national recovery plan for the Natural Temperate Grassland was published recently (ACT Government 2005). This detailed document outlines the process and resourcing required. The plan is visionary, practical and achievable.

Canberra was designed to allow people and nature (present as patches and corridors) to co-exist and interact. Australian nature is found in the natural grassland and woodland on urban and peri-urban land and to a lesser extent in the planted native and exotic vegetation of the Parks and Gardens on public land, along roads verges and in residential and business gardens. Most people value these natural and semi-natural areas and the nature they experience whilst motoring, cycling, walking, playing and sitting. People will widely differ in their description and appreciation of nature within the City. However the 2002 survey indicates there is a strong demand for a city of nature to be sustained.

The terrestrial ecosystems, on which Canberra is built, were not pristine at the commencement of the city. Aboriginal people, and in recent years farming and pastoral people, greatly modified the vegetation by fire management, grazing of domestic herbivores and vegetation clearing for farming. At European settlement, hills were wooded and the extensive valleys were grassed. These "valley" grasslands have been recognised to be part of the temperate grasslands of Australia (Pryor 1938). In south-eastern Australia, prior to settlement, there were 2 million ha of natural temperate grasslands. 99.5 per cent of these have now been destroyed or severely modified by clearing and agriculture (McDougall 1994). With such extensive modification, natural temperate grassland is the most threatened natural plant community in Australia (Parsons 1994). Therefore an important task for managers of the grasslands is to maintain the ecological fabric of the high Conservation Category sites (1 and 2) and rehabilitate grassland sites to restore their ecological value for the enjoyment and satisfaction of people living amongst the patches and corridors of grasslands and linked wooded grasslands.

There were 20,000 ha of Natural Temperate Grassland in the ACT at European settlement (S. Sharp unpublished data). Field surveys undertaken for the ACT Government between 1991 and 1996 revealed this once extensive grassland within the ACT to be highly fragmented and now greatly reduced in area. The Natural Temperate Grassland is now confined to 38 small and isolated patches. About 1000 ha of these patches are in a more or less natural condition and a further 550 ha are in poorer condition. The patches or sites of Natural Temperate Grassland are embedded in highly degraded grasslands dominated by weeds (plant species of exotic origin or native species not natural to the area). These isolated patches range in size from <1 ha to 300 ha. In 1996 the Natural Temperate Grassland in the ACT was declared endangered and an action plan was developed to conserve the remnants (Action Plan 1997). The scientific literature relevant to the ecology and management of native and weedy grasslands in urban Canberra was reviewed and management recommendations drawn in a report to the ACT Government (Hodgkinson 2005).

The urban grassland ecosystem (Natural Temperate Grassland patches within a predominant matrix of degraded grasslands) comprise many unique plant and animal species; grasses, forbs, shrubs, trees, vertebrate animals and invertebrate animals. Responses to human activity of the populations of each species have been variable; some have increased in population size, while others have decreased (Dorrough 1995) or been unaffected. It will take some time to fully document and monitor these changes. Six species of the Natural Temperate Grassland ecosystem have been declared endangered or vulnerable in the ACT; Striped Legless Lizard (*Dema impar*), Grassland Earless Dragon (*Tympanocryptis pinguicolla*)[2], Golden Sun Moth (*Synemon plana*), Perunga Grasshopper (*Perunga ochracea*), Button Wrinklewort (*Rutidosis leptorrhynchoides*) and Ginninderra Peppercress (*Lepidium ginninderrense*). The Action Plan Number 28 (Environment ACT 2005) details the management and strategies required to conserve viable populations of these endangered and vulnerable species in the Natural Temperate Grasslands of the ACT.

Given Natural Temperate Grassland is the most endangered ecosystem in Australia and given that four animal and two plant species of this ecosystem are endangered or vulnerable in the ACT, it is appropriate to review the management of these lands from time to time. The now fragmented remnant grassland ecosystems, although small, has the potential of higher ecological function and extent to meet the conservation goals set by the ACT Government in 1998.

In many capital cities around the world, Governments are striving for more effective retention of nature in the urban environment and there is considerable intellectual attention given to the issues involved, see (Pickett 2001). Given the views of Canberra residents, the development of guiding principles for the ACT Government underpinning policy for sustainability in the ACT and knowledge that key floral and faunal components of the Natural Temperate Grassland ecosystems are now missing from much of urban and peri-urban Canberra, their retention and management is now of high and critical importance if Canberra is to remain the Bush Capital.

[2] When the name of a species first appears in the text both the common and the scientific names are used. When each species is named again, only the common name is used.

Methods for determining critical thresholds

Many of the ecological processes within a grassland ecosystem are well buffered and are unresponsive to change in stress (grazing, drought, physical and other disturbances) levels until a critical threshold is crossed. Once the threshold has been crossed, the response can be sudden and severe and lead to a change in state or equilibrium in the ecosystem. Change to another state may be irreversible or very expensive to reverse by inputs and management.

The time and resources available for accurately determining what, if any, critical thresholds were being approached at each grassland site were limited. Subjective assessments based on the experience and perceptions of the author were used. The landscapes were 'read' for evidence of approaching critical thresholds. Drought prevailed during assessments and this was recognised for its importance in accentuating the effects of other stresses such as grazing (Hodgkinson *et al* 2000). The following visual methods were sequentially employed for each major stress.

Grazing

First, the species of herbivores present at each site were determined by direct observation, by the size and shape of dung scats and other knowledge, such as presence of active rabbit warrens and sometimes verbal and written information provided by managers.

Second, the level of current grazing was judged on the height of grasses, grass seed reproduction in the last growing season, inter-tussock spaces, the appearance of the soil surface and presence of current erosion. If maximum heights of grasses were commonly below 5 cm, if little or no grass seed production was occurring and there was soil erosion, the site was judged top be approaching a critical threshold beyond which plant survival and landscape function were being compromised. The area or combined total area deemed to be overgrazed needed to be of significant size and the overgrazing needed to be recent. There had to be more than one patch overgrazed in the area for this judgment to be made. The prevailing drought also was taken into account, given the strong interaction that occurs. When drought and grazing stresses combine there is synergy in the ecological response (Hodgkinson *et al* 2000, Hodgkinson 2005a and b).

Weed invasion

First, the weeds present were named.

Second, the area invaded by these weeds was subjectively judged. If weeds were becoming dominant at the site it was deemed to be approaching a critical threshold beyond which the density of weeds would compromise native plant survival and reproduction. This judgement was made with the understanding that weeds may remain at low densities for a long time but then irrupt because of changed climate and/or disturbance.

Mowing

First, the site was judged on whether it was being mowed regularly.

Second, if the grasses were mown below 10 cm, if no or little reproduction occurred this year, if there was a presence of Chilean Needle Grass (*Nassella neesiana*) and/or African Lovegrass (*Eragrostis curvula*) and if native species known to be sensitive to mowing were observed, the site was deemed to be approaching a critical threshold beyond which native species were compromised.

Fire

First, the degree of canopy closure was visually assessed.

Second, if the canopy was generally closed then the site was judged to be approaching a critical threshold beyond which lack of fire to open the canopy inhibits reproduction and establishment of forbs. An additional reason for burning sites is that all Australian grasslands have evolved with the occurrence of fire for millennia and the plant communities and all species are adapted to fire. This means that all the sites should be burnt every 5 to 10 years to sustain populations of all species. Grazing does not substitute for environmental fires because fire only occurs when the foliage is mostly dead leaves and when the climatic conditions are conducive to fire being carried. Grazing can occur at any time and condition of the foliage (generally grazing occurs when leaves are green and the plants actively growing. The need for environmental fires across all the sites is a matter for close attention and renewed manager commitment.

Physical disturbance

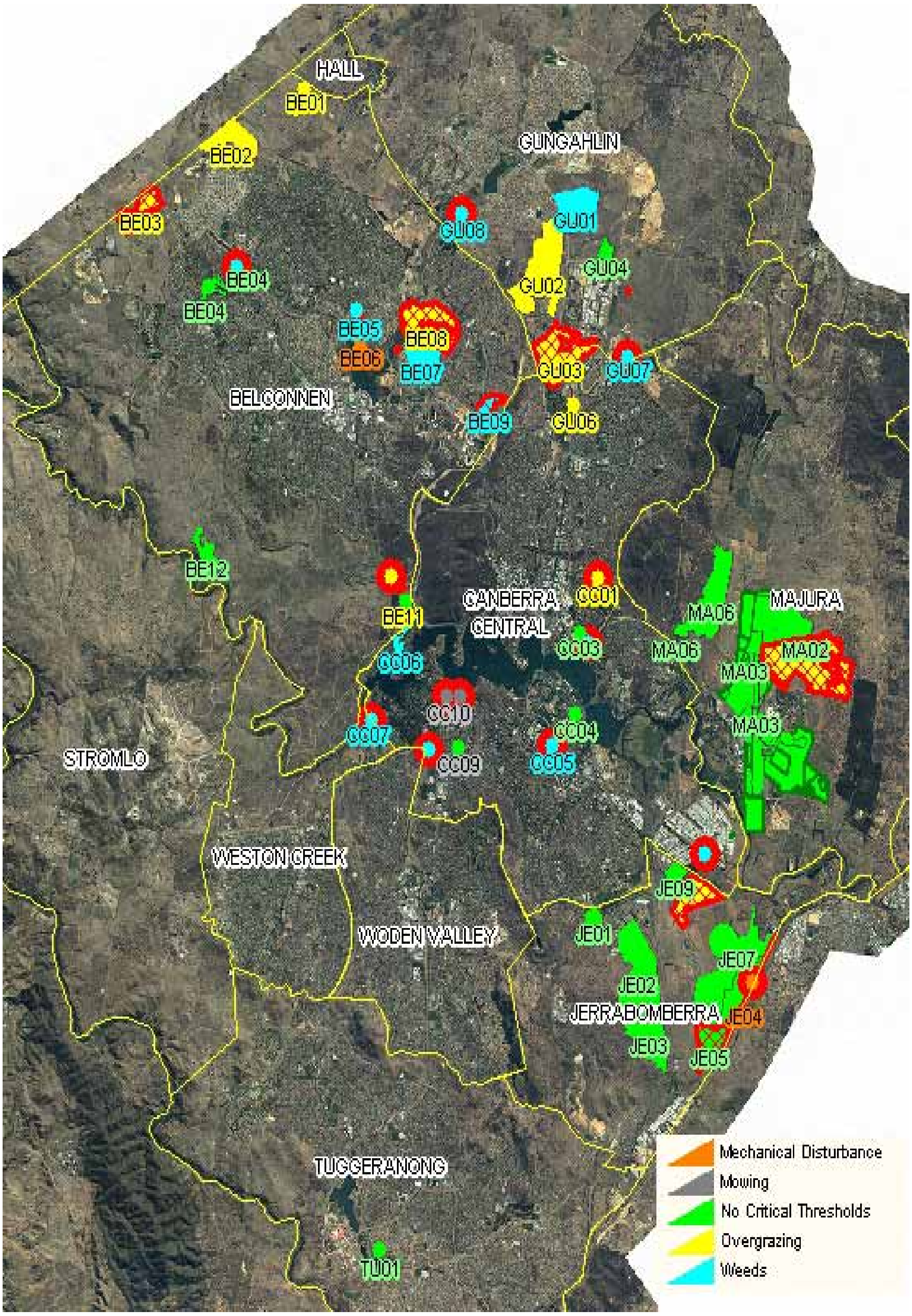
First, the presence of areas where earth had been moved or compacted was visually determined.

Second, if this disturbance was over a significant area within the site and continuing, a critical threshold was being approached beyond which native plant and animal species would be compromised.

Sites at critical thresholds

The sites where a critical threshold was judged to be approaching are listed in the following Table (page 8) and their location shown in the associated Figure (page 9). Note that some sites are listed twice under different threatening processes. Sites not approaching critical thresholds are not listed in the Table.

Threatening Process	Site Name and Code
GRAZING	**Ginninderra Exper'l Station (BE01)** **Dunlop Nature Reserve (BE02)** **'Jarremlee' (BE03)** **Lawson Territory (BE07)** **Caswell Drive (BE10)** **CSIRO Headquarters, (CC01)** **Crace Nature Reserve (GU03)** **Belconnen Pony Club (GU06)** **'Cookanalla' (JE08)** **'Malcolm Vale' (MA04)** **Majura West (MA06)** **Jerrabomberra East Reserve (JE05)**
WEED INVASION	**Umbagong Park North (BE04b)** **Evatt Power Line (BE05)** **Lawson Territory (BE07)** **Belconnen Navel (BE08)** **Kaleen East paddocks (BE09)** **CSIRO Headquarters (CC01)** **York Park, Barton (CC05)** **Lady Denman Drive Yarra. (CC07)** **Dudley Street, Yarralumla (CC08)** **Wells Station Road (GU07)** **Nicholls (GU08)** **Jerrabomberra West Reserve (JE03)** **'Cookanalla' (JE08)** **'Malcolm Vale' (MA04)**
MOWING	**Umbagong Park South (BE04)** **Yarralumla Reach (CC06)Novar Street** **Kintore Street, Yarralumla (CC09)** **Yarralumla (CC10)** **Black Street Yarralumla (CC11)**
PHYSICAL DISTURBANCE	**Lake Ginninderra (BE06)** **Woods Lane (JE04)**
FIRE EXCLUSION	**All Sites**



Satellite-based image showing the regions (outlined in yellow) of urban and peri-urban Canberra used in this report and the location and code of medium and large sites. Sites that are approaching a critical threshold are outlined in red and hatched where possible. The 'fill' colour denotes the threatening process. Sites where there were non-critical levels of the threatening processes are 'filled' with the colour green. Sites where a single threatening process was of concern but not critical are 'filled' with the colour for the threatening process.

Ginninderra Experimental Station (BE01)
Belconnen: National Land

General view of site with extensive areas of Kangaroo Grass (*Themeda triandra*) in the foreground on the "flat" portion of the landscape (image on 7 August 2008).

Close up of the closely grazed native grassland showing high levels of recent kangaroo dung and active soil erosion (image on 7 August 2008).

Site report: This medium site of 19.4 ha comprises 18.9 ha of Natural Temperate Grassland and 0.8 ha of Exotic Pasture. No threatened species are known to be at the site and the Conservation Category is 2. Weeds were not observed at the site probably because of committed investment in weed control and the practice of sustainable grazing management at the site. The site is only intermittently grazed by sheep. The flat portion of the landscape was heavily grazed by kangaroos. All Kangaroo Grass plants were grazed to 2 cm or lower; no seed appeared to be produced in 2008, the risk of accelerated mortality from drought-induced stress was raised and there was loss of landscape function evidenced by surface movement of soil, litter and probably seed in new but local erosion patches on steeper slopes. Portions of the area are approaching a critical threshold for landscape stability and maintenance of native grasses in the grassland. The cause is overgrazing by kangaroos. Sheep were removed two months earlier. The action needed in the short term is to substantially reduce the population of kangaroos at the site and on surrounding farms. Inspected 7 August 2008.

Management arrangements: A general "Biodiversity and Conservation Management Advise" document has been issued to CSIRO. A specific MOU and a MP should be jointly developed for formal agreement. The MP should state how all threatening processes are to be managed in the context of climate variability.

Dunlop Nature Reserve (BE02)
Belconnen: Territory Land

View of the general landscape near a water point in the paddock showing a large area of closely grazed Kangaroo Grass dominated grassland. Note ungrazed Yanganbil (*Austrostipa bigenticulata*).plants and eroding soil surface from prevailing drought coupled with local overgrazing, probably by sheep (image on 15 May 2008).

General landscape view, to the left of the above image, showing serious erosion around the top of a gully and lesser erosion in the foreground. (image on 15 May 2008).

Site report: This is a medium site of 81.9 ha of Natural Temperate Grassland. Populations of the threatened species of Golden Sun Moth are at the site and the Conservation Category is 1. Weeds (Serrated Tussock (*Nassella trichotoma*) and Thistles (various species) were in localised populations and they were adequately controlled. Sheep, kangaroos and rabbits grazed most of the site. A smaller area in the midst of the suburb was grazed by cattle and was stable. The sheep grazed portion was however overgrazed in parts. Here, all Kangaroo Grass plants were closely grazed to 2 cm height with the result that no seed was produced in 2008, the risk of accelerated mortality from drought-induced stress was raised and there was loss of landscape function evidenced by surface movement of soil, litter and probably seed, especially along sheep tracks. Portions of the area are approaching a critical threshold for landscape stability and maintenance of native grasses in the grassland. The cause is overgrazing by kangaroos, sheep and rabbits. The actions needed in the short term are to substantially reduce populations of kangaroos and rabbits at the site (and surrounding farms) and the number of sheep. Inspected 7 August 2008.

Management arrangements: The Agistment Licence forbids overgrazing and in an attachment to the Licence states that grazing should be undertaken when pasture species are in an active growing phase. At the time of inspection non-growing conditions prevailed because of drought but grazing by sheep continued.

'Jerramlee' (BE03)

Belconnen: Territory Land

View into paddock showing close grazing of the Kangaroo Grass plants in the grassland (image on 17 June 2008).

Close view of a sloped area where the close grazing is predisposing the landscape to erosion in patches and dysfunction (image on 17 June 2008).

Site report: This medium site of 52 ha is Natural Temperate Grassland. No threatened species are known at the site and the site and the Conservation Category is 2. Weeds (Serrated Tussock, Thistles, Sweet Briar (*Rosa rubiginosa*) and Phalaris (*Phalaris aquatica*)) were present but were adequately controlled. The site is grazed by cattle. Large portions were overgrazed by rabbits and kangaroos. Most Kangaroo Grass plants were closely grazed preventing reproduction by seed and substantially raising the risk of accelerated mortality from drought-induced stress. Surface soil movement is beginning on slopes. Portions of the area are approaching a critical threshold for landscape stability and maintenance of the native grassland. The cause is overgrazing by cattle, kangaroos and possibly rabbits. The action needed in the short term is to substantially reduce the population of kangaroos at the site and on surrounding farms and to review the licence terms for grazing domestic stock. Inspected 17 June 2008

Management arrangements: The Licence to Graze Stock, between the Territory and the 'licensee', was made on 12 February 2001 and specifically sets out the powers of the Operations Manager to direct grazing management and the control of pest animals and plants. This means that failure has occurred by both the 'licensee' and the Operations Manager.

Umbagong Park South, Florey (BE04a)

Belconnen: Territory Land

General view showing excellent cover grassland and erosion along an *ad hoc* track through the center of the grassland (image on 27 May 2008).

Site report: This small site of 2.8 ha of Natural Temperate Grassland is a high quality native grassland in the Conservation Category of 2. No threatened species are known at the site. There was African Lovegrass along the bike path presumably brought in by mowing equipment. The main portion of the site has been regularly weeded by Rob Cruickshank for many years. The critical threshold of losing forbs from the site because of the smothering effect of Kangaroo Grass is approaching. The actions needed are to burn the grassland, as well as the adjacent BE04b site, and to reduce erosion along the *ad hoc* track. Inspected 27 May 2008.

Management arrangements: The Management Plan is brief but directs that this grassland site should be burned every 2 to 3 years in autumn. I consider the frequency to be too high and should be lowered to 5 to 10 years. These environmental burns do not appear to be occurring.

Umbagong Park North, Florey (BE04b)
Belconnen: Territory Land

General view showing a portion of native grassland. Most of the grassland is weedy (image on 27 May 2008).

Site report: This medium site of 12.7 ha comprises 7.2 ha of Natural Temperate Grassland, 1.8 ha of Native Pasture and 4.7 ha of Exotic Pasture. No threatened species are known at the site and the Conservation Category is 3. Weeds are approaching a critical threshold at the site especially Chilean Needle Grass. Many of these were presumably brought in by mowing equipment. A critical threshold for losing forbs from the site because of the smothering effect of patches of Kangaroo Grass, is approaching. The actions needed in the longer term are to late autumn-burn the grassland, as well as the adjacent BE04a site, and to increase weed control measures. Inspected 27 May 2008.

Management arrangements: The Management Plan is brief and does not mention the need to burn the site. This change is desirable. It is recommended the Plans for BE04a&b be revisited and updated in the longer term.

Evatt Powerlines (BE05)

Belconnen: Territory Land

General view of site showing a bike path through the middle of the site (image on 27 May 2008).

View of a native and weedy portion of the grassland trial burnt in autumn 2008 (image on 27 May 2008).

Site report: This small site of 1.1 ha is Natural Temperate Grassland. No threatened species are known at the site and the Conservation Category is 3. Environmental weeds are abundant, especially Phalaris and Chilean Needle Grass. The site is not grazed by domestic animals but human activity is high. Demonstration trials are located at the site to demonstrate the effects of various managements prior to sowing native grasses and the effects of treating weedy grassland by fire and mowing regimes. These trials are the work of the North Belconnen Landcare Group within the Ginninderra Catchment Group. The action needed in the short term is to control weeds by spot spraying, especially the Chilean Needle Grass brought to the site by grass mowing equipment. Inspected 27 May 2008.

Management arrangements: The Management Plan is brief but states the site should not be mown and should be burnt in autumn every 2 to 3 years. Neither of these directed managements appear to be followed and weed management is not addressed. The fire frequency should be raised to 5 to 10 years.

Lake Ginninderra (BE06)

Belconnen: Territory Land

General view of grassland on a steep slope from Lake edge to hilltop 9image on 27 May 2008).

Site report: This small site of 1.9 ha comprises Natural Temperate Grassland. No threatened species are known at the site and the Conservation Category is 2. Weeds (mainly exotic grasses) were present but not abundant. A possible critical threshold is local erosion associated with an informal track from bike path to the top of the hill. It is not apparent what should be the appropriate action; no recommendation is made. Inspected 27 May 2008.

Management arrangements: There is no Management Plan for this site.

Lawson Territory (BE07)
Belconnen: Territory Land

General view from flatter land towards the hill showing creek bank erosion and invasion by Serrated Tussock (image on 26 July 2008).

Closer image of eroded stock paths and general erosion on the flatter portion of the site (image on 26 July 2008).

Site report: This medium site of 59.2 ha is a mixture of Natural Temperate Grassland (3.3 ha), Native Pasture (46.9 ha) and Exotic Pasture (9.1 ha). No threatened species occur at the site and the site is placed in Conservation Category 3. Weeds (Serrated Tussock and Thistles) are abundant in places. The site is grazed by cattle and there is substantial erosion of creek banks and high use areas as a result of grazing. The actions needed in the short term are to rest the flatter portion of site from cattle grazing for two years, ameliorate the erosion and control the weeds. Inspected 17 June 2008.

Management arrangements: The Grazing Licence appears to have been issued on 28 June 2006 (no signed copy was cited). The Licensee must not overstock the land. Given the erosion evidence, it is possible overgrazing occurred before the present Licence was issued.

Belconnen Naval Transmitting Station (BE08B)

Belconnen: Territory Land

General view towards the entrance of the Station showing the Kangaroo dominated grassland (image on 8 January 2009)

Invasion of trees into the grassland from a row of trees just outside the boundary (image on 8 January 2009).

Site report: This area of Natural Temperate Grassland is adjacent to the security fence. The site is placed in Conservation Category 1. The threatened species, Striped Legless Lizard, Grassland Earless Dragon, Golden Sun Moth, and Perunga Grasshopper, occur at the site. The condition of the grassland is good but canopy closure is suppressing forbs over much of the area. An autumn burn is required to open the canopy. Weeds are adequately controlled except for woody species that are slowly increasing along one perimeter and along the valley in the middle of the site. Inspected 8 January 2009.

Management arrangements: No documents were sited.

Kaleen East Paddocks (BE09)
Belconnen: Territory Land

General view across site (image on 6 June 2008).

General view from edge of site showing a very large Firethorn Bush (*Pyracantha augustifolia*) which is the source of seed carried by birds into the site (image on 6 June 2008).

Site report: This medium site of 28.2 ha comprises 4.0 ha of Natural Temperate Grassland and 24.2 ha of Native Pasture. No threatened species are known at the site and the Conservation Category is 3. Weeds (Serrated Tussock, Firethorn and other shrubs) were present and semi-controlled. The site is intermittently grazed by horses and kangaroos. The critical threshold being approached is an irruption in Firethorn bushes. The action needed immediately is to remove the 'source' Firethorn Bush from just outside the boundary of the site. Inspected 6 June 2008.

Management arrangements: The Services Agreement for the site directs the Contractor to control weeds according to the ACT Weed Strategy, to follow sustainable agricultural practices and to protect areas of significant conservation value. It is uncertain which Authority should control weeds outside the site.

Caswell Drive (BE10)
Belconnen: Territory Land

General view towards Black Mountain (image on 4 August 2008).

Close up of overgrazed grassland and active erosion between surviving Kangaroo Grass plants (image on 4 August 2008).

Site report: This small site of 4.8 ha is Native Temperate Grassland. No threatened species have been reported for the site. The Conservation Category is 1 for the site. The site is heavily grazed by kangaroos and some rabbits. Most Kangaroo Grass and other native grass plants were closely grazed preventing reproduction by seed and substantially raising the risk of accelerated mortality from drought-induced stress. Soil erosion was evident over the area because of the loss of plant cover. The site is approaching a critical threshold and unless the kangaroo grazing pressure is urgently reduced the grassland will lose function. The action required in the short term is to reduce kangaroo numbers at the site and if possible, in the nearby Black Mountain area because this maybe the source area for the kangaroos. Inspected 4 August 2008.

Management arrangements: The Land Management Agreement (dated 18 October 2004) is not a grazing lease and does not direct the lessee on the management of kangaroos and pest animals.

Glenlock interchange (BE11)
Belconnen: Territory Land

General view of the site towards Black Mountain. (August 2008).

Close of small scale erosion that is not recent. Note that the grass plants are safely grazed to about 10 cm in height (image on 24 August 2008).

Site report: This small site of 2.2 ha of Natural Temperate Grassland was placed in the Conservation Category of 1. The site was found to be diverse in plant species. No critical thresholds were being approached at this site. 24 August 2008.

Management arrangements: No Memorandum of Understanding appears to exit.

Kama South (BE12)
Belconnen: Territory Land

General view towards Black Mountain. In the middle foreground is a clump of Spiny-Headed Mat-Rush (*Lomandra longifolia*) (image on 7 August 2008).

Close up view of an isolated weedy area containing Serrated Tussock (image on 7 August 2008).

Site report: This medium site of 38.5 ha of Natural Temperate Grasslands has been placed in the Conservation Category of 1. No threatened species are known at the site. Weeds are Serrated Tussock, Thistles and St. John's Wort (*Hypericum perforatum*). Although kangaroos are on the site their grazing pressure is low and there are no critical thresholds being approached. Inspected 7 August 2008.

Management arrangements: A Grazing Licence for use of Unleased Territory Land is in place and the 'lessee' is complying with the terms of the lease.

Evatt Footbridge (BE13)
Belconnen: Territory Land

General view towards Black Mountain. (image on 26 August 2008).

Close up view of an isolated weedy area containing Serrated Tussock (image on 26 August 2008).

Site report: This very small site of <1 ha is botanically diverse and comprises an area of 'environment weed' and an equal sized fenced area of dense kangaroo grass. The site is weeded and 'managed' by the north Belconnen Landcare Group. The critical threshold being approached at the site is closure of the grass canopy because of failure to burn the site to encourage and maintain perennial forbs. The action needed in the short term is to prescribe burn the site in the autumn of 2009. Inspected 26 August 2008.

Management arrangements: No Management Plans were sighted.

CSIRO Headquarters, Campbell (CC01)

Central Canberra and Tuggeranong: National and Territory Lands

View upslope towards CSIRO Headquarters Building. Note very close grazing by kangaroos of the Kangaroo Grass dominated grassland. The steep slope predisposes this site to active and serious soil erosion (image on 13 June 2008).

Closer view of the slope in the foreground of the above image. Erosion is occurring over most of the site and on both National and Territory lands (image on 13 June 2008).

Site report: This small site of 3.0 ha of Native Temperate Grassland is home to the threatened Golden Sun Moth. The site has been placed in Conservation Category 2. The site is grazed by kangaroos that are probably resident on nearby Mount Ainslie. Currently it is being overgrazed by kangaroos. Most Kangaroo Grass plants were closely grazed preventing reproduction by seed and substantially raising the risk of accelerated mortality from drought-induced stress. Loss of landscape function with the surface soil moving down slope carrying vital plant resources of litter and seed is also noted. A critical threshold for landscape function is approaching because of heavy grazing. Action is needed in the short term to reduce kangaroo numbers at the site. Inspected 13 June 2008.

Management arrangements: A Memorandum of Understanding to establish and maintain a framework and agreed procedures for a co-ordinated, consistent and open approach to conservation and management issues, between CSIRO, Department of the Environment and Department of Urban Services was signed in 7 September 1998. No Management Plan is available for assessment of procedures to be used to address overgrazing by herbivores and to meet conservation requirements on the site.

Constitution Avenue, Reid (CC02)
Central Canberra and Tuggeranong: Territory Land

General view of the site (image on 13 June 2008).

Site report: This very small site of 0.7 ha of Natural Temperate Grassland is habitat for the Golden Sun Moth. The site is placed in a Conservation Category of 2. Weeds were sparse on the site but the grassland is surrounded by a 'sea' of exotic plants including Chilean Needle Grass. The site is approaching a critical threshold in that the Kangaroo Grass has closed the canopy and fire is required to prevent local extinction of forbs. The action required in the short term is to autumn burn in 2009. Inspected 13 June 2008.

Management arrangements: In the brief Management Plan the issue of burning is not addressed and mowing twice a year is advocated. Mowing should be removed from the Plan because the area is surrounded by a large infestation of Chilean Needlegrass. The Plan should include a requirement to autumn burn the site every 5 to 10 years.

St John’s Church, Reid (CC03)

Central Canberra and Tuggeranong: Territory Land

General view across “’Rectors’ Horse Paddock”. (image on 16 July 2008).

General view across recently sown and transplanted patches aimed at restoring grassland in the graveyard area. (image on 16 July 2008).

Site report: This very small site of 0.9 ha of Natural Temperate Grassland and provides habitat for the threatened species, Golden Sun Moth. The Conservation Category is 2 for the site. Weeds (Chilean Needle Grass, Paspalum (*Paspalum dilatatum*), African Lovegrass) were evident. The only threatening process at the moment is weed invasion. The actions needed to combat weeds would be to continue monitor weed levels and increase control measures in weedy locations. Inspected 16 July 2008.

Management arrangements: The Lease dated 20 February 1967, does not address conservation or grassland management at the site.

ACC&C, Barton (CC04)

Central Canberra and Tuggeranong: Territory Land

General view across the grassland towards the base of the prominent “cross” in the grounds of the Center.

Site report: This small site of 1.9 ha is an iconic Natural Temperate Grassland, well known to ecologists and friends of grasslands in the ACT. Two threatened species are present at the site; the Golden Sun Moth and the Button Wrinklewort. The site has been placed in the Conservation Category of 1 and a Botanical Significance Rating of 1 (the *only* site with this rating in Canberra). Weeds were few. The grassland is approaching a critical threshold with respect to canopy closure and associated loss of forbs. The action needed is to autumn burn in 2009. Inspected 13 June 2008.

Management arrangements: The ‘lessee’ is required to minimise human disturbance at the site but there is no agreement to manage the grassland site with fire.

York Park, Barton (CC05)
Central Canberra and Tuggeranong: National Land

General view across site with the information board in the middle foreground (image on 13 June 2008).

Site report: This very small site of 0.4 ha is located in the 'heart' of the Government Department precinct. The Natural Temperate Grassland is habitat for the threatened Golden Sun Moth and has been placed in the Conservation Category of 2. Weed (Chilean Needle Grass, Prickly Lettuce (*Lactuca serriola*), Plantago (*Plantago lanceolata*), Paspalum, Awnless Brome (*Bromus inermis*)and Cocksfoot (*Dactylis glomerata*) invasion is serious at the site and a critical threshold is being approached beyond which native grasses and forbs will be out competed for space and resources. The action needed in the short term is to substantially reduce the weed populations. Inspected 13 June 2008.

Management arrangements: The Memorandum of Understanding for the site has not been supplied. A comprehensive Grassland Maintenance Plan was available and this provides clear and scientific guidelines on the management of environmental weeds at the site.

Yarramundi Reach (CC06)

Central Canberra and Tuggeranong: National Land

General view of site showing invasion by Chilean Needle Grass from the mown bike path verges, into Kangaroo Grass-dominated grassland (image on 28 May 2008).

Site report: This medium and iconic site of 21.2 ha of Natural Temperate Grassland is placed in the Conservation Category of 2. On the site are two threatened species; the Golden Sun Moth and the Stripped Legless Lizard. Weeds are sparse in the middle of the grassland but are actively spreading from the lower bike path verges as seen in the image above. The weed invading is Chilean Needle Grass brought to the site on mowing equipment. The canopy of the grassland is also closing over in many places smothering the forbs. Portions of the area are approaching critical thresholds for maintenance of native grasses and forbs. The actions needed in the short term are to control invasions of weeds and to autumn burn the grassland in 2009. Inspected 28 May 2008.

Management arrangements: The MOU for the site has not been supplied.

Lady Denman Drive, Yarralumla (CC07)
Central Canberra and Tuggeranong: National Land

General view along road verge (image on 28 May 2008).

Site report: This very small site of 0.4 ha of Natural Temperate Grassland is surrounded by weedy exotic grassland. The site placed in Conservation Catalogue of 2 and provides habitat for the threatened species of Golden Sun Moth. Weeds were present especially Chilean Needle Grass. The was considered to be approaching a critical threshold with respect to mowing; the close and frequent mowing was threatening survival of Speargrass (*Austrostipa scabra*) plants and the native forbs. The action needed immediately to remove the threat, is to raise the height of mowing and to avoid moving during the growing and reproduction season for the native species. Inspected 28 May 2008.

Management arrangements: The Management Plan adequately specifies the once-a-year mowing regime except that no critical height, that is, above 10 cm, is specified.

Dudley Street, Yarralumla – part only (CC08)
Central Canberra and Tuggeranong: Territory Land

General view of the boundary of the site. The site is on the left and marked by painted steel 'posts' (image on 28 May 2008).

Site report: This small site of 2.2 ha, of which 1.5 ha is Natural Temperate Grassland and 0.7 ha are Exotic Pasture. is surrounded by weedy exotic grassland. The site placed in Conservation Catalogue of 2 and provides habitat for the threatened species of Golden Sun Moth. Weeds were present especially Chilean Needle Grass. The was considered to be approaching a critical threshold with respect to mowing; the close and frequent mowing was threatening survival of Speargrass plants and the native perennial forbs. The action needed in the short term to remove the threat is to raise the height of mowing and to avoid moving during the growing and reproduction season for the native species. Inspected 28 May 2008.

Management arrangements: The Management Plan specifies a twice-a-year mowing regime with no recommended height. The MP needs to be revisited and once-a-year mowing in autumn at a minimum height of 10 cm needs to be specified.

Guilfoyle Street, Yarralumla (CC09)
Central Canberra and Tuggeranong: National Land

General view of site showing Chilean Needle Grass invasion from mown road verge with native grassland in the background.

Site report: This very small site of 0.8 ha of Natural Temperate Grassland contains a population of the threatened plant species, Button Wrinklewort. The site is placed in the Conservation Catalogue as 2. Weeds were present especially abundant Chilean Needle Grass. The site is considered to be approaching a critical threshold with respect to mowing and weeds; the close and frequent mowing was threatening survival of Speargrass plants and the native forbs, preventing plant succession and spreading Chilean Needle Grass throughout the site. The actions needed to remove the threats from mowing would be to fence the area and to autumn burn the site every 5 to 10 years and to address weed invasion would be to increase weed control at the site. Inspected 28 May 2008.

Management arrangements: There is no Memorandum of Understanding or other management document available for this site.

Novar Street, Yarralumla (CC10)
Central Canberra and Tuggeranong: Territory Land

General view of site across main bike path. On the left is a part of a patch of Natural Temperate Grassland and on the right is a much larger area of exotic grassland (image on 28 May 2008).

Site report: This very small site of 0.2 ha of Natural Temperate Grassland is surrounded by exotic/weedy grassland. No threatened species are known to occur at the site. The site is placed in the Conservation Catalogue of 3. Weeds were present in the site especially Chilean Needle Grass. The was considered to be approaching a critical threshold with respect to mowing; the close and frequent mowing was threatening survival of Speargrass plants and the native forbs, preventing plant succession and spreading Chilean Needle Grass throughout the site. The action needed to remove the threats from mowing would be to fence the area in the short term and autumn-burn the site every 5 to 10 years. Inspected 28 May 2008.

Management arrangements: The Management Plan does not differentiate the site from adjacent areas, nor address mowing and burning regimes.

Black Street, Yarralumla (CC11)

Central Canberra and Tuggeranong: Territory Land

General view of site towards Black Mountain Tower (image on 28 may 2008).

General view of site showing vehicle disturbance in the middle of a Kanagroo Grass dominated Natural Temperate Grassland patch (image on 28 May 2008).

Site report: This medium site of 3.6 ha of Natural Temperate Grassland is surrounded by exotic/weedy grassland. The threatened species of Golden Sun Moth is known to occur at the site. The site is placed in the Conservation Catalogue of 2. Weeds were present in the site were Chilean Needle Grass and Serrated Tussock. The site was considered to be approaching a critical threshold with respect to mowing; the close and frequent mowing was threatening survival of Speargrass and Kangaroo Grass plants and the native forbs, preventing plant succession and spreading Chilean Needle Grass throughout the site. The action needed to remove the threats from mowing would be to fence the area in the short term and burn the site every 5 to10 years. Inspected 28 May 2008.

Management arrangements: The Management Plan specifies a twice-a-year mowing regime. The plan should be adjusted to remove mowing and apply a burning regime.

Isabella Pond, Monash (TU01)
Central Canberra and Tuggeranong: Territory Land

General view of the site.

Close up view of the 'closed' grassland canopy.

Site report: This small site of 1.2 ha of Natural Temperate Grassland is surrounded by exotic/weedy grassland. No threatened species are known to occur at the site. The site is placed in the Conservation Catalogue as 1. Weed level at the site was low. The site was considered to be approaching a critical threshold with respect to fire; the 'closed' canopy would prevent regeneration of forbs from seed and given the short seed-life of many of the species it is necessary to 'open' the grassland soon. The action needed is to burn the site in autumn of 2009 and introduce a fire management program that involves a fire frequency of 5 to 10 years. Inspected 28 May 2008.

Management arrangements: The Management Plan specifies burning every 2 to 3 years. It is recommended this be altered to autumn burning every 5 to 10 years.

Mulanggari Nature Reserve (GU01)

Gungahlin Valley: Territory Land

General view west at gate showing a mob of cattle (image 26 May 2008).

Close up view of a grazed patch of Kangaroo Grass dominated grassland (image on 26 May 2008)..

Site report: This medium site of 68.5 ha; 58.6 ha of Natural Temperate Grassland, 9.4 ha of Native Pasture and 0.5 ha of Exotic Pasture. There are populations of several threatened species at the site; Golden Sun Moth, Perunga Grasshopper and Striped Legless Lizard. The site has been placed in the Conservation Category of 1. Weeds are few and well controlled. Cattle and kangaroos were seen grazing the site and the grazing was light and patchy. There were not critical thresholds being approached at the site. Inspected 27 May 2008.

Management arrangements: The Management Plan adequately addresses grazing, weed invasion, fire and pest animal control.

Gungaderra Nature Reserve (GU02)
Gungahlin Valley: Territory Land

General view towards communication tower operated by Broadcast Australia (image on 26 May 2008).

General view from the hill at the site showing localised weeds (image on 26 May 2008).

Site report: This large site of 187.3 ha (41.9 ha of Natural Temperate Grassland, 115.2 ha of Native Pasture and 30.2 ha of Exotic Pasture) is quite diverse in plant communities some of which are wooded. Populations of two threatened species occur at the site (Striped Legless Lizard and Perunga Grasshopper) and the also the rare Key's Matchstick Grasshopper (*Keyacris scurra*). The site has been placed in the Conservation Category of 1. Weeds (Serrated Tussock, Thistles, Chilean Needle Grass, St John's Wort) were in localised populations and appear to be adequately controlled. Cattle, kangaroos and rabbits graze the site but at this time are not threatening the grassland and biodiversity. Inspected 26 May 2008.

Management arrangements: The Management Plan adequately addresses grazing, weed invasion, fire and pest animal control.

Crace Nature Reserve (GU03)

Gungahlin Valley: National Land

Landscape view towards mobs of cattle and kangaroo's grazing at the base of the wooded hill. In the foreground is native grassland currently losing function and control of resources because of overgrazing in drought times (image on 26 May 2008).

Closer view of overgrazed Kangaroo Grass dominated grassland. Rabbit and kangaroo dung is abundant here and this 'marsupial lawn' is approaching a critical threshold. The landscape processes are becoming dysfunctional and surface resources are being moved by erosion (image on 26 May 2008).

Site report: This large site of 136 ha, is a mixture of Native Temperate Grassland (61.5 ha), Native Pasture (41.1 ha) and Exotic Pasture (33.3 ha). Three threatened species occur at the site (Button Wrinklewort, Striped Legless Lizard and Perunga Grasshopper) and the site is placed in the Conservation Category of 1. The site is grazed by sheep, cattle, kangaroos and rabbits. Large areas of NTG on the flatter portion of the landscape were found on close inspection to be overgrazed by rabbits and kangaroos. Most Kangaroo Grass plants were closely grazed preventing reproduction by seed and substantially raising the risk of accelerated mortality from drought-induced stress, and surface soil and vital plant resources of litter and seed is being eroded. Soil erosion was evident over large areas. The action needed to prevent a significant part of the site from crossing the critical threshold to a less functional state is a substantial reduction in kangaroo and rabbit numbers in the short term. Inspected 26 May 2008.

Management arrangements: The Land Management Agreement between the Lessee and the Territory (dated 12 April 2000) adequately addresses grazing management required during drought and pest animal build up.

North Mitchell (GU04)
Gungahlin Valley: Territory Land

General view of grassland (image on 17 June 2008).

Site report: This medium site of 17.0 ha of grassland (15.8 ha of Natural Temperate Grassland and 1.2 ha of Exotic Pasture) is not grazed. A population of the threatened species of Striped Legless Lizard are at the site and the site is placed in the Conservation Category of 2. Weeds (Thistles, Phalaris and Cocksfoot) were in localised populations and were adequately controlled. No critical thresholds were being approached. Inspected 17 June 2008.

Management arrangements: There is no Memorandum of Understanding available.

Mitchell (GU05)
Gungahlin Valley: Territory Land

General view of site with Black Mountain Tower in the distance. (image on 26 August 2008).

Close up of low infestations of the weed, St John's Wort (image on 26 August 2008).

Site report: This small site of 1.6 ha of Natural Temperate Grassland contains a population of the threatened species, Golden Sun Moth. The site has been placed in the Conservation Category of 3. Weeds (St John's Wort, Blackberry (*Rubus fruticosis*) and Phalaris) are in low densities at the site. No critical thresholds exist for the site except that the site should be autumn burnt in 2009. Inspected 26 August 2008.

Management arrangements: There is no Management Plan for the site as the land is vacant.

Canberra Riding/Pony Club (GU06)
Gungahlin Valley: Territory Land

General view towards the Barton Highway (image on 10 June 2008)

Closer view of heavily grazed grassland and horse dung (image on 10 June 2008).

Site report: This very small site of 0.3 ha of Native Temperate Grassland is heavily grazed by horses. No threatened species occur at the site and the site is in Conservation Category 3. It is recommended the site be removed from the Natural Temperate Grassland inventory given the very degraded nature of the site. Inspected 10 June 2008.

Management arrangements: No Management Plan or any agreement appears to exist for the site.

Wells Station Road (GU07)
Gungahlin Valley: Territory Land

General view towards the Federal Highway (image on 4 August 2008).

Site report: This very small site of 0.2 ha of roadside is classed as Natural Temperate Grassland. The site contains no threatened species and is placed in the Conservation Category of 3. Weeds (Plantago, African Lovegrass, Chilean Needle Grass and Paspalum) are in high densities at the site and are out-competing the native plant species. A critical threshold for maintenance of native plants at the site is being approached because the weed infestation. The action needed in the short term is to allocate more resources to weed control at the site. Inspected 4 August 2008.

Management arrangements: No Management Plan or any agreement appears to exist for the site.

Nicholls (GU08)
Gungahlin Valley: Territory Land

General view towards the Barton Highway (image on 4 August 2008).

Close up of Chilean Needle Grass infestation (image on 4 August 2008).

Site report: This very small site of 0.3 ha of Natural Temperate Grassland contains no known populations of threatened species. The site has been placed in the Conservation Category of 3. Weeds (St John's Wort, Chilean Needle Grass, Paspalum and Phalaris) are in high densities at the site. A critical threshold for maintenance of native plants at the site is being approached because weeds are out-competing the native plants. The action needed in the short term is to allocate more resources to weed control at the site. Inspected 4 August 2008.

Management arrangements: No Management Plan or any agreement appears to exist for the site.

‘Mugga Mugga’ Homestead (JE01)
Jerrabomberra Valley: Territory Land

General view upslope from entry road, towards the “Homestead” (image on 2 June 2008).

Site report: This medium site of 15.1 ha is Natural Temperate Grassland. Threatened species have not been reported at the site and the site is placed in the Conservation Category of 2. Weeds (Thistles, Common Couch (*Cynodon dactylon*), Prairie Grass, African Lovegrass, and Cocksfoot) are in low densities at the site. There is some limited erosion at the site. No critical thresholds are being approached for the maintenance of native plants at the site. Inspected 2 June 2008.

Management arrangements: A comprehensive Draft Management Plan exists.

‘Callum Brae’ (JE02)
Jerrabomberra Valley: Territory Land

General view across grassland (image on 6 June 2008).

General view across grassland (image on 6 June 2008).

Site report: This large site (162.7 ha) of Native Pasture supports populations of two threatened species; Golden Sun Moth and Grassland Earless Dragon. The site has been placed in the Conservation Category of 1. Weeds (Serrated Tussock, Thistles and Chilean Needle Grass) are well controlled at the site. Grazing by sheep is modest and there was no indication of a critical threshold from grazing or other threats, being approached. The Model Aircraft Club leases a small area and this too was well managed with no critical thresholds recognised. The Club were planning to hard surface the take-off and landing strip and this would not endanger the surrounding grassland. Inspected 6 June 2008.

Management arrangements: An excellent Management Plan detailing appropriate management for the site is in operation.

Jerrabomberra West Reserve (JE03)
Jerrabomberra Valley: Territory Land

General view showing an isolated patch of Chilean Needle Grass (image on 2 June 2008).

Site report: This large site of 116.9 ha (115.2 ha of Natural Temperate Grassland and 1.7 ha of Natural Pasture) contains populations of three threatened species (Golden Sun Moth, Grassland Earless Dragon and Perunga Grasshopper). The site has been placed in the Conservation Category of 1. Weeds (Serrated Tussock, Thistles (3), St John's Wort, Chilean Needle Grass, Tall Fescue (*Festuca arundinacea*) Phalaris, Great Mullein (*Verbascum thapsus*)) are throughout the site but not in sufficient densities to cause concern. There is now no grazing from domestic stock at the site. Inspected 2 June 2008.

Management arrangements: An excellent Management Plan was sighted.

Woods Lane (JE04)
Jerrabomberra Valley: Territory Land

General view along the long narrow Lane showing the large amount of disturbance at the site (image on 6 June 2008).

The site where there is a population of the threatened species Button Wrinklewort (image on 6 June 2008).

Site report: This medium and very elongated site of 10.3 ha of Natural Temperate Grassland contains a vulnerable population of the threatened species, Button Wrinkle Wort. The site has been placed in the Conservation Category of 2. Weeds are present but not in high densities. Soil disturbance, on a large scale, has occurred throughout the site, some recently. As shown in the first image the disturbance is caused by 4 Wheel Drive vehicles during a time when the soil was wet and road making by grader. A critical threshold for maintenance of native plants at the site is being approached because of the substantial physical disturbance at the site. The action needed is to rehabilitate the site by the sowing of seed of grasses and forbs native to the area and to prevent future occurrence of physical disturbance. Inspected 6 June 2008.

Management arrangements: No Management Plan was sighted.

Jerrabomberra East Reserve (JE05)
Jerrabomberra Valley: Territory Land

General view from the lowest part of the landscape towards the highest. The dam provides permanent water for kangaroos.

An extensive area of degrading and dysfunctional patches of landscape near the dam. Note the active erosion (image on 8 January 2009).

Site report: This medium site of 72.0 ha of grassland (62.2 ha of Natural Temperate Grassland, 7.8 ha of Native Pasture and 2.0 ha of Exotic Pasture) contains populations of three threatened species (Golden Sun Moth, Grassland Earless Dragon and Perunga Grasshopper). The site has been placed in the Conservation Category of 1. Weeds (Serrated Tussock, Thistles (3), St John's Wort and Phalaris) are widespread at the site but controlled. Wallaby Grasses were closely grazed, where they occurred. No seed appeared to have been produced by these plants in 2008. There was loss of landscape function evidenced by surface movement of soil, litter and probably seed in new but local erosion patches on steeper slopes. Portions of the area are approaching a critical threshold for landscape stability and maintenance of some native grasses. The cause is overgrazing by kangaroos. Inspected 8 January 2009.

Management arrangements: An excellent Management Plan was sighted as for JE03.

Harmon Bonshaw North & South (JE06/JE07)

Jerrabomberra Valley: National and Territory Lands

General view of the site. The leasee is on the left of the inspecting party (image on 6 June 2008).

Close up of the grassland (image on 6 June 2008).

Site report: These two large sites are leased for grazing to one Lessee. Given there were no critical thresholds apparent at either site and there was one manager, the two sites are considered together. On JE06 the 105.7 ha of Native Pasture contains populations of three threatened species, Striped Legless Lizard, Perunga Grasshopper and   The site has been placed in the Conservation Category of 3. Weeds (Serrated Tussock, Thistles, St John's Wort, Chilean Needle Grass, Paspalum, Blackberry and Cootamundra Wattle (*Acacia baileyana*)) are in high densities at the site and are out-competing the native plant species and possibly the Golden Sun Moth. A critical threshold for maintenance of native plants at the site is being approached because the weeds are out-competing the native plants. The action needed in the short term is to allocate more resources to weed control at the site. Inspected 7 August 2008.

Management arrangements: The Land Management Agreements for these sites contains the requirement to control weeds.

‘Cookanalla’ (JE08)
Jerrabomberra Valley: Territory Land

General view from the top of a hill showing in the foreground, erosion from persistent sheep tracks and very close grazing of many palatable grass plants (2 June 2008).

A dense thicket of the woody weed, African Boxthorn (*Lycium ferocissimum*) and large eroding areas bare of plant cover (2 June 2008).

Site report: This medium site of 81.5 ha of Native Pasture there is a population the threatened species, Grassland Earless Dragon. The site has been placed in the Conservation Category of 2. Weeds are abundant. Thistles (2 species) occur densely over the site and a population of African Boxthorn is located on the hill. The thistles are symptomatic of persistent high grazing pressure. Surface erosion of soil was prevalent. Critical thresholds for maintenance of native plants at the site are being approached because the weeds are out-competing the native plants and overgrazing is lowering the functionality of the grassland. The overgrazing is primarily by sheep and rabbits. The actions needed are in the short-term to remove the Boxthorn and in the longer term to control thistles and to lower the grazing pressure by reducing the stock carried on the land and fumigating and ripping rabbit warrens. Inspected 2 June 2008.

Management arrangements: In a Land Management Agreement dated August 2004 the Boxthorn bushes were to be removed and thistles controlled.

Amtech (JE09)

Jerrabomberra Valley: Territory Land

General view across site. Cattle are grazing in the distance and there is an infestation of Blackberry in the foreground (image on 2 June 2008).

Site report: This medium site of 18.0 ha of Natural Temperate Grassland contains a population of the threatened species, Grassland Earless Dragon. The site has been placed in the Conservation Category of 2. Weeds (Chilean Needle Grass, Serrated Tussock, Phalaris, Blackberry, Orange Firethorn (*Pyracantha angustifolia*), Thistles (2), Sweet Briar) are across the site and their control level is marginal. The action needed in the longer term is to allocate more resources to weed control at the site. Inspected 2 June 2008.

Management arrangements: No Management Plan exits for this site.

Tennant Street, Fyshwick (JE10)
Jerrabomberra Valley: Territory Land

General view of site towards Tennant Street (image on 22 October 2008).

Close up of an area being overgrazed by rabbits and kangaroos (image on 22 October 2008).

Site report: This very small site of 0.3 ha of Natural Temperate Grassland contains a population of the threatened plant species, Button Wrinklewort. The site is floristically quite rich and has been placed in the Conservation Category of 2. Weeds (Serrated Tussock, Sweet Briar and Barley Grass (*Hordeum leporinum*)) are at moderate densities at the site. Grazing from rabbits and kangaroos are a problem but the site is not approaching any critical thresholds. Inspected 22 October 2008.

Management arrangements: No Management Plan exits for weed control; only a Licence to graze was noted.

Majura Training Area (MA01)
Majura Valley: National Land

General view along 'kangaroo-proof' fence towards Black mountain Tower (image on 11 June 2008).

General view (image on 11 June 2008).

Site report: This large iconic site of 126.6 ha (113.7 ha of Natural Temperate Grassland, 5.8 ha of Native Pasture and 7.1 ha of Exotic Pasture) contains populations of five threatened plant, reptile and insect species (Button Wrinklewort, Grassland Earless Dragon, Golden Sun Moth, Perunga Grasshopper and Striped Legless Lizard). The site has been placed in the Conservation Category of 1 and as such the site is of very high ecological significance. If the site were fragmented or reduced in size it is likely species would become locally extinct and the ecological function of other nearby Natural Temperate Grassland would be significantly weakened. Weeds (Thistles, Serrated Tussock) are well controlled. The site is not grazed; kangaroos are kept out by a high electric fence and this is appropriate. No critical thresholds are being approached. Inspected 2 June 2008.

Management arrangements: A Memorandum of Understanding was noted and no Management Plan exits.

Airservices Australia Facility (MA02)
Majura Valley: National Land

General view of site with the location beacon in the foreground and the Canberra International Airport in the distance (image on 12 June 2008).

Site report: This medium and iconic site of 10.7 ha of Natural Temperate Grassland contains populations of four threatened reptile and insect species (Grassland Earless Dragon, Golden Sun Moth, Perunga Grasshopper and Striped Legless Dragon). The site has been placed in the Conservation Category of 1. Weeds (Serrated Tussock and Thistles) are in low densities at the site and appear to be controlled. Kangaroos occasionally enter the fenced site. The action needed in the short term is to autumn burn the site in 2009 to keep the grass canopy from smothering forbs and some grasses. Inspected 12 June 2008.

Management arrangements: A MOU to establish and maintain a framework and agreed procedures for a co-ordinated, consistent and open approach to conservation and management issues, between Department of Defence, Department of the Environment and Department of Urban Services was signed in 7 September 1998. No Management Plan is available for assessment of procedures to be used to manage the site.

Canberra International Airport (MA03)
Majura Valley: National Land

General view showing weed infestations (image on 31 July 2008).

General view of high quality Kangaroo Grass dominated grassland (image on 31 July 2008).

Site report: This large and potentially iconic site of 203.6 ha (73.6 ha of Natural Temperate Grassland, 62.9 ha of Native Pasture and 67.1 ha of Exotic pasture) contains populations of three threatened reptile and insect species (Grassland Earless Dragon, Golden Sun Moth and Perunga Grasshopper) The site has been placed in the Conservation Category of 1. As such the site is of very high ecological significance and the Airport building is a significant and effective place to mount advertising information on the ecological significance of the site and the Airport management in place to conserve the grassland and the unique biota and threatened species. Weeds (Serrated Tussock, Chilean Needle Grass, Paspalum and Gorse (*Ulex europaeus*)) are in moderate densities at the site but an active weed management program is in place. Inspected 31 July 2008.

Management arrangements: No MOU between parties was sighted. A comprehensive document titled 'Grassland Management Plan: Natural Temperate Grasslands at Canberra Airport', dated November 2004, sets out in detail the grassland management and monitoring at the Airport. Canberra Airport is principally subject to Commonwealth law. The key pieces of legislation controlling the operation of the airport are the *Airports Act 1996*, the *Airports (Environment Protection) Regulations 1997* and the Canberra Airport is principally subject to Commonwealth law.

'Malcolm Vale' (MA04)
Majura Valley: National Land

General view across the flat portion of this large site. Hills dominate the site to the right of this image (image on 11 June 2008).

Closer view of overgrazed grassland showing erosion and linked dysfunction of this grassland. Already many native grass plants have been killed by heavy grazing (image on 11 June 2008).

Site report: This large site of 155.4 ha is Native Pasture and contains a population of the threatened Grassland Earless Dragon. The site has been placed in the Conservation Category of 2. Weeds (Serrated Tussock and St Johns Wort) are at high densities in localised infestations. Kangaroos are at high density and a critical threshold with respect to grazing pressure is being approached. There is active soil erosion, visual evidence of loss of native plants and of diminished landscape function. The action needed immediately is to substantially reduce the size of the kangaroo population. Another action, needed in the short term, is to increase resources for ongoing weed management. Inspected 11 June 2008.

Management arrangements: A Memorandum of Understanding to establish and maintain a framework and agreed procedures for a co-ordinated, consistent and open approach to conservation and management issues, between Department of Defence, Department of the Environment and Department of Urban Services was signed in 7 September 1998. No Management Plan is available for assessment of procedures to be used to address overgrazing by herbivores or weed management.

Campbell Park (MA05)
Majura Valley: National Land

General view towards Campbell Park Defence complex (image on 11 June 2008).

Site report: This medium and iconic site of 11.7 ha (10.9 ha of Natural Temperate Grassland and 0.8 ha of Exotic pasture) contains populations of five threatened plant, reptile and insect species (Button Wrinklewort, Grassland Earless Dragon, Striped Legless Lizard, Golden Sun Moth and Perunga Grasshopper). The site has been placed in the Conservation Category of 1. Weeds (Thistles) are in low densities and controlled. No critical threshold is being approached. Inspected 11 June 2008.

Management arrangements: A Memorandum of Understanding to establish and maintain a framework and agreed procedures for a co-ordinated, consistent and open approach to conservation and management issues, between Department of Defence, Department of the Environment and Department of Urban Services was signed in 7 September 1998. No Management Plan is available for assessment of procedures to be used to address overgrazing by herbivores or weed management.

Majura West (MA06)
Majura Valley: National and Territory Lands

General view towards a distant mob of sheep and the Canberra Airport complex (image on 4 August 2008).

Close up showing heavy grazing of Wallaby Grasses (*Austrodanthonia spp.*) and emerging bare patches (image on 4 August 2008).

Site report: This large site of 133 3ha of Native Pasture contains a population of the threatened species of Stripped Legless Lizard. The site has been placed in the Conservation Category of 1. The site is grazed by sheep, kangaroos and rabbits and a critical threshold is being approached beyond which soil erosion will become serious, native plants will die at an accelerating rate and landscape will lose functionality. Soil erosion was evident in small patches. The action needed immediately is to substantially reduce the kangaroo numbers on the site. Inspected on 4 August 2008.

Management arrangements: A Grazing Licence dated 2008 allows intermittent grazing but not continuous grazing by livestock. A Management Plan is provided by the Canberra Nature Park Management Plan but this is too broad and requires specific management for the site.

10 commitments for future-proofing the Natural Temperate Grasslands of Canberra

Areas are now critically small and on the brink of extinction	1. Protect sites with a Conservation Category rating of 1 or 2 from any further development (roads, suburbs etc).
Environmental work by volunteers is significant and in some cases, indispensible	2. Extend the successful model of volunteer work at grassland sites to enhance community advocacy and care.
Kangaroo grazing is now threatening survival of some grassland sites	3. Develop a kangaroo management program for the ACT and implement the program as soon as possible to prevent further environmental damage especially to sites BE01, BE02, BE03, BE10, CC01, GU03, MA04 and MA06.
Total Grazing Pressure is approaching critical levels at many sites in this drought period	4. Lower or cease the grazing of domestic stock on sites BE01, BE02, BE03, BE07, GU03, JE08, and MA06.
Environmental weeds are threatening functioning of many grassland ecosystems	5. Review the management of environmental weeds in the short term and make an assessment of the appropriateness of the level of resources allocated to weed control.
Mowing is threatening the functioning and integrity of the grasslands	6. Review in the short term urban mowing practices at all sites where mowing occurs.
Species in grassland communities are adapted to fire and may require prescribed fire to persist	7. Develop a fire management plan for each site and allocate resources to conduct environmental burns.
Many sites are degraded	8. Develop and support research programs on management(s), including sowing seed of native grass and forb species, necessary for returning 'weedy' grasslands to climax states.
The 50 sites are in many jurisdictions and largely managed independantly	9. Convene a meeting of grassland and landscape ecologists and managers to develop a best-practise monitoring system to guide management decisions.
Management plans for many sites are fragmented and inadequate	10. Develop, update and replace all management plans in the short term.

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APPENDIX 1:

CURRICULUM VITAE

Kenneth Charles HODGKINSON

Academic Qualifications

1967	Ph.D. (Agriculture), University of New England, Australia Thesis title: 'Studies on the Physiology of Regeneration of Lucerne (*Medicago sativa* L.)'
1963	B.Agric.Sc., Massey College, Victoria University of Wellington, New Zealand

Research Fields

Grassland ecology; plant critical thresholds for adaptive management; conservation of biodiversity; management of urban, farmed and pastoral landscapes.

Professional Affiliations

Australian Rangeland Society
Australian Society of Plant Scientists
Ecological Society of Australia
Linnean Society of London (elected Fellow)
Royal Society of New Zealand

Appointments

2007-	Visiting Professor, Northeast Normal University, Changchun, China
2002-	Honorary Fellow, CSIRO Sustainable Ecosystems, Canberra, Australia
1990-2001	Senior Principal Research Scientist, CSIRO Wildlife and Ecology (CSIRO Sustainable Ecosystems from 2000), Canberra, Australia
1999-	Guest Professor, Open Research Laboratory of Forest Plant Ecology, Northeast Forestry University, Harbin, China
1983	Visiting Principal Research Scientist, CSIRO Tropical Crops and Pastures, Brisbane, Australia
1975	Visiting Associate Professor, Range Science Department, Utah State University, USA
1968-90	Research Scientist to Principal Research Scientist, CSIRO Rangelands Research Centre, Deniliquin, Australia
1964-67	Research Assistant, Agronomy Department, University of New England, Australia
1963	Research Assistant, DSIR Plant Physiology Unit, New Zealand

Externally-funded projects (as Principal Investigator)

2005	Canberra Urban Parks and Places, ACT to evaluate management of urban corridors of semi-natural vegetation
2000	Parks Victoria to evaluate vegetation monitoring in Mallee National Parks

1999	Bureau of Resource Sciences, Agriculture Fisheries and Forestry Australia for simulating the 4-year forage levels in the Ivanhoe and Cobar districts of NSW
1998	Land and Water Resources Research and Development Corporation to evaluate the ability of SEESAW to predict forage levels from rainfall in wooded rangelands for the Aussie GRASS project
1997-0	Murray Darling Basin Commission for indicators to manage total grazing pressure in mulga lands
1992-96	International Wool Secretariat for evaluating tactical grazing management to maintain/improve wooded sheep-rangelands
1990-92	National Soil Conservation Program to develop restoration managements for degraded rangelands
1988-90	Australian Wool Corporation for development of grazing strategies to improve rangeland pastures
1987-90	Australian Wool Corporation for economic research on sheep production in semi-arid sheep lands

Invitations to address major conferences (from 1995)

2005	16th International Conference on Quantitative Methods for the Environmental Sciences, the International Environmetrics Society, Beijing, China
2005	International Symposium on biodiversity in Grassland, 20th International Grassland Congress, Dublin, Ireland
2002	National Biennial Conference of the Australian Rangeland Society, Kalgoorlie, Australia
2001	International Conference on Landscape Change and Human Activity, 2nd IALE Asia-Pacific Region Conference, Lanzhou, China
2001	International Symposium on De-intensification with Grasslands, 19th International Grassland Congress, Sao Pedro, Brazil
1999	National Conference on Bushfires, Albury, Australia
1998	International Symposium on Managing Grazing, 6th International Rangeland Congress, Townsville, Australia
1995	International Symposium on Ecological Aspects of Rangeland Management arrangements: Community and Lower Level Processes, 5th International Rangeland Congress, Salt Lake City, USA

Publications

123 publications including 42 papers in refereed journals, 22 book chapters, 33 conference papers and 3 edited books.

Selected publications

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Appendix 9: Quote from Mr Shane Mortimer, of the Ngambri People

The entire Ngambri land area is a site of cultural significance

These grasslands fed Ngambri ancestors for over a thousand generations. Ngambri families have been buried in these lands for over 25,000 years. Well in excess of 500,000 Ngambri People form part of this land.

Too much grasslands development has taken place in Ngambri Country, particularly the ACT section. The yam daisy was to Ngambri People, what corn is to American Indians or rice to Asians. Only a handful of yam daisies have survived in the ACT because of land development. The emu, koala, cod, platypus, brolga, bush turkey are no longer to be seen. We have witnessed the mass extinction of innumerable species in the past 200 years. The population of Ngambri People is indicative of the state of the land, but we are far from a spent force.

In 21st century terms

Indigenous Grasslands have more biodiversity and sequester more carbon per hectare than trees, and create the silicates that lock carbon into the ground for up to 20,000 years. Similar silicates to those that make opals.

The once over-grazed Mulligan’s Flat area, having been left to regenerate, is responding well to being left for two years now to do so, Indigenous grasses among other biota have returned. Areas where *Themeda triandra* (Kangaroo Grass) now thrive preclude serrated tussock. All Grasslands in the ACT must now be left to regenerate. The seed of Indigenous understorey is in the ground and will germinate if all sheep and cattle are removed and the land left to spell for at least five years. Future development in the ACT must be concentrated in existing urbanised areas and made attractive for residents to want to live there. Global warming is going to bring rising sea levels and severe weather conditions; and for this governments must be prepared. A high-tech, desirable city for a million residents, built to withstand the rigours of harsh windy weather, must be sustainably constructed on existing urban area, possibly over the top of existing commercial centres and Indigenous grass covered. What do you see growing in high-wind regions? Grasses! We must take a lesson from nature and consider shelter beneath the surface.

The micro-organisms and root systems that support the ecosystem above far exceed the surface story in every way. Aboriginal People have an intuitive understanding of such matters. Ngambri People know this land better than any, as this is Ngambri land.

‘Caring for Country’ is essential for Ngambri future.

Appendix 10: Advice from the expert panel

In January 2009, a draft of this report was considered by an expert panel comprising:

- Dr Andrew Baird (CSIRO Veterinarian)
- Dr Ken Hodgkinson (CSIRO Ecologist)
- Dr Sue McIntyre (CSIRO Senior Principal Research Scientist)
- Dr Will Osborne (University of Canberra).

Mr Darro Stinson, the ex-Commissioner for the Environment, facilitated the expert panel and Ms Sarah Sharp provided technical advice.

The advice from the expert panel is as follows:

1. An emphasis needs to be given to strategic field-based work programs and in using an adaptive management approach for the management of all lowland native grassland sites. Such an approach must be based on:

- a site monitoring and assessment program being undertaken on a regular basis
- research
- outcomes
- evaluation of outcomes to ensure that management strategies achieve the desired results.

2. A best practice ('how to') guideline needs to be developed for site-specific actions, for example, mowing regimes, ecological burns, specifications to be used when engaging contactors.

3. It maybe necessary to reintroduce some species to restore the ecosystem.

4. The most threatening processes for lowland native grassland sites are generally weeds and inappropriate mowing regimes.

5. Overgrazing by pests, stock and/or kangaroos is a threatening process, at this time, for some lowland native grassland sites.

6. Fire needs to be used to explicitly manage the ecological condition of lowland native grassland sites. This is generally not done. When grassland is burnt it is for fire management purposes. Ecological burns need to be undertaken and burns to reduce fuel loadings need to be modified so they do not destroy seed production but allow regeneration. Implementation of such burns needs to take into consideration the life-history requirements of the plant and animal species at the site, and the specific spatial and resource requirements of any threatened species present.

7. Use of the grounds maintenance rubbish tip (managed and used by the Department of Defence) that is enclosed by Campbell Park (MA05) should cease and the site rehabilitated. The piles of logs and branches and other debris attracts cats, foxes and rabbits that threaten Grassland Earless Dragon and the Button Wrinkle Wort Daisy population at this site.

8. To protect the Grassland Earless Dragon, strategically located kangaroo management fencing should be erected around Campbell Park (MA05) and possibly parts of Majura West (MA06), if the removal of stock on Campbell Park (MA06) does not significantly assist the recovery of the lowland native grassland, and if the kangaroo density is not reduced, within

the next six months. This should only be considered a temporary measure. Furthermore, this grassland and the affect on the Grassland Earless Dragon (and other species) need to be monitored.

9. Compliance with conditions in land management agreements that support rural leases is an issue that needs to be addressed; Cookanalla (JE08) is of concern.

10. The field assessments under taken by Dr Ken Hodgkinson involved both objective and subjective elements and were not a substitute for routine ecological monitoring; they reflect drought conditions at the time and were limited by out-of-season assessment of perennial forb components.

ARCHIVAL RECORD

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A STRATEGIC APPROACH TO THE CONSERVATION AND ENVIRONMENTAL ASSESSMENT OF GOLDEN SUN MOTH SITES IN THE CANBERRA AREA

INTERIM REVISED REPORT

D.McC. Hogg

Prepared on behalf of Land Development Agency

December 2010

Note: This is a discussion paper which is subject to review and currently has no formal status with any ACT Government agency.

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In addition to the cited references, much of the information presented in this report has been obtained through personal communication with staff at the Research and Planning Section, Parks Conservation and Lands, ACT Government, Mark Dunford (formerly Research and Planning), Alison Rowell and Tom O'Sullivan.

Alison Rowell has also reviewed a previous draft of this paper and provided additional information and constructive suggestions. Comments from Murray Evans (Research and Planning) on that draft are also appreciated. All views expressed in the paper, however, are those of the author.

INTERIM STATUS

This report has been prepared as an interim report with a view to updating it if necessary following the summer 2010-11 GSM flying season. Due to the atypically wet spring and early summer period, it is expected that the flying season, if it occurs at all, will be delayed. Some limited observations from this season are included in the interim report.

CONTENTS

APPENDICES

EXECUTIVE SUMMARY

The golden sun moth (GSM, *Synemon plana*) is one of several threatened species commonly associated with natural temperate grassland in the Canberra area. It is listed as endangered under the ACT *Nature Conservation Act* 1980 (*NC Act*) and critically endangered under the Commonwealth *Environment Protection and Biodiversity Conservation Act* (*EPBC Act*).

The following paper proposes a strategic approach for the conservation of the GSM in the ACT. It summarises the habitat and land use characteristics of approximately 60 known GSM sites throughout the Canberra area within the five valley systems where the sites are located, namely Central Canberra, Jerrabomberra, Majura, Gungahlin and Belconnen. Many of these sites are within large grassland reserves that have been established by the ACT Government to conserve natural temperate grassland or lowland woodland communities, while others are within Commonwealth land where the management regime to date has been compatible with GSM conservation. Some sites, however, particularly within Central Canberra, are small remnant grassland patches where the GSM has survived for many years despite surrounding development and without any deliberate management measures. There are also many sites within secondary grassland (part of the lowland woodland communities) where the GSM has been found recently in relatively low numbers, and which are likely to be impacted by future urban development or regeneration of woodland tree cover.

There are so many GSM sites in the ACT that it is inevitable that future developments, whether on Territory or Commonwealth land, will adversely affect some GSM habitat. Conservation of the species does not necessarily mean conserving every site at which it has been recorded. Rather, it is proposed that a strategy be developed to build on the major initiatives that the ACT Government has already taken to conserve known GSM habitat, by improving habitat quality or implementing indirect offsets in those areas of highest conservation value and/ or greatest long-term security.

To address GSM conservation objectively and proactively, it is desirable to set realistic targets against which the achievements of a GSM conservation strategy for the ACT can be assessed. These targets are proposed as follows:

1. Two separate grassland conservation reserves containing viable GSM populations in each of:

   - Majura;
   - Jerrabomberra;
   - Gungahlin; and
   - Belconnen.

   These should contain relatively large areas of GSM habitat, managed under regimes which have potential to sustain GSM populations in the long term, recognising that the optimum management requirements for GSM may not be fully understood. These reserves would be the core conservation areas for GSM in an environment which is as close as practicable to the typical natural habitat for the species.

2. At least two additional GSM habitat sites as current or former natural temperate grassland in each of the above four areas which could be used, if required, as a local (i.e. same valley system) source of specimens for translocation to the main reserves in the event of population loss (e.g. through an intense fire).

3. At least six apparently stable GSM habitat sites within Central Canberra, recognising that the opportunity to conserve large grassland reserves in this area is no longer available (and has not existed for many years).

4. At least six viable sites within secondary grassland, recognising that GSM populations in such sites may decline over time as a result of woodland tree regeneration. These sites are likely to be in Gungahlin, where most sites of this type have been recorded.

5. Any sites which have a long and reliable history of scientific monitoring, which would be difficult to replicate elsewhere, or are otherwise particularly significant from a scientific perspective, for example, because of their use for major grassland rehabilitation trials.

Some of the sites conserved under points 4 and 5 may be the same as those conserved under points 1, 2 or 3.

Habitat that is contiguous with or otherwise well connected to nature reserves or otherwise secure conservation areas should be given priority as this would increase the effective size of the habitat and the viability of GSM populations. In addition, any sites which fall into an existing or potential corridor, albeit one which may be fragmented, should also be given high priority with the prospect that such corridor could evolve either naturally or with specific management to become more continuous over time.

The conserved areas should also be representative of genetic differences that may exist between local populations.

While the above targets are considered reasonable from the viewpoint of balancing conservation and development needs, there may well be the opportunity to exceed them. It is likely that additional situations will arise in GSM habitat areas where development is considered to be of higher priority than habitat conservation, but there is still the opportunity to retain limited areas of habitat in association with the development. There may also be areas where suitable habitat does not currently support a GSM population, but is likely to do so if suitable translocation techniques can be developed. Such areas do not form part of the main targets, but should nevertheless be recognised as having supporting value.

The existing situation goes a long way towards meeting the proposed conservation targets, the main deficiencies being a lack of either formal conservation reserve status or a secure management regime in some areas. The strategy lists specific actions that would be required by the ACT or Commonwealth Governments to implement the proposed strategy.

The achievements of the ACT Government in GSM conservation have resulted from a proactive planning approach, which has gone a long way to achieve all that is practicable and realistic, having regard to the competing social and economic needs of the ACT population. Such a strategic approach is needed also in the review of proposals under the *EPBC Act*, for example, through the processes of strategic environmental assessment or bioregional planning.

Such a strategic approach is important in the identification of offsets under the *EPBC Act* in situations where significant GSM habitat is adversely impacted by development. Because the ACT Government has adopted a proactive approach in conserving GSM habitat in advance of development, there is little suitable land remaining within the ACT that can be used as a direct offset. Instead offsets should be directed primarily at improving the quality of existing conservation reserves and other secure GSM habitat areas, either directly or through indirect means such as monitoring and research, negotiating management agreements for land not managed directly by the ACT Government, or funding to support such initiatives.

While it may not be recognised as an offset for loss of GSM habitat, translocation of GSM from existing sites (particularly those directly impacted by development) is a potential means of establishing additional GSM populations in suitable habitat throughout the Canberra area. If effective translocation techniques can be developed, it may be feasible to establish numerous small GSM populations throughout much of the Canberra area, utilising for example, urban open space, grounds of schools and other institutions, and road verges and medians. Areas which were originally natural temperate grassland may be the most favourable for achieving success in such an exercise. The strategy could embrace a systematic search for such areas.

While the present paper is focused on the GSM, it is important to emphasise that this species is just one component of lowland native grassland communities. A further logical progression in the preceding argument is to move up a level and address such communities and their component species holistically. While this has been achieved under the ACT *NC Act*, it may be more difficult under the *EPBC Act*. It is nevertheless an important challenge to be faced if the *EPBC Act* is to be effective in conserving Australia's biodiversity.

1. INTRODUCTION

The golden sun moth (GSM, *Synemon plana*) is one of several threatened species commonly associated with natural temperate grassland in the Canberra area. It is listed as endangered under the ACT *Nature Conservation Act* 1980 (*NC Act*) and, in accordance with the provisions of that Act, its conservation has been addressed through an Action Plan prepared for that species (Ref. 1) and subsequently through a more comprehensive Action Plan for natural temperate grassland (Ref. 2).

The GSM has also been listed as critically endangered under the Commonwealth *Environment Protection and Biodiversity Act* 1999 (*EPBC Act*). As such, any development proposals which have potential to affect its known habitat are usually subject to a referral under that Act. To date, such proposals have been reviewed on an individual basis without necessarily considering the wider implications for GSM conservation in the ACT. (This is true for referrals in general that relate to threatened species or ecological communities).

Amendments to the *EPBC Act* made in 2006 provide for the use of **strategic environmental assessment** (SEA) to provide a context for reviewing more specific development proposals. In overseas experience, SEA is commonly applied to broad policy decisions made by governments. SEA can also be applied at a broad planing level to address the overall cumulative impacts of complex developments such as a new town, with a view to reducing the need to refer specific components of such a development, which may have minor separate impacts and which cannot be assessed in a meaningful way in isolation.

Both of the above applications of SEA are essentially reactive in being based on a particular policy or plan, then reviewing the effects of that policy or plan on relevant aspects of the environment. If there is an unacceptable adverse effect, a feedback loop may enable the policy or plan to be modified to reduce the adverse effect to an acceptable level or to offset it in some other way.

There is another way in which a strategic approach can be applied, however, which is particularly applicable to the conservation of threatened species and ecological communities. This is based on a proactive approach, which is driven by the conservation needs of the species or community. If these needs can be established and satisfied with an adequate level of security and an appropriate management regime (e.g. dedicated conservation reserves or equivalent form of alternative tenure), this can simplify the arguments about conserving other areas of more marginal value.

Potential limitations to this approach include the following:

- For the ACT Government to implement the approach, it must be in a position to exercise a high degree of control over the relevant areas. This may be a significant limitation in that many of the largest habitat areas (core areas) are located on Commonwealth land (see Chapter 2).
- In addition to land being conserved as GSM habitat, that land also needs to be managed appropriately on a long term basis.

- For the process to work in practice, it must be accepted the conservation of the species does not necessarily imply conservation of **all** sites where the species is currently known. Rather, it is desirable to develop a hierarchy of sites in terms of conservation value and balance this against a hierarchy based on development value.
- While many GSM sites have been identified in the Canberra area, new sites are often being found. For example, in November – December 2009, approximately 15 new GSM sites were identified through reconnaissance surveys or casual observations, many of these being in what previously was considered as atypical habitat (Ref. 13). There are many other areas with similar habitat characteristics to known sites which have not been adequately surveyed. Furthermore, while records of known sites tend to be well documented, there are not necessarily records of sites which have been surveyed with negative results.

The ACT Government has made substantial progress in its strategic approach towards the conservation of threatened grassland species and communities in the ACT through the integrated approach adopted in Action Plan No. 28 (Ref. 2). This Action Plan demonstrates a level of sophistication that is advanced well beyond that reflected in the *EPBC Act*, which is focused solely on single species or communities. While the SEA approach under the *EPBC Act* may ultimately achieve a similar level of sophistication, based on the current rate of progress, this is likely to be some time away and will not assist in addressing current conservation versus development concerns. For purposes of the present exercise, it is considered necessary to focus on a single grassland species, namely the GSM, but the strategic approach to grassland conservation as developed by the ACT Government should still provide the context for this.

The present report is a revision of a previous report with the same title prepared in February 2009 (Ref. 10). The main changes from the previous report are as follows:

- Inclusion of information about additional GSM sites recorded in 2009 and 2010 (Ref. 13).
- Review of the present and possible historical patterns of GSM habitat to reflect the 2009 findings.
- Refinement of the proposed strategy to take account of the above two points.

2. SUMMARY OF KNOWN GOLDEN SUN MOTH SITES

2.1 Introduction

Based on information compiled for this report, plus some additional records identified in the GIS database maintained by CPR, there appear to be more than 60 sites in the ACT where the GSM has been recorded since it became a high-profile threatened species in the early 1990s. These sites vary widely in terms of their size and GSM populations. Some sites can be defined fairly precisely due to surrounding development constraints, while others are quite ill-defined, with any estimates of area being subject to a wide margin of error.

The characteristics of most of the known sites are documented in Appendix A, and are summarised in Table 2.1 by geographical area. The locations of the sites in Table 2.1 are shown in Figure 2.1, which shows the habitat type and indicative size and site area of each of the GSM populations. Figure 2.2 shows the approximate areas over which GSMs have been recorded at each site, based on information in the GIS database maintained by CPR. There are some minor discrepancies between these two maps, due to differences in the respective information sources used to prepare them, but the overall pattern is similar.

As the GSM is primarily a natural temperate grassland species, and natural temperate grassland occurs most commonly along the floors of valleys, most of the GSM sites relate to the valley systems within the Canberra area. They are grouped according to the following areas:

- Central Canberra
- Jerrabomberra
- Majura
- Gungahlin
- Belconnen

In developing and refining the present strategy, it has become apparent that the remnant GSM sites in the Canberra area should be viewed not as a series of separate sites but in a wider geographical context which relates in the first instance to the above valley systems. The following sections summarise the known GSM distribution in each of the above areas in turn, then considers how these fit together in a total Canberra context.

2.2 Central Canberra

Of the sixteen existing or former GSM sites in Central Canberra listed in Appendix A and Table 2.1, all are relatively small and most are subject to relatively intensive development or use pressures within or around the sites. Despite these pressures, at least twelve and possibly fourteen of these sixteen sites appear to be maintaining viable, albeit small, GSM populations, irrespective of the extent to which they are deliberately managed for GSM conservation. This suggests that, provided a small area of habitat is maintained (1 ha or possibly less), the GSM is sufficiently resilient to maintain its population in a small isolated site for several decades (e.g. St John's

Table 2.1 Summary of known GSM sites

Site	2009	2008	Area	Population size/activity	Grass type	Habitat type	Land use/security	Comments	Conservation priority	References
Central Canberra										
C1. York Park, Barton	✓	✓	Small	Moderate	Mainly native	B+	Urban park/ conservation site	High scientific value	1	2, 12, 17
C2. ACCC, Barton	✓	✓	Small	Low	Native	B	Urban lease		2	2, 12
C3. Black Street, Yarralumla			Medium	Moderate	Native, some CNG	B	Urban open space		2	2, 94
C4. Dudley Street, Yarralumla	✓	✓	Medium	Moderate to high	Mostly native, some CNG	B	Urban open space		2	2, 12, 95
C5. Guilfoyle Street, Yarralumla	✓		Medium	Moderate	Mostly native, some CNG	B	Urban open space, part to be developed	Larger than previously assessed	2	18
C6. Beale Street, Deakin	✓		Small	Very low	Weedy native pasture	B-	Likely to be developed		3	95
C7. St John's Church, Reid	✓	✓	Small	Low	Native		Church grounds, road verge	Translocation of larvae in sods has been attempted	2	2, 12, 54
C8. Campbell Section 5 (Constitution Avenue)	✓	✓	Medium	Low to moderate	Some native, much exotic including CNG	C	Part likely to be developed, with some retained as open space		2	2, 12, 19, 20
C9. CSIRO Headquarters, Campbell		X	Medium	No longer present?	Native/exotic	C	Future use uncertain	No recent records	5	12
C10. Yarramundi Reach			Large	No longer present?	Native	A-	Open space	No recent records	5	11
C11. Lady Denman Drive		✓	Uncertain	Moderate	Native	B	Road reserve	May be part of a more extensive site?	3	12
C12. Fisher Park, Ainslie	✓		Small	Low	Native/exotic	C	Urban open space		3	95
C13. McIntyre Street, Griffith			Very small	Low	Native/exotic	C	Road verge		4	95
C14. Captain Cook Crescent, Griffith	✓		Small	Low	Native	B	Road median	New record 2009, extension of Site C13?	4	96
C15. City Hill South	✓		Small	Moderate	?	NC	Road verge	New record 2009	4	
C 16. Royal Canberra Golf Club			Small	Low	Native	B	Golf course	Close to site C11?	4	97
Jerrabomberra										
J1. Callum Brae South	✓	✓	Large	High	Native	A	Nature reserve		1	2, 11, 12, 94, 97
J2. Mike's Hill			Large	Uncertain	Mostly native	A	Nature reserve		1	94
J3. Harman – Bonshaw South		✓	Large	Uncertain	Native	A	Defence, grazed		1	2, 94
J4. Harman residential area		✓	Small	High	Native	A	Defence, subject to possible development		1	95
J5. Amtech, Symonston	✓	✓	Medium	Low	Native	A	Potential industrial development		2	12, 95
Majura										
M1. Majura Training Area		✓	Large	High	Mostly native	A+	Army training		1	2, 11, 95
M2. Canberra Airport	✓	✓	Large	High	Native/exotic	A+	Airport, some development pressures	Several surveys between 2001 and 2009	1	2, 12, 95
M3. Malcolm Vale		✓	Large	Moderate	Native	A	Rural, associated with Majura Training Area		1	2, 94, 95
M4. Campbell Park	✓	✓	Medium	Low	Native	A	Commonwealth land, future use uncertain		1	2, 11, 12, 94
M5. Majura West		✓	Large	Low	Native	A	Rural, potential nature reserve and Majura Parkway		1	63, 94

Table 2.1 (continued)

Site	2009	2008	Area	Population size/activity	Grass type	Habitat type	Land use/security	Comments	Conservation priority	References
Gungahlin G1. Mulanggari Nature Reserve		✓	Large	Low	Mostly native	A	Nature reserve		1	2, 11, 12, 94
G2. Crace Nature Reserve	✓	✓	Large	Moderate	Native/exotic	A	Nature reserve		1	2, 12, 94, 97
G3. Gungaderra Nature Reserve		✓	Large	Low	Mostly native, some exotic	A	Nature reserve		1	2, 12, 94
G4. North Mitchell grasslands		✓	Medium	Low	Mostly native	A	Urban open space/grassland reserve		1	2, 12, 94
G5. Mulligans Flat North/Bonner 4	✓		Medium/ large	Low	Native	D	Part nature reserve, part proposal urban		2	11, 21, 22
G6. Mulligans Flat South-east	X	X	Medium/ large	Very low	Native	D	Nature reserve	No recent records	2	11, 30, 94, 98
G7. Mulligans Flat South-west	✓	✓	Medium	Very low	Native	D-	Nature reserve	Extent of habitat uncertain	2	30
G8. Moncrieff South	✓	✓	Large	Moderate	Native	D	Proposed urban, some open space/ conservation reserve	Subject to review to establish conservation reserve	2	23, 24
G9. Goorooyarroo Nature Reserve		✓	Uncertain	Uncertain	Native	D	Nature reserve		2	12
G10. Jacka North	✓		Large	Low	Mostly native	D-	Rural, proposed urban	Several small localised sites. New record 2009	4	25
G.11 Jacka South/ Moncrieff North	✓		Large	Very low	Native/exotic	D-	Rural, proposed urban	Several small localised sites. New record 2009	5	25
G12. Throsby residential	✓	✓	Large	Low	Native/exotic	D	Rural, proposed urban	Several small localised sites.	4	2, 12, 95
G13. Throsby playing fields	✓		Medium	Low	Native/exotic	D-	Rural, proposed urban open space	New record 2009	4	26
G14. Well Station Drive (hill)	✓		Small	Low	Native	D	Proposed urban, possible open space	New record 2009	4	27
G15. Harrison 4	✓		Uncertain	Very low	Native/exotic	D-	Proposed urban	New record 2009	5	29
G16. Forde North	✓		Small	Low	Native patches surrounded by exotic	D	Proposed urban	New record 2009	4	30
G17. Ngunnawal 2C	✓		Medium	Low	Native/exotic	D-	Proposed urban	New record 2009	4	31
G18. Gold Creek (Hall)	✓		Uncertain	Moderate	Native	D	Uncertain	New record 2009	4	95
G19. Block 799, Gungahlin			Small?	Low	Native/exotic	C	Proposed tourist development	New record 2010	4	99
Belconnen B1. Former Belconnen Naval Transmitting Station		✓	Large	High	Native	A	Commonwealth land, potential nature reserve		1	2, 12, 32, 33
B2. Lawson South	✓	X	Large	Moderate	Native/exotic	D	Proposed urban, some open space		3	12, 34, 35
B3. Lake Ginninderra			Small	Low	Native	B	Urban open space	Current presence uncertain	3?	81, 95
B4. Dunlop Nature Reserve North	✓	?	Large	Low – moderate	Native	A	Nature reserve		1	2, 12, 36, 94
B4. Dunlop Nature Reserve South	✓	?	Large	Low	Native	A	Nature reserve		1	12, 36
B5. Macgregor West – north-east	✓	✓?	Large	Very high	Native/exotic, including CNG	E+	Proposed open space/grassland reserve		3	12, 36, 37, 38
B6. Macgregor West– west	✓		Medium	Low	Native	B	Proposed urban	New record 2009	4	36, 39
B7. Lower Ginninderra Creek	✓		Medium	Low	Exotic?	E	Rural		4	36, 37

Table 2.1 (continued)

Site	2009	2008	Area	Population size/activity	Grass type	Habitat type	Land use/security	Comments	Conservation priority	References
B8. Jarramlee Road – west	✓		Medium/ large	Low	Native/exotic?	C	Rural	New record 2009	4	36
B9. Wallaroo Road	✓		Medium	Low	Native/exotic?	C	Rural	New record 2009	4	36
B10. Ginninderra Creek, Macgregor	✓		Small scattered patches	Very low	Mostly exotic, some native	E-	Urban open space		5	36, 37
B11. Dunlop powerlines	✓		Medium	Very low	Native/exotic?	C-	Powerline easement		5	36, 37
B12. Umbagong Park, Latham	✓	X	Large	Very low	Mostly exotic, some native	C-	Urban open space	New record 2009	4	12, 97
B13. Balamara Street, Giralang	✓	✓	Small	Low	?	NC	Road verge		4	12, 97
B14. University of Canberra	✓		Medium	Low	Mostly native?	C	University campus/road verge	New record 2009?	4	97

Notes on Table 2.1

1. See Section 2.9 for explanation of habitat types and Section 2.12 for explanation of conservation priorities.
2. Sites where GSM were recorded in 2009 or 2008 are ticked in the relevant column. A cross indicates that GSM were searched for but not found. A question mark for 2008 indicates that GSM were found in one of the two sites listed together but it is unclear which one. The 2008 records are based largely on Reference 12 but also on other anecdotal records..
3. Areas are notional only due to difficulties on defining the boundaries of some sites. Indicative areas are: Small - < 1 ha, medium 1-20 ha, large >20 ha.
4. Population size/activity is also indicative only but broadly follows the guidelines in Appendix B.
5. Habitat information is provided where known. Appendix A provides further details in some cases.
   CNG = Chilean needle grass, which may be present at more sites than indicated.
6. Assessments of future land use in some cases are assumptions only and do not necessarily represent current Commonwealth or ACT Government policy.
7. The ‘Comments’ column indicates which records are believed to be new in 2009 or 2010.
8. The references listed are not exhaustive and do not include verbal advice or maps from CPR.

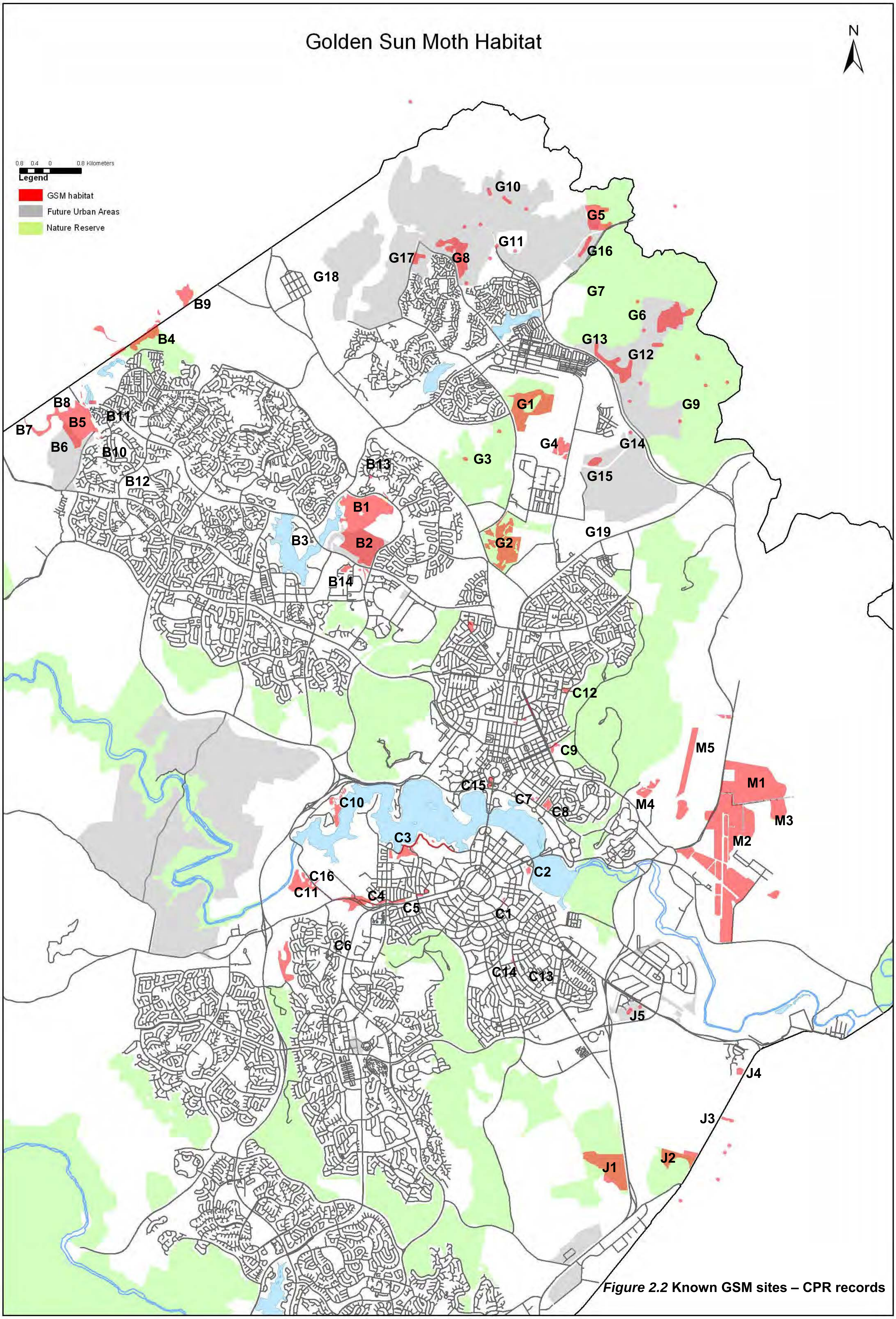

Figure 2.2 **Known GSM sites – CPR records**

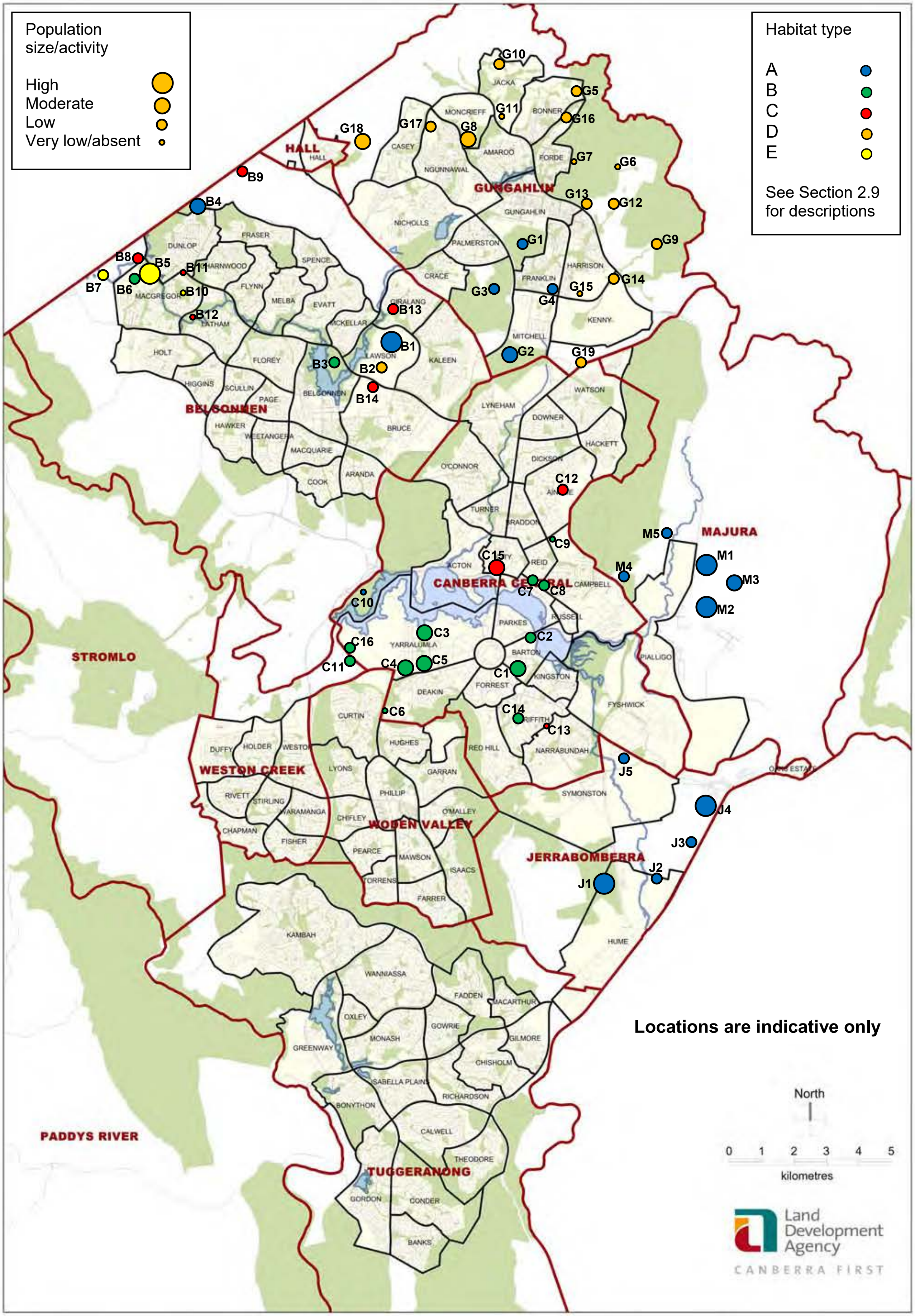

Figure 2.1 Known GSM sites – habitat type and indicative size

Church (C7), Constitution Avenue (C8), York Park (C1), Guilfoyle Street, (C5), Beale Street (C6), Fisher Park (C12), McIntyre Street/ Captain Cook Crescent (C13/ C14) and does not support the view that such sites are necessarily unviable in the long term. It is acknowledged, however, that such small sites are relatively vulnerable to edge effects and catastrophic events, are difficult to recolonise in the event of population loss, tend to be low in species diversity, and are relatively expensive to manage for biodiversity conservation. All of these factors detract from their long-term biodiversity potential.

On the other hand, the only relatively large grassland site in Central Canberra, which is also the site probably least affected by development pressures (Yarramundi Reach, C10), is one of the two sites which appears to have lost its GSM population. One possible explanation may be the lack of grazing or mowing at this site but other explanations also need to be considered (e.g. fire history, effect of Lake Burley Griffin on microclimate and water table). It is understood that while the grassland site is large, the GSM sightings were localised.

The City Hill South site (C15) is unusual in terms of the apparent re-establishment of a small GSM population in an area that has been subject to total disturbance in the past and is not connected to any other current GSM sites.

The most important of the Central Canberra sites is probably York Park (C1), particularly for its cultural scientific value and extensive monitoring records, rather than necessarily the quality of its GSM habitat. The ACCC site (C2), has other important grassland values apart from GSM habitat, and appears to be in a stable, long term management situation and is also of relatively high value.

The remaining sites where GSM is still found all contribute to a small degree but with none being of special value, although the Dudley Street and Guilfoyle Street sites are convenient reference sites for GSM surveys in other areas. These, along with the two sites where GSM now appears to be absent, were all either rated as being of low or minimal conservation value for GSM in AP7 or have been identified since AP7 was prepared.

A common feature of all of the Central Canberra sites is that they are located on land which probably supported natural temperate grassland prior to European settlement. Many of these sites were withdrawn from rural use early in Canberra’s development and either retained such grassland remnants or were not so modified by rural use that regeneration of such grassland was precluded. Some sites, on the other hand, appear to have undergone major disturbance in the past but have still been able to regenerate as GSM habitat (e.g. City Hill South (C15) and Captain Cook Crescent (C14)). How these regenerated sites became repopulated with GSM is not clear, however.

While most of the Central Canberra sites may appear to be isolated, there are some which are geographically related. In particular, there is a fragmented distribution of sites along the Lady Denman Drive/ Cotter Road corridor on the western and southern side of Yarralumla, including Sites C11, C16, C4 and C5, as well as other habitat which is shown in Figure 2.2 but is not listed in Appendix A or Table 2.1.

2.3 Jerrabomberra

The Jerrabomberra Valley in the ACT and New South Wales contains extensive areas of natural temperate grassland and native pasture with potential to provide core conservation areas for a range of threatened grassland species, including the GSM. The most important of those areas which are within the control of the ACT Government are being managed as nature reserves, specifically Callum Brae South (J1) and Mike's Hill (J2). The Harman – Bonshaw South area (J3) is under a form of land management by the Commonwealth which is compatible with protection of their grassland values. This may not be the case with the site on Commonwealth land within the Harman residential area (J4). A small, low population site on Territory land within the Amtech estate in Symonston (J5) is currently identified for industrial development.

While there is a large area of protected or well managed grassland within the Jerrabomberra Valley which is potentially available as GSM habitat, the proportion actually supporting GSM appears to be relatively small, possibly due to unsuitable grassland characteristics.

2.4 Majura

Unless further monitoring confirms significant numbers of GSM in Site M5 (Majura West), almost all of the known GSM habitat in the Majura Valley is under the control of the Commonwealth. This includes this largest continuous area of GSM habitat in the ACT within the Majura Training Area (M1) and adjacent former leases (M3), and Canberra International Airport (M2). Securing this area under a form of management appropriate for grassland conservation would be one of the most effective actions that could be taken towards GSM conservation in the ACT, but is beyond the direct control of the ACT Government.

Site M4 (Campbell Park) appears to be a useful additional site of moderate conservation value but is also under Commonwealth control.

The fact that these sites are under Commonwealth control and do not have any formal conservation reserve status does not in itself imply that they are not being managed appropriately or that the GSM populations are under threat. Indeed, given the ability of the GSM to survive for many decades in developed situations in Central Canberra (see Section 2.2), it may be expected that the prospects for maintaining populations on much larger and more natural areas in the Majura Valley would be even more favourable. Periodic monitoring to confirm that this is happening would nevertheless be desirable.

The only potentially important GSM habitat area in the Majura Valley which is under ACT control is Site M5 (Majura West). The addition of this site to Mount Ainslie Nature Reserve with appropriate management for its grassland values could become important for the GSM and other threatened grassland species in the future. The site has been identified as a potential reserve in the Eastern Broadacre Planning Study (Ref. 64).

All of the GSM sites in the Majura Valley appear to be in existing or former areas of natural temperate grassland.

2.5 Gungahlin

The GSM distribution in Gungahlin contrasts with that in Central Canberra, Jerrabomberra and Majura in that the majority of the recorded sites are not in former natural temperate grassland, but in secondary grassland which is part of the box – gum woodland community.

While the secondary grassland sites are more numerous, they generally appear to maintain relatively small GSM populations. The key GSM habitat areas in Gungahlin are located in two of the three major grassland nature reserves, Mulanggari Nature Reserve (C1) and Crace Nature Reserve (G2). The GSM is present also in the third grassland nature reserve, Gungaderra Nature Reserve (G3) and in the grassland reserve at North Mitchell (Franklin, G4). These four areas offer a high degree of security for the GSM in Gungahlin.

Recent observations in 2008 and particularly 2009 have revealed a large number of additional sites, generally with a low level of GSM activity, throughout most of the undeveloped areas of Gungahlin. Most of these new sites are in secondary grassland areas which have not been subject to previous surveys, probably because of the view that the GSM was a natural temperate grassland species. Some of these secondary grassland sites are in the woodland nature reserves (Mulligans Flat (G6 and G7 and part G5) and Goorooyarroo (G9)) but the majority are in proposed urban areas (Moncrieff (G8 and part G11), Ngunnawal (G17), Jacka (G9), Throsby (G12 and G13), Harrison (G15), Bonner (part G5) and Kenny (G14)). In some cases (Harrison 4, Forde North) a decision has been made to proceed with urban development, while in other cases (Bonner 4 East, Moncrieff) significant areas of land have been withdrawn from development. In the latter cases, the general biodiversity values of the perspective areas are relatively high and are not confined to the GSM.

In November 2010, the GSM has been recorded in former natural temperate grassland on Block 799, Gungahlin (G19), which is proposed for tourist accommodation development.

One of the features of the Gungahlin area in the years leading up to 2009 was a gradual reduction in the intensity of agricultural activities (i.e. grazing and pasture improvement) in anticipation of land withdrawal and urban development. This easing of land use pressures, coupled with a series of dry years, saw a marked change from predominantly exotic pasture to native pasture, which may have created more favourable habitat for the GSM. A resulting increase in GSM numbers coupled with focused search effort in these areas are likely factors underlying the large number of GSM sites recorded recently in Gungahlin.

2.6 Belconnen

The most important GSM habitat in Belconnen appears to be at the former Belconnen Naval Transmitting Station (BNTS) in Lawson (B1). This has been assessed as a key habitat area for GSM, as well as a core conservation area for natural temperate grassland. If this area ultimately becomes a nature reserve, this would be a major step in conserving the species in Belconnen. The GSM is present also over a significant area in Lawson South (B2).

Other smaller sites in proximity to Lawson have small populations but are probably related geographically. These include University of Canberra (B14), Balamara Street, Giralang (B13) and Lake Ginninderra (B3).

The remaining GSM sites in Belconnen are spread around on the north-western edge of Belconnen and, to a very limited extent, along the lower reaches of Ginninderra Creek. The most significant of these, at least in population size, is Macgregor West – north east (B5). This site has been considered potentially important from a scientific perspective because part of the site is so different in vegetation characteristics from other previously known GSM sites in the ACT, due to the dominance of Chilean needle grass along the creek, where the moth density is highest. While it remains probably the largest of the Chilean needle grass GSM sites in the ACT, and supports the largest GSM population of any of these sites, the role of Chilean needle grass as a GSM host plant is now more widely acknowledged.

Site B5 has direct or indirect links to other sites within the Macgregor West 2 Estate (B6), along Ginninderra Creek (B7, B10, B11, B12) and towards or along the ACT border between Macgregor West and Wallaroo Road (B8, B4, B9). While these have all been identified as separate sites, they may be better considered as fragmented remnants of a large habitat area established in what was probably originally natural temperate grassland.

2.7 Overall Distribution

There are now more than 60 sites in the ACT where the golden sun moth has been recorded in the last 20 years. This is about four times the number of sites known in the ACT when Action Plan No. 7 was prepared, and is likely to increase further with additional searching. While identification of specific sites may have been useful in the past in nominating areas of high conservation priority, this approach is becoming less relevant as occurrences of GSM become more numerous and widespread over large areas. Instead, it is more useful to look holistically at the types of areas which are now known to function as GSM habitat to a greater or lesser extent, and to determine how a selection of such areas can be managed on a long term basis to conserve the GSM, as well as other grassland values.

The types of areas where the GSM is found include the following:

1. Large areas of natural temperate grassland or high quality native pasture which, through design or chance, have experienced a long period free from intensive agricultural activity, enabling the GSM to survive with a reasonable degree of security. These include the large grassland nature reserves in Gungahlin, Dunlop and Jerrabomberra, as well as Commonwealth institutional (mainly Defence) land in Majura, Jerrabomberra and Lawson.

2. Small to medium-sized remnants of present or former natural temperate grassland which have survived in urban open space, road verges and other urban sites despite the presence of nearby development. Some of these sites are very isolated, while others form part of a fragmented chain of such remnants (e.g. around the western and southern edge of Yarralumla).

3. Areas of Chilean needle grass which has been found increasingly in recent years often to support sizeable populations of GSM. The prime example of this is Macgregor West (B5), but there are several other smaller urban sites where the presence of Chilean needle grass has coincided with an active GSM population (e.g. Dudley Street (C4), Guilfoyle Street (C5), Campbell Section 4 (C8)).

4. Large areas of secondary grassland/ native pasture within box – gum community. Such areas occupy a high proportion of the undeveloped land in Gungahlin as well as parts of the woodland nature reserves in Gungahlin (Mulligans Flat and Goorooyarroo). A feature of these areas is that, while the GSM is widespread, it is present at relatively low levels of activity, and its distribution does not correlate strongly with particular native grass species. The observations of GSM in these areas are best regarded as random observations within a large habitat area, rather than as specific sites.

5. 'Surprise' areas, where the history of land use and development, coupled with isolation from other GSM habitat, makes it extremely unlikely that GSM would be present. City Hill South (C15) is such an example. If the GSM can somehow find its way into such areas, there could be hundreds of sites throughout Canberra which contain regenerating native grassland or Chilean needle grass, where some chance event may enable the GSM to re-establish itself.

The main geographical centres of GSM activity in Canberra can be summarised as follows:

1. Native grassland reserves in the lower parts of Gungahlin. There are three nature reserves (G1, G2 and G3) as well as the North Mitchell grasslands (G4) surrounding the Mitchell – Franklin area. At least some of these reserves support moderate levels of GSM activity, although not necessarily throughout the whole of the reserves.

2. The lower Majura Valley, especially within the airport and the Majura Training Area (M1, M2 and M3) where sympathetic land use and management has resulted in large populations, despite development of parts of the grassland habitat. Other nearby sites in Majura (M4 and M5) have smaller GSM numbers but still have high potential as habitat.

3. Parts of Jerrabomberra Valley where nature reserves (J1 and J2) and Commonwealth land within Harman – Bonshaw (J3 and J4) provide known or potential habitat.

4. The Lawson area (B1 and B2) which extends also into Giralang (B13) and the University of Canberra (Site B14), and possibly the Lake Ginninderra foreshores (B3). The highest activity within this area appears to be within the Commonwealth land in the former Belconnen Naval Transmitting Station (B1).

5. Beyond the north-western edge of Belconnen. This area includes Macgregor West (B5 and B6), Dunlop Nature Reserve (B4) and several other areas along or outside the ACT border (B7, B8 and B9). The full extent of GSM distribution in this area has not been determined and it may be considerably wider than is currently known. According to Figure 2.2, GSM habitat extends across the border into New South Wales. Much of this area has a high content of exotic pasture grasses and the habitat used by the GSM may be discontinuous.

6. The 'Yarralumla corridor' extending along Lady Denman Drive, Cotter Road and the northern side of Adelaide Avenue. This contains several sites of low to moderate GSM activity in a fragmented distribution, extending from road reserves into adjacent land which has not been intensively modified.

7. Secondary grassland within the Gungahlin woodland belt. These grassland areas have a discontinuous distribution around the undeveloped midslopes of Gungahlin from the Federal Highway through to Hall. The area includes undeveloped land in the suburbs of Kenny, Harrison, Throsby, Forde, Bonner, Jacka, Moncrieff, Ngunnawal and possibly Taylor and Kinlyside, as well as parts of the Goorooyarroo and Mulligans Flat Nature Reserve. A feature of this area is that the GSM is present only in low numbers, has a very scattered distribution covering a range of grass species associations, and its detection can be variable over time. These factors make it very difficult to map or measure the extent of GSM habitat within this area.

The remaining GSM sites are small, isolated sites located mainly in Central Canberra. Despite their small size and isolation from other sites, they have successfully maintained GSM populations over several decades, suggesting that the GSM is quite a resilient species.

2.8 A Possible Explanation of Golden Sun Moth Distribution

Following the discovery of GSM in many secondary grassland locations in 2009, the following explanation was proposed for the historical processes leading up to its current distribution (Ref. 13):

Under pre-European conditions, the GSM was a natural temperate grassland specialist, possibly due to microclimatic factors and/or predation by woodland birds and other species. With European settlement, the extent of native grassland was increased substantially as box – gum grassy woodlands were substantially cleared, leaving a grassy understorey. Initially this grassy understorey contained a high component of the native grasses used by the GSM, predation by birds was reduced due to loss of habitat trees and shrub cover, and the GSM was able to move into those areas.

The natural temperate grassland areas, with their deep, relatively fertile soils and gentle slopes, experienced the greatest impacts due to grazing, ploughing, cropping and pasture improvement. These processes disrupted the life cycle of the golden sun moth and largely destroyed its habitat, except in a few pockets which remained relatively undisturbed, despite some weed invasion due to degradation of surrounding land. Consequently, much of the remaining GSM population became concentrated in the secondary grassland, where the habitat quality was not as high and the level of GSM activity was lower than in the preferred natural temperate grassland habitat.

Over time, however, much of the secondary grassland suffered a similar fate to the natural temperate grassland, with heavy grazing pressures and exotic pasture replacing the native grasses as a result of pasture improvement and fertiliser application. The cumulative impacts of agricultural development reduced GSM populations to very low numbers in scattered pockets within remnants of natural temperate grassland and secondary grassland.

With the development of Canberra, agricultural activities declined as land was withdrawn for urban purposes. In areas where urban development and infrastructure works were located, any residual GSM habitat was destroyed, but there were some pockets in land bank or informal open space areas where the GSM survived, along with suitable native grass species. Over time, both the native grasses and the GSM have recovered to some degree under benign management, resulting in the remnant urban sites such as York Park (C1), Section 5 Campbell (C8), and Guilfoyle Street, Yarralumla (C5). Where more extensive areas of natural temperate grassland or native pasture have survived under a reduced level of grazing activity (e.g. West Belconnen) or a nature conservation regime (e.g. Gungahlin grassland reserves), larger more extensive populations have recovered.

Likewise in areas of secondary grassland, where impending development has resulted in lessees ceasing pasture improvement and reducing stocking rates, native grasses are recovering, possibly assisted by recent climate trends. This has also enabled GSM numbers to build up and spread, facilitating their detection. Because the habitat quality of those areas is not as high as that of natural temperate grassland, the level of GSM activity in those areas tends to be relatively low. It is perhaps significant that most, if not all, of the areas supporting high levels of GSM activity are located within or close to the original natural temperate grassland boundary, as identified in Action Plan No. 28 (Ref. 2).

In the longer term, however, areas of secondary grassland which remain undeveloped may eventually regenerate to woodland. This may reverse the process which enabled them to be colonised by GSM, resulting in the GSM eventually disappearing from those areas.

A possible major boost to GSM numbers may have come through the invasion of many grassland areas by Chilean needle grass. While more research is needed into the role of this species as a host plant, circumstantial evidence suggests that it has physical or chemical properties which are particularly attractive to the GSM, perhaps even more so than the native host species. The spread of Chilean needle grass appears to be relatively recent in Canberra, and there are some sites where it appears to have been beneficial to the GSM.

For example, the very high numbers of GSM rcorded on the Ginninderra Creek floodplain at Macgregor West (B5) in 2004 and 2005 may have been a result of the high concentration of Chilean needle grass in that area. Moderately high numbers at small sites at Guilfoyle Street and Dudley Street, Yarralumla (C4 and C5), appear to be associated with Chilean needle grass rather than native grasses which are present in the same areas.

The detection of GSM may in itself be a factor in explaining its apparent population increases. Over 20 years, the GSM has gone from being a species studied by only a handful of scientists to one which has attracted wide community interest. As a flagship species for native grasslands, it is probably the easiest of the threatened grassland species to detect, at least as flying males, despite the limited period and constrained conditions when it is active. Its cultural value is quite significant for that reason, irrespective of how threatened it is.

Contrary to what is written or implied in the literature, the GSM appears to be quite a resilient species. It has survived in the grounds of St John's Church (C7) since the early days of Canberra. There are other sites in Central Canberra where it has survived several decades of adjacent development (or alternatively has recolonised these sites from surrounding areas). The greatest threat to such sites may be the development of a dense grass sward, due to cessation of grazing and a lack of suitable alternative management (e.g. Yarramundi Reach (C10)).

2.9 Defining Golden Sun Moth Habitat

One issue which has been raised by the recent records of GSM distribution, particularly in Gungahlin and Belconnen, is the difficulty of defining GSM habitat. The past assessment of GSM habitat requirements emphasised the importance of *Austrodanthonia* species, a point which was strongly emphasised in its *EPBC Act* listing advice (Ref. 4). More recent observations, however, suggest that this relationship is not as strong as originally believed, and that the GSM may be more versatile with respect to its habitat requirements. This first became evident with the discovery that one of the largest GSM populations in the ACT (Macgregor West, B5) was utilising Chilean needle grass as a host plant (Ref. 37). Chilean needle grass has since been found to apparently contribute to the habitat at several other sites (see Section 2.8). There is evidence also that native species other than *Austrodanthonia* are also utilised (e.g. *Austrostipa*, *Bothriochloa*).

It is not known whether the recently observed affinity with Chilean needle grass reflects a genetic adaptation to a changing environment. Furthermore, the ability of GSM to utilise this species as well as a range of native grasses does not necessarily negate the belief that *Austrodanthonia* is the preferred habitat species, subject to other environmental conditions being favourable.

Most of the local Gungahlin populations have been found in areas of secondary grassland, remote from the likely former limit of natural temperate grassland as identified in AP28. As discussed in Section 2.8, while the GSM is a grassland specialist, it is not necessarily a **natural temperate** grassland specialist, and can adapt to other grassland environments. Natural temperate grassland is still likely to be its **preferred** habitat, because of the risk of secondary grassland reverting to woodland under natural conditions, and its numbers in secondary grassland tend to be lower than in natural temperate grassland.

A further consideration with respect to habitat quality is the structure of the grassland. A relatively open structure, such as that commonly associated with *Austrodanthonia*, appears to be desirable for GSM mating and egg-laying. Such a structure is promoted by light to moderate grazing, or by deliberate management prescriptions. Consequently, a change in management which leads to a significantly increased grass density may adversely affect the survival of a GSM population. Such a change, which has potential to affect the whole of a GSM site, may prove to be a more serious long-term threat to that site than partial development. There is some evidence of this at Site G5, where the GSM numbers within the former rural lease that has been lightly grazed were found to be higher than in the grassland in the adjacent area of Mulligans Flat Nature Reserve (Ref. 21).

Based on the above considerations and the information in Section 2.7 describing the types of areas where the GSM is found within the ACT, the local habitat for the GSM can be described in the terms outlined below. This description takes account of not just the presence or absence of GSM, but also its level of activity, which reflects population size, and other environmental components which are important from a broad biodiversity conservation perspective. The last of these points reflects the importance of conserving the GSM not just as a species, but a species supported by the ecological processes of its natural environment. This is consistent with the approach adopted in the most recent series of Action Plans prepared under the *NC Act*. The following habitat descriptions rank the various habitat types according to their quality.

Type A habitat. The preferred (and probably most natural) habitat for the GSM is natural temperate grassland (or high quality native pasture) which desirably has a moderate to high component of *Austrodanthonia* and is sufficiently large to avoid being impacted significantly by surrounding development. Examples include the grassland nature reserves in Gungahlin, Jerrabomberra and Dunlop, the former Belconnen Naval Transmitting Station and the central area of Majura (airport and Majura Training Area).

Type B habitat. This is similar to the Type A habitat but exists in smaller remnants which may be subject to the impacts of surrounding development and more intense use. Most of the smaller GSM sites in Central Canberra would fall into this category. While the level of GSM activity per unit area may be similar to that of the Type A habitat, these sites are more vulnerable to external impacts because of their small size.

Type C habitat. This is lower quality habitat (e.g. mixed native and exotic) in areas that were probably previously natural temperate grassland and have been found to support at least a small GSM population.

Type D habitat. This habitat consists of the extensive areas of secondary grassland, possibly with an exotic component, within the box – gum woodland community which, as discussed in Section 2.8, may have emerged as GSM habitat as a result of past land clearing, and have an uncertain future as such woodland regenerates. GSM numbers are generally low to very low in these areas and individual records can be widely scattered, making precise definition of the habitat difficult.

Type E habitat. This is the lowest quality habitat, being dominated by Chilean needle grass or other exotic grasses with little or no native grasses present. While it can support very high numbers of GSM (e.g. Macgregor West, B5), this habitat may have no other features of biodiversity conservation significance. The environmental conflict between protecting GSM and eradicating Chilean needle grass poses a major challenge to the management of such habitat.

The most appropriate habitat description is identified against each of the sites listed in Table 2.1. There are a few sites which do not fall readily into any of the above categories, or for which insufficient information has been obtained to assign a classification. These sites are listed as ‘not classified’ (NC).

The ranking as GSM habitat quality from A (best) to E (worst) does not necessarily reflect their wider biodiversity values. For example, Type D is ranked relatively low because of doubt about the long term potential to support GSM in regenerating woodland. Such regeneration, however, is important for other ecological reasons. Type E habitat, on the other hand, may have high potential for maintaining GSM but would be under constant threat from a weed control perspective.

The categories do not directly reflect the GSM populations at each site, to the extent that these are known but, where a site has been recorded as having a relatively high (or exceptionally high) population **for that category of site**, this is indicated by ‘+’. Those where the known GSM counts are very low are indicated by ‘-’.

The ranking of sites in this way is considered to be important in assigning conservation priorities to the site, and in evaluating the case for offsets in the event of development.

2.10 Seasonal Variations

Apart from the limited period when flying GSM can be detected, GSM surveys are subject to considerable variations from both annual and daily weather conditions. For example, 2009 appeared to be a particularly favourable year for GSM emergence and flying (Ref. 13), which may be a factor underlying the large number of newly reported sites. In a less favourable season, the number of moths emerging from some of those sites may be so low that they would not be detected by chance observation, even during a targeted survey. The 2009 season, however, appeared to be finished by mid-December, as was evident at Macgregor West (B5, Ref. 36), where very large numbers of GSM were recorded on later dates during 2004 (Ref. 37) and 2005 (Ref. 38).

At Lawson South (B2), the GSM was recorded in low to moderate numbers in 2007 (Ref. 34) and 2009 (Ref. 35), but not in 2003 (Ref. 94) or 2008 (Ref. 12). Several years of observations under suitable conditions, and not just several days within the one season, may be required at some sites to demonstrate conclusively the absence of GSM or to obtain reliable quantitative data on its level of activity.

The 2010 season is shaping up to be particularly atypical due to persistent heavy rainfall. At the time of writing, early observations of GSM have been confined to small numbers in a limited period in late November, with little prospect of the main flying season (if there is one) commencing until at least mid-December, about the time that the 2009 season ended.

2.11 Sites where Golden Sun Moth is Absent

While there is a tendency not to report sites where GSM have not been recorded in target searches, such information is still useful in clarifying the distribution of the species. The University of Canberra/ Friends of Grasslands surveys in 2008 (Ref. 12) reported several such sites including:

- CSIRO Headquarters, Campbell (C9)
- Lawson South (B2)
- Umbagong Park, Latham (B12)
- The Pinnacle Nature Reserve
- Kaleen East paddock
- Glenloch Interchange

Surveys undertaken for the LDA in 2009 did not record GSM at the following sites:

- Kenny (Ref. 28)
- Sections 57, 58 and 59, Greenway (Tuggeranong Town Centre, Ref. 40)
- Sections 45 and 47, Fyshwick (Ref. 41).

The GSM has not been recorded in the south-eastern part of Mulligans Flat Nature Reserve (Ref. 30) or on the Pinnacle (Ref. 98) in brief reconnaissance surveys in 2008 or 2009. Based on these surveys and observations in other secondary grassland areas, it appears that where GSM is present in secondary grassland, it tends to favour the lower slopes, although this observation requires further testing.

2.12 Conservation Priorities

Decisions as to whether sites containing GSM should be conserved for biodiversity purposes or whether they should be allowed to be developed involve balancing conservation priorities against development priorities. This balancing process reflects a range of environmental and other values.

The following factors are considered relevant to assessing the relative conservation priorities of GSM sites:

- Known GSM population, including typical numbers and consistency between different years.
- Viability as GSM habitat, whether based on native grasses or Chilean needle grass, taking account of the past history of GSM survival.
- General ecological quality in terms of native plant diversity and ability to support other grassland fauna.
- Special attributes, for example, for scientific research or other cultural values.
- Geographical context in terms of potential security for the site as GSM habitat, particularly current reserve status.

These factors are essentially the same as those that have been adopted in a methodology developed for assessing the impacts of development on the GSM in relation to the *EPBC Act* (see Appendix C).

Based on these factors, the conservation priority for each of the known GSM sites is assessed provisionally in Table 2.1. These are subjective judgements which relate to the relevant factors as described in Table 1 of Appendix C, and may require further interpretation in relation to each site. As a broad indication, some typical characteristics for each conservation priority level are as follows:

Level 1

- Existing natural temperate grassland nature reserves.
- Other large areas of natural temperate grassland or high quality native pasture.
- Sites with moderate to high GSM population levels that have been maintained over a long period.
- Sites with a range of other grassland biodiversity values for threatened species.
- Sites with a history of scientific monitoring.
- Sites of high cultural significance from a GSM perspective.

Level 2

- Existing secondary grassland in woodland nature reserves.
- Small areas of natural temperate grassland or high quality native pasture.
- Sites with low to moderate GSM population levels that have been maintained over a long period.
- Sites with a range of other grassland biodiversity values, but not necessarily threatened species.

Level 3

- Other native pasture sites with low to moderate GSM population levels that have been maintained over a long period.
- Chilean needle grass sites with a high GSM population.

Level 4

- Other native pasture sites with a low to very low GSM population level, but which has not yet been shown to be maintained over a long period.
- Chilean needle grass sites with a low to moderate GSM population.

Level 5

- Highly degraded sites where occasional observations of GSM have been recorded.
- Sites where GSM have been recorded in the past but now appear to be absent (may be potential future habitat, however).

The above characteristics have been interpreted as guildelines only, and the assessments may change as further information relating to some sites becomes available.

3. STRATEGIC BACKGROUND

3.1 Strategic Achievements by the ACT Government

The strategic approach towards the conservation of the GSM in the ACT is part of the wider conservation strategy embodied in AP28 to conserve natural temperate grassland communities in the ACT. While there is a small number of GSM sites which are not natural temperate grassland, these are a minor component of the overall strategy.

While AP28 has legal force to the extent that it is prepared under the *NC Act*, its implementation requires further action which is beyond the scope of that Act. In particular, the formal dedication of nature reserves requires variations to the Territory Plan, while other actions are required to ensure that appropriate management measures are in place to achieve the objectives of AP28. AP28 nevertheless provides the context and the scientific basis for such actions.

The main opportunities to achieve effective GSM conservation in the ACT rest partly with the ACT Government and partly with the Commonwealth government which, between them, control most of the land where the GSM is found. Since the 1990s, the ACT Government has taken significant steps to conserve natural temperate grassland and the species that depend on it on land which it controls. A summary of these from the viewpoint of GSM conservation is as follows:

- Three large grassland reserves (G1, G2, G3) plus one other viable grassland area containing GSM (G4) have been set aside in central areas of Gungahlin. Two of the reserves (G1, G2) are assessed as containing key GSM habitat.
- One large grassland reserve (J1) has been established in Jerrabomberra and a further reserve (J2) is being established. Both of these are key habitat for GSM.
- One minor GSM site under Territory control in the Majura Valley (M5) has been identified for future incorporation into Mount Ainslie Nature Reserve.
- Of the other known GSM sites in Belconnen, one is within a nature reserve (B4), while most of the others are predominantly within existing or potential urban open space or rural leases. A notable exception is the Territory land at Lawson (B2), which has been committed for urban development on the basis that better quality native grassland/ GSM habitat within Commonwealth land is likely to be conserved.
- All of the confirmed GSM sites on Territory land in Central Canberra are small, close to development and are either within urban open space, road verges or the grounds of institutions. Some of these sites are subject to specific management measures to conserve the GSM or other grassland values, while at others the GSM have survived for many years without any deliberate management measures. A few of these sites are subject to direct or indirect impacts of proposed development.
- There are fourteen areas of GSM habitat in Gungahlin (G5 to G18) which are not located in existing or former natural temperate grassland, and are hence not addressed in AP28. Three of these are in secondary grassland on the edge of Mulligans Flat Nature Reserve and one in Goorooyarroo Nature

Reserve. These sites may be adversely affected by natural regeneration of woodland. The remaining sites contain areas which are potentially subject to the impacts of future residential development.

In summary, all of the key GSM habitat on Territory land in Gungahlin and Jerrabomberra identified in AP28 is located in nature reserves. In addition, much of the other known habitat is in nature reserves, in secure areas in urban open space, or in situations where the management appears appropriate for GSM conservation. The ACT Government is therefore in a strong position to maintain populations of GSM at selected sites throughout much of its natural range despite the loss of habitat that has occurred historically as a result of development or inappropriate management.

3.2 Strategic Achievements by the Commonwealth Government

The Commonwealth land that is important for GSM conservation has been identified in AP28, but the scope for the ACT Government to implement conservation measures on this land is indirect only, for example, through memoranda of understanding or other negotiations with the Commonwealth Government. Commonwealth measures to conserve GSM habitat have emerged mainly in terms of land management. In some cases, such management measures have been deliberately aimed at grassland and/or GSM conservation, while in other cases they have been fortuitous. A summary of the position with regard to GSM conservation in Commonwealth-controlled land is as follows:

- Four of the five GSM sites in the Majura Valley are currently controlled by Commonwealth. These include the key habitat north of the airport (M1), which is located within the Majura Training Area. Together with the airport (M2) and Malcolm Vale (M3), these constitute the largest area of GSM habitat in the ACT and support one of the largest GSM populations. While the management of these areas to date has been favourable for the GSM, the long-term security of these areas as grassland habitat is at best uncertain. This applies also to a smaller site at Campbell Park (M4) where some deliberate grassland conservation measures have been implemented.
- The most important GSM habitat in Belconnen (BNTS, B1) is currently controlled by the Commonwealth and is managed in part for its grassland values, although it has no formal conservation status as a nature reserve.
- There is an extensive area of Commonwealth land in Jerrabomberra associated with the Harman – Bonshaw defence facility. The majority of this (J3) is under sympathetic management for GSM conservation, but appears to be of minor importance for GSM. A more important site (J4) is within the Harman residential area but may be subject to development pressures.
- Within the Central Canberra Area, York Park (C1) is managed on behalf of the National Capital Authority as GSM habitat. Other sites on Commonwealth land in Central Canberra are at Guilfoyle Street (C5) and Beale Street (C6), which is likely to be at least partly developed in due course, and Yarramundi Reach (C10), where the GSM no longer appears to be present.

In summary, the only Commonwealth land where there is a specific commitment to managing GSM habitat (or native grassland) as its primary use is York Park and possibly Campbell Park. In most of the other areas, the current management regime is compatible with GSM conservation, but there is no formal commitment to conservation while the current land uses continue. It is feasible that nearby development (or other circumstances) may ultimately make much of this land unsuitable for its Commonwealth purpose, resulting in it being transferred to ACT control. In this event, this is a strong possibility that any large areas with native grassland values would become ACT nature reserves, increasing their long-term security for conservation. In the meantime, the ongoing management of these areas would rest in the hands of the responsible Commonwealth department.

3.3 Potential Threats

The main threat to GSM has been described (Ref. 82) as the continued destruction of habitat due to urbanisation, agriculture, mining, roads, rail and inappropriate tree planting. The invasion of native grasslands by weeds also contributes to a decline in the quality of the habitat (Ref. 1). Ploughing and inappropriate grazing are also detrimental, but light grazing does not seem to be detrimental, as some populations have thrived where light grazing was practised (Ref. 82). The extent to which predation and fire can be regarded as threats appears to be uncertain.

It appears from the known distribution of GSM that the species is capable of surviving within small, partly developed sites for extended periods (e.g. several decades). This suggests that, provided an adequate patch of grassland is maintained free of a high level of disturbance such as ploughing or intensive grazing, and biomass is maintained within a suitable range, the GSM is not particularly vulnerable to other moderate intensity impacts such as mowing or occasional trampling. This bodes favourably for its long term survival in those nature reserves and other large areas where it is currently found in the ACT.

The ability of the GSM to maintain viable populations on small sites suggests that many of those sites which are subject to development pressures may be able to maintain GSM populations if only a part of these sites is developed and the rest kept as grassland under an appropriate management regime. There is some uncertainty, however, as to whether certain parts of those sites (e.g. the natural temperate grassland in the Constitution Avenue area) are critical for GSM which spread through other parts of the site. While the highest observed concentrations of moths do not necessarily correlate with what may appear to be the best habitat, there may be explanations for this apparent anomaly.

As discussed in Section 2.9, simply retaining a GSM site free from development will not necessarily conserve it as GSM habitat in the long term. There is evidence that reduced grazing or mowing pressures may lead to decline of a site through excessive grass growth (e.g. Mulligans Flat North (G5), Yarramundi Reach (C10)). Natural regeneration of woodland trees and shrubs within secondary grassland sites is likely to create conditions that will lead to the eventual loss of GSM sites in those areas, unless they are deliberately managed to inhibit such regeneration.

What then would constitute a significant threat to the survival of the GSM in the ACT, given the existence of several large, secure sites and many smaller, potentially less secure sites throughout a representative range of the original GSM habitat in the ACT? This question is directed at conserving the species, which does not necessarily mean conserving every site at which it has been recorded.

One point which is evident from the preceding discussion is that direct physical impacts as a result of development have the potential to affect only a small proportion of the Type A and Type B habitat under the current land use and management arrangements. While such impacts are likely to have been a reason for the decline of the GSM in the past, the actions taken by the ACT Government to conserve grassland communities mean that such impacts should be limited in the future.

In contrast, a large proportion of the Type D habitat is under threat from urban development or, if that development did not take place and the land was allowed to regenerate naturally, is likely to experience a decline in GSM numbers due to habitat changes.

The main threats to the Type E habitat are associated with the control of Chilean needle grass as a nationally significant weed. Removal of that species from the grassland could see a parallel decline in GSM numbers unless such control programs are accompanied by re-establishment of suitable native grass species. This issue is currently being investigated at Macgregor West (B5).

From a strategic viewpoint the types of impacts that may affect the GSM to the extent of constituting a real threat are those which are wide-ranging, affecting a high proportion of the habitat within the ACT, or the majority of some of the key habitat areas. Possible examples include:

- climate change, which is potentially a threat to many species or communities through direct or indirect means, which are commonly speculative or uncertain, and are beyond the control of the ACT Government;
- natural regeneration as discussed above in the context of secondary grassland/ woodland, but may apply to other grassland communities where grazing pressures are reduced (e.g. by stock being removed, or areas becoming isolated from kangaroos);
- changes to management practices (e.g. grazing, mowing) in sites where such practices have deliberately or fortuitously enabled the GSM to persist despite the impacts of nearby development; or
- intense grass fires at a critical stage of the GSM life cycle, although this would tend to affect only individual sites.

The types of impacts which are identified as significant in the *EPBC Act* guidelines (Ref. 6) are relevant to the local site level rather than the strategic level. Impacts on specific sites which may be judged as significant under these guidelines are not necessarily significant in relation to the ACT population of GSM as a whole.

The focus of the *EPBC Act* as it has operated to date in relation to threatened species conservation has been on avoiding or minimising development impacts at specific sites, rather than achieving the best strategic outcomes for the conservation of the species. This contrasts with the focus of the *NC Act* and is a major limitation which needs to be overcome if the *EPBC Act* is to be effective in biodiversity conservation at the 'big picture' level, having regard to wider sustainability issues.

3.4 Potential Offsets

3.4.1 Introduction

It is inevitable that future developments in the ACT, whether on Territory or Commonwealth land, will adversely affect some GSM habitat, raising the question of the provision of offsets against those impacts. Given the major initiatives that the ACT Government has already taken to conserve known GSM habitat, the scope for it to implement additional offsets through land allocation for conservation purposes appears very limited. Indeed, it can be argued that the ACT Government has already established a significant credit balance in this respect through the Action Plans and subsequent land use decisions, some of which have still to be carried to their conclusions.

In terms of securing additional areas of land for additional GSM conservation in the ACT, whether to offset the impacts of development or in its own right, the main potential rests with the Commonwealth Government, particularly in the Majura Valley and at the former Belconnen Naval Station.

A draft policy statement on offsets under the *EPBC Act* (Ref. 8) categorised offsets as direct or indirect. Direct offsets include those discussed above, such as securing additional habitat, but could also involve improving habitat quality in areas which are already secure. Indirect offsets can involve survey, research, management planning or financial arrangements to assist conservation of the species. The opportunities for implementing these various types of offsets are discussed in the following sections.

3.4.2 Direct offsets

Allocation of additional habitat. In the ACT, there is probably little scope for setting aside additional natural temperate grassland habitat for GSM as offsets, other than by the Commonwealth transferring some large areas to the ACT Government for management as nature reserves. Most of the important GSM habitat within natural temperate grassland in the ACT is likely to have been identified already. While further sites may be discovered, there are likely to be small pockets within established urban areas which have survived several decades of surrounding development. Most of the land identified in AP28 as originally supporting natural temperate grassland has been developed or protected within nature reserves or other open space, or has already been surveyed, at least at a general level for GSM. There is the possibility, however, that some better quality native pasture which has been withdrawn from development could improve further in quality and diversity and could develop GSM populations over time, if the environmental conditions and management regime are suitable.

Improvement of existing habitat. The main scope for providing direct offsets for loss of GSM habitat or other impacts on that habitat (e.g. shading) is likely to be in improving existing habitat quality in other areas. Based on existing records, it appears that GSM numbers in some of the grassland reserves that have been established partly for GSM conservation are low in relation to the size of the reserve, and in comparison with some areas outside reserves. A greater focus on reserve management to maintain favourable conditions for the GSM (as well as other important native species) is desirable to add value to what has already been a major opportunity cost in terms of allocation of land resources. This may include biomass management, control of weeds and feral animals, fire management, human uses and interpretive activities. Such management needs to be underpinned by a strong knowledge base, as discussed below.

3.4.3 Indirect offsets

Monitoring. With regard to indirect offsets, one area which could benefit in the ACT is in building knowledge of existing GSM populations and their habitat, both qualitatively and quantitatively. At a qualitative level, it is evident that the number of known GSM populations has increased steadily in recent years. For AP7 (1997) there were 16 sites listed although three of those did not have recent records of GSM. For AP28 (2005), there were 23 sites listed. The current number of known sites (December 2010) described in detail in Table 2.1 and Appendix A is 60, although a few of these may no longer support GSM populations, while some other minor sites shown in Figure 2.2 have not been specifically described.

There are several reasons why the number of known sites has been well below the number of actual sites until recently:

- The GSM is detectable only during a six- to eight-week period in summer with numbers affected by seasonal and weather conditions.
- It is not particularly conspicuous to the casual observer.
- It can be confined to small grassland patches.
- It has potential to occur in areas that are generally not accessible to or used by the public.

Even with the monitoring over large areas of Gungahlin and north-west of Belconnen that was undertaken in 2009, there are still many potential habitat areas that have not yet been surveyed. The 2009 records were obtained during what appears to be an exceptional season for GSM, and should desirably be checked under a range of seasonal conditions.

Further monitoring, if only on a qualitative basis, may reveal additional sites or extensions to known sites. On one hand, such sites may be seen as potential development constraints but, on the other, could give greater confidence with respect to the conservation security of the GSM in the ACT. At the same time, it is desirable to confirm that existing sites, some of which have not been monitored for several years, are still supporting GSM populations.

Monitoring undertaken in 2009 (Ref. 13) demonstrated the widespread occurrence of remnant GSM populations in secondary grassland within woodland communities in nature parks, rural leases or broadacre areas. Such areas have apparently received relatively little survey effort in the past, presumably because of the perception of GSM being a natural temperate grassland species.

At a further level of monitoring, it would be useful to determine whether existing GSM populations are increasing, decreasing or remaining stable, and how this might relate to habitat conditions. This is more difficult to assess because the results of quantitative monitoring of GSM, which is a skilled and labour-intensive task, are very prone to daily weather patterns, as well as annual fluctuations. The latter may be the result of climatic conditions and other ecological pressures as well as management of the site. Several years of data are therefore necessary to determine meaningful quantitative trends.

An alternative monitoring approach based on detection of pupal cases has been trialled in late 2008 through the community group, Friends of Grasslands (Ref. 12). It is understood that this program is aimed primarily at assessing the methodology, rather than extending the number of known sites, although some new sites were recorded in the process. While that study, as well as several monitoring projects undertaken in 2009 (e.g. Refs. 13, 18, 36) demonstrated the ability to locate pupal cases as evidence of GSM breeding habitat, this method has not been found to be effective for quantitative survey purposes.

Background research. In addition to simply counting GSM, there is potential for more detailed scientific research as background to understanding the habitat needs of the species and applying this knowledge to management of GSM sites. This includes developing an understanding of the specific grasses utilised by GSM in different locations (e.g. *Austrodanthonia* and other native species, as opposed to Chilean needle grass). Have the moths at different sites developed genetic adaptations which offer greater habitat versatility than was previously believed?

Even within some recently monitored sites, the observed concentration of GSM does not correlate readily with what appears to be the best native habitat, although this may reflect unusual movement patterns on the days of observation.

Biological research and monitoring is labour-intensive and costs money, unless it is done on a voluntary basis. Effective land management is also expensive, although its costs are probably much lower than the opportunity costs of foregoing land development because of ecological constraints. Through one means or another, any offsets are likely to involve direct or indirect costs. One possible mechanism for meeting such costs could be through the establishment of a dedicated trust fund financed as an offset to the development of sites where loss of GSM habitat is unavoidable. In terms of achieving good conservation outcomes for GSM through improved management or knowledge, this may be a more productive and practicable offset than seeking to create or conserve alternative habitat in suboptimal locations. Such an approach to offsets requires a strategic view and is unlikely to be achieved if developments are addressed on a site-by-site basis.

4. PROPOSED STRATEGY

4.1 Objectives

The primary objective of the proposed strategy is to conserve sufficient viable populations of the GSM in the ACT to effectively eliminate the risk of it becoming extinct under current environmental conditions. Furthermore, it is desirable for the species to be conserved within its natural environment (i.e natural temperate grassland) to the extent that it is achievable, although populations conserved under modified environmental conditions would also enhance its long term viability.

Conservation of the GSM should be viewed not only in relation to the species in its own right, but as a ‘flagship’ species for natural temperate grassland, the conservation of which is a wider issue. The approach towards the preparation of Action Plans under the *NC Act* that has been adopted by the ACT Government recognises the importance of this ‘big picture’ approach, and provides a more useful contribution towards biodiversity conservation than the environmental impact assessment processes under either ACT or Commonwealth legislation. This offers a rational approach for prioritising areas for GSM conservation, with the highest priority given to these areas with more extensive native grassland values.

It is important also to consider the social and economic implication of GSM conservation. On one hand, there are positive benefits to people who have an affinity with the GSM or with the grassland ecosystems that support it. These benefits can be direct for those people who use or study such areas for their personal enjoyment. They can also be more subtle through people having the confidence that the natural environment that they care about is being adequately protected and managed, even if they are not in the habit of experiencing it at first hand.

On the other hand, the implementation of biodiversity conservation measures and the administrative processes underpinning them can have adverse social or economic effects. These effects can be direct, for example, through loss of land sale revenue to the ACT Government, which ultimately impacts on the wider ACT population, or can be indirect through investigation costs, delays and temporary shortage of land forcing up land prices to unnecessarily high levels. In cases where such land prices contribute to severe financial hardship, this can lead to a range of serious secondary social impacts.

A further important objective of the strategy is for it to be capable of implementation without excessive direct or indirect costs to the ACT community.

The strategy has been proposed with all of the above objectives in mind, and consists of the following steps:

1. Setting of conservation targets which are realistic in the context of Canberra’s development needs.
2. Comparison of the existing situation against targets to identify the effectiveness of existing conservation measures and identify deficiencies.

3. Identification of additional measures required to fully achieve the conservation targets. These may be implemented either as direct ACT Government initiatives or as offsets to developments which impact on GSM habitat.

4.2 Proposed Conservation Targets

To address GSM conservation objectively and proactively, it is desirable to set realistic targets against which the achievements of the conservation strategy can be compared. It is neither necessary nor realistic to expect to conserve in their entirety all of the sites where GSM has been recorded in the ACT.

The Canberra area contains a relatively high proportion of the sites where the GSM is currently known. This is largely due to the presence of the leasehold system with its consequent effect in limiting the intensity of past agricultural development, the large areas of Commonwealth land under broadacre use, and the conscious decisions by the ACT Government to create grassland nature reserves on high value, developable land while there was still the opportunity to do so.

From a national perspective, there is a strong case for conserving more of the known or potential GSM sites in remnant grassland habitat in New South Wales (including Queanbeyan) and Victoria. This is the responsibility of those jurisdictions. A series of proposed contributions by the ACT towards the conservation of the species is as follows:

1. Two separate grassland conservation reserves containing viable GSM populations in each of:

   - Majura;
   - Jerrabomberra;
   - Gungahlin; and
   - Belconnen.

   These should contain relatively large areas of GSM habitat as current or former natural temperate grassland, managed under regimes which have potential to sustain GSM populations in the long term, recognising that the optimum management requirements for GSM may not be fully understood. These reserves would be the core conservation areas for GSM in an environment which is as close as practicable to the typical natural habitat for the species.

2. At least two additional GSM habitat sites as current or former natural temperate grassland in each of the above four areas which could be used, if required, as a local (i.e. same valley system) source of specimens for translocation to the main reserves in the event of population loss (e.g. through an intense fire). The issue of translocation is discussed in Section 4.6.

3. At least six apparently stable GSM habitat sites within Central Canberra, recognising that the opportunity to conserve large grassland reserves in this area is no longer available (and has not existed for many years).

4. At least six viable sites within secondary grassland, recognising that GSM populations in such sites may decline over time as a result of woodland tree regeneration. These sites are likely to be in Gungahlin, where most sites of this type have been recorded.

5. Any sites which have a long and reliable history of scientific monitoring, which would be difficult to replicate elsewhere, or are otherwise particularly significant from a scientific perspective, for example, because of their use for major grassland rehabilitation trials.

Some of the sites conserved under points 4 and 5 may be the same as those conserved under points 1, 2 or 3.

Habitat that is contiguous with or otherwise well connected to nature reserves or otherwise secure conservation areas should be given priority as this would increase the effective size of the habitat and the viability of GSM populations. In addition, any sites which fall into an existing or potential corridor, albeit one which may be fragmented, should also be given high priority with the prospect that such corridor could evolve either naturally or with specific management to become more continuous over time.

In addition to conserving a sufficient total number of sites spread over a wide geographical area, it is desirable to ensure that any genetic differences that may exist between local populations are also addressed. Genetic analysis of GSM populations in Victoria, New South Wales and the ACT (Refs. 83, 84), has identified significant genetic differences between the Victorian populations and those in the ACT and New South Wales, with five distinct population groups based on genetic variation and diversity.

GSM from ACT sites were included in a group with Sutton, Gundaroo and Letchworth, but there was some variation within that group. Few significant differences in genotype frequencies among the ACT district populations were found, and genetic distances were low within the group. The patterns of variability within ACT populations were consistent with recent fragmentation of near contiguous habitat into small patches.

It has been recommended that a minimum of two populations from each genetically defined cluster should be considered for priority conservation management with the aim of conserving and maintaining as much genetic variability as possible within the species (Ref. 83).

While the above targets are considered reasonable from the viewpoint of balancing conservation and development needs, there may well be the opportunity to exceed them. It is likely that additional situations will arise in GSM habitat areas where development is considered to be of higher priority than habitat conservation, but there is still the opportunity to retain limited areas of habitat in association with the development. There may also be areas where suitable habitat does not currently support a GSM population, but is likely to do so if suitable translocation techniques can be developed. Such areas do not form part of the main targets, but should nevertheless be recognised as having supporting value.

4.3 Comparison of Existing Situation with Targets

A comparison of the existing situation in terms of ACT and Commonwealth Government achievements with respect to the proposed conservation targets is summarised in the following table:

Target	Current achievements	Additional action required and responsibility
1. Two grassland conservation reserves in:		
• Majura	Large habitat area in Majura Training Area etc. (M1, potential)	Formalise conservation status (or alternative secure management regime) – Commonwealth
	Majura West (M5, potential)	Declare nature reserve (or alternative secure management regime) – ACT
• Jerrabomberra	Callum Brae Nature Reserve (J1)	None
	Mikes Hill Nature Reserve (J2)	Complete nature reserve declaration – ACT
• Gungahlin	Mulanggari Nature Reserve (G1)	None
	Crace Nature Reserve (G2)	None
• Belconnen	Belconnen Naval Station (B1, potential)	Formalise conservation status (or alternative secure management regime) – Commonwealth
	Dunlop Nature Reserve (B4)	None
2. Additional GSM habitat sites in:		
• Majura	Canberra Airport (M2)	Establish secure management regime for at least part of area – Commonwealth
	One of:	
	Malcolm Vale (M3)	Establish secure management regime – Commonwealth
	Campbell Park offices (M4)	Establish secure management regime – Commonwealth
• Jerrabomberra	Harman – Bonshaw South (J3)	Formalise conservation status (or alternative secure management regime) – Commonwealth
	One of:	
	Harman residential area (J4, potential)	Establish secure management regime – Commonwealth
	Amtech (J5, potential)	Establish viable habitat area outside development – ACT
• Gungahlin	Gungaderra Nature Reserve (G3)	None
	North Mitchell Grasslands (G4)	Establish secure management regime – ACT

Target	Current achievements	Additional action required and responsibility
• Belconnen	Macgregor West – north-east (B5) **Any two of:** Lawson South (B2, potential) Lower Ginninderra Creek (B7) Jarramlee Road – west (B8) Wallaroo Road (B9) University of Canberra (B14)	Develop appropriate management regime for habitat in rural lease or urban open space – ACT Conserve and manage selected areas in urban open space – ACT Develop appropriate rural management regime – ACT Develop appropriate rural management regime – ACT Develop appropriate rural management regime – ACT Establish secure management regime within campus – ACT
3. At least six stable areas in Central Canberra	York Park (C1) **Any five of:** ACCC, Barton (C2) Black Street (including Stirling Park Ridge, C3 Dudley Street, Yarralumla (C4) St John's Church, Reid (C7) Lady Denman Drive (C11) and associated land (C16) Fisher Park Ainslie (C12) Other Central Canberra sites are smaller and/ or have a less secure future but some could also be included	Implement existing management plan (Ref. 51) – Commonwealth Establish secure management regime – ACT Establish secure management regime – ACT, Commonwealth for Stirling Park Ridge Establish secure management regime – ACT Establish secure management regime – ACT Establish secure management regime – ACT Establish secure management regime – ACT
4. At least six viable secondary grassland sites	Mulligans Flat North (G5) Mulligans Flat South-west (G7) Goorooyaroo Nature Reserve G9) Moncrieff South (G8) **Any two of:** Throsby residential (G12, potential) Throsby playing fields (G13, potential) Well Station Drive (G14, potential)	Formalise status and management provisions for undeveloped part of Bonner 4 – ACT None None Establish viable habitat area outside development - ACT Establish viable habitat outside development - ACT Establish viable habitat outside development - ACT Maintain land outside development with secure management regime - ACT

Target	Current achievements	Additional action required and responsibility
5. Scientifically significant/ long monitoring history	York Park (C1) Canberra International Airport (M2) Macgregor West – north-east (B5)	See point 3 See point 2 See point 2

Where the existing status of any area does not currently meet the relevant objectives for the target, that area is identified as potential. For example, some of the potential conservation areas related to Targets 1 and 2 do not have formal status as such even though their current management may be appropriate, while some other sites are dependent on adequate areas being excluded from development.

In summary, the existing situation goes a long way towards meeting the proposed conservation targets, the main deficiencies being a lack of either formal conservation reserve status or a secure management regime in some areas. Most of the larger areas are on Commonwealth land. Some of the small sites currently appear to be managed appropriately, although there may not be a deliberate management regime in place which can promise ongoing security in this respect.

In the context of the proposed strategy, any development which would prejudice the ability of the above sites to conserve GSM may be regarded as having a significant impact on GSM, unless an alternative site of comparable value can be identified and protected.

In some cases, the proposed conservation targets are exceeded, but this should not be interpreted as meaning that those areas are 'surplus to requirements', and hence do not justify conservation. In most cases, the sites have numerous conservation values, and the fact that they exceed the minimum targets set for GSM can be seen as a bonus. Furthermore, those sites which are not included in the above table still have conservation value as complementary habitat beyond the nominated targets.

Sites where there may be additional opportunities to conserve small areas of GSM habitat, subject to future development initiatives and/ or appropriate management:

- Guilfoyle Street, Yarralumla (C5)
- Section 5, Campbell (C8)
- Canberra Avenue/McIntyre Street, Griffith (C13, C14)
- City Hill South (C15)
- Block 799, Gungahlin (G19)
- Macgregor West – west (B6)
- Balamara Street, Giralang (B14)

The following sites may not support viable GSM populations at present, but may be capable of being rehabilitated and managed to support at least small populations if the GSM is reintroduced:

- CSIRO Headquarters, Campbell (C9)
- Yarramundi Reach (C10)
- Lake Ginninderra (B3)
- Ginninderra Creek corridor between Lake Ginninderra and Macgregor West, including Umbagong Park (B10, B11, B12)

There may also be scope for strengthening the GSM corridor around the western and southern sites of Yarralumla, incorporating several of the sites identified above.

The ability to maintain viable GSM populations in the following sites following development, even with a small proportion of the habitat conserved, appears unlikely due to very low levels of GSM activity:

- Beale Street, Deakin (C6)
- Jacka North (G10)
- Jacka South/Moncrieff North (G11)
- Harrison 4 (G15)
- Forde North (G16)
- Ngunnawal 2C (G17)

The potential for maintaining GSM at the Gold Creek/ Hall site (G18) following the development of Kinlyside is uncertain due to limited knowledge of that GSM population.

Further review of the genetic information about the ACT populations is required to confirm that there is an appropriate level of conservation of genetic diversity within areas which desirably have formal conservation status or at least a secure management regime.

4.4 Further Action Required

Based on the assessments in Section 4.3, the actions that would be required by the ACT or Commonwealth Governments to implement the proposed strategy are summarised as follows. Where an action is identified by an asterisk (*), this is one of two or more options required to satisfy the strategy.

ACT Government

- Declare a nature reserve at Majura West (M5)
- Complete nature reserve declaration for Mikes Hill (J2)
- Establish viable habitat area outside development at Amtech site (J5)*
- Establish secure management regime for North Mitchell Grasslands (G4)
- Develop an appropriate management regime for habitat in rural lease or urban open space at Macgregor West – north-east (B5)
- Conserve and manage selected areas in urban open space at Lawson South (B2) *

- Develop an appropriate rural management regime for one or more of the following areas:
  - Lower Ginninderra Creek (B7)*
  - Jarramlee Road – west (B8)*
  - Wallaroo Road (B9)*
- Establish a secure management regime for habitat within the University of Canberra campus (B14)*
- Establish secure management regimes for:
  - ACCC Barton
  - Black Street (C3)
  - Dudley Street (C4)
  - St John's Church (C7)
  - Lady Denman Drive and associated land (C11, C16 and other areas)
  - Fisher Park (C12)
- Formalise status and management provisions for the undeveloped part of Bonner 4/ Mulligans Flat North (G5)
- Establish a viable habitat area outside development in planning for Moncrieff South (G8)

Other potential actions outside the strategy targets would be addressed as the opportunities arose.

Commonwealth Government

- Formalise conservation status of alternative management regime for habitat in the Majura Training Area (M1)
- Formalise conservation status or alternative management regime for BNTS (B1)
- Formalise secure management regime for at least part of Canberra Airport (M2)
- Establish secure management regime for either:
  - Malcolm Vale (M3)*; or
  - Campbell Park Offices (M4)*
- Establish secure management regime for Harman – Bonshaw South (J3)
- Formalise conservation status or alternative secure management regime for Harman residential area (J4)*
- Implement existing management plan for York Park (C1)
- Establish secure management regime for Stirling Park Ridge (part C3)

The most important actions are those relating to new nature reserves or alternative secure management regimes in the Majura Training Area, Majura West, Belconnen Naval Station and Harman – Bonshaw South. Of these four areas, three are currently Commonwealth responsibilities, which limit the extent to which the ACT

Government can be responsible for implementing the strategy. This would change if such areas passed from Commonwealth to ACT Government responsibility.

4.5 Implications for Offsets

Procedures currently implemented under the *EPBC Act* require the provision of offsets for any GSM habitat that is lost or adversely impacted as a result of development. Possible offset mechanisms include:

- Declaration of additional nature reserves which support GSM.
- Setting aside other areas of land from development under a management regime which is appropriate for GSM conservation.
- Upgrading the management of existing GSM areas (both nature reserves and other public land).
- Negotiating management agreements for GSM conservation with rural landholders and other lessees with respect to land under their control.
- Various monitoring or research projects which are useful in informing the above actions, as discussed in Section 3.4.
- Providing funding to assist any of the above actions.

For offsets to be effective in the ACT, it is important for them to be provided in accordance with the preceding strategy. An unstructured approach to offsets which is not strategic is likely to run the risk that substantial resources may be committed for minimal real benefit.

In terms of providing land for GSM conservation as an offset to development, it must be appreciated that almost all of the suitable land available to the ACT Government has been conserved in advance of development. Of the currently known GSM sites on Territory land, the only areas which appear to offer promise as additional future GSM core conservation reserves are Majura West (M5) and part of Moncrieff South (G8). Majura West is of particular interest because it adjoins an existing woodland nature reserve, providing a woodland/grassland continuum, and is known to support other threatened grassland species. It has been identified as a potential reserve in the Eastern Broadacre Planning Study (Ref. 64). Moncrieff South is of more limited value as GSM habitat in the long term because of its potential to regenerate to woodland, and its isolation from other conservation reserves, but it still has potential to be a small and significant reserve in its own right.

While there are many other areas which could be set aside from development as GSM habitat, these would generally be small and support low levels of GSM activity, and would serve more as complimentary conservation areas. Because of their small size, they could contribute to only a minor extent as offsets for major development.

It is therefore likely that the provision of offsets on an ongoing basis will need to be focused on mechanisms which are based not on land areas but on direct or indirect measures to enhance the substantial gains towards GSM conservation that have already been achieved by the ACT Government.

4.6 Translocation

While it may not be recognised as an offset for loss of GSM habitat, translocation of GSM from existing sites (particularly those directly impacted by development) is a potential means of establishing additional GSM populations in suitable habitat throughout the Canberra area. In particular, these sites include areas where native grasses (particularly *Austrodanthonia*) have persisted throughout Canberra's development, or have regenerated through natural processes. Many of these sites are small but recent observations in areas such as City Hill South (C15) and Captain Cook Crescent, Griffith (C14) suggest that repopulation of small sites is viable. Translocation to large grassland nature reserves where population appears to be depleted would be even more valuable.

There are several scientific, ethical and practical issues to be addressed in considering translocation of GSM. In particular, the fact that the GSM spends only a very small proportion of its life cycle in a detectable form above the ground surface raises the question of whether translocation should be addressed through trapping and relocating male and female adults, or whether it may be more productive to translocate soil sods which may contain eggs or larvae. A further approach may be to develop captive populations under controlled conditions which can be used for subsequent translocation. These questions generate a range of scientific research opportunities which may in themselves be considered justified as offsets through funding arrangements.

Given the range of habitat conditions which now appear capable of supporting GSM populations, if effective translocation techniques can be developed, it may be feasible to establish numerous small GSM populations throughout much of the Canberra area, utilising for example, urban open space, grounds of schools and other institutions, and road verges and medians. Based on the known records of GSM, it is suggested that, other factors being equal, areas which were originally natural temperate grassland may be the most favourable for achieving success in such an exercise. The strategy could embrace a systematic search for such areas.

5. CONCLUSIONS

The ACT Government has been proactive in seeking to conserve the GSM within its more widely embracing approach to the conservation of lowland native grassland communities. While its direct influence is limited to Territory land which it controls, its actions to date have gone a long way to achieving all that is practicable and realistic, having regard to competing social and economic needs of the ACT population.

While there is no question that the available habitat for GSM has been substantially reduced by past land management and development in the ACT, most of the habitat that remains appears to maintain viable, albeit sometimes small populations, and there are few obvious threats that cannot be averted by appropriate management.

Some areas of habitat will be at least partly lost to future development, but the potential offsets to such losses include improved habitat quality elsewhere within the ACT and the funding of additional research, monitoring and planning to understand and secure populations of the GSM in nature reserves and other areas that have been set aside partly for this purpose by the ACT Government. This achievement requires an extension of the strategic conservation approach developed by the ACT Government in recent years to the review of proposals under the *EPBC Act*. There are several provisions in the *EPBC Act* which may not offer greater scope for enhancing GSM conservation than those applied through the environmental assessment of scientific proposals. There include strategic environmental assessment and bioregional planning which, while not described as such, have been implicit in planning processes in the ACT for many years (Ref. 89).

While the present paper is focused on the GSM, it is important to emphasise that this species is just one component of lowland native grassland communities. A further logical progression in the preceding argument is to move up a level and address such communities and their component species holistically. While this has been achieved under the ACT *NC Act*, it may be more difficult under the *EPBC Act*. It is nevertheless an important challenge to be faced if the *EPBC Act* is to be effective in conserving Australia's biodiversity.

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APPENDIX A. KNOWN GOLDEN SUN MOTH SITES IN THE ACT

A.1 Introduction

This appendix lists all of the sites in the ACT where the GSM is known or has previously been recorded.

The characteristics of these sites are summarised in terms of:

- habitat characteristics (the botanical significance rating or BSR as native grassland identified in AP28 is noted where relevant – 1 = highest quality, 5 = lowest quality);
- current land tenure, use and development;
- size of site (Note: In some cases, only part of the site may be GSM habitat. Shape and fragmentation are noted if these are constraints);
- indicative GSM population size (if known);
- known history of GSM records;
- potential development pressures;
- future land use – known or potential;
- management issues; and
- overall assessment of site as GSM habitat.

The sites are described in geographical groupings in terms of the five valley systems where the sites are located, namely:

- Central Canberra
- Jerrabomberra
- Majura
- Gungahlin
- Belconnen

These reflect the main lowland areas where there is remnant natural temperate grassland in the ACT, although not all of the GSM habitat is associated with natural temperate grassland. There are no GSM records from the Tuggeranong Valley or from the Molonglo Valley downstream of the Tuggeranong Parkway.

These sites are numbered for convenience in relation to the present discussion. The numbering system differs from those used for GSM in Action Plan No. 7 (AP7, Ref. 1) or for native grassland sites in Action Plan No. 28 (AP28, Ref. 2) but, where applicable, the numbering used in these reports is also identified (e.g. MA01 etc. for AP28 grassland sites, GSM1 etc. for AP7 sites). Many sites are not listed in either of these Action Plans.

Unless otherwise referenced or explained in the text, the descriptive information for the sites is based on AP28.

There is still much to be learnt above the biology and distribution of the GSM, which could further influence the strategy for its conservation. The present report is therefore seen as being potentially subject to further refinement as such knowledge becomes available.

A.2 Central Canberra

Site C1. York Park (part Blocks 3 and 12, Section 22, Barton, CC05, GSM7)

Habitat characteristics: Natural temperate grassland dominated by tall speargrass (*Austrostipa bigeniculata*) and wallaby grasses (*Austrodanthonia* ssp.), BSR 4.

Current land tenure, use and development: Predominantly Commonwealth land (Block 3) maintained on behalf of National Capital Authority, some Territory land (Block 12), urban open space reserved from development.

Size: 0.4 ha. Most of the site is used by GSM, which also uses the verge on Sydney Avenue.

GSM population size: High density of GSM, medium-sized population.

Known history: This is the first site in the ACT to be subject to extensive scientific work on the GSM, and has become a ‘flagship’ site for this reason, despite its small size and the threats of surrounding development. The decision to conserve it as GSM habitat embraced an acknowledgement that this was partly on an experimental basis with no assurance of long term success (Ref. 50). The moth population has persisted, however, with no evidence to date of long term decline, having been surveyed quantitatively on four occasions between 1992 and 2006, with subsequent observations noted (Refs. 12, 13).

Potential development pressures: Most of the site is potentially secure for the foreseeable future, although a strip on the northern edge is proposed as an access road to a nearby proposed parking structure (Ref. 70). There is the prospect of shading from adjacent development to the north-west, which could adversely affect GSM habitat and behaviour. Such development, however, is capable of being designed to limit shading to a minor level, particularly when compared with other environmental influences (Refs. 52, 53).

Future land use: Because of its scientific significance, the site is likely to remain as open space as long as the GSM population is maintained.

Management issues: A comprehensive maintenance plan has been prepared for the site (Ref. 51). A mowing regime has been established to maintain the grassland habitat in a form suitable for GSM, and appears to be working. Such a regime will need to continue.

Overall assessment: A small site in the big picture of GSM conservation but important because of its scientific/ flagship status. Based on current evidence, it appears that it could continue to be maintained, subject to appropriate management.

Site C2. ACCC, Barton (Australian Centre for Christianity and Culture and St Marks Theological College, CC04)

Habitat characteristics: High quality natural temperate grassland dominated by kangaroo grass (*Themeda australis*), BSR 1.

Current land tenure, use and development: Urban lease proposed to be managed under a conservation agreement (Ref. 2), although this agreement has not yet been finalised.

Size: 1.9 ha. May not all be suitable as GSM habitat.

GSM population size: Small population.

Known history: Has not been surveyed systematically, low numbers recorded in 2008 (Ref. 12).

Potential development pressures: None known.

Future land use: Uncertain. Existing land use is assumed to continue, but with the possibility of some further development within the site.

Management issues: It is desirable to implement the proposed conservation management agreement for the site.

Overall assessment: While this site is regarded as one of the best of the small natural temperate grassland sites within the urban area and has other important grassland values, including a population of button wrinklewort (*Rutidosis leptorrhynchoides*), its GSM population may be small. Its situation is favourable in terms of protection from peripheral development impacts, and it should be capable of maintaining a GSM population subject to appropriate management.

Site C3. Black Street, Yarralumla (CC11, GSM9)

Habitat characteristics: Natural temperate grassland, BSR 3. Also native pasture among planted exotic trees and a lower area dominated by Chilean needle grass (*Nassella neesiana*).

Current land tenure, use and development: Urban open space.

Size: 3.6 ha grassland. Not all GSM habitat. There are separate smaller areas nearby on the edge of Stirling Park Ridge.

GSM population size: Low numbers spread over a large area. Abundant in one of the Stirling Park Ridge areas along Hopetoun Circuit (Ref. 94). The other Stirling Park Ridge areas along Alexandrina Drive have low numbers.

Known history: Surveyed in 2006 (A. Rowell).

Potential development pressures: Located towards the edge of an area centred on Yarralumla Bay ('Yarralumla Hub'), which has been the subject of a development study by the National Capital Authority.

Future land use: Assumed to remain as open space but may be influenced by future development at Yarralumla Bay.

Management issues: Would require appropriate grassland management to maintain optimum conditions for GSM.

Overall assessment: Provided that it is not subject to intensive development, and management continues as in the past, this is likely to continue as a minor urban site for GSM.

Site C4. Dudley Street, Yarralumla (CC08, GSM11)

Habitat characteristics: Natural temperate grassland, low and open dominated by wallaby grasses and spear grasses, BSR 3. Some Chilean needle grass, poisoned in 2009 (Ref. 13).

Current land tenure, use and development: Urban open space.

Size: 2.2 ha grassland, 0.9 ha GSM habitat. There is a separate narrow area nearby, near some oak trees.

GSM population size: Moderate to large numbers in a small area.

Known history: Surveyed in 2006 and 2009 (A. Rowell) and 2008 (Ref. 12).

Potential development pressures: None apparent.

Future land use: Remain as urban open space under similar management.

Management issues: Current management regime appears appropriate for maintaining GSM population and should continue (or be enhanced).

Overall assessment: Likely to continue as a minor urban site for GSM.

Site C5. Guilfoyle Street, Yarralumla (CC09)

Habitat characteristics: Natural temperate grassland mostly dominated by *Themeda* with patches of *Austrodanthonia* spp. and *Austrostipa*, and Chilean needle grass along Kintore Crescent and in the lower part of the site.

Current land tenure, use and development: Urban open space and embassy.

Size: Small (0.8 ha), narrow. There is a separate small area further east along Adelaide Avenue beyond Hopetoun Circuit along Hampton Circuit, which could be considered a separate site. GSM habitat extends also to the northern side of Guilfoyle Street and along Gunn Street (Ref. 18).

GSM population size: Moderate density, high numbers have been recorded in Chilean needle grass.

Known history: Surveyed in 2005 (A. Rowell) and 2009 (Ref. 18).

Potential development pressures: Embassy development.

Future land use: Some has been incorporated into the grounds of the Nigerian embassy. Part of the site is proposed for a future Czech embassy. The remainder remains as open space.

Management issues: Open space would require an appropriate mowing regime.

Overall assessment: Likely to continue as a minor urban site for GSM, but reduced in size by embassy development. The future of areas retained within embassy grounds is uncertain.

Site C6. Beale Street, Deakin (Block 9, Section 97, Deakin; not recorded in APs)

Habitat characteristics: Small area (less than 0.25 ha) of weedy native pasture, dominated by redleg grass (*Bothriochloa macra*) and *Austrostipa bigeniculata*, bounded on all sides by planted trees.

Current land tenure, use and development: Commonwealth land, undeveloped blocks identified for future embassy use in National Capital Plan.

Size: Small area, GSM in one patch.

GSM population size: Very low numbers, isolated.

Known history: Surveyed in 2005, 2006 and 2009 (A. Rowell).

Potential development pressures: Expected to be developed for future embassies.

Future land use: Embassies.

Management issues: Not a priority because of likely future development.

Overall assessment: Small, isolated site subject to future development.

Site C7. St John's Church, Reid (CC03)

Habitat characteristics: Natural temperate grassland dominated by *Austrodanthonia* and *Bothriochloa*, BSR 4.

Current land tenure, use and development: Church grounds and adjacent nature strip.

Size: 0.9 ha, fragmented by development and landscaping within church grounds. There are five distinct GSM habitat areas, namely:

- the old horse paddock fronting Constitution Avenue;
- an adjoining area along the main driveway which was disturbed by construction works in early 2007, but has partly regenerated;
- some remnant grassland patches within the carpark area which are fenced for their protection;
- part of the area within the graveyard; and
- the nature strip along Anzac Park.

GSM population size: Small population.

Known history: The original St John's Church was completed in 1845, and it was extended between then and 1878 (Ref. 54). The construction of adjacent streets took place as part of the early development of Canberra, and additional buildings have been constructed within the church grounds. Despite an ongoing history of disturbance, the GSM has persisted in those remnants of native grassland that have survived within the church site and nearby nature strip. There have been several observations of GSM in recent years (e.g. Refs. 12, 54).

Potential development pressures: New development in the carpark area of the site may be essential economically for maintaining the future of the historic church (Ref. 54). It is further understood that the St John's Precinct Development Board supports measures to enhance GSM habitat in the remaining four habitat areas within the site as an offset. There is also potential for increased shading of remnant habitat along the main driveway and in part of the hose paddock due to redevelopment of the adjacent Jamieson House site (Ref. 55).

Future land use: Three of the four habitat areas within the church grounds would remain as open space surrounding the church. The nature strip along Anzac Park West would also presumably remain as such, but is likely to experience more intensive pedestrian pressure as a result of increased development along Constitution Avenue. Any remnant habitat within the carpark would be lost if development takes place within the carpark.

Management issues: Maintaining GSM habitat within the church grounds would benefit from the implementation of a deliberate management regime aimed at optimising GSM habitat value along with other landscaping considerations. Members of the church community have recently implemented measures to conserve the GSM.

Overall assessment: The St John's site is an example of the ability of the GSM to maintain a population in the long term in a situation which is subject to ongoing development and intensive use in areas surrounding the small remnant grassland patches. The fact that it has achieved this with no deliberate management of grassland habitat values suggests that, with a conscious effort to maintain such values, it should be possible to continue to conserve the GSM within the church grounds, at least within the horse paddock and graveyard areas. This site is nevertheless of minor significance in the big picture of GSM conservation in the ACT.

A particular issue associated with this site, which may be of scientific importance, is that moths on the site have been found to utilise *Bothriochloa* rather than the commonly accepted *Austrodanthonia* for placing eggs (Ref. 80). This appears to be the only *Bothriochloa* site where this has been observed to date.

Site C8. Constitution Avenue (Section 5, Campbell, CC02, GSM14)

Habitat characteristics: Natural temperate grassland and exotic grassland, BSR 3.

Current land tenure, use and development: Territory land, but Designated Area under National Capital Plan. Urban open space.

Size: 0.7 ha (natural temperate grassland), approx. 7 ha (whole site)

GSM population size: Small to medium population (Ref. 7), but high numbers have been recorded on occasions (e.g. Ref. 12).

Known history: Surveyed in 2007 (Ref. 19), 2008 (Ref. 12) and 2009 (Ref. 20).

Potential development pressures: High priority for major development along Constitution Avenue as part of the National Capital Authority's Griffin Legacy.

Future land use: Because of the strategic development importance of this site (or at least the Constitution Avenue frontage), there is a high probability that that frontage, which contains the natural temperate grassland, will eventually be developed. The GSM has been recorded in poorer quality habitat elsewhere within the site but much of that habitat is also likely to be disturbed for a water quality control pond and associated works, as well as by site contamination investigations.

Management issues: Management of any remaining grassland (native and exotic) throughout the site is likely to be required to maintain optimum GSM habitat. The existing management regime may not be the optimum, with very dense grass cover developing during late 2010.

Overall assessment: While this site has survived in an urban situation for many years, the intense development pressures on the site compared with its relative conservation value suggest that it is not realistic to expect to maintain the whole site as GSM habitat in the long term. Even with loss of the better quality grassland near Constitution Avenue, plus disturbance in other parts of the site, some limited areas of suitable habitat may remain and may be adequate to maintain a small GSM population with appropriate management, based on experience at the nearby St John's site. The site is not considered to have high conservation priority, however.

Site C9. CSIRO Headquarters, Campbell (CC01, GSM15)

Habitat characteristics: Mostly natural temperate grassland, BSR 3, some exotic grassland.

Current land tenure, use and development: Commonwealth land, occupied by CSIRO.

Size: 3.0 ha (natural temperate grassland), 0.5 ha (exotic).

GSM population size: While shown in Table 3.8 of AP28 as containing GSM, AP7 indicates that GSM recorded previously may no longer be present. The current presence of GSM is therefore doubtful. It is not mapped as a GSM site in AP28.

Known history: Inspected in November 2003 (M. Dunford) with no moths recorded. None recorded in 2008 (Ref. 12).

Potential development pressures: None known but may be affected in the event of future expansion of CSIRO Headquarters (no known plans).

Future land use: Landscaping around CSIRO Headquarters in short term. Long term use uncertain.

Management issues: Management of the site would be the responsibility of CSIRO. A management plan has been prepared by the ACT Government but has not been acknowledged by CSIRO.

Overall assessment: Appears to be of doubtful current value as GSM habitat, although further monitoring would be desirable to check this. If the GSM is present, management of its habitat would be a CSIRO responsibility, outside the control of the ACT Government. In any case, the site does not appear to be of high conservation priority.

Site C10. Yarramundi Reach (CC06, GSM16)

Habitat characteristics: Natural temperate grassland, BSR 3(5).

Current land tenure, use and development: Commonwealth land, urban open space, part of Lake Burley Griffin foreshores.

Size: 21.2 ha.

GSM population size: Former GSM site but, based on information in AP7 and AP28, GSM no longer appear to be present. It is not shown as a GSM site in AP28.

Known history: Historical record of GSM but none recorded during a survey in December 1993 (Ref. 11). No more recent surveys known.

Potential development pressures: Uncertain, responsibility of National Capital Authority.

Future land use: Open space.

Management issues: Apparent loss of GSM from site may be a consequence of unsuitable grassland management.

Overall assessment: Probably of no further value as a GSM site, unless habitat improvement and translocation can be undertaken successfully. Further monitoring to confirm the absence of GSM would nevertheless be worthwhile.

Site C11. Lady Denman Drive (CC07, GSM12)

Habitat characteristics: Natural temperate grassland dominated by *Austrodanthonia* ssp., BSR 3.

Current land tenure, use and development: Roadside.

Size: Uncertain. May have been continuous with a nearby site in the Royal Canberra Golf Club grounds (Site C16), and appears to extend into Yarralumla Equestrian Park. May extend through to other Yarralumla sites (Ref. 12).

GSM population size: Identified as GSM site in AP7 but not in table or map in AP28. Moderate numbers recorded in 2008 (Ref. 12).

Known history: Surveys and other observations in 2008 (Ref. 12).

Potential development pressures: None known.

Future land use: Road reserve.

Management issues: Would be managed as part of the road reserve, which may make management specifically as GSM habitat difficult, given the relatively small area of habitat.

Overall assessment: May be part of a fragmented but extensive habitat area extending around the western and southern edge of Yarralumla.

Site C12. Fisher Park, Ainslie (not recorded in APs)

Habitat characteristics: Native pasture/ secondary *Austrostipa – Austrodanthonia* grassland, with exotic grasses (mainly Chilean needle grass), and occasional remnant eucalypts (yellow box and red gum).

Current land tenure, use and development: Urban open space, extends along nature strips in Duffy Street and Cox Street.

Size: Moderate area of parkland but extent of habitat is uncertain.

GSM population size: Not a dense population but widespread.

Known history: Recorded only recently (c. 2005) as a GSM site. Not subject to detailed survey. Parkland has been established with nearby residential development established progressively since 1950s or earlier. Observed in 2009 (Ref. 95).

Potential development pressures: None known.

Future land use: Urban open space.

Management issues: Has not been subject to any specific management regimes to conserve GSM population. Park would be mown periodically and probably subject to grazing by kangaroos moving down from nearby Mount Ainslie Nature Reserve. Planting of local eucalypt species has probably reduced the area available for GSM.

Overall assessment: A small, apparently stable GSM site which has survived within urban development for 50 years or more, despite lack of deliberate management. Should continue to survive under such conditions, but may be capable of enhancement.

Site C13. McIntyre Street, Griffith (not recorded in APs)

Habitat characteristics: Native pasture and exotic grasses.

Current land tenure, use and development: Road verge (near Stuart Street).

Size: Very small, possibly linked tenuously with other very small patches in similar condition nearby, and within the road median along Captain Cook Crescent (Site C14, Ref. 13).

GSM population size: Small population, presence of females confirmed.

Known history: First recorded and surveyed in 2006 (A. Rowell). The surrounding area has been developed since the early days of Canberra.

Potential development pressures: None known.

Future land use: Road verge.

Management issues: Has not been subject to any specific management regimes to conserve GSM population. Verge is presently mown periodically.

Overall assessment: A small, apparently stable GSM site which has survived since the early development of Canberra.

Site C14. Canberra Avenue, Griffith (not recorded in APs)

Habitat characteristics: Native grassland remnants with road median and nearby areas.

Current land tenure, use and development: Predominantly road median, plus a small area within the corner of the Brumbies site.

Size: Extends for some distance along median. Size uncertain.

GSM population size: Small population.

Known history: First recorded in 2009 (Ref. 96), but may be an extension of Site C13.

Potential development pressures: The area along median may be subject to services upgrades etc., but no immediate developments are known. The area within the Brumbies site is outside the area recently proposed for development.

Future land use: Road median or urban open space.

Management issues: Desirable for the mowing regime for the median to take account of GSM habitat requirements and breeding cycle.

Overall assessment: A minor site which has apparently re-established itself since the road was constructed and has survived despite lack of any deliberate management measures.

Site C15. City Hill South

Habitat characteristics: Not determined. A totally modified site which has presumably regenerated with native grasses and/ or Chilean needle grass. Isolated from other known GSM sites.

Current land tenure, use and development: Road reserve within the loops formed by the interchange ramps at Commonwealth Avenue bridge/ Parkes Way.

Size: Small areas.

GSM population size: Moderate level of activity.

Known history: First recorded in 2009 from anecdotal advice.

Potential development pressures: None known.

Future land use: Road reserve.

Management issues: Would be influenced by mowing regime.

Overall assessment: An interesting site given its past history of disturbance and apparent isolation from other GSM sites. If the GSM has become established only recently, it is not clear how it would have found its way to the site.

Site C16. Royal Canberra Golf Club

Habitat characteristics: Native grassland. Probably a remnant retained within the former ‘Lee’s Paddock’ area when the Royal Canberra Golf Club expanded its course approximately 30 years ago.

Current land tenure, use and development: Within golf course.

Size: Small area but may be connected with other habitat patches along Lady Denman Drive (Site C11).

GSM population size: Probably small.

Known history: Known from previous records (Ref. 97) but not surveyed recently. Current presence subject to confirmation.

Potential development pressures: None known.

Future land use: Golf course.

Management issues: If still present, its long term survival would be influenced by management of the area surrounding the golf course greens and fairways.

Overall assessment: A minor site in its own right, but part of a more extensive corridor along the western side of Yarralumla.

A.3 Jerrabomberra

Site J1. Callum Brae South (Woden Station, JE03, GSM3)

Habitat characteristics: Natural temperate grassland, BSR 3.

Current land tenure, use and development: Nature reserve.

Size: 115 ha (natural temperate grassland only, additional area in woodland).

GSM population size: Moderate, not densely populated.

Known history: Originally surveyed in November 1993 (Ref. 11). GSM observed in 2005 (Ref. 94), 2008 (Ref. 12) and 2009 (Ref. 97).

Potential development pressures: None.

Future land use: Nature reserve.

Management issues: Area to be managed for a range of grassland values including GSM habitat.

Overall assessment: One of the high conservation value areas for GSM identified in AP7 and a core grassland conservation site and key GSM conservation area identified in AP28.

Site J2. Mike's Hill (Woden Station East, JE05)

Habitat characteristics: Predominantly natural temperate grassland, some native pasture or exotic, BSR 4(3).

Current land tenure, use and development: Proposed nature reserve but still to be formalised in Territory Plan.

Size: 62.2 ha natural temperate grassland, 7.8 ha native pasture, 2.0 ha exotic.

GSM population size: Uncertain.

Known history: Casual observations made in the course of pitfall trapping in about 2002 (Ref. 94).

Potential development pressures: None.

Future land use: Nature reserve.

Management issues: Area to be managed for a range of grassland values including GSM habitat.

Overall assessment: A core grassland conservation site and a key GSM conservation area identified in AP28. (Not identified as GSM habitat in AP7).

Site J3. Harman – Bonshaw South (JE06)

Habitat characteristics: Native pasture, BSR 5.

Current land tenure, use and development: Commonwealth land, occupied by Defence but under agistment grazing.

Size: 105.7 ha, contiguous with Site J2. Includes ‘round paddock’.

GSM population size: Uncertain. GSM shown as being present in Table 3.5 of AP28 but not in Figure 2.4.

Known history: Casual observations made in the course of pitfall trapping in about 2002 (Ref. 94).

Potential development pressures: None known due to Commonwealth ownership.

Future land use: Potential nature reserve, otherwise existing use likely to continue.

Management issues: Current agistment grazing may be an appropriate form of management.

Overall assessment: Part of an extensive core conservation area for native grassland in the Jerrabomberra Valley identified in AP28 but not key habitat for GSM.

Site J4. Harman residential area (part of JE07)

Habitat characteristics: Natural temperate grassland (southern *Rutidosis* site), BSR 4 in Ref. 2, but probably higher (BSR 2/3) (Ref. 95).

Current land tenure, use and development: Commonwealth land, within Harman residential area.

Size: Small area (less than 2 ha).

GSM population size: Large number, dense population.

Known history: Surveyed in 2004 and 2005 (A. Rowell).

Potential development pressures: Subject to expansion of Harman residential area.

Future land use: Defence (Harman residential area).

Management issues: Past management regime appears satisfactory but this has potential to change in the event of further development.

Overall assessment: A small site with a large population, but subject to future development pressures. The GSM may still maintain a population in the event of partial development if the remaining area is managed appropriately.

Site J5. Amtech site, Symonston (JE09)

Habitat characteristics: Natural temperate grassland, BSR 4.

Current land tenure, use and development: Potential industrial development.

Size: 18 ha.

GSM population size: Low level of activity.

Known history: GSM observed in 2008 (one moth, Ref. 12) and 2009 (Ref. 95).

Potential development pressures: Subject to industrial development with the expansion of Symonston (Ref. 64).

Future land use: Potentially industrial.

Management issues: May be managed for a range of grassland values including GSM habitat, pending potential future development.

Overall assessment: GSM counts to date suggest that it is a minor GSM site, although it has other grassland values. It is not assessed as key habitat for threatened species, but has been assessed as a complementary grassland conservation site (Ref. 2). If all or part of it is retained for biodiversity conservation, it has the potential to be managed to develop a more viable GSM population.

Other areas in Jerrabomberra Valley

Other areas of natural temperate grassland containing GSM are located further up the Jerrabomberra Valley in New South Wales. These include the Letchworth

Nature Reserve and other land with potential to become conservation areas if it is not subject to urban development. The ACT Government has no direct influence over the conservation or management of this land.

A.4 Majura

Site M1. Majura Training Area/ Air Services Beacon (MA01, MA02, GSM2 – part)

Habitat characteristics: Mostly natural temperate grassland, some native pasture or exotic, BSR 2(1, F).

Current land tenure, use and development: Commonwealth land, army training or operations associated with airport.

Size: 124.4 ha natural temperate grassland, 5.8 ha native pasture, 7.1 ha exotic, most has been identified as GSM habitat. Contiguous with Sites M2 and M3. Smaller areas of habitat in native pasture to north and north-east.

GSM population size: Large population spread over a large area.

Known history: Initially surveyed in December 1993 (Ref. 11), followed by ongoing casual observations. Systematic survey undertaken in December 2006 (A. Rowell), and subject to ongoing monitoring.

Potential development pressures: Northern access road to airport has been proposed through the area. This would fragment the GSM habitat.

Future land use: Remain under existing Commonwealth uses in short term. Long term use may depend on proposed future development in the Kowen area.

Management issues: Has been maintained under natural grazing regime including kangaroos. Because of concerns about potential for overpopulation by kangaroos, kangaroos have been fenced out since December 2007. Lack of grazing could then become a concern, requiring monitoring by Defence.

Overall assessment: A large, potentially secure area under the current management although, because it is Commonwealth land, the ACT Government has no direct control over future land use and management. Assessed as a core conservation area and key habitat for GSM in AP28, as well as having other grassland values, particularly for the grassland earless dragon (GED).

Site M2. Canberra International Airport (MA03, GSM2 – part)

Habitat characteristics: Mixture of natural temperate grassland (MA03), native pasture and exotic pasture, BSR 3(1,2,5). Other threatened species (particularly GED) also present in part of the area.

Current land tenure, use and development: Airport land under Commonwealth control. Parts of the area are subject to ongoing development.

Size: Total area of grassland approximately 200 ha in AP28, with about 137 ha being natural temperate grassland or native pasture. Some has since been developed. Broad area fragmented by runways. Contiguous with Sites M2 and M4.

GSM population size: Large population spread over a large area.

Known history: At least four detailed surveys have been undertaken (three by A. Rowell in 2001, 2003, 2006, one by Biosis in 2007).

Potential development pressures: Ongoing development of airport facilities and associated development in some peripheral parts of area. Areas close to runways expected to remain as grassland, unless required for future aircraft movement or storage, or disturbed for infrastructure works (e.g. drainage).

Future land use: Airport and associated uses.

Management issues: Current mowing regime is favourable for maintaining GSM habitat.

Overall assessment: Despite the development pressures, there appears to be potential for suitable GSM habitat to remain within the runway area. While GSM is present, it is not identified as key GSM habitat in AP28, although its proximity to Site M2 suggests that it could extend that key habitat. It is identified as a core grassland conservation area in AP28.

Site M3. 'Malcolm Vale'

Habitat characteristics: Native pasture, BSR 5.

Current land tenure, use and development: Commonwealth land previously under rural lease for grazing. Destocked in June 2007 after withdrawal of rural lease.

Size: 155.4 ha, only part is GSM habitat. Contiguous with sites M2 and M3.

GSM population size: At least a medium population.

Known history: No systematic surveys undertaken to date. Casual observations in about 2000 (Ref. 94) and 2003 (Ref. 95).

Potential development pressures: Northern access road to airport has been proposed through the area. This would fragment the GSM habitat. Long term development may be influenced by Kowen development and possibly airport expansion.

Future land use: Associated with Majura Training area for foreseeable future.

Management issues: Kangaroo grazing is at (or above) the intensity required to maintain GSM habitat.

Overall assessment: This site contributes to the large GSM population in the lower Majura Valley, and is part of the largest continuous area of GSM habitat in the ACT. It is an important site in that context.

Site M4. Campbell Park (MA05, GSM5)

Habitat characteristics: Mostly natural temperate grassland, small area of exotic, BSR 3(2).

Current land tenure, use and development: Commonwealth land, buffer around Campbell Park offices (Defence).

Size: 10.9 ha natural temperate grassland, 0.8 ha exotic.

GSM population size: Low numbers but regularly observed.

Known history: Surveyed in December 1993 (Ref. 11), and on several occasions between the late 1990s and 2005 (Ref. 94) and in 2008 (Ref. 12).

Potential development pressures: Potential to be affected by some options for a previously proposed northern access road connecting Majura Parkway with Central Canberra (Ref. 62). Other options would have little or no impact.

Future land use: Uncertain, subject to Commonwealth determination.

Management issues: It is understood that the area is currently managed by Defence for its grassland values, but not necessarily specifically for GSM.

Overall assessment: Useful additional GSM habitat in the Majura Valley which is probably fairly secure in terms of land use, but less significant than Sites M1 to M3. While it is assessed as a core grassland conservation area in AP28, it is not key habitat for GSM, and was assessed as being of moderate conservation value for GSM in AP7.

Site M5. Majura West (adjoining Mount Ainslie Nature Reserve, MA06)

Habitat characteristics: Native pasture, BSR 5, GED habitat.

Current land tenure, use and development: ACT rural lease previously under grazing, but recently withdrawn.

Size: 133.3 ha, adjacent to Site M4.

GSM population size: Probably low. GSM shown as being present in Table 3.4 of AP28, but not shown in Figure 2.3.

Known history: Occasional sightings between late 1990s and 2005 (Ref. 94). Recorded in studies for the Majura Parkway EIS (Ref. 63).

Potential development pressures: Majura Parkway and possible connections to Central Canberra could marginally impact on the outer edge of the area (Refs. 62, 63), but the more likely options for the road would not have a significant impact.

Future land use: There is a strong case for adding this area to Mount Ainslie Nature Reserve and it is understood that there has been a government commitment to do so.

Management issues: It is understood that withdrawal of grazing has resulted in improvement of the habitat in the area. Further monitoring of the area for GSM is desirable to assess its current habitat value. With appropriate management, there may be the possibility of the GSM spreading into the area from Site M4 in the long term.

Overall assessment: Site M5 is a large and potentially important area for native grassland conservation in the Majura Valley. Monitoring of GSM numbers would be useful to confirm its potential as GSM habitat.

A.5 Gungahlin

Site G1. Mulanggari Nature Reserve (GU01, GSM4)

Habitat characteristics: Predominantly natural temperate grassland (or secondary grassland), some native pasture or exotic, BSR 2(3).

Current land tenure, use and development: Nature reserve.

Size: 58.6 ha natural temperate grassland, 9.4 ha native pasture, 0.5 ha exotic. The majority is GSM habitat.

GSM population size: At least moderate populations in 1993 (Ref. 11), although recent observations found low numbers only (Refs. 12, 94).

Known history: Originally surveyed in December 1993 (Ref. 11). Observed in low numbers in December 2003 (Ref. 94) and 2008 (Ref. 12).

Potential development pressures: None within area, residential development on boundary, leading to increased human use of area, but unlikely to affect GSM.

Future land use: Nature reserve.

Management issues: Managed for a range of grassland values.

Overall assessment: A secure core conservation area for grassland and a key habitat area for GSM.

Site G2. Crace Nature Reserve (GU03)

Habitat characteristics: Mixture of natural temperate grassland (45%), native pasture (30%) and exotic (25%), BSR 3(5). (These percentages are subject to annual and seasonal change).

Current land tenure, use and development: Nature reserve.

Size: 136 ha in total, only part is GSM habitat.

GSM population size: Small population (Ref. 94).

Known history: Observed in December 2003 (Ref. 94). Moderate numbers recorded in 2008 (Ref. 12) and 2009 (Ref. 97).

Potential development pressures: None.

Future land use: Nature reserve.

Management issues: Managed for a range of grassland values.

Overall assessment: A secure core conservation area for grassland and a key habitat area for GSM.

Site G3. Gungaderra Nature Reserve (GU02)

Habitat characteristics: Mixture of natural temperate grassland (22%), native pasture (62%) and exotic (16%), BSR 5(2,4). (These percentages are subject to annual and seasonal change).

Current land tenure, use and development: Nature reserve.

Size: 187.3 ha in total (not all GSM habitat).

GSM population size: Small populations restricted to shorter vegetation.

Known history: Observed in December 2003 (Ref. 94). Low numbers recorded in 2008 (Ref. 12).

Potential development pressures: None within area, residential development on boundary, leading to increased human use of area, but unlikely to affect GSM.

Future land use: Nature reserve.

Management issues: Managed for a range of grassland values.

Overall assessment: A secure core conservation area for natural temperate grassland. While GSM is present in low numbers, it is not key GSM habitat.

Site G4. North Mitchell (Franklin) Grasslands (GU04)

Habitat characteristics: Predominantly natural temperate grassland (mainly *Austrostipa*, small area of exotic, BSR 3(4).

Current land tenure, use and development: Urban open space.

Size: 14.8 ha natural temperate grassland, 1.2 ha exotic (not all GSM habitat).

GSM population size: Probably a small population.

Known history: Observed in December 2003 and in 2005 (Ref. 94), low numbers recorded in 2008 (Ref. 12).

Potential development pressures: Possible paths etc. for recreational use within area, residential development adjacent.

Future land use: Urban open space/ grassland reserve.

Management issues: As an urban open space area, rather than part of Canberra Nature Park, this area is likely to require a similar management regime to the small GSM sites in Central Canberra (Ref. 56).

Overall assessment: Probably a relatively minor site in the context of GSM conservation in Gungahlin, but nevertheless useful. Potential for more intensive management as GSM than is feasible in the nature reserves (Sites G1, G2 and G3).

Site G5. Mulligans Flat North (GSM6)

Habitat characteristics: Secondary native grassland (part of yellow box – red gum grassy woodland community).

Current land tenure, use and development: Predominantly short term rural lease pending future development. Part of the site is within the section of Mulligans Flat Nature Reserve west of Mulligans Flat (formerly Gundaroo) Road.

Size: Approximately 20 ha within rural lease. Area within nature reserve uncertain.

GSM population size: Small to moderate population within rural lease, fewer in nature reserve.

Known history: Originally surveyed in November 1993 (Ref. 11), but not resurveyed until late 2007 (Ref. 21). In the latter survey and again in 2009 (Ref. 22), the GSM appeared to be concentrated mainly within the rural lease but were not necessarily associated with the *Austrodanthonia* patches. While the adjacent nature reserve area was not surveyed systematically, there was much less evidence of GSM in this area, where the grass cover was dominated by *Themeda* and there was some eucalypt regeneration.

Potential development pressures: Most of the area outside the nature reserve has previously been identified for future residential development on the Bonner concept plan (Ref. T). Subsequent planning, however, resulted in most of the area being withdrawn from development because of its biodiversity values.

Future land use: Urban open space or nature reserve (details subject to review), with limited residential development along the southern edge.

Management issues: This site is one of several sites in Gungahlin which are different from most of the earlier known GSM sites in the ACT in that they are located within secondary grassland rather than natural temperate grassland. In the long term, if not developed, they are likely to regenerate at least partly to woodland, and this may reduce their suitability as GSM habitat. If they are retained as open space with a view to conserving GSM habitat, they are likely to require deliberate management of the secondary grassland to maintain it in its present condition.

Overall assessment: This site is one of the better examples of GSM habitat within secondary grassland in the ACT, although it is still a relatively minor site in terms of GSM conservation. It was assessed as being of moderate conservation value in AP7 and has other biodiversity values apart from GSM habitat. Because of the dynamic natural regeneration processes occurring in the secondary grassland, however, it may be one of the highest risk sites in terms of habitat change. There is evidence of this already in the part of the site that has been conserved within Canberra Nature Park since the early 1990s, and has not experienced ongoing, low intensity domestic grazing. A similar change may occur if the secondary grassland is added to the nature reserve as opposed to being managed more intensively as urban open space.

Site G6. Mulligans Flat South-east (GSM8 – part)

Habitat characteristics: Secondary native grassland (part of yellow box – red gum grassy woodland community), which is regenerating as woodland.

Current land tenure, use and development: Nature reserve.

Size: Approx. 50 ha surveyed, but may not all be GSM habitat. Part of the survey area may be outside the nature reserve (see Sites G12 and G13).

GSM population size: Small population in 1993 (Ref. 11), none found in 2003 (Ref. 94), or in 2008 and 2009 (Refs. 30, 98).

Known history: Originally surveyed in November 1993 (Ref. 11), searched in 2003, 2008 and 2009 with none recorded (Refs. 30, 94, 98).

Potential development pressures: None within nature reserve. Adjacent to future Throsby residential and district playing fields development (see Sites G12 and G13).

Future land use: Nature reserve.

Management issues: This site faces similar management challenges to Site G5. Given the less intensive management approach used in Canberra Nature Park, it seems inevitable that the site would eventually regenerate to woodland with a reduced value as GSM habitat. It can therefore not be relied on as a long term site for GSM.

Overall assessment: As with Site G5, because the site is secondary grassland, it is a high risk site from the viewpoint of habitat change. The lack of recent records within the nature reserve suggests that the GSM may no longer be present in that area.

Site G7. Mulligans Flat South-west (not recorded in APs)

Habitat characteristics: Secondary native grassland associated with regenerating woodland.

Current land tenure, use and development: Nature reserve.

Size: Not determined, potentially approx. 5 ha.

GSM population size: A few scattered individuals observed under sub-optimal conditions in 2008 and 2009 (Refs. 30, 98).

Known history: Reconnaissance surveys in 2008 and 2009 recorded very low numbers of individuals (Refs. 30, 98).

Potential development pressures: None within nature reserve. Adjacent to Forde residential development.

Future land use: Nature reserve.

Management issues: Intensity of human use likely to increase as Forde is settled. Parts of the area may regenerate to woodland with a reduced value as GSM habitat.

Overall assessment: This site is of similar value to Sites G5 and G6 as secondary grassland habitat. It may also be subject to woodland regeneration, although there are some treeless areas which may remain as grassland for at least the medium term.

Site G8. Moncrieff South (not recorded in APs)

Habitat characteristics: Secondary native grassland associated with woodland.

Current land tenure, use and development: Short term grazing agistment.

Size: Approx. 28 ha.

GSM population size: Medium-sized population.

Known history: Identified as possible GSM habitat in April 2008 (Ref. 58), confirmed with indicative mapping in November 2008 (Ref. 23) and further survey in 2009 (Ref. 24).

Potential development pressures: All of this area is prime residential development land, but a large area is now being considered for biodiversity conservation.

Future land use: Partly residential development with some land as grassland/ woodland habitat and informal open space. Planning for Moncrieff is currently in progress.

Management issues: Any secondary grassland retained has potential to regenerate to woodland, which would affect its long term value as GSM habitat. There is opportunity, however, to manage the secondary grassland to maintain its existing values.

Overall assessment: This appears to be the most extensive of the secondary grassland GSM sites, with potentially the highest GSM population among those sites. It also has other high biodiversity values. It is poorly located from a conservation perspective because of competing pressures from development and, in contrast to the other secondary grassland sites, is isolated from woodland conserved within nature reserves, but there is nevertheless high potential for some land to be retained as a medium-sized conservation reserve.

Site G9. Goorooyarroo Nature Reserve (not recorded in APs)

Habitat characteristics: Secondary native grassland associated with woodland.

Current land tenure, use and development: Nature reserve.

Size: Uncertain.

GSM population size: Uncertain, several specimens have been sighted in casual observations (Ref. 12).

Known history: Early records based on casual observations, possibly by Kruno Kukolic. Noted in casual observations in November 2008 (Ref. 12).

Potential development pressures: None within the nature reserve boundary, although the local GSM population extends also into Throsby (see Site G12).

Future land use: Nature reserve.

Management issues: Potential for woodland regeneration affecting habitat quality.

Overall assessment: This is a further secondary grassland site with the advantage of being located within an existing nature reserve. Again, because it is secondary grassland, there is the possibility of GSM habitat being adversely affected by woodland regeneration in the future.

Site G10. Jacka North (not recorded in APs)

Habitat characteristics: Predominantly native pasture (secondary grassland associated with woodland), variously dominated by *Austrodanthonia* or *Themeda*, with some *Austrostipa*.

Current land tenure, use and development: Rural lease.

Size: Not definable. GSM sightings are spread sparsely over a large area.

GSM population size: Very low and sparsely spread, based on existing observations.

Known history: First recorded in 2009 (Ref. 25).

Potential development pressures: Proposed for urban development as part of the suburb of Jacka.

Future land use: Urban, predominantly residential.

Management issues: Recorded GSM sites are too small and too dispersed to enable any management measures to conserve the GSM in selected locations to be implemented with confidence. Woodland regeneration would be likely to adversely affect the value of the area as GSM habitat.

Overall assessment: Because of the very low numbers of GSM and their dispersed distribution, this site is considered to be of low priority for GSM conservation, irrespective of any development pressures.

Site G11. Jacka South/ Moncrieff North (not recorded in APs)

Habitat characteristics: Degraded native pasture with scattered remnant woodland trees.

Current land tenure, use and development: Rural lease.

Size: Not definable. GSM sightings are spread sparsely over a large area.

GSM population size: Very low and sparsely spread, based on existing observations.

Known history: First recorded in 2009 (Ref. 25).

Potential development pressures: Proposed for urban development as part of the suburbs of Jacka and Moncrieff, and for construction of Horse Park Drive.

Future land use: Urban, predominantly residential.

Management issues: Recorded GSM sites are too small and too dispersed to enable any management measures to conserve the GSM in selected locations to be implemented with confidence. Woodland regeneration would be likely to adversely affect the value of the area as GSM habitat, which is of poor quality.

Overall assessment: Because of the very low numbers of GSM and their dispersed distribution, this site is considered to be of low priority for GSM conservation, irrespective of any development pressures.

Site G12. Throsby residential (not recorded in APs)

Habitat characteristics: Native pasture or degraded native pasture with scattered remnant woodland trees.

Current land tenure, use and development: Rural lease.

Size: Not definable. GSM sightings are spread sparsely over a large area.

GSM population size: Low and sparsely spread.

Known history: Part of the area may have been part of Site G6 surveyed in 1993 (Ref. 11). GSM first noted specifically in Throsby in 2008 (Ref. 12). Surveyed by meandering traverses in 2009 (Ref. 2).

Potential development pressures: Proposed for urban development for the suburb of Throsby.

Future land use: Urban, predominantly residential.

Management issues: Recorded GSM sites are generally too small and too dispersed to enable any management measures to conserve the GSM in selected locations to be implemented with confidence. Woodland regeneration would be likely to adversely affect the value of the area as GSM habitat.

Overall assessment: Because of the very low numbers of GSM and their dispersed distribution, this site is considered to be of low priority for GSM conservation, irrespective of any development pressures.

Site G13. Throsby district playing fields (not recorded in APs)

Habitat characteristics: Native pasture or degraded native pasture, with scattered remnant woodland trees.

Current land tenure, use and development: Rural lease.

Size: Playing field area covers approx. 25 ha, but GSM has been recorded in only localised parts of this area.

GSM population size: Small population.

Known history: First surveyed systematically in 2009 (Ref. 26), but may have been earlier observations as for Site G12. (Sites G12 and G13 are listed separately because they were subject to separate surveys in 2009, but could be combined within the whole area of Throsby).

Potential development pressures: Playing fields and associated works. It may be feasible to retain some GSM habitat as a buffer between the playing fields and Mulligans Flat Nature Reserve.

Future land use: Urban open space (playing fields).

Management issues: There is potential for retaining some GSM habitat within the playing fields area, subject to appropriate landscaping and management.

Overall assessment: This is a minor GSM site but could supplement the apparently limited habitat within the adjacent Mulligans Flat Nature Reserve, utilising selected native pasture remnants which are not impacted by development.

Site G14. Well Station Drive hill (not recorded in APs)

Habitat characteristics: Native pasture on moderate steep slopes.

Current land tenure, use and development: Rural lease, may have been withdrawn.

Size: Approx. 2.5 ha but may extend onto adjacent land in Kenny.

GSM population size: Small population.

Known history: First recorded in 2009 (Ref. 27).

Potential development pressures: Shown as residential in the Territory Plan but relatively steep for development. Edge of site within proposed Well Station Drive road reserve.

Future land use: Urban, details to be determined.

Management issues: Given the small area and its relative steepness and isolation from other development, there may be an argument for retaining this as an open space area and road buffer. If so, it appears feasible to manage it as GSM habitat.

Overall assessment: While this is a small site in area and population, it appears to be well defined with potential for retaining indefinitely as an remnant urban population. It is of interest also in that, while the GSM is reported to prefer gentle, north-facing slopes, this site is relatively steep and its population was observed largely on the south-facing slope, at least in the initial reconnaissance survey.

Site G15. Harrison 4 (not recorded in APs)

Habitat characteristics: Native pasture, largely degraded with exotic grasses. Relatively poor habitat.

Current land tenure, use and development: Rural lease.

Size: Not definable due to very low GSM counts.

GSM population size: Very small. Most surveys recorded no moths (Ref. 29).

Known history: Recorded in one of two surveys undertaken in December 2009 (Ref. 29). Not recorded in a preliminary survey in 2008.

Potential development pressures: Proposed for urban development in the suburb of Harrison.

Future land use: Urban, predominantly residential.

Management issues: Future management of GSM is not applicable due to proposed development of the site.

Overall assessment: A poor quality site with a very low level of GSM activity.

Site G16. Forde North (not recorded in APs)

Habitat characteristics: A few very small patches of secondary native grassland. While flying male moths have been observed on one occasion in surrounding areas of exotic or degraded native pasture, that pasture is unlikely to be part of the normal habitat. The area is likely to have been contiguous with Site G5 in the past.

Current land tenure, use and development: Partly within the Forde North residential estate which is currently being developed and partly within an adjacent infrastructure corridor, which is subject to major drainage and soil stabilisation works.

Size: Approx. 0.8 ha in several smaller areas, but boundaries may not be well defined.

GSM population size: Small population.

Known history: Recorded in surveys undertaken in 2009 (Ref. 30).

Potential development pressures: All of the site will be impacted directly by proposed residential estate development or infrastructure works.

Future land use: Residential or drainage corridor.

Management issues: Future management to retain GSM habitat is not practicable because of proposed development. An *EPBC Act* referral has resulted in offset provisions being agreed (Ref. 71).

Overall assessment: A small site in terms of area and population which could not be retained in a manner compatible with surrounding development.

Site G17. Ngunnawal 2C (not recorded in APs)

Habitat characteristics: Native or degraded native pasture (secondary grassland) which has regenerated from exotic pasture in recent years (Refs. 31, 65).

Current land tenure, use and development: Vacant Territory land, pending development.

Size: Approx. 8 ha of known habitat.

GSM population size: Small population.

Known history: Recorded in surveys undertaken in December 2009 (Ref. 31).

Potential development pressures: Proposed for urban development in the suburb of Ngunnawal (Ref. 72).

Future land use: Urban, predominantly residential.

Management issues: Throughout most of the site, future management as GSM habitat would not be feasible due to development. There may be the possibility of retaining or creating habitat along a drainage corridor linking Ngunnawal with the future suburbs of Moncrieff and Taylor.

Overall assessment: A poor quality site with a relatively low level of GSM activity.

Site G18. Gold Creek (Hall) (not recorded in APs)

Habitat characteristics: Native pasture (secondary grassland).

Current land tenure, use and development: Rural lease.

Size: Unknown.

GSM population size: Unknown.

Known history: Recorded through casual observations in 2009 (A. Rowell). No systematic surveys have been undertaken to date.

Potential development pressures: May be subject to development within or associated with the proposed suburb of Kinlyside.

Future land use: Probably within buffer area between the Village of Hall and the proposed suburb of Kinlyside, but subject to confirmation of its location.

Management issues: The current rural land management regime appears appropriate, pending the future development of Kinlyside, when a review of all issues relevant to the GSM would be required.

Overall assessment: There is currently insufficient information about this site to assess its relative importance for GSM. It appears to be a secure site for the immediate future.

Nearby New South Wales sites

AP7 shows some GSM in areas of New South Wales immediately north of Gungahlin (see Figure 2.2). Detailed information has not been obtained on these sites but from their mapped locations, it appears that they may also be in secondary grassland (i.e. above the elevation limits for natural temperate grassland).

A.6 Belconnen

Site B1. Former Belconnen Naval Station, Lawson (BE08, GSM1)

Habitat characteristics: Natural temperate grassland, BSR 2(3,4), other threatened species also present.

Current land tenure, use and development: Commonwealth land, former naval transmitting station site.

Size: 120.3 ha, most appears to be GSM habitat.

GSM population size: Large population within a large area.

Known history: Density mapping was undertaken in 1999 (Ref. 32) and 2003 (Ref. 33).

Potential development pressures: High potential for urban development, but a large proportion is likely to be conserved because of its grassland values.

Future land use: Potential nature reserve under Territory control, once it is released by the Commonwealth.

Management issues: Control of existing kangaroo population to achieve optimum grassland characteristics has been a major issue in managing the site.

Overall assessment: A large, potentially secure area which appears to have potential to support a viable GSM population in the long term. Assessed as a core grassland conservation area and key habitat for GSM in AP28, and as a high conservation value site for GSM in AP7. The site is listed on the Commonwealth Heritage List and the Register of the National Estate.

Site B2. Lawson – Territory Land (BE07)

Habitat characteristics: Mostly native pasture (46.9 ha), some natural temperate grassland (3.3 ha) or exotic (9.1 ha), BSR 5(3).

Current land tenure, use and development: Agistment grazing.

Size: 59.3 ha, not all GSM habitat.

GSM population size: Uncertain. GSM widespread but in low numbers when surveyed under non-optimal conditions in 2007.

Known history: Inspected in November 2003 (M. Dunford) with no GSM recorded. GSM recorded relatively recently in this area. Surveyed in detail in 2007 (Ref. 34). None found in 2008 (Ref. 12), but present in 2009 with a similar distribution to 2009 (Ref. 35).

Potential development pressures: Proposed for urban development.

Future land use: Planned to become predominantly urban, although some selected habitat areas would be retained as urban open space.

Management issues: Any remnant grassland/ GSM habitat following development would justify management for its habitat values and should relate to Site B1.

Overall assessment: Recent GSM monitoring indicates that this area is more important for GSM than was assessed in AP7 or AP28. Given the development pressures at Lawson and the higher ecological values of the Commonwealth land at Lawson, the latter is more likely to be given priority for conservation with the Territory land being subject to development.

Site B3. Lake Ginninderra (BE06, GSM13)

Habitat characteristics: Natural temperate grassland, BSR 3.

Current land tenure, use and development: Urban open space.

Size: 1.9 ha grassland but less than 0.2 ha of habitat.

GSM population size: Small, if present. While AP7 reported absence of GSM in recent surveys, it is shown as being present in AP28. There is an anecdotal report of GSM still being present (Ref. 95).

Known history: Reported to be present in 1999 (Ref. 81). Originally recorded by T. Edwards.

Potential development pressures: None at present.

Future land use: Urban open space.

Management issues: A small site within a much larger area which is not subject to intensive management (cf. Site C10, Yarramundi Reach). May be subject to excessive growth of groundcover or overstorey, although it is understood to be mown adjacent to the cyclepath.

Overall assessment: A minor site (rates as minimal conservation value in AP7) and potentially vulnerable to vegetation changes which may reduce GSM habitat value.

Site B4. Dunlop Nature Reserve (BE02, GSM10)

Habitat characteristics: Natural temperate grassland, BSR 3(2).

Current land tenure, use and development: Nature reserve. Fragmented into two areas (north and south) by Douglas Waterhouse Drive.

Size: 81.9 ha, not all GSM habitat.

GSM population size: Probably small.

Known history: A small population was recorded in an area partly outside the existing nature reserve in December 1993 (Ref. 11). Casual observations near powerlines in about 2000 (Ref. 94). Reconnaissance survey undertaken in 2009 (Ref. 36).

Potential development pressures: None within area, residential development nearby leading to increased human use of area, but unlikely to affect GSM. Potential for further fragmentation by extension to Douglas Waterhouse Drive.

Future land use: Nature reserve.

Management issues: Managed for a range of grassland values.

Overall assessment: A secure core conservation area for grassland. While GSM is present, it is not key GSM habitat.

Site B5. Macgregor West – north-east (not recorded in APs)

Habitat characteristics: Predominantly exotic grasses (especially Chilean needle grass) on the floodplain of Ginninderra Creek with degraded native pasture (*Austrostipa*-dominated) on the higher slopes. While the higher slopes are typical GSM habitat, the floodplain area is not and is of scientific interest for that reason.

Current land tenure, use and development: Short-term rural lease. The upper edge of the area is within the Macgregor West 2 estate.

Size: A relatively large site (approx. 70 ha) with extensions up and down Ginninderra Creek (see Sites B7 and B10).

GSM population size: A large population spread over a wide area, with the highest moth density in 2004-05 recorded close to Ginninderra Creek (Ref. 37). In wetter years, the GSM may favour the native pasture on the higher slopes.

Known history: First recorded in December 2002. Surveyed in detail in December 2004 (Ref. 37), with a subsequent survey in late 2005 (Ref. 38).

Potential development pressures: Upper part of the area is prime residential land, but is no longer proposed for development. The lower parts are constrained by flooding but are a potential urban open space corridor.

Future land use: Parts of the upper slopes where very low moth densities have been recorded are to be developed for residential purposes. Most of the area, including the floodplain will remain as rural lease but will be managed for GSM conservation.

Management issues: The GSM habitat has been subject to cattle grazing for many years, and is planned to remain within a rural lease in the immediate future. It has also been identified as an offset area for development of other GSM habitat within the Macgregor West 2 Estate (B6). As part of the offset package, a management plan for the site is being developed. That plan includes a proposal to investigate the rehabilitation of the Chilean needle grass areas on the floodplain to native grassland, thus seeking a feasible resolution to the conflict between controlling a nationally significant weed and conserving habitat for a threatened species. The measures to conserve the offset area as GSM habitat have the potential to conflict with other possible management objectives for the Ginninderra Creek corridor, particularly the planting of trees along the creek.

Overall assessment: From a native grassland conservation viewpoint, the West Macgregor site is of low priority because of the high exotic content, and particularly because Chilean needle grass is an aggressive invader of native pastures. It nevertheless has a large population of GSM and has been of particular scientific interest as the first site, at least in the ACT, to challenge the conventional wisdom that GSM is highly dependent on *Austrodanthonia* spp. for breeding habitat. It also demonstrates that grassland mapping is not always a reliable determinant for GSM habitat.

Despite some of the site having high development potential, virtually all of the area has been retained as GSM habitat. That area is much larger than most other GSM sites in similar development situations in Belconnen or Central Canberra. The replacement of Chilean needle grass with native species without prejudicing the survival of the GSM population may be a major management challenge for part of the area.

Site B6. Macgregor West – west (not recorded in APs)

Habitat characteristics: High quality native pasture with a limited forb component, including a small area of natural temperate grassland.

Current land tenure, use and development: Part of the Macgregor West 2 residential estate.

Size: Not well defined but of the order of 5 ha.

GSM population size: A low level of GSM activity spread over a relatively large area.

Known history: Casual observations of GSM recorded in December 2007 (Ref. 39). Low numbers recorded in 2009 (Ref. 36).

Potential development pressures: Most of the area will be impacted by the development of the Macgregor West 2 Estate, although the natural temperate grassland patch and some limited areas of native pasture will remain as open space.

Future land use: Urban, predominantly residential.

Management issues: It would be desirable for any remnant areas of native grassland to be managed in a way which retains their GSM habitat. Based on observations in Central Canberra and elsewhere in Belconnen, it is likely that such remnants could continue indefinitely to support small GSM populations.

Overall assessment: Site B6 appears to be a relatively minor area in terms of GSM numbers compared with Site B5, although its native vegetation quality is higher. While most of the site will be developed, there is the prospect of retaining some limited habitat areas which could support small local GSM populations if managed appropriately.

Site B7. Lower Ginninderra Creek (not recorded in APs)

Habitat characteristics: Predominantly exotic pasture including Chilean needle grass downstream of Site B5.

Current land tenure, use and development: Short-term rural lease or public land along access track/ equestrian trail.

Size: Narrow corridor over along the creek, width ill-defined. Assessed as 42 ha.

GSM population size: Small population.

Known history: The presence of GSM along the Ginninderra Creek floodplain between Site B5 and the ACT border was recorded in 2004 (Ref. OO). It was recorded also in a reconnaissance survey along the creek corridor in 2009 (Ref. RR).

Potential development pressures: None known.

Future land use: Predominantly rural lease in short term. Long term use uncertain.

Management issues: Depends largely on management of rural lease.

Overall assessment: This site can be viewed as an extension of Site B5, with connectivity depending on maintaining a habitat corridor along Ginninderra Creek. That corridor is generally not of high biodiversity value at present because of the high component of exotic pasture including Chilean needle grass.

Site B8. Jarramlee Road (West) (not recorded in APs)

Habitat characteristics: Native and exotic pasture, with *Themeda* along part of Jarramlee Road. Continuous with Site B7.

Current land tenure, use and development: Rural lease or road reserve.

Size: Assessed as 28 ha but ill-defined.

GSM population size: Small population.

Known history: Recorded in a reconnaissance survey in 2009 (Ref. 36).

Potential development pressures: None known.

Future land use: Rural lease or road reserve.

Management issues: Depends on management of rural lease.

Overall assessment: Part of a large area of low GSM activity on the north-west edge of Belconnen, with relatively low general biodiversity value.

Site B9. Wallaroo Road (not recorded in APs)

Habitat characteristics: Native and exotic pasture. Continuous with Site B4.

Current land tenure, use and development: Rural use lease.

Size: Assessed as 30 ha but ill-defined.

GSM population size: Small population.

Known history: Recorded in a reconnaissance survey in 2009 (Ref. RR).

Potential development pressures: None known.

Future land use: Rural lease.

Management issues: Depends on management of rural lease.

Overall assessment: Part of a large area of low GSM activity on the north-west edge of Belconnen, with relatively low biodiversity value.

Site B10. Ginninderra Creek, Macgregor (not recorded in APs)

Habitat characteristics: Mostly exotic pasture remnants (including Chilean needle grass), with some native grasses. The natural grassland corridor is fragmented by tree plantings, with habitat probably confined to isolated small patches.

Current land tenure, use and development: Urban open space surrounded by residential development.

Size: Difficult to estimate because of fragmented nature, but probably small.

GSM population size: Very small fragmented population.

Known history: Recorded in 2004 (Ref. 37), with one record in 2009 (Ref. 36).

Potential development pressures: Habitat modification associated with landscaping of Ginninderra Creek corridor.

Future land use: Urban open space.

Management issues: Retention of GSM habitat may not be compatible with other management objectives for the Ginninderra Creek corridor.

Overall assessment: Very small localised remnant populations which are unlikely to remain viable in the long term under the current management regime.

Site B11. Dunlop powerlines (not recorded in APs)

Habitat characteristics: Native and exotic pasture.

Current land tenure, use and development: Powerline easement surrounded by residential development.

Size: Narrow corridor along powerlines, ill-defined.

GSM population size: Very small population.

Known history: Recorded in 2004 (Ref. 37), with one record in 2009 (Ref. 36).

Potential development pressures: None known.

Future land use: Powerline easement.

Management issues: Depends on management of powerline easement. There may be the potential to enhance GSM habitat and increase the population size.

Overall assessment: Currently on very minor site, but may have greater potential in the future, subject to appropriate management and rehabilitation.

Site B12. Umbagong Park, Latham (BE04) (not recorded in APs)

Habitat characteristics: Mostly exotic pasture, some natural temperate grassland.

Current land tenure, use and development: Urban open space.

Size: Potentially a large area, although GSM habitat may be confined to a small percentage of this area.

GSM population size: Very small population.

Known history: No GSM recorded in 2008 (Ref. 12). Very low numbers recorded in 2009 (Ref. 97)

Potential development pressures: None known.

Future land use: Urban open space.

Management issues: Dependent on management of open space to maintain suitable habitat. Potential conflict with other landscape management objectives.

Overall assessment: Currently a very minor site but may have potential for significant enhancement, subject to appropriate management.

Site B13. Balamara Street, Giralang (not recorded in APs)

Habitat characteristics: To be determined.

Current land tenure, use and development: Road verge.

Size: Not determined, appears to be a small site.

GSM population size: Small population.

Known history: Recorded in 2008 (Ref. 12) and 2009 (Ref. 97).

Potential development pressures: None known.

Future land use: Road verge.

Management issues: Depends on management of road verge.

Overall assessment: A minor urban site but potentially capable of supporting GSM in the long term, subject to appropriate management.

Site B14. University of Canberra (not recorded in APs)

Habitat characteristics: Mostly native pasture.

Current land tenure, use and development: University campus and road verge.

Size: Not determined, medium sized area?

GSM population size: Small population.

Known history: Recorded in 2009 (Ref. 97).

Potential development pressures: Subject to future developments within university campus.

Future land use: Uncertain.

Management issues: Depends on management of campus. Current management regime appears adequate, but there may be scope for improvement.

Overall assessment: While currently a minor site, it could have greater potential in the future, subject to development in this part of the campus. Its educational potential is significant, given its proximity to the Applied Science building which has been a centre for GSM research in recent years.

A.7 Other Sites

Based on GIS data provided by Conservation Planning and Research (see Figure 2.2), there appear to be some further sites which have not been identified from other sources. These include the following:

- Cotter Road/ Dunrossil Drive/ North Curtin horse paddocks
- Yarralumla Equestrian Park (extension of Site C11?)
- Iloura horse paddocks
- Wattle Street, Lyneham
- Yarralumla foreshores (north of Alexandrina Drive)
- Majura Road (west side, related to Site M5?)

Further information above these sites is required in order to document them in the preceding format.

Figure 2.2, on the other hand, does not appear to identify the following sites that are located in this appendix:

C6, C13, J3, G18, B6, B8, B9, B12

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SEMI-QUANTITATIVE ASSESSMENT OF GOLDEN SUN MOTH SITES

David Hogg
January 2010

1. Introduction

The number of sites known to be used by the golden sun moth (GSM, *Synemon plana*) in the Canberra area has increased gradually each year as new sites are recorded, and has shown a very sharp increase in late 2009. Many of these sites are in areas affected by the orderly development in Canberra. In order to make sensible planning decisions with respect to the conservation of selected sites as GSM habitat (and for other biodiversity values), it is desirable to evaluate the relative importance of the respective sites for the GSM.

There are various methodologies available for attempting to quantify GSM activity based on flying males, sedentary females or pupal cases, but these are subject to the following limitations:

- After emerging from their pupal state, GSM have a life of only a few days. The moths counted in successive surveys undertaken a few days apart will be different individuals. It is therefore meaningless to consider a ‘population size’ in the same way as one might count plants or many other animals within a season.
- The number of moths recorded at a site during a survey will vary from year to year depending on the seasonal response to hatching, from day to day within a season depending on daily weather conditions, and from hour to hour within a day, again dependent on variations in temperature, cloud cover and wind speed. This is particularly true for observing flying males. Pupal cases are less affected by weather, and are understood to survive for at least two weeks under typical summer conditions.
- The number of flying males may be influenced by whether the observer is stationary or moving through the habitat, in the latter case disturbing moths and causing them to fly.
- The observation of both live moths and pupal cases may be influenced by the experience and visual acuity of the observer.

Because of these limitations, any observations of GSM are only representative samples in terms of time and space, and cannot be used to generate absolute numbers in a meaningful way. Instead, they are better interpreted in a relative sense which may describe GSM activity at a site in terms of high, moderate, low or zero, for example.

In terms of making planning decisions, such a semi-quantitative assessment is the most useful way of presenting GSM survey results. It is difficult enough for trained scientists to apply quantitative data for GSM objectively, let along expecting broadly based decision-makers to make such interpretations.

The remainder of this paper examines the various methodologies for assessing GSM sites, and proposes guidelines for expressing the results in a broadly consistent semi-quantitative manner.

2. Overview of Methodologies

There are various approaches that can be used for identifying GSM habitat, as follows:

Vegetation mapping of potential habitat. This approach is based on the assumption that there is a correlation between vegetation characteristics (particularly the presence of certain wallaby grass (*Austrodanthonia*) species and the potential value as GSM habitat. While this appeared to be the case during the early days of GSM research, there is a mounting body of evidence that this is at best an oversimplification of the current relationship between the GSM and grass species. In particular, the GSM appears to have a strong affinity (and possibly even a preference) for the introduced weed, Chilean needle grass (*Nassella neesiana*). On the other hand, *Austrodanthonia carphoides* which has commonly been cited as a good indicator of GSM habitat, often dominates well-drained or exposed sites, or sites with shallow soil, and such sites do not appear to be correlated with the highest numbers of moths. In any case, the presence of certain grasses indicate **potential** habitat only and, in the majority of cases, is not associated with actual moth populations. Vegetation mapping is therefore not considered further as a useful technique for establishing GSM presence, although it may be useful as an out-of-season indicator for sites warranting further investigation.

Flying males. Observation or counting of flying males is the simplest method of establishing the presence and relative numbers of moths. It is highly weather-dependent, however, and is not an absolute indicator of breeding habitat as males may stray (or be blown) several hundred metres outside the breeding area when searching for females. Flying male counts can readily be expressed in quantitative or semi-quantitative terms.

The method of counting flying males depends on the nature of the site. For large sites, the most rigorous method is to establish a series of parallel transects and count moths in defined sections (typically 100 m) along the transect and for a set width (say 25 m) on either side. Data collected in this way can be interpreted or averaged over several surveys, although such mathematical manipulation can sometimes give rise to results which do not always reflect reality, and need careful interpretation.

Alternatively, the site can be inspected through a meandering or structured traverse with the total number of moths recorded within a given period of walking.

For smaller sites, flying males can be detected by repeated point rotational counts (e.g. in sets of ten) in which the observer stands at a certain point and rotates the body over a set period (commonly 30 sec), counting the number of moths for a distance of (say) 30 m, as they cross the path of the observer's extended arm. Alternatively, if the whole site can be seen from a single point, a moth count can be made over a set period (say 3 minutes) for the whole site. This method is useful for indicating presence or absence, but is difficult to quantify if large numbers of moths (e.g. more than 5) are flying.

Sedentary females. Female GSM have a very limited flying ability and are most readily detected on the ground, where they may be laying eggs. Detection of females is much more difficult than detection of flying males, and is not widely used as a survey method, particularly on a quantitative basis. The observation of ovipositing females, however, can be taken as a reliable indicator of breeding habitat.

Pupal cases. The detection of pupal cases has several advantages in that:

- it is not directly weather-dependent, enabling surveys to be done during low temperatures, cloudy periods or windy conditions, although recent rain may make their detection more difficult;
- it indicates breeding habitat as opposed to flying areas, although its use for breeding would relate to a previous year when eggs were laid, and not necessarily to the current year; and
- it can be done on a semi-quantitative basis, although it is still subject to variation between or within breeding seasons.

On the other hand, it requires more effort per unit area and a higher level of observer skill, both to locate the pupal cases and to distinguish them from those of other insects.

The techniques can be quantified by thoroughly searching a given number of quadrats which may be distributed randomly or systematically, or may target areas of high habitat potential or ground visibility. (Finding pupal cases in dense grass is difficult).

The choice of methodology for GSM survey depends on many factors, including:

- the size and shape of the study area;
- whether the purpose of the survey is to detect presence/ absence, to quantify moth numbers for comparative purposes, or to distinguish the boundary between breeding habitat and other areas visited by flying males;

- the time available within the season to undertake the surveys, the human resources available and their level of skill; and
- the experience and personal preferences of the persons involved.

As many relevant surveys have already been undertaken using a range of techniques, it is desirable to have a means of interpreting their results on a semi-quantitative basis which is reasonably consistent. That same basis can be applied to future surveys, thus avoiding the need for a rigid approach to these surveys, and allowing the persons involved to adapt their methods to the circumstances of the site, the weather and the resources available.

3. The Proposed Classification Methodology

The proposed classification can apply to a site as a whole, if the GSM distribution appears to be fairly uniform within a site or if it is not practicable to subdivide the site, or to different areas within the site.

Four levels of GSM activity are proposed, namely zero, low, moderate or high. A ‘very high’ or ‘very low’ level may be considered appropriate in some situations but, in practical terms, is likely to be treated on the same basis as a ‘high’ or ‘low’ level respectively, and is therefore not distinguished in the present classification.

A site has **zero** level if no flying male moths are detected during a minimum of four reconnaissance surveys under suitable weather conditions during the season when GSM are known to be flying. A minimum survey effort of (say) 5 minutes per hectare is suggested as appropriate to justify a ‘zero’ conclusion for a site of 10 to 20 ha, but this level of effort may be increased for smaller sites or reduced for larger ones.

For the other levels of activity, the following criteria are suggested in relation to the respective methodologies identified above. The numbers stated have generally been rounded, are intended to be indicative only, and do not cover the full range of values. Intermediate values may be included in the closest range, or may be described, for example, as ‘low to moderate’. In practice, repetitions of counts even within the one session, have potential to vary widely, making subjective judgement inevitable. Because counts may vary widely with the conditions, it is suggested that the highest repeatable range of counts should form the basis for the assessment.

Standing rotational counts (based on a 30 second rotation)

High	10 or more per rotation
Moderate	3 to 5 per rotation
Low	1 or less per rotation

Standing fixed counts (whole site)

The following times are similar on a per minute basis to the rotational counts.

High	20 or more per minute
Moderate	5 to 10 per minute
Low	2 or less per minute.

Walked transects

Based on a typical walking pace of 3 km/ hr (i.e. 50 m/ min or 2 min for 100 m of transect), comparable counts would be as follows:

High	40 or more per 100 m of transect
Moderate	10 to 20 per 100 m
Low	4 or less per 100 m

For slower walking paces, the count should be increased proportionately (e.g. for 3 min per 100 m, multiply by 1.5).

Meandering or structured traverses

Based on the above walking pace, counts would be recorded on a per minute basis as follows:

High	20 or more per minute
Moderate	5 to 10 per minute
Low	2 or less per minute

For all of the flying male counts, it is assumed that the effective field of view for the count at a given time is approximately the same in all cases. For walking observations, this area is assumed to be 25 m either side of the line and 10 m ahead (i.e. 2 x 25 x 10 = 500 m^2). For rotational point counts over a radius of 30 m, the total area surveyed is just over 2800 m^2 but the effective area of view at a given time is much less than this.

Sedentary females

As counting females is difficult and generally results in low numbers, no semi-quantitative scale is proposed. Instead, the presence of females should be treated as a qualitative indicator of breeding habitat.

Pupal cases

Pupal cases can also indicate breeding habitat, but in theory could be used semi-quantitatively in terms of pupal case counts per square metre of grassland searched. In practice, however, the detection of pupal cases can be random and very variable due to clustering at one extreme and zero results in known habitat areas at the other. There is not considered to be enough reliable data from pupal case count techniques to suggest meaningful figures for assessing GSM activity on a semi-quantitative basis. The presence of pupal cases can nevertheless be used qualitatively as an indicator as a likely breeding site.

4. Concluding Comments

All of the numbers quoted above are arbitrary and are based on recent surveys undertaken in the Canberra area. They are intended to apply primarily to the Canberra context, where the GSM appears to be relatively widespread, with large counts on some sites, and may not be appropriate for use in some other parts of Australia.

The scientific basis for nominating the numbers and comparing numbers for different survey methods is questionable. While this basis could be made more rigorous through further research and statistical analysis, this has not been practicable within the recent (2009) flying and breeding season. It is therefore necessary at this stage to rely on educated guesses. The more input that is received from people working with golden sun moths, the more reliable these guesses should be. The figures can be revised for future application as better knowledge is accumulated.

It is evident also that the relative levels of GSM at different sites can vary from year to year, depending on environmental conditions and possibly other factors. It is therefore desirable for assessments to be based on several years of observations if possible.

Acknowledgement

Comments by Alison Rowell on a draft version of this paper are gratefully appreciated.

Any further comments would be welcome.

Note: While the above guidelines were used for purposes of comparing 2009 GSM records, some additional comments have been received in relation to some details. It is intended to review these comments in refining the guidelines for future use.

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ASSESSING THE SIGNIFICANCE OF IMPACTS ON THE GOLDEN SUN MOTH IN RELATION TO THE *EPBC ACT*

David Hogg
4 February 2010

The Commonwealth *Environment Protection and Biodiversity Act* requires a proposed action to be referred if it is likely to have a significant impact on a matter of national environmental significance (Ref. 1). The term *significant impact* is not defined in the Act itself, but the following explanation is provided in various policy statements issued under the Act (e.g. Refs. 2, 3):

> *A 'significant impact' is an impact which is important, notable, or of consequence, having regard to its context or intensity. Whether or not an action is likely to have a significant impact depends upon the sensitivity, value, and quality of the environment which is impacted, and upon the intensity, duration, magnitude and geographic extent of the impacts. You should consider all of these factors when determining whether an action is likely to have a significant impact on matters of national environmental significance.*

The key terms, *important, notable* and *of consequence*, are emphasised in supporting documentation issued under the Act, but are all subjective and depend on the application of professional judgement. More specific criteria have been determined to assist in their interpretation, but even these are not always definitive.

In relation to the golden sun moth (GSM, *Synemon plana*), which is listed as critically endangered under the Act, the following significant impact criteria are relevant (Ref. 2):

> *An action is likely to have a significant impact on a critically endangered or endangered species if there is a real chance or possibility that it will:*
>
> - *lead to a long-term decrease in the size of a population;*
> - *reduce the area of occupancy of the species;*
> - *fragment an existing population into two or more populations;*
> - *adversely affect habitat critical to the survival of a species;*

- *disrupt the breeding cycle of a population;*
- *modify, destroy, remove, isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline;*
- *result in invasive species that are harmful to a critically endangered or endangered species becoming established in the endangered or critically endangered species' habitat;*
- *introduce disease that may cause the species to decline; or*
- *interfere with the recovery of the species.*

It is not difficult to appreciate how most of these criteria could have a 'significant' impact within a certain context, but the second criterion, *reduce the area of occupancy of the species*, is open to inappropriate interpretation if considered literally. For example, removal of 5 square metres of grassland habitat for erecting a minor structure within a 5 hectare area of habitat could be considered as 'reducing the area of occupancy' in that location, if only by 0.1 percent. This criterion, if interpreted literally, could be considered to trigger a referral, although it is difficult to imagine how it could be considered important, notable or of consequence.

A more specific policy statement has been prepared for the GSM (Ref. 3). This is supported by a background paper (Ref. 4). These documents identify significant impact thresholds related to habitat loss, degradation or fragmentation, as follows:

Ecological element affected	**Impact threshold**	**Comment**
Large or contiguous habitat area (>10 ha)	Habitat loss, degradation or fragmentation >0.5 ha	Habitat is a similar or connected area within which the golden sun moth is found during surveys or known from records. The function of the area may include, but is not limited to: feeding, breeding, dispersal.
Small or fragmented habitat area (<10 ha)	Any habitat loss, degradation or fragmentation	Small areas of habitat are more likely to suffer significant impacts from loss, degradation and fragmentation that larger areas. The limited dispersal ability of the golden sun moth means habitat areas separated by >200 m are effectively isolated and should be considered as separate habitat areas. Extremely small, isolated and degraded habitat patches (e.g. <0.25 ha) may support populations of golden sun moth but are unlikely to contribute to the overall ecological health of the species.
Habitat connectivity	Fragmentation of a population through the introduction of a barrier to dispersal	Barriers to dispersal could include: breaks in habitat of >200 m; structures that prohibit movement (e.g. buildings, solid fences).

At first sight, these thresholds may also be considered to be extreme (e.g. in relation to the above example), but it is important to interpret them in the context of other advice provided in the same documents.

Notes accompanying the table state:

> *The elements and thresholds in the table above give guidance to the level of impact that is likely to be significant for the species at a site. They are not intended to be exhaustive or prescriptive, but rather to highlight the need to maintain the ecological function of the habitat area.*

This emphasis on 'maintaining the ecological function of the habitat area' is important, and underlies the fundamental basis of biodiversity conservation. It can apply in two quite different ways to the conservation of threatened species habitat:

- There can be situations where an action may avoid any direct habitat loss, degradation or fragmentation, but could still threaten the ecological function of the area, for example, as a result of indirect impacts of development on nearby land. Such impacts may be significant.

- There can be situations where limited loss of habitat can occur while still maintaining the ecological function of the remainder of the area. Such impacts may not be significant.

A further consideration stated in these documents is as follows:

> - *Significant impact judgements must be made on a case by case basis and with consideration for the context of the action* (Ref. 3)*; or*
> - *… decisions on significance will **always** need to be on a case to case basis with consideration for the context of the action* (Ref. 4)*.*

The evaluation of impacts in a broad context is fundamental best practice in impact assessment. The context in this sense can include the geographic surroundings of the action, the planning and development context for the area, including the timing of other development, the cumulative impacts of such development, the known local and regional distribution of the threatened species, and the ecological processes affecting that species and influencing its threatened status. The actions taken to date to conserve the GSM in the ACT also form part of that context.

Important points relating to the context of the GSM in the ACT include the following:

- When the GSM first came to prominence as a threatened species in the ACT during the 1990s, it was regarded as a native grassland specialist that was surviving in relatively few locations. Since then, it has been recorded in many more locations (now approaching 60) and in a wider range of habitat conditions (although generally in native or exotic grassland).

- The GSM appears to be quite widespread, although sometimes only in low numbers, in undeveloped land in Gungahlin, Belconnen, Majura and

Jerrabomberra. It is also being found in an increasing number of sites in Central Canberra.

- Many of the areas where the GSM has been found recently have been withdrawn from regular grazing and pasture improvement, or have had grazing intensity reduced, with the result that they are reverting to native pasture. This may be increasing the area of favourable habitat for GSM. This process may be assisted by recent climate patterns favouring the regeneration of native grasses over exotic pasture grasses.

- Many of the areas containing GSM habitat are planned for future urban development. These are generally areas where GSM are present in relatively low numbers, and where habitat quality is low to moderate.

- The GSM appears to be fairly resilient to the effects of surrounding development, being present in small isolated areas adjacent to housing, roads etc. which have been established for several decades. It does not appear to depend on buffer areas for its survival or on connectivity to other habitat. Small, isolated areas would nevertheless remain relatively vulnerable in the long term, due to the limited opportunity for repopulating if an event causes a major population loss.

- Most of the areas with high GSM populations and high quality habitat are located within existing or potential nature reserves, or on Commonwealth land.

- Where local GSM numbers have declined, this may be due to reduced grazing pressures leading to dense grass growth, which in turn can be unfavourable for moth breeding.

- A strategic approach has been proposed for the conservation of the GSM in the ACT (Ref. 5), based on conserving a large number of GSM sites in different parts of the ACT. A high proportion of these sites are within existing native reserves or other relatively secure areas.

Applying the general *EPBC Act* criteria for endangered species (Ref. 2) in the context of the GSM distribution in the ACT, an action could have a significant impact on the GSM in terms of the *EPBC Act* if, for example, it would:

- result in permanent loss or fragmentation of a sizeable proportion (say 5% or more) of GSM habitat in conservation reserves or other land which is important to the GSM conservation strategy (Ref. 5);

- result in the removal of most or all of a small but viable GSM site, thus reducing the number of GSM sites in the Canberra area;

- have a substantial impact on a GSM site of particular scientific or cultural importance (e.g. York Park); or

- result in management changes (e.g. burning, mowing, altered grazing regime) which could adversely affect GSM survival or disrupt breeding in a sizeable proportion of important habitat or throughout a small but otherwise viable site.

On the other hand, an action would generally not be considered significant if it would:

- result in the loss of fragmentation of only a small proportion of a GSM site without materially affecting the ecological function of the site, i.e. the site would remain viable with a GSM population size of the same order of magnitude;

- result in limited and temporary disturbance which would be rehabilitated to a condition similar to or better than that preceding the disturbance;

- involve deliberate modification of the site to improve in native quality for GSM (e.g. replacement of Chilean needlegrass with suitable native species); or

- improve the management regime from the viewpoint of GSM survival and breeding.

The above examples are intended to be indicative only, and should be interpreted in relation to each action and each site, i.e. on a case by case basis in the context of the action, as emphasised in the *EPBC Act* guidelines (Refs, 3, 4). Furthermore, these examples address significance in the context of specific sites because this is the level at which the *EPBC Act* generally operates at present. If an impact is judged significant in relation to the site, the action should be subject to referral. If, however, it is judged not to be significant, this does not preclude the submission of a referral on a precautionary basis, as is common practice by some proponents. The latter judgement is based on political/management considerations rather than technical considerations.

While an action may be considered to have a significant impact in relation to the *EPBC Act*, this does not necessarily mean that its impact is significant from a strategic conservation perspective, at least in the Canberra context. With the large number of GSM sites now known in Canberra, the prospect of many more being found as native habitat regenerates and searching intensifies, and the location of a significant proportion of these sites in areas essential for development of the city, there will be an increasing number of GSM sites unavoidably lost to development in the near future. At the same time, there is the prospect that other sites which have been deliberately excluded from development for biodiversity conservation reasons (including GSM conservation) will be enhanced through natural regeneration or deliberate intervention. This could increase the size and security of their GSM populations.

It is in this context that strategic biodiversity planning becomes important, and the loss of small GSM sites may be considered not to be significant strategically, despite being assessed as significant for *EPBC Act* purposes. This, however, does not negate the value of the *EPBC Act* referral process. Rather, it means that if there is a significant impact (in *EPBC Act* terms), it would justify implementation of offsets elsewhere to achieve a net gain in GSM conservation. The nature of such offsets and the mechanisms for implementing them are beyond the scope of the present paper, but it would be appropriate to address them in reviewing the GSM conservation strategy (Ref. 5).

For actions in which the impacts on GSM are considered not to be significant in terms of the *EPBC Act*, specific offsets are not considered to be warranted. The additional benefits gained from implementing offsets for other actions are likely to more than compensate for any marginal effects of actions where the impact is not significant.

The basis for assessing significant impacts on GSM outlined above and discussed further below is more flexible in terms of threshold than that suggested in the *EPBC Act* policy statement (Ref. 3) or its background paper (Ref. 4). The basis for those thresholds, however, is not explained other than by stating that they were 'developed in consultation with experts'. It is not clear whether that expert advice reflected the current situation in Canberra, or that in other parts of Australia, where the future of the GSM may be more tenuous and the opportunity to implement strategic measures for GSM conservation may be more limited.

It is therefore important to apply the basic explanation of a significant impact, i.e. *an impact which is important, notable, or of consequence, having regard to its context and intensity*, and applying this in relation to current knowledge of GSM in the Canberra area and the actions that have been taken or are proposed to secure the long term conservation of the GSM in the ACT.

Proposed Methodology for Assessing Significant Impacts

The methodology described below expands on the preceding discussion as a basis for assessing whether impacts on a GSM site in the ACT should be considered significant in the context of the local situation. Table 1 lists a number of factors which should be considered in this process. These include factors relating to the site and its GSM population, as well as factors relating to the proposed action and to its geographical context.

This table is intended as a guide only, which is not meant to be followed prescriptively but requires critical and objective thinking to determine the significance of any impacts on the GSM. It addresses separately the site attributes relevant to the GSM and nature of the impacts in terms of extent and intensity. These factors need to be considered together in determining whether an impact should be regarded as significant in the context of the site.

The geographical context of the site in terms of use and potential development of surrounding land is strictly not relevant to the site itself, but is important in determining significance of impacts at a strategic level. For example, the impact of a road in a narrow corridor through an area where the remainder of that area is to be developed for other urban uses would not be considered significant in a strategic context.

Some specific comments relevant to each of these factors are as follows:

Known GSM populations. This assessment is based on criteria presented in a separate paper on the semi-quantitative assessment of GSM sites (Ref. 6).

Viability as GSM habitat. This takes account of the area of the site and its known history. Small sites in urban areas where GSM have survived for several decades, despite the presence of surrounding development, are considered to be viable. The 'uncertain' category reflects the precautionary principle.

General ecological quality. Native grassland includes natural temperate grassland and secondary grassland within the box – gum community. The descriptions are based on those in the lowland grasslands Action Plan (Ref. 7). Ecological quality can also embrace other grassland fauna, irrespective of whether they are threatened. Where weed species include Chilean needlegrass, this can be considered as potentially enhancing the habitat for GSM, but is still a negative factor in terms of general ecological quality.

Special attributes. This applies to sites of particular scientific or cultural value for GSM, e.g. York Park.

Proportion of site affected. The percentages quoted are notional only and are intended to apply only to GSM habitat, not to other parts of the area which may not support GSM. It will often be difficult to delineate the GSM habitat and particularly to distinguish breeding habitat from areas where male moths may disperse at times. This assessment should take account of indirect as well as direct impacts, including issues such as fragmentation if relevant.

Nature of impact. This assessment is intended to reflect the possibilities that some activities (e.g. trampling, vehicle movement) could take place outside the breeding season with only minimal effects on GSM, and that it may be feasible for GSM to recolonise limited areas that have been disturbed and rehabilitated. Again, indirect impacts should be considered where relevant.

Geographical context. This should be based on current planning intentions, for adjacent or surrounding land assuming that, if there are wider strategic issues associated with development in other GSM habitat, these will be addressed through offsets.

Where conditions in Table 1 are shaded, this indicates that the impact is likely to be potentially significant, while where they are not shaded, the impact would generally not be significant. However, this is not intended to be an absolute indication, and all factors should be considered together.

As a general rule, if all of the conditions applying to an action within a site were shaded, it is expected that the impact would be significant at the site level, while if all of the conditions were unshaded, it would not. In most situations, however, it is likely that some will be shaded and some unshaded, necessitating a further level of subjective judgement as indicated in the following examples:

Example A. A site has a moderate GSM population and moderate viability as GSM habitat, consists of native grassland with moderate to low forb diversity, and has no special attributes. The proposed action would involve minor disturbance followed by reinstatement, and would affect a very low proportion of the site on a short term basis only. In this case, the overall ecological function of the site would not be affected and the impact is not considered significant.

Example B. A site with similar attributes to that as Example A would experience total removal of habitat in the majority of the site. While some remnants of GSM habitat may remain, their viability would be uncertain. In this case, the overall ecological function of the site as GSM habitat would be adversely affected, and the impact **in the context of the *EPBC Act*** is considered significant, i.e. the action warrants referral and there is a need to address offsets. The site, however, is within a larger area containing extensive GSM habitat which is either within conservation reserves or is secure through other land uses. At the **strategic** level, the impact would **not** be considered significant.

Example C. A small area of native pasture with no special attributes supports a low but viable GSM population, but would experience a total removal of 20% of the habitat. Following development, it would be a slightly smaller site, but would still support a low but viable GSM population. Its overall ecological function would be retained and the impact is not considered significant.

Example D. A large area of native pasture or degraded native pasture which supports a scattered distribution of GSM in very low densities would be almost totally developed. The scattered sites where GSM has been recorded may be individually too limited in extent and GSM populations too low to retain as remnant patches of viable habitat. In this case, the overall function of the area as very low density GSM habitat would be lost, and the impact **in the context of the *EPBC Act*** is considered significant. At a **strategic** level, while a large area of low grade GSM habitat would be lost, the impact on total GSM populations in the ACT would be minimal, and the impact would **not** be considered significant.

Example E. In the case of Example D, a major road is proposed through the centre of the area well in advance of other development. Because of the large area with only a very low proportion being affected, the very low GSM density, and the relatively poor quality of the habitat, the limited ecological function of the area as GSM habitat would not be materially affected, and the impact is not considered significant. If, however, the situation was different with the habitat quality and the GSM density being high, this impact may be significant.

Examples where the impact on GSM would be considered significant at both the site level and the strategic level could include:

- A major road through an area with a high GSM population and high overall ecological quality.
- A major development within a grassland nature reserve with a high GSM population.
- Loss of a small but viable GSM site which is particularly significant for scientific reasons.

- Major disturbance to a series of several small, formerly connected GSM sites within the one geographical area.

There are numerous other examples which could be described to cover the full range of situations likely to be encountered in assessing impacts on GSM in the Canberra area. In all cases, it is important to give careful thought to how impacts are evaluated, and not to attempt to apply the above methodology or *EPBC Act* policy guidelines in a prescriptive manner.

Table 1. Assessment of significance of impacts on golden sun moth

The relevant assessment for each factor is indicated in bold type.

Factors related to the site				**Factors related to the action**		**Geographical context (adjacent or surrounding land)**
Known GSM population	**Viability as GSM habitat**	**General ecological quality**	**Special attributes**	**Proportion of site affected**	**Nature of impacts in affected area**	
High to very high	High	Native grassland – high forb diversity	High	All	Total removal of habitat	Conservation reserve
Moderate	Moderate	Native grassland – moderate to low forb diversity	Moderate	High proportion (>70%)	Major disturbance followed by reinstatement	Area secure through land use
Low	Uncertain	Native pasture	Low	Moderate proportion (30 – 70%)	Minor disturbance followed by reinstatement	Area that is not secure but is unlikely to be developed
Very low	Low	Degraded native pasture	None	Low proportion (5 – 30%)	No direct physical disturbance, e.g. access impacts only	Area that is likely to be developed
		Exotic pasture/ weeds		Very low proportion (< 5%)		Development unavoidable

Shaded boxes indicate that the impact has potential to be significant. Unshaded boxes indicate that the impact would generally not be significant. All factors are considered together in assessing significance.

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BARTON SECTION 22 BLOCK 14
STAGE 1 DEVELOPMENT
ECOLOGICAL ASSESSMENT INCLUDING POTENTIAL SHADING IMPACTS ON THE YORK PARK CONSERVATION SITE

D.McC. Hogg, D.J. Moore and K. Nash

Report prepared for
the DOMA Group

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1. INTRODUCTION

The DOMA Group proposes to develop Block 14, Section 22, Barton as a mixed use development in two stages. Stage 1 would include a carpark for 500 cars with retail frontage to Windsor Walk and a 120 room budget luxury design hotel. Stage 2 would include an office building with retail frontage to Windsor Walk and Darling Street and associated carparking.

The Stage 1 development is located on the south of the site on previously disturbed land and part of an existing carpark. This part of the site is adjacent to the York Park Conservation Site on parts of Blocks 3 and 12, Section 22, Barton. That area was set aside in the early 1990s for conservation of the golden sun moth (*Synemon plana*, GSM) in an urban setting, and has since been managed for this purpose.

Because the golden sun moth is listed as critically endangered under the Commonwealth *Environment Protection Impact of Proposals Act* (*EPBC Act*), it is appropriate to assess the extent to which the proposed development would impact on the species through a referral prepared under the *EPBC Act*. A referral was previously submitted by the Land Development Agency (LDA) for the construction of an access road through the northern edge of Block 12 (EPBC 2010/ 5548). That proposal was determined not to be a controlled action under the *EPBC Act*, subject to it being undertaken in the matter set out in the relevant *EPBC Act* decision (see Section 4.2 for further details). That road has still to be constructed.

As part of the referral process for the access road, an assessment was made of the potential shading impacts on the York Park Conservation Site of a carpark building located on what was then described as Block 11, Section 22, Barton (Ref. 1). That report considered two potential building options for the development site, which is now described as Block 14.

The proposed development of Block 14 by the DOMA Group is somewhat different from either of the previous options. It is therefore appropriate to review the ecological impacts of this development in relation to both Block 14 and the York Park Conservation Site.

The following report addresses the following issues:

- The physical impacts of the proposed development within Block 14,
- The impacts of the proposed access road in the context of the previous *EPBC Act* decision.
- The shading impacts of the proposed building on the York Park Conservation Site and its GSM population.

2. OVERVIEW OF THE PROPOSAL

The location of the proposal within Barton is shown in Figure 2.1. The full proposal is shown in the Masterplan in Figure 2.2. The works proposed in Stage 1 are shown in the site works plan in Figure 2.3, which also shows the location of the access road previously approved under the *EPBC Act*.

The proposed carpark and hotel would extend to an elevation of RL591 in keeping with the development conditions set by the National Capital Authority (NCA) (see Figure 2.4). The hotel component of the development would be located on the two upper floors, with the multi-level carpark located underneath. Access to the hotel and carpark would be via the proposed access road from National Circuit, with that road also being used for construction access.

The corner of Block 14 closest to the York Park Conservation Site would be kept free of building development. There is also a small triangle of land on Block 12, between the edge of Block 14 and the fenced area of the York Park Conservation Site, which would also remain free of any building development.

In accordance with the EPBC 2010/5548 referral decision, a temporary fence would be erected no more than 1 metre from the proposed footpath along the future access road during the construction period to prevent access of construction workers, vehicles and equipment onto the grassland conservation site. Following construction, that fence would be replaced with a permanent 1.5 metre galvanised post and rail fence with webbing immediately adjacent to the proposed road and the 1 metre wide construction area would be rehabilitated to native grassland. The permanent fence would be designed to prevent human activities from entering the adjacent grassland, while allowing maximum access of sunlight and air movement. The road would be designed and constructed to prevent runoff water from entering the grassland.

The permanent fence would extend in a similar style along the remaining section of access road west of the Conservation Site and around the boundary of Block 14 until it met the future building.

The Stage 1 site is largely occupied by a large soil stockpile remaining from previous building construction on a nearby site. All the stockpile within the site would be removed and the end of the stockpile outside the site would be regraded to a stable profile, in accordance with the requirements of Territory and Municipal Services (TAMS).

As the building would be constructed to the block boundary on the south-western and north-western sides, a 3 metre wide construction zone outside the block is proposed (see Figure 2.3). This would be rehabilitated on completion of the works.

A condition of the EPBC referral decision for the access road (EPBC 2010/5548) is that construction of the access road must not occur when golden sun moths are flying (typically November and December). This condition is not expected to apply to the building itself, however, which would be constructed over a continuous period of about 18 months.

3. DESCRIPTION OF THE SITE

Part of Block 14 is occupies by a restricted-access carpark, the south-western corner of which would be occupied by the building and associated construction zone (see Figure 2.3). Most of the remainder of the Stage 1 building area has been substantially modified by the dumping of a large stockpile from nearby building works in 1995. This stockpile has become overgrown with exotic grasses and weeds. The grasses include oats (*Avena* sp.), cocksfoot (*Dactylis glomerata*), paspalum (*Paspalum dilatatum*), tall fescue (*Festuca elatior*), bromes (*Bromus* spp.), rat's tail fescue/ squirrel tail fescue (*Vulpia* spp.) and Chilean needle grass (*Nassella neesiana*). The exotic weeds include plantain (*Plantago lanceolata*), Paterson's curse (*Echium plantagineum*), medic (*Medicago polymorpha*), white clover (*Trifolium repens*) and vetch (*Vicia* sp.). Some scattered patches of native red leg grass (*Bothriochloa macra*), which readily colonises disturbed sites, are also present. On the north-western side of the site, there are a number of planted casuarina trees of relatively recent origin.

The adjacent York Park Conservation Site has been classified as natural temperate grassland (Site CC05) in the ACT Lowland Native Grassland Conservation Strategy (Action Plan No. 28, Ref. 2). This site covers about 0.4 ha and has been given a botanical significance rating under the Strategy of 4 on a scale of 1 to 5 where 1 is highest and 5 is lowest.

The native quality of the grassland is variable within the site, being generally higher towards the northern end. Mapping of the grassland undertaken in November 2007 as part of a grassland maintenance plan is shown in Figure 3.1 (Ref. 3). The grassland quality is prone to seasonal variation but has been generally confirmed in a site inspection in October 2012.

The Conservation Site supports a GSM population which has been monitored periodically since the early 1990s, and has been subject to detailed population estimates. It is the most intensively studied GSM site in the ACT out of approximately 60 sites, and hence is of significant scientific importance in the context of this species. It is also culturally important in a broader sense, being the site in Canberra that first raised the GSM as a significant environmental issue locally. It is also used as an interpretive site, with an information board erected on the National Circuit frontage, and is fenced in a way that discourages incidental access across the site without excluding visitors with a specific interest in its natural attributes.

As far as is known, GSM habitat in the area is confined to the York Park Conservation Site and does not generally extend into the adjacent land to the west. Male moths, however, have a flying range of at least 100 metres (Ref. 4) and may move across nearby areas (including nature strips and medians) even though they may not constitute breeding habitat. The grassland quality of the land on Block 14 is generally unsuitable as GSM breeding habitat, being densely covered with exotic grasses, which would make it difficult for flying males to locate females, should they be present. While the grassland contains small amounts of Chilean needle grass and red leg grass, which may be utilised by the GSM, the general site characteristics would make the site unsuitable for the species.

4. PHYSICAL IMPACTS OF DEVELOPMENT

4.1 Stage 1 Building on Block 14

The construction of the Stage 1 building on Block 14 would result in the total clearing of the site and of a construction strip 3 m wide to the south-west and north-west, including the removal of the existing stockpile within the site. There would be some additional disturbance beyond this area to regrade the end of the remaining stockpile to an acceptable gradient.

All existing groundcover would be removed, together with several planted casuarina trees. The removal of the groundcover, however, would not have any direct adverse impact on the GSM, as it is unlikely to provide suitable habitat for that species. There may be a minor beneficial impact on the York Park Conservation Area to the extent that existing weeds within Block 14, which is located upwind of the Conservation Site, would be removed, reducing the risk of seeds being blown into the native grassland. This benefit, however, would be limited while the remaining vacant land to the south-west remains undeveloped and unmanaged for weed control.

The construction of the building itself would have no direct physical impacts on the York Park Conservation Site.

4.2 Access Road

The construction of the access road would impact directly on the York Park Conservation Area as described in the *EPBC Act* referral, EPBC 2010/5548. That referral estimated the development footprint of the access road as approximately 0.04 ha out of a total site area of 0.55 ha. The impacted area includes a 1 metre wide construction zone, which would be rehabilitated to native grassland on completion of the works.

Runoff from the access road would be designed so that it did not result in changes to the soil water regime of the grassland within the Conservation Site. A fence along the access road would prevent vehicle or pedestrian access from the road into the Conservation Site.

As previously stated, the construction of the access road would be in accordance with the conditions of referral decision EPBC 2010/5548, and the impacts of road construction would remain as assessed in the course of that referral process.

5. SHADING IMPACTS ON YORK PARK CONSERVATION SITE

5.1 Reasons for Considering Shading

The GSM is predominantly a natural temperate grassland species which, as its name implies, has an association with sunny conditions. While it occurs also in secondary native grassland, which is part of a grassy woodland community, its occurrence there is also confined generally to areas which are free of trees and do not experience shading.

Within the Canberra area, there are some urban GSM sites within remnant or former natural temperate grassland, which experience partial shading due to planted trees but still support a viable GSM population and have done so for many years. These include Section 5, Campbell, the grounds of St John's Church in Reid and Guilfoyle Street, Yarralumla. In the last case, GSM pupal cases have been found in an area shaded at times by deciduous trees (Ref. 5), indicating that partially shaded areas may still be used as breeding habitat.

Hence, while shading may reduce the quality of GSM habitat for reasons discussed below, it is not necessarily an absolute constraint on the ability of a site to support GSM. There are no sites in the Canberra area, however, which are known to support GSM despite a significant level of shading caused by an adjacent building.

While the assumed impacts of shading on the GSM have a logical basis, they are nevertheless largely speculative, based on observed habitat characteristics of the GSM, and have not been confirmed by scientific experiments. Possible mechanisms through which such impacts may occur include the following:

- Shading during the day in summer is likely to affect the flying movement of male moths, which move mainly in the middle of the day in direct sunlight. It is also likely that direct sunlight on the habitat would influence the behaviour of female moths, which are less mobile and tend to be evident later in the day, as well as the emergence of adult moths from pupal cases. Shading may also affect mating success and the location of egg-laying.
- Shading would create cooler, moister conditions within the grassland site, potentially favouring some introduced grasses and weeds rather than native grasses and forbs. Such shading would be most marked during winter, when little plant growth is occurring, but would extend to a lesser extent into the spring growing period. If soil moisture accumulated due to reduced evaporation in winter, this may benefit non-native species in the warmer times of the year. There are also seasonal differences in the life cycles of different plants, with many introduced weed species germinating from late autumn to late winter, with rapid growth in spring. Shading is likely to favour such species over most natives.
- Soil conditions which are colder and moister between autumn and spring may have a negative effect on the survival and growth of larvae, although larval activity is likely to be suppressed in any case when soil temperatures are low. If shading is severe enough to extend winter-like conditions and hence shorten the growing period, this could lead to failure to reach maturity or

delayed emergence. Late emerging adults could encounter unsuitable conditions for mating and egg-laying.

There are other microclimatic factors which may reinforce or counteract the effects of shading. Modification of wind patterns, which commonly is associated with large buildings, could reduce evaporation and create a moister site, further favouring exotic grass growth. Urban heat island effects associated with buildings or pavements could have the opposite effect. All of these effects have the potential to be overridden by long term climatic trends or annual climatic variability.

There are likely to be differences between the respective effects of buildings and trees on the local microclimate and soil conditions in that trees draw water out of the soil for much of the year, while buildings do not. This may lead to differences in the types of plants which grow in the shade of trees (deciduous or evergreen) and those in the shading of buildings. Unless trees are growing very densely, the effects of trees on wind patterns are likely to be less marked than those of buildings. On the other hand, the accumulated leaf letter produced by trees is likely to affect soil moisture and exposure of groundcover vegetation to sunlight in ways which are not relevant to building shading, generally favouring increased soil moisture by reducing evaporation.

In summary, the overall comparative environmental effects of buildings and trees are more complex than can be determined through a shading analysis. The following discussion addresses these issues to the extent that is practicable without attempting a sophisticated modelling exercise.

5.2 Shading Analyses Undertaken

A series of shading analyses has been undertaken by May and Russell, the architects responsible for the building design. Their results are presented in the following formats:

- A series of cumulative shading diagrams, showing the number of hours of shading experienced within the Conservation Site on selected dates. The diagrams are similar to those prepared for the previous shading report (Ref. 1). The dates selected for analysis are as follows:
  - The summer solstice (22 December) when shading would be least.
  - The winter solstice (21 June) when shading would be greatest.
  - The spring and autumn equinoxes (23 September and 21 March), when intermediate levels of shading would occur.
  - The middle of the GSM flying season (nominally 25 November) when potential impacts on moth breeding are likely to be most critical.
- A series of computer animations showing the progression of shading across the site for each of the above dates. This is presented on a CD included with this report.

Three building designs have been assessed in the shading diagrams, as follows:

A. Full development of the site at its south-eastern corner. The building would extend to the site boundary.

B. Exclusion of development from the south-eastern corner of the site with the exception of the liftwell structure, with a view to reducing shading impacts by increasing the distance between the building and the boundary of the Conservation Site.

C. As for Design B, but with the liftwell located more centrally within the building, where it would not add to the shading of the Conservation Site.

5.3 Results of Shading Analysis

Figures 5.1 to 5.5 compare the extent of shading for each of the three building designs considered for the five analysis periods.

The results of the shading analysis are expressed in Table 5.1 in terms of the percentage of the York Park Conservation Site (excluding the access road) that would be shaded at different times of the day. This information is expressed with respect to Eastern Standard Time (i.e. not for Eastern Summer Time for the March, November and December results).

Table 5.1 Percentage of Conservation Site shaded by time of day

Date	Time	% shaded		
		Design A	**Design B**	**Design C**
21 March (autumn equinox)	1.00 pm	4	1	0
	2.00 pm	7	4	3
	3.00 pm	9	6	5
	4.00 pm	10	7	7
	5.00 pm	7	4	4
21 June (winter solstice)	11.00 am	5	0	0
	12 noon	11	7	6
	1.00 pm	18	14	13
	2.00 pm	27	23	22
	3.00 pm	30	30	30
	4.00 pm	20	20	20
23 September (spring equinox)	1.00 pm	5	1	1
	2.00 pm	6	4	4
	3.00 pm	9	6	6
	4.00 pm	10	7	6
	5.00 pm	6	4	3
25 November (GSM flying peak)	1.00 pm	1	0	0
	2.00 pm	3	0	0
	3.00 pm	4	1	1
	4.00 pm	4	1	1
22 December (summer solstice)	1.00 pm	1	0	0
	2.00 pm	2	0	0
	3.00 pm	3	1	0
	4.00 pm	3	1	0

Figures 5.1 to 5.5 also show the cumulative extent of shading for each of these situations in terms of the number of times assessed when parts of the site would be shaded (i.e. shading frequency). This is an approximation to the number of hours of shading experienced during daylight hours (i.e. shading duration), which could be refined by interpolating between the angular shapes shown in these figures to produce a series of smooth curves. A previous application of this method on the site (Ref. 1), however, which is illustrated in Figure 5.6, found only very minor differences between shading frequency and shading duration which would not be significant in assessing the impacts on the GSM and its habitat, given other variables that are involved.

The percentage of the Conservation Site affected by selected ranges of shading frequencies is summarised in Table 5.2. The shading frequencies have been grouped as zero, 1 to 2 hours and 3 or more hours. All shading percentages and totals are rounded to the nearest whole number in this table and in Table 5.1. This rounding may give rise to apparent minor discrepancies.

Table 5.2 Percentage of Conservation Site shaded according to shading frequency

Date	**Frequency (hrs)**	**% shaded**		
		Design A	**Design B**	**Design C**
21 March (autumn equinox)	0 1 to 2 3 or more Total shaded	84 9 7 16	89 7 3 11	90 8 2 10
21 June (winter solstice)	0 1 to 2 3 or more Total shaded	58 20 22 42	62 21 17 38	64 19 17 36
23 September (spring equinox)	0 1 to 2 3 or more Total shaded	84 9 7 16	90 7 3 10	91 6 3 9
25 November (GSM flying peak)	0 1 to 2 3 or more Total shaded	95 2 3 5	98 1 0 2	99 1 0 1
22 December (summer solstice)	0 1 to 2 3 or more Total shaded	95 2 3 5	99 1 0 1	99 1 0 1

The results in Tables 5.1 and 5.2 illustrate the following points:

- Varying the extent of the building envelope changes the extent of shading, particularly in winter. This is most apparent when comparing Design A, which extends to the Block 14 boundary, with Design B, where the building envelope is withdrawn back from the boundary. Relocating the liftwell structure from the south-eastern corner of the building to a more central location has a minor additional effect in reducing shading.

- For all designs, the extent of shading is substantially greater at the winter solstice than on the other dates investigated. This winter shading would commence on the edge of the Conservation Site shortly after 11.00 am and would continue throughout the afternoon to various extents in different parts of the site. A small part of the site would be in shade from 12 noon throughout the afternoon.
- At the time of the equinoxes, no more than 10 percent of the Conservation Site would experience any shading, and most of this shading would be for only one or two hours. A negligible area would experience four hours shading or more.
- At the time of the summer solstice, only about 1 percent of the Conservation Site would be shaded by Designs B and C, and 5 percent by Design A. Most of the shading for Designs B and C would be for about one hour only.
- During the GSM flying period (based around 25 November), the extent of shading would be only slightly greater than for the summer solstice, and would mainly be for about one hour only.
- The maximum extent of shading on the Conservation Site at any one time would cover about 30 percent of the site, and would be similar for all building designs. This would be experienced at 3.00 pm at the winter solstice.
- Other shading maxima experienced at the site, depending on the building design, would be as follows:
    - Autumn equinox – 7 to 10 percent at 4.00 pm
    - Spring equinox – 6 to 10 percent at 4.00 pm
    - GSM flying peak – 1 to 4 percent at 3.00 and 4.00 pm
    - Summer solstice – less than 1 percent to 3 percent at 3.00 and 4.00 pm

The shading extent and frequency in Tables 2.1 and 2.2 do not take account of the cumulative effect of shading from Centenary House, which is located to the north of the Conservation Site. Existing shading from that building has been assessed separately. Being a smaller building, its shading impacts would be much less than those of the proposed development. As shown in Figure 5.7, it would cause shading in the north-western corner of the Conservation Site for one to two hours in the morning at the time of the winter solstice, having a small cumulative effect on the part of the site most extensively shaded by the proposed building.

No shading of the Conservation Site would be caused by Centenary House on the other dates investigated.

5.4 Effects on Golden Sun Moth Flying and Breeding

Adult GSM typically emerge from pupal cases between early November and late December, although this period can vary depending on seasonal conditions. The shading diagrams indicate that during this period, the extent of shading on the Conservation Site would be minimal and would occur only in the afternoon in the north-west corner of the site. While this shading may discourage males from flying through the area for an hour or so, in the case of Designs B and C, the shading would affect only about 1 percent of the Conservation Site, and would be towards the later part of the typical daily flying period. There are other times within this flying period when these parts of the site would not be shaded. Furthermore, the shaded corner of the site is within an area where the native quality of the grassland is relatively low (see Figure 5.8), and is likely to be of correspondingly low importance as GSM habitat.

The females are more active later in the day and, if they were shaded severely enough and are reluctant or unable to leave the shaded area, may not display, mate and lay eggs. Females which emerge in adjacent areas may be reluctant to enter shaded areas to lay, even if it is suitable for GSM for most of the time, thus reducing the effective area of GSM breeding habitat at the site. While the limited summer shading for Designs B and C would coincide with this time of day, it is restricted to a very small part of the site where the grassland quality is relatively low (see Figure 5.8). Hence any impacts on female moth activity are likely to be minimal.

Taking account of the above factors, any impacts of shading from Designs B and C on the flying and breeding behaviour of adult GSM are likely to be minimal and would be insignificant in the context of typical annual fluctuations in response to weather conditions.

5.5 Effects on Golden Sun Moth Larval Development

The eggs laid by female moths at the base of grasses on the ground surface hatch later in the summer and the larvae find their way into the soil where they grow and mature, over probably a two-year period, apparently feeding on the roots of selected grasses. The rate of their development is likely to be influenced by conditions in the soil, including soil temperature, soil moisture and food availability, all of which may be interrelated.

After an extended period of larval growth, which appears typically to cover nearly two years, the larvae pupate into adult moths and emerge at ground level, leaving behind pupal cases. The subsurface conditions are likely to influence their development throughout this period.

If there is any direct impact on GSM, this is more likely to affect larvae, which are present underground during the winter period, than adult moths. The extent to which larvae are active during winter is uncertain, but such activity would be expected to be influenced by underground soil temperature. The shading analysis indicates a significant drop in the level of solar exposure in the northern part of the site for all building designs during winter.

A consideration of whether this shading would significantly influence the rate of larval growth and development raises the following questions:

- What are the typical unshaded winter temperatures in Canberra soil during winter at the depths likely to be occupied by GSM larvae? How do these compare with soil temperatures at other times of the year?
- To what extent is soil temperature controlled by exposure to sunlight as opposed to heating and cooling by conduction from the atmosphere?

- How does soil temperature influence the development of GSM larvae, both directly and through the stimulation of the root growth of grasses, on which the larvae feed?

The first two questions have been addressed by analysing data on soil temperature, air temperature and solar exposure obtained from the Bureau of Meteorology (BOM). The soil temperature data are available only as raw data covering a limited period and with some gaps in the data. For practical reasons, it has been necessary to limit examination of those data to the year 2012, although it is expected that the conclusions would not change significantly if a more extensive data bank was considered.

The data are from the BOM meteorological station at Canberra Airport (Station no. 070351), where the topography, soils and land use are different from those at Barton. Such differences may influence the meteorological factors considered. The soil temperature data are supplied on the basis that they are not quality controlled. Despite these limitations, the data are likely to be the best that are readily accessible and are considered adequate to support the following discussion.

The period of greatest relevance to the potential effects of shading is during winter, in particular in the period around the winter solstice (21 June). Figure 5.9 shows the variation in air and soil temperature between 14 and 26 June 2012, based on three-hourly measurements at the synoptic hours, expressed on a 24 hour time scale. Figure 5.10 shows a typical winter pattern between 3 and 5 July at a larger scale.

Typically the minimum air temperature is experienced between 3:00 and 6:00, rising most rapidly between 11:00 and 12:00, with the maximum around 15:00. Soil temperatures are at their minimum between 6:00 and 9:00, but rise with the increased air temperature (and solar exposure) to a maximum at 15:00. At a shallow depth (5 cm), the variation in temperature is greatest, but it not as great as the variation in air temperature. At 10 cm depth, the pattern is similar but less marked. The variation at 20 cm depth is less again, but still clearly evident on a diurnal basis. There is a lag in peak soil temperature each day as the soil depth increases, reflecting the time taken for heat absorbed at the ground surface to be conducted downwards.

The typical winter soil temperatures at 5 cm depth, based on a review of a more extensive range of data at Canberra Airport, vary between about 2 and 12°C. At 10 cm depth, the variation is typically between about 3 and 11°C. At 20 cm depth, the variation is typically between 5 and 9°C. In all cases, however, there are occasional records which fall outside these ranges.

Air temperature clearly has a significant influence on soil temperature, hence would be expected to show significant variation throughout the year. Figure 5.11 shows the mean monthly temperatures at various soil depths from October 2011 to September 2012. (This period was dictated by the availability of reasonably complete data). As would be expected, soil temperatures in the winter months are significantly lower than in the summer months. In the winter months, the soil temperatures are lower than the air temperatures but, as summer progresses, the soil temperatures at 5 cm and 10 cm depths increase significantly and are above the mean air temperatures.

The influence of solar exposure on soil temperature cannot be determined directly from the available data, but the following observations can be made. Figure 5.12 shows the same soil temperature data as Figure 5.9 with solar exposure added. On days when the level of solar exposure (expressed as megajoules per square metre) is relatively low, soil temperatures also appear to be slightly below typical levels. The air temperature also tends to be relatively low on those days. This may partly reflect the low solar exposure although other factors can also have a significant influence.

Figure 5.13 shows the relationship between soil temperature at various depths at 15:00 (the time when winter soil temperature is usually highest) against solar exposure for the period from 1 May to 31 August 2012. Trend lines drawn on these graphs shows that, while there is some relationship between soil temperature and solar exposure, this relationship is fairly weak. A value of $R^2 = 0.2356$ means that about 24 percent of the variance in soil temperature at 5 cm can be attributed to solar exposure. The relationships at greater depths are much weaker with R^2 being 0.1126 at 10 cm depth and 0.0118 at 20 cm depth. On the other hand, as shown in Figure 5.14, there is a much stronger correlation between soil temperature and air temperature for the May to August period. The values of R^2 are 0.6242 at 5 cm, 0.4825 at 10 cm and 0.267 at 20 cm. This indicates that, during winter, air temperature rather than solar exposure is the main factor influencing soil temperature.

In summer, however, the situation is quite different, with a strong correlation between soil temperature and solar exposure. This is indicated by Figure 5.15 which shows soil temperature in relation to solar exposure from November 2011 to February 2012, and can be compared with Figure 5.16 which relates soil temperature to air temperature for the same period. It appears that in summer with solar exposure and air temperature (which depends in part on solar exposure) can both have a significant influence on soil temperatures, particularly close to the surface, although the relative contribution of solar exposure declines with depth.

A further point, which is evident from Figure 5.9 (or Figure 5.12) and in more detail in Figure 5.10, is that the greatest rise in air temperature typically occurs between 9:00 and 12:00 and the greatest rise in soil temperature at 5 cm depth occurs at the same time. That rise is partly paralleled and partly followed by a rise in soil temperature at 10 cm depth. This slight lag period presumably results from the time taken for heat transferred to the ground surface in the morning to be conducted to the lower layers of the soil. There is a further lag period before the soil at 20 cm depth reaches its maximum temperature.

An implication of this observation is that the most important period for transfer of heat to the soil appears to be in the morning (i.e. prior to 12:00). While much of this transfer is likely to be by conduction from the air, if radiation through solar exposure is also a significant contributor, the morning would be the most critical period. Hence shading in the afternoon, as would occur as a result of the proposed development, would be less critical in influencing soil temperature than shading in the morning.

As shown in Figure 5.7, there is currently also some limited winter shading of the north-western corner of the York Park Conservation Site early in the morning due to the existing Centenary House building. That shading, however, does not extend beyond 10:00, hence its influence during the most intense period of solar exposure would be minor.

A potential future building in part of Block 3, Section 22 Barton to the north-west of the York Park Conservation Site is also likely to cause some shading within the Conservation Site. Such a building has previously been addressed through *EPBC Act* referral EPBC 2009/4871, with the referral decision specifying limits on the extent of shading at certain dates and times. The shading diagrams prepared for this building indicate that it would cause shading within the Conservation Site throughout the year, particularly in the afternoon, but that the areas shaded would be largely different from those shaded by the building on Block 14. The main cumulative effect with the current proposal would be an increased duration of winter shading in areas where the building on Block 14 would otherwise cause shading for only 1 or 2 hours.

In summary, based on the limited soil temperature data obtained for the Canberra area, it appears that, while reduced solar exposure due to afternoon shading may be expected to have some influence on soil temperatures, any change is likely to be minor. The magnitude of any change would be substantially less than the temperature variations that would occur throughout the day or from day to day during the winter season, when shading is more evident.

If there is a slight shading effect on soil temperature, the remaining question is what effect would it have in turn on the GSM in the York Park Conservation Site, either by directly affecting larval development and survival, or indirectly through altering the grassland characteristics. The current knowledge of larval development for the GSM is limited and the effects of temperature on larval development are uncertain.

Some indication of likely effects may be derived from an English study of the effects of temperature on larval development on the ghost swift moth (*Hepialus humuli*, Ref. 6). While this moth is not closely related to the GSM, it has a common feature in that its larvae bury themselves in the soil, feeding on roots, and eventually emerge from pupae as adult moths. That study demonstrated that low temperatures significantly reduced the rate of larval development, which takes place through a series of up to twelve instars. Furthermore, a temperature of 10°C under controlled laboratory conditions resulted in a rapid decline in survival, with no larvae surviving past the fourth instar.

As GSM are adapted to surviving for at least two years in an environment where winter soil temperatures typically fluctuate between about 2 and 12°C, the observations of the ghost swift moth are not directly relevant. However, they do confirm the expectation that, in principle, reduced soil temperature is likely to have an adverse effect on the rate of larval development.

In applying this principle to the shading impacts on GSM at the York Park Conservation Site, the following considerations are relevant:

- Shading is most concentrated in the north-western corner of the site, where the native grassland quality is relatively low (see Figure 5.8). Consequently, the extent to which this area is used as GSM breeding habitat may also be relatively low.
- While there would also be winter shading in the centre of the northern part of the site, where there is a native grassland area of relatively high quality, much of this area would experience shading for only 1 or 2 hours and the most prolonged shading would occur towards the north-western corner of the site (see Figure 5.8).
- Taking account of the cumulative shading effect of both the proposed development and that of Centenary House, the period when solar exposure appears most likely to influence soil temperature (i.e. morning period) is when shading impacts would be least.
- If there is a reduction in soil temperature due to shading, the magnitude of this appears to be significantly less than the typical fluctuations in soil temperature within the day or from day to day during winter.
- The period when shading would be greatest is the time of the year when the rate of GSM larval development is likely to be slowest.
- Shading of habitat is likely to be most relevant to development during the warmer months of the year when the influences of solar exposure (as opposed to air temperature) on soil temperature is most evident.

Taking account of the above factors, it is considered that the effects of shading on larval development during winter are likely to be minor and would be indistinguishable from typical seasonal and annual variations in atmospheric temperature, solar exposure in response to cloud cover, nighttime radiation from the ground to the atmosphere, rainfall and evaporation, all of which could affect winter soil temperature. In addition, there is the potential urban heat island effect associated with surrounding building development which would tend to raise ambient air temperatures and hence soil temperatures, thus tending to counteract any cooling effects of shading.

5.6 Effects on Grassland Composition and Quality

Shading of grassland is likely to reduce evaporation and hence increase soil moisture, which tends to favour exotic groundcover species over native grasses and forbs. These exotic species tend to grow particularly during early spring, and may be favoured by increased soil moisture accumulated during winter.

The part of the Conservation Site most affected by shading is native grassland but contains a significant component of exotic grasses and weeds (e.g. plantain, catsear, St John's wort, bromes, oats) among the native *Austrodanthonia* and *Austrostipa* grasses. Some native forbs (bulbine lily, spur velia) are also present in low numbers.

It is possible that the increased shading could cause the exotic grasses and weeds to increase in abundance in this area, with an indirect impact on GSM due to the effects on habitat quality. Such impacts on adjacent areas of higher quality native grassland are also possible, but the extent of winter shading to these areas would be less and, being higher on the slope, this part of the site is naturally drier.

The rate of evaporation varies widely throughout the year, largely in response to ambient temperature (see Figure 5.17)*. The period when part of the Conservation Site would experience the most shading coincides with the period when evaporation rates would be lowest. Any reduction in evaporation would therefore be minor in the context of total annual evaporation. In terms of influencing the overall water balance of the site, evaporation would be much less important than rainfall at this time of the year.

During the later period of the year, when GSM are active, the extent of shading and its impacts on vegetation, either directly or through influencing evaporation, would be minimal. The majority of GSM habitat within the site is unlikely to be affected by vegetation changes resulting from shading.

The quality of the York Park Conservation Site as natural temperate grassland is unlikely to be affected significantly for the reasons discussed above. As shown in Figure 3.1, its quality is variable and a previous assessment (Ref. 2) rated it overall as being of relatively low quality (see Section 3). The quality of the grassland is more likely to be influenced by the extent of proactive management in controlling the spread of exotic grasses and weeds than by the indirect impacts of partial and seasonal shading.

* The data in Figure 5.17 relate to the former Canberra City meteorological station (Station no. 070282) which is not longer operational but is the closest site to Barton.

6. IMPLICATIONS FOR DEVELOPMENT

6.1 Mitigation of Shading Impacts

While the direct and indirect impacts of shading on the York Park Conservation Site are likely to be minor, it is nevertheless desirable to mitigate these impacts to the extent that is reasonable and practicable. Of the three building designs presented in Figures 5.1 to 5.5, Design B would be significantly beneficial in increasing the unshaded percentage of the site in winter from 58 percent to 62 percent and in reducing the area shaded for 3 or more hours from 22 percent to 17 percent. Design C would further increase the unshaded percentage to 64 Percent, with the further reduction in shading applying only to areas which are shaded for one or two hours (i.e. the area shaded for 3 or more hours would remain at 17 percent).

6.2 Additional Grassland Area

Between Block 14 and the York Park Conservation Site there is a small triangle of predominantly exotic grassland which would remain as an isolated patch following the development of Block 14. This area would be totally enclosed by the existing fence around the Conservation Site and the proposed permanent fence on the boundary of Block 14 and associated access road. It is within the area that would experience the greatest level of shading, particularly in winter, potentially favouring the development of exotic groundcover within the triangle.

While it is not directly related to the impact of building shading on the Conservation Site, there is the prospect that, if increased exotic plant growth occurs within this triangle, this could increase the risk of weed spread to the Conservation Site. This spread would focus most closely on the part of the Conservation Site receiving the most winter shading, and would hence be relatively receptive to the spread of exotic plants.

The most appropriate strategy for countering this risk may be to include this triangle within the Conservation Site, despite its low quality, and to manage it, along with the adjacent low quality native grassland within the Conservation Site, to improve the native quality. This could have the effect of extending the suitable summer habitat of the GSM marginally, despite the shading that would be experienced in winter.

7. CONCLUSIONS

While the proposed building on Block 14, Section 22, Barton would result in some shading of the York Park Conservation Site, that shading would take place mainly during winter which would be the least important time of the year for GSM activity and grassland growth. There would be minimal shading during the late spring – early summer period when GSM are flying and breeding, hence the mating and egg-laying phase of the GSM life cycle is unlikely to be affected.

During the winter shading period, the shading would not occur during the morning, which appears to be the most important time for solar exposure to influence soil temperatures. During winter, however, the influence of solar exposure on soil temperature appears much less than that of air temperature. Any reduction in soil temperature due to shading is likely to be minor, particularly on a daily basis, and is unlikely to significantly affect the development of GSM larvae, which would probably occur at a relatively slow rate during this period.

The grassland in the most shaded part of the Conservation Site is of relatively low native quality. While shading may be expected in principle to favour exotic groundcover species through reduced evaporation, most shading would occur at the time of the year when the evaporation rate is naturally very low and any impacts on the annual water balance and the effects in plant growth would be minor. Any effects of shading in changing the grassland composition are likely to be much less significant than annual variation in rainfall.

While the existing shading from Centenary House would have a slight cumulative effect in the north-western corner of the Conservation Site during the period when the proposed building would also cause the most shading, this would be limited to the winter period and shading would not occur during most of the morning period. A future building on part of Block 3, Section 22, would be likely to have a cumulative effect on winter afternoon shading in parts of the Conservation Site, but this would not alter the above conclusions.

In summary, while there would be minor environmental changes affecting the natural temperate grassland and GSM habitat in winter, these are unlikely to be distinguishable from natural fluctuations in environmental conditions. Of the three building designs considered, Design B would result in a clear benefit over Design A in reducing any possible shading impacts, while Design C would result in a marginal additional benefit.

Direct physical impacts of development would be as previously assessed for the access road (EPBC 2010/5548), or would not affect native grassland or GSM habitat. The management of a small patch of exotic grassland between Block 14 and the Conservation Site would need to be addressed to ensure that it does not become a source of weed spread into the Conservation Site. This issue, however, is relevant more to the management of the Conservation Site than to the development of Block 14.

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ARCHIVAL RECORD

REFERENCE No. 17

Edwards, T 1990
'Belconnen naval station harbour endangered moth'
NPA Bulletin, vol. 21, No. 2. Canberra

NPA Bulletin V. 21 No. 2

ENDANGERED

Belconnen naval station harbours endangered moth

Synemon plana is a brown, orange and black moth, white or pale grey on the underside and about three and a half centimetres across. It is a day-flying moth active in the late mornings and the afternoons of sunny days. The males a have a rapid, energetic flight just above the grassland in which they live. In a warm dry spring adults fly from early November until the beginning of December. In cooler or moister conditions they do not begin to fly until about 20 November and will fly until Christmas. In suitable habitat they are very common.

The *Synemon* moths belong to the family Castniidae. This family contains about 120 species in Central and South America, about 40 species in Australia and two species in South East Asia. Most of these species live in rainforests. In Australia however they inhabit seasonally dry habitats where they feed on sedges or grasses. The family is well distributed over the mainland with tropical as well as temperate species, and the moths are most diverse in southwestern Western Australia. With such a wide distribution it is likely that the Castniidae family had its origin on Gondwana.

Synemon plana only inhabits native grasslands dominated by silver-top wallaby grass, Danthonia carphoides, and another grass, Danthonia auriculata. The larvae tunnel in the soil and feed on the underground parts of the grass. The moths cannot survive if the grassland is not dominated by wallaby grass or if the area is heavily invaded by introduced plants.

With other members of its family, *Synemon plana* shares a number of peculiarities. They almost certainly recognise potential mates visually. They have antennae with well developed, clubbed tips, like the butterflies although not closely related to them. *Synemon plana* males and females are very different in appearance and behaviour. The females have bright orange hind wings unlike the bronze-brown of the males. When a patrolling male flies over an unmated female she flips the fore wings forward exposing the hind wings to which the male responds by alighting beside her.

The endangered moth, Synemon plana.

The females have small wings. While they can fly, and do so when disturbed, they do not fly far. This implies they once inhabited an extensive and continuous habitat and had no need of powers of flight to colonise unconnected areas. With the fragmentation of grasslands, this limited mobility of females has become a significant disadvantage for the species.

At the time of European settlement *Synemon plana* and its habitat were widespread. There are reliable records from Winburndale near Bathurst, the Yass plains, Canberra, Bright, Eildon, Broadmeadows, the Grampians and other places in Victoria and at Bordertown in South Australia. With grazing by sheep the wallaby grass survived well and the effects of trampling on the underground-feeding species were small.

Pressure on the moth population increased greatly with widespread pasture improvement in the 1950s, with the use of chemical fertilisers and the sowing of introduced pasture plants into native pastures. Scientists and naturalists have been unable to locate any *Synemon plana* in New South Wales or South Australia in the last few years. There is a small population near Kiata near the Grampians in Victoria but the locality is not part of a conservation reserve. The major remaining known colonies are in Canberra.

Three other species of castniid moths are known to feed on wallaby grasses, although another six or eight probably do. One of these, with no scientific name, feeds on *Danthonia eriantha* and is known only from a 100-metre patch of grass, beneath power lines, at an altitude of 1000 metres in Kosciusko National Park. By contrast, a related moth, *Synemon magnifica*, which feeds on sedges surrounding large sandstone or granite rocks is not endangered. Such habitats are useless for agriculture and the eight or ten known locations of this moth are all in national parks.

The grassland-inhabiting moths have suffered almost total destruction through the agricultural development of their habitat. *Synemon plana* and other species of Synemon were listed by the Australian National Parks and Wildlife Service in their 1988 list of threatened insects. They received international mention in the International Union for the Conservation Nature *Bulletin* in September 1987.

Suburbs replace moth habitat

Wallaby grass habitats contain many other moths and butterflies as part of their animal communities but no others have been identified which are confined to the grassland. *Synemon plana* has never been found in other grassland communities in Canberra, namely those dominated by *Themeda*, *Bothriochloa*, *Stipa* or *Poa*.

The wallaby grasses of the Limestone Plains were heavily grazed until the urbanisation of Canberra began in the 1930s. However, in the suburban environment they escaped the total replacement by improved pastures which occurred in rural areas. There are a few remnants in the older parts of Canberra.

The newer parts of Canberra occupy land improved in the 1950s and 1960s with ryegrass, phalaris and clovers. The native silver-top wallaby grassland has disappeared. No individual plant species has become endangered because the plants exist in other places, but the plant community is endangered. There are no national parks or nature reserves in the ACT, New South Wales, Victoria, or South Australia which include silver-top wallaby grassland.

Several old entomologists in Canberra remember the moth as plentiful around Civic and Acton. It is now extinct in these areas. There are eight sites in the older parts of Canberra where *Synemon plana* survives. Four of these sites are so small, about 20 by 30 metres, that there is no chance of the moths lasting long in them. Three other sites may be large enough if no contraction occurs. The largest of these measures 100 by 35 metres but even here the moth's survival is problematical.

The only remaining large site, some hectares in size and in excellent condition, is the Belconnen naval station. There the wallaby grasses have survived because of high mowing, light grazing by sheep and limited public access.

All known moth sites are in areas which are likely to be developed for houses, public buildings, roads, parking areas or cycle paths. Several grasslands, which are often viewed as waste lands, have recently been damaged: one by a road construction depot, another by spoil from the construction of Parliament House, another by the planting of oak trees the shade of which will destroy the native grassland. In addition to threats posed by development, the moth sites are threatened by weed invasions, especially during moist springs. The principal introduced plants are clovers, flatweed, plantain, paspalum and wild oats.

The reservation of five hectares or more of wallaby grassland becomes urgent.

Conservation needs

To prevent the extinction of *Synemon plana* in the near future the remaining sites, and in particular the Belconnen naval station, need to be protected and carefully managed. In small sites weeds must be kept to a minimum. High mowing is one of the best techniques and could maintain these sites. A search for further sites should also be made. More study is needed to know what size of population is viable, how much weed invasion the grasses can tolerate and how to control the weeds.

Synemon plana is a moth of scientific interest. It was once successful across a large area of southeastern Australia. It survived grazing, mowing and fires but because it was confined to a single plant community and not very mobile, the moth was vulnerable to modern agriculture.

As well as the moth a whole plant community is at risk. We do not know how many other animal species may go with it. It should be remembered that this moth is a large, day flying and conspicuous insect which is easy to study and find. There may well be other less conspicuous fauna confined to the same habitat.

Should the Belconnen Naval Station site be developed for housing, the reservation and appropriate management of five hectares or more of wallaby grassland becomes urgent. This would not just save *Synemon plana* from extinction but would also save one of the last remnants of a complete plant community containing a little known fauna, and preserve for Canberrans a piece of the original landscape of the Limestone Plains.

Adapted from a more detailed paper by Ted Edwards of the CSIRO Division of Entomology, Black Mountain, Canberra.

Vic alps reprieve

The new Victorian Minister for Conservation, Environment and Tourism, Steve Crabb, has abandoned plans for the state government to support resort development in the alps. After many studies by the Alpine Resorts Commission and a major proposal for Mount Stirling, a popular cross-country skiing area near Mount Buller, he has decided that the skiing industry is not worth support. He told advisers that the government would not spend money when the commercial lodge owners had shown disinterest in staying open in summer and refused to market their products properly. However, he will still be allowing the resorts to evolve 'naturally'.

Presumably that means with their own money.

The Age, Melbourne,
9 April 1990

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***Synemon plana* – a grassland case history, in**
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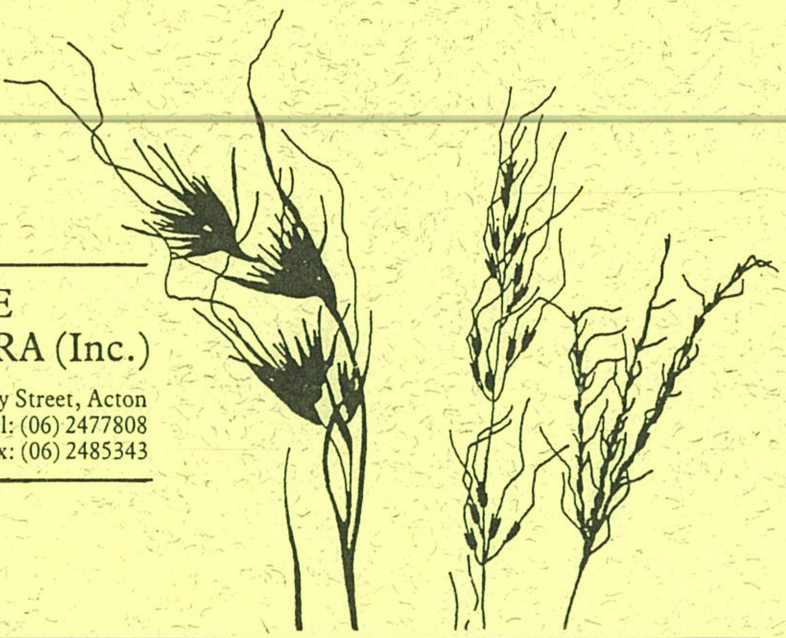

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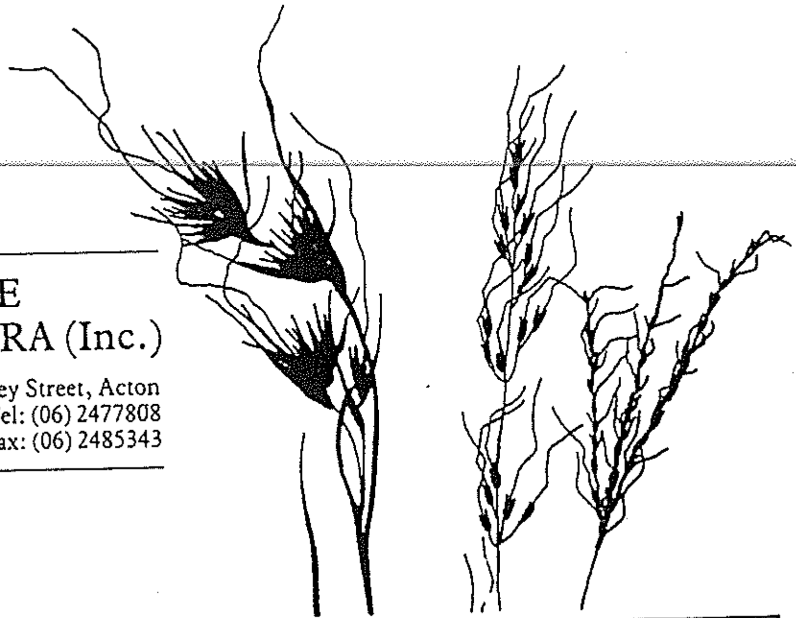

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17 February 1991

Edited by Rodney Falconer

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I would like to thank all those who participated in the Workshop, both as speakers and as part of the well-informed and highly motivated audience on the day. A considerable debt of gratitude is owed to the National Capital Planning Authority, the ACT Parks and Conservation Division and the ACT Planning Authority . Thanks in particular are due to David Wanless and the Wanless family, who put in the time and energy in organising and running a bush dance to enable the Conservation Council to raise money to help publish these proceedings.

Rodney Falconer

October 1991

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INTRODUCTION

Graeme Evans, Acting President of the Conservation Council of the South-East Region and Canberra

I welcome all speakers and others attending, and gave particular thanks for their help to:

- Meredith Smith, who has kindly volunteered to take minutes of these proceedings,
- The ACT Planning Authority (ACTPA) (who helped fund the lunch),
- The National Capital Planning Authority (NCPA) (who helped fund the lunch),
- The ACT Environment & Conservation Bureau (who helped fund the lunch),
- The Auxiliary of the Royal Blind Society (Canberra), who organised the lunch, and
- The Director and staff of the National Museum.

The Conservation Council of the South-East Region and Canberra sees this workshop as an exchange day, to debate:

- Where shall we go from here in the preservation of native grasslands?
- What should each organisation do?
- What should the group as a whole do?
- Why has grasslands preservation not had a higher priority in the community mind?

We need to examine our inherited and developed value system about this. Our major objective here today is to raise the profile of the grasslands, and to help experts communicate with each other and others about how this can be done.

OPENING ADDRESS

Mr John Langmore MP, Chairman of the Joint Parliamentary Committee on the ACT.

Summary

I am pleased to be able to open this important and imaginative seminar. The problems of forest conservation are well known, but those of grassland conservation far less so, although the Conservation Council's Director Rodney Falconer's eloquent recent article on the subject in the Canberra Chronicle (5 February 1991, Appendix 1) should help in that.

It is clear that only a few remnants of grasslands remain in a pristine condition — here at the Museum, at the Naval Station, and some river corridors are really the only pockets left.

There are implications for the whole ecosystem in the disappearance of the grasslands, and specifically for the moth *Synemon plana*, and for the legless lizard *Delma impar.*

So, it is important to look at the place of native grasslands. Experts today will emphasise this importance, review studies and action to date, and make proposals for future management of this resource, including the possible commercial use of native grasses, which need little water and no fertiliser, for landscaping.

I congratulate Rodney Falconer and the Conservation Council for organising this seminar.

ACT's GRASSLANDS - PLANNING AND MANAGEMENT

Dr David Shorthouse, author of "Ecological Resources of the ACT" (National Capital Development Commission, 1984)

Summary

Table 1 outlines the history of plans and surveys undertaken in the ACT since 1975 which are relevant to this Workshop on native grasslands. The overall theme is that a significant amount of information has been available for much of this time, but that implementation of known management prescriptions has been ignored. Note that:

1975 There was no reference to open areas or grasslands in the 1975 land use plan, which concentrated mainly on water catchment and wilderness areas.

1977 The important Seddon report showed that wetlands and grasslands were not adequately represented in the ACT. It saw a transition of indigenous vegetation, with grassland having an ecological function and forming part of parks.

1975 Chan et al called for management plans for grasslands, as they were so fragmented and dissipated, but little notice was taken.

1979 The NCDC's Report on the Ecological Resources of the ACT noted that grasslands were largely unmapped, and were modified by grazing.

1982 The development plan for the site of the National Museum recognised the natural features of the site, but these were seen as mainly the trees and the wetlands. The native grasslands were called "open paddock".

1984 Barrett and Mitchell, for the Conservation Council, noted the need for protection and management of grasslands, and laid down rationale and principles. However, this has gone largely unheeded.

1987 The management plan for one grassland area, at Yarramundi Reach, was not effectively implemented.

1987 In the NCDC register of Sites of Significance, main grasslands locations were noted, and these were sometimes coupled with rare and endangered species, and planning and management issues were identified.

1988 In *Canberra's Environment*, grasslands were noted as one of four vegetation types not well protected in the ACT.

1989 The ACT Government Paper (ALP) made no reference to grasslands, despite concentration on flora and fauna of alps, woodlands and rivers.

1990 The ACT Government Paper (Alliance) made no reference — emphasised forests and woodlands, although it called for an outstandingly representative system.

1990 The NCPA's paper on Ecological Resources of the ACT gave highest priority to the need to protect lowland grasslands (and woodlands) on lower slopes and adjacent to reserves.

1990 The Conservation Council's policy statement, which notes the potential of the ACT and SE Region as a model for the rest of Australia, makes no specific reference to grasslands.

Conclusions (See Figure 1)

1. Early warnings, plus information and management plans were available back to 1979 (Chan report), but largely ignored.

2. The original "Bush Capital" vision for Canberra recognised the value of the total landscape, but this is not fulfilled in relation to native grasslands.

DATE	SOURCE	GRASSLAND	OTHER COMMENT
1975	ACT Land Use Plan (NCDC)	no reference	'open areas' as landscape foregrounds
1977	An open space system for Canberra (NCDC)	wetlands and grasslands not adequately represented	grassland as part of parks indigenous vegetation transition
1979	Chan et al (CSIRO for DCT & NCDC)	initial inventory of ACT grasslands	management prescriptions
1979	*Ecological Resources of the ACT* (NCDC)	grasslands largely unmapped, fragmented and modified by grazing	role in landscape setting need for site management
1982	Development Plan Museum of Australia	'open paddock'	ecological displays, crops, animals natural features of site recognised
1984	Barrett & Mitchell (CCSERAC)	grasslands need protecting and managing	rationale for conservation management principles
1987	Conservation Plan Yarramundi (NCDC/ACTPCS)	focus on one grassland area	management prescription not effectively implemented
1988	Sites of Significance (NCDC)	main locations identified	coupled with rare and endangered species planning and management issues
1989	Lake Burley Griffin Policy Plan (NCDC)	no reference	conservation plans to be prepared for key sites
1989	*Canberra's Environment*	grasslands identified as 1 of 4 vegetation types not protected	task ahead — evaluate and protect
1989	ACT Government (ALP)	no reference	sections on forests, flora, fauna, alps, rivers, wilderness, management plans
1990	ACT Government (Alliance)	no reference emphasis on forests and woodlands	"outstandingly representative" system "most comprehensive and far-sighted in the country" focus on gazetting reserves identified
1990	*Ecological Resources of the ACT* (NCPA)	section on grasslands: none with representative status	locations and land use of remaining areas highest priority is woodland/grasslands on lower slopes and adjacent to reserves
1990	*Policy Statement* (CCSERAC)	no specific reference	potential of ACT as model for Australia context of South-East Region

Table 1. **Plans and Surveys undertaken in the ACT since 1975**

3. The remnant grasslands — Murrumbidgee corridor, Cathedral site at Barton, Yarramundi Reach, etc — will now be critical. Site management, including a "landscape sense of design" needs to think beyond just grasslands in reserves, and must encourage their incorporation into the total landscape.

4. The real blind spot in ACT planning and management of native vegetation is that the focus has always been on trees , forests and wetlands, and not on grasslands as well.

- early warnings and management prescriptions were available for those that wanted to act
- native grasslands have potential as landscape element of the National Capital
- remnants will be important
- need for thorough inventory of what is left
  - — regional context
  - — part of ACT reserve system

    and/or
  - — site management
  - — landscape design
- species not endangered but the community is
- 'blind spot' by all parties — focus elsewhere

<u>Figure 1.</u> **Conclusions from previous documents**

Therefore, the challenges for the future (see Figure 2) are that we need to:-

- Compile an inventory — documentation now about the location and the quality of grasslands is uneven.
- Apply current management knowledge about nutrients, burning, timing of mowing, damage, e.g. by stock tramplin).
- Look at both public and private situations, and consider management covenants for private landowners. Reserves are not the only way to protect our resources.
- Develop the landscape potential of grasses along roadsides and in savannah woodland and rural management.
- Encourage ACT to give a lead to others by use of permanent native grasses in landscape by linking ACT experience in research, planning and management of grasslands.
- Turn existing knowledge into committed action, and make native grasslands into an important part of the national capital.

- inventory of remaining grasslands and opportunities for conservation
- application of management knowledge
  - nutrients
  - burning
  - mowing (timing)
  - trampling
  - other flora and fauna
- private and public grassland management
  - reserves
  - other sites, e.g. Museum of Australia, Cathedral site
- landscape potential
  - roadsides
  - savannah woodland/scenic foregrounds
  - rural management (Paddy's River)
- National Capital lead to others
  - remnant grassland management
  - native grasses in the landscape
- turn available knowledge into committed action

Figure 2. **Planning and management challenges**

Responses to Questions/Comments

- This seminar's focus is regional rather than just on the ACT, although our knowledge of the surrounding region is less. The 1954 regional survey by Alec Costin should be updated to improve the regional database.
- "Herblands" are certainly important in total conservation terms, and are certainly, like grasslands, threatened by overgrazing, but they are technically different from grasslands, and need separate consideration.
- Grasslands are part of a whole dynamic ecosystem, including the fauna component and the rest of the vegetative component, and management plans should maintain them as part of and not separate from the context of this original system.
- Implications for bushfire management must be considered - we must strike an ecologically responsible balance between maintenance of grasses and safety.

FLORA OF THE ACT's NATURAL GRASSLANDS

Dr Richard Groves, CSIRO Division of Plant Industry

&

Mr Mark Lodder, ACT Landscape, ACT Public Works and Services Group, Department of Urban Services.

Summary

Dr Groves, who studies grasslands on a national scale, put the ACT situation into perspective:-

Natural grasslands occur extensively in many regions of the world, and usually where low temperatures and/or cracking clay soils limit seedling establishment or growth of woody species. In Australia, four types of natural grasslands have been recognised, which together cover at least one-third of the land mass. (See Figure 3.) They are:-

1. Arid tussock grasslands, e.g. Mitchell grasses, extensively distributed in inland Queensland and Northern Territory.
2. Arid hummock grasslands (cover most of arid Australia).
3. Coastal grasslands on the tropical northern coastline.
4. Sub-humid grasslands.
   a. Sub tropical grasslands - mostly in Queensland.
   b. Temperate grasslands - distributed irregularly around south-eastern Australia, from north of Adelaide, through basalt plains of Victoria, to northern NSW. The dominant genera are *Themeda*, *Poa* and *Stipa*.
   c. Sub-alpine grasslands, in the Monaro region of southern NSW, north-eastern Victoria and Tasmania. The dominant genera are *Danthonia* and *Poa*.

Each of these grassland types may be composed of different grasses and herbs.

The most common grasses in the ACT are:

- *Themeda* (Kangaroo Grass), which is abundant around the ACT.
- Several species of *Danthonia* (Wallaby Grass)

There is also a wide range of attractive herbaceous. species between the grass tussocks. Introduced species have become a permanent component of natural grasslands — management has to decide how to cope with this latter component.

It is also necessary to understand the role of the eucalypt forests in relation to grasslands, and how conversion into paddocks for sheep grazing, halting the encroachment of the eucalypts, encouraged grasslands. (Note the Penleigh Boyd picture of the Limestone Plains in 1913, showing the sclerophyll woodland around Black Mountain, which later converted to paddocks and grassland.)

Now we have only small remnant areas of grassland, and we have to manage them to meet the different criteria for agriculture and of urban park settings.

We have a mosaic of different species that need different management plans in relation to local land use patterns, e.g. an unusual number of species all grow together on the Museum site.

Different strategies are needed. Different animals are associated with different grassland areas, and we should use them as indicators for appropriate management.

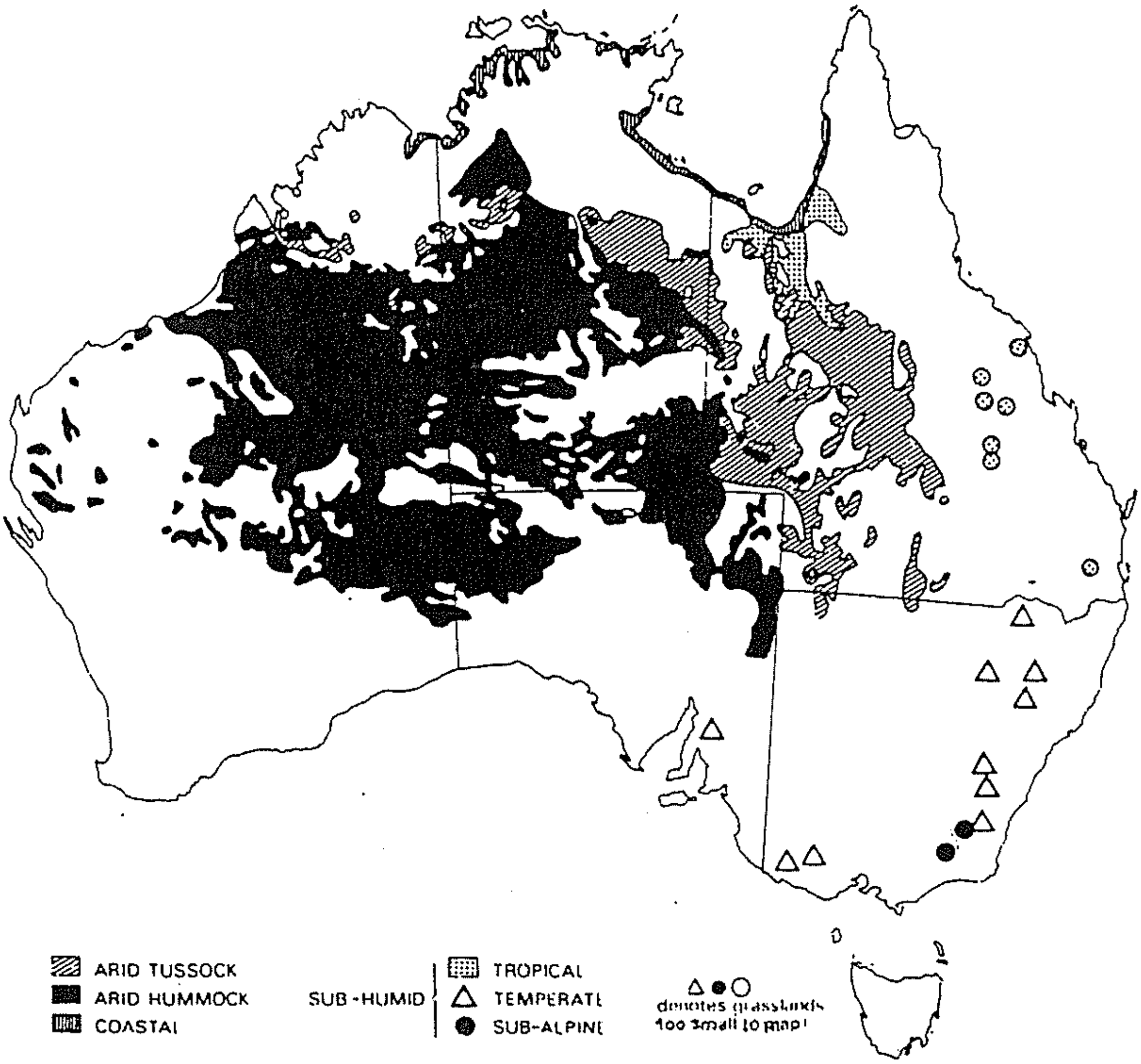


Figure 3. **Distribution of major grassland types in Australia**
(after Moore and Perry, 1970)

Why keep native grasslands?

1. NCDC landscape architects are beginning to see their value as a design alternative — they plant native trees and shrubs, but until recently, only exotic grasses.

   (See the "*Australian Grasses in Landscape Architecture*" poster and see Appendix 2 for attached offprint prepared for the Australian Institute of Landscape Architects, *Landscape Australia* 4/1990, pp. 446 - 448.)

2. But conservation is important in the grasslands' own botanic right — the "nature conservation value", whereby we need to conserve representative types to preserve the gene pool, e.g.:

   - a certain rare (purple) legume *Swainsona recta*, now only found at Wellington and in southern Canberra — should some plants be removed to attempt preservation elsewhere?
   - a yellow flowered form of a paper daisy occurs on the roadside between Braidwood and Bungendore that has just recently been bulldozed;

We need a good management model for these species and other remnant areas.

Conclusion

We need to consider:

1. How our grasslands fit into the whole Australian scene.
2. The need to maintain representative samples of all species, including subspecies where important.
3. The place of native grasslands in the revegetation of our inland cities.

Responses to Questions/Comments

Dr Groves

- On the issue of the best management of native grasses in Queanbeyan threatened by increased cover of eucalyptus, it is necessary to decide what you want — to return to pre-settlement Queanbeyan values, i.e. cleared grazing land, or to allow it to revert to the original woodland if left ungrazed? Note that it is much more resource- expensive to keep grass than to revert to woodland.
- Conservation values for the future require us to preserve a mosaic of different habitat types for the future. This also requires a delicate balance with measures for stock control, fire control, etc.

  With the ACT Environment and Conservation Bureau looking after broadacres, we are still looking to introduce native grasses near urban areas.
- Other examples of native grasses in the region are:
  - some *Stipa* (spear grass) near Cooma — it flowers earlier than other grasses, and the graziers don't like it, as it gets into the sheep's wool.
  - abundant *Themeda* down Caswell Drive
- On the issue of conflicting pressures of increasing industrial and domestic land development and the need to conserve grasslands, and the suggestion for buffer zones to increase their viability — areas such as those opposite the Macquarie Hostel are examples of high quality *Danthonia* grassland, which mown regularly would probably be viable, but nearby changes would probably lead to their extinction on those sites. This could happen through further building activity leading to changes in drainage or to the sites being dumped on.
- On the issue of preservation of diversity of species' (e.g. *Swainsona recta*) sites if we have climatic shifts, e.g. if our winters become warmer — yes, we can collect seeds and spread them, but it needs money and a sense of purpose, and, if there is a major climate shift in the next 100 years, then we will have to be introducing sub-tropical species, like red grass which does very well in a hot wet summer — we can do a lot.

- On rehabilitation — in the Greening Australia program where trees are being planted in the ACT amongst *Phalaris* stands, there should an effort to combine other roadside vegetation with the *Phalaris* and the native grasses — there should be gaps between the trees to allow for tussock grasses.
- Information material on native grasses should be developed for the education and use of ACT householders.

Mark Lodder

- On the issue of the potential of native grasses for the rehabilitation of disturbed sites, the ACT Landscape design brief is oriented to this solution, especially with the use of *Danthonia*, which is already being successfully commercialised. Other species (e.g. *Poa*) need to be commercially developed to compete with vigorous introduced grasses where there have been subtle changes in drainage and nutrient levels in the soil. These conditions favour introduced grasses, rather than native grasses.

	Mowing season in the ACT	Mowing height in the ACT
Danthonia: Wallaby Grass	May/June to remove spent flower heads; winter (June to August) to reduce fuel load	200 millimetres maximum 100 millimetres minimum Rejuvenate by firing sward in June to August
Poa Tussock Grass	February/March to remove spent flower heads; winter (June to August) to reduce litter load	500 millimetres to remove spent seed heads 200 millimetres to reduce litter load Rejuvenate by firing sward in June to August
Themeda Kangaroo Grass	March/April to remove spent flower heads dormant winter period (June-August) to reduce litter load	200 millimetres maximum 50 to 100 millimetres minimum Rejuvenate by firing sward in June to August

NOTE: The vigour and persistence of native grasses is reduced considerably if mowing is performed more than once or twice in any twelve month period.

Firing should not be undertaken more frequently than once every three years.

Table 2. Future maintenance for native grass plots
(Recommendations by Dr R.H. Groves, CSIRO, Division of Plant Industry, GPO Box 1600, Canberra ACT 2601 and Mr Mark Lodder, Landscape Architecture Branch, ACT Public Works,GPO Box 56, Canberra, ACT 2601 Telephone: 246 8648)

FAUNA OF THE ACT's NATIVE GRASSLANDS

Dr Keith Williams and Kruno Kukolic, ACT Parks and Conservation Service

Dr Keith Williams — Grassland Fauna

Summary

While there may have been some lack of government focus on protecting grasslands in the ACT, the Environment & Conservation Bureau has been and is focusing on grassland areas and associated fauna.

The Wildlife Research Unit of the Service began investigations into the distribution and relative abundance of the Pink-tailed Legless Lizard *Aprasia parapulchella* in 1984-85. The first study of this endangered species concentrated on the urban hills of Canberra and the importance of the grassland ecosystem on Mount Taylor became evident. Work has continued on *Aprasia* since then and we now know its preferred habitat structure and that native grasses, particularly *Themeda triandra* are important for its existence.

While temperate grasslands are widely distributed, as Dr Groves has indicated, this distribution does not correlate well with distributions of grassland fauna. For example, *Aprasia* is known from two sites at Tarcutta but has not been located at other similar sites in New South Wales. It occurs also on the slopes of the Murrumbidgee River and Molonglo River corridors.

Our existing information about distributions of species frequently is based on insufficient survey. Preliminary studies of *Aprasia* have shown that what was formerly considered a very localised species in the ACT is more widely distributed (though still localised and disjunct) than previously recognised. It has been found now over the NSW border north near Dog Trap Road, at Burra to the east and as previously mentioned at Tarcutta. In NSW and to a lesser extent in the ACT, agriculture and grazing (e.g. from pasture improvement and sheep camps) have affected what previously, we suppose, may have been *Aprasia* sites.

The research work and gathering of information has been labour intensive and slow which creates difficulties when the political process and/or development actions require information quickly — it takes years to do the relevant research and to produce useful scientifically sound reports for planners and land managers.

This year we will be producing a management plan for *Aprasia*, the first of a series of species specific plans. The plan will include management recommendations for individual sites of occurrence.

Our interest in grassland ecosystems was extended broadly to the Gungahlin area in the spring of 1989 when it was recognised that little information was available about the non-avian fauna of the area (Canberra Ornithologists Group has a good data base on birds) and particularly those areas planned for reservation as part of Canberra Nature Park. Also above the 650 contour level little was known of what occurred on the hill tops and there was a requirement to provide data for the management of the region.

The broad scale study aimed to locate (if they still existed), the Earless Dragon *Tympanocryptis lineata* and the Striped Legless Lizard *Delma impar.* While the Earless Dragon appears to exist no longer in the ACT, the Striped Legless Lizard turned up in new ACT locations. Apart from the ACT, it is thought to still occur only in Victoria, and a few sites in NSW and SA. It has been recommended for national listing as vulnerable, i.e. — likely to become endangered if changes to current management adversely affect its conservation.

The study of Gungahlin started as a broad study but in this current season, we have altered our emphasis and concentrated on the Striped Legless Lizard *Delma impar.* This action was taken because of the limited knowledge we had about its ecology, distribution and abundance in the ACT coupled to the existing threats contributing to its disappearance from what looked like suitable lizard habitat.

We have found that the Striped Legless Lizard occurs at more sites in Gungahlin than previously known but generally at low densities. It appears that suitable habitat is patchy and we are researching the species' ecology through studies of plant communities and structure at trap sites. We are still far from knowing the details.

These are two of the myriad of grassland fauna species. We expect to gather much more information about frog distributions and to address the disappearance of species from our region. Invertebrate fauna is equally as important, and of note is the endangered moth *Synemon plana* and the scientifically important Morabine Grasshopper *Keyacris scurra.*

Provided grasslands can be conserved, the future for grasslands research in the ACT is bright. The emphasis will be on grasslands ecosystems, an integrated approach which recognises not only the interactions and dynamics of flora and fauna species on an area but also the impacts of activities which affect the long-term productivity of the ecosystem for our native flora and fauna.

Kruno Kukolic - Report on the Vertebrate Fauna Surveys at Gunghalin

Transcript

Introduction and Methods

As mentioned in the previous talk by Keith Williams the information that I am presenting briefly is the preliminary compilation of data from two vertebrate fauna surveys. The results to be discussed here refer mainly to information obtained on reptiles and amphibians from all survey sites, but particular reference will be made to those species caught in the grassland areas.

A summary of the objectives, sites selection and timing of surveys are as follows:

SURVEY (I)

The initial general vertebrate fauna survey of the Gungahlin hills was carried out at eight sites (Figure 4). These were established in existing woodland vegetation communities, but also included two sites in relict native grasslands. Sampling commenced in mid-February 1990 after a wet early summer.

Based on the results of the preliminary surveys a modified survey was designed to obtain more detailed information on the distribution and relative abundance of the Striped Legless Lizard *Delma impar.* Efforts were concentrated mainly in sampling the remnant native grasslands present in the lower altitude areas of Gungahlin. A total of 12 sites were sampled; these included 11 new sites and a previously established site which was monitored as a control (Figure 5). The sampling was carried out between the end of November 1990 until mid February 1991, during a dry and very hot spring-summer season.

The selection of the initial survey sites in woodlands and grasslands was based on the vegetation map compiled by David Shorthouse in the "Ecological Resources of the ACT" (NCDC 1984) together with our field assessments. However, as field work progressed it became apparent that the available information on native grasslands was inadequate and not up to date. At our request Ms I Crawford, a volunteer working for the Wildlife Research Unit, carried out preliminary mapping of the extent of the major occurrences of native grasslands in the Gungahlin lower altitude grasslands. This provided a useful reference for future site location and vegetation survey. Two grass species dominated the lower altitude native grassland patches at Gungahlin; these were Tall Spear Grass *Stipa bigeniculata* and Kangaroo Grass *Themeda triandra.* In some locations these species formed extensive stands dominated by one or other of these species. The species *Stipa bigeniculata* was present in well-formed swards and patches only at altitudes below about 650 m. This information is of particular significance given that an estimated 80 per cent of Gungahlin has been proposed for development with only land above 650 m altitude being excluded.

With the exception of Gungahlin Hill reserve, most of the study area has been subject to livestock grazing. Much of the lower altitude area also has been converted to improved pasture by cultivation and the application of fertiliser. Grazing at the 2CY site, however, has been controlled by the lessee (Telecom) and only used as a fire hazard reduction measure.

Data on reptiles and amphibians was obtained mainly using the modified pitfall trapping method which consisted of 20 pits per site in a cross pattern. When stock were present the sites were fenced off in order to minimize damage to pits and drift fences. The sampling period, in keeping with standard methods for surveying reptiles and amphibians, extended over 3 to 4 weeks per site to allow adequate time for rare or uncommon species to be caught. Some information was also obtained by hand-searching under rocks and logs and additional information on amphibians was gathered on the basis of surveys of calling frogs during their breeding seasons.

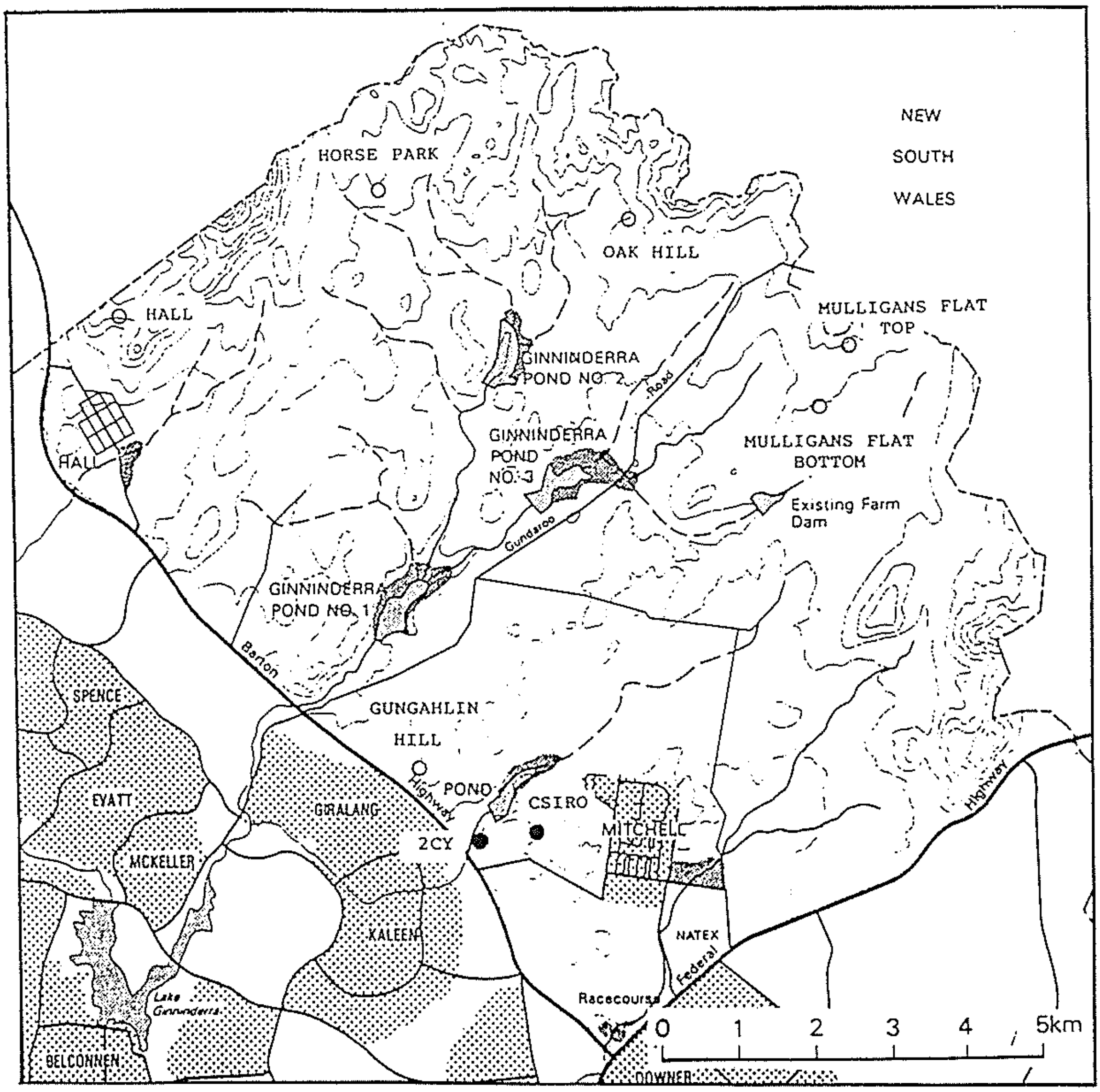


Figure 4. **Map of Gungahlin area showing February-March 1990 pitfall survey sites.**
Closed circles indicate locations where *Delma impar* were caught.
Open circles indicate other pitfall survey sites.

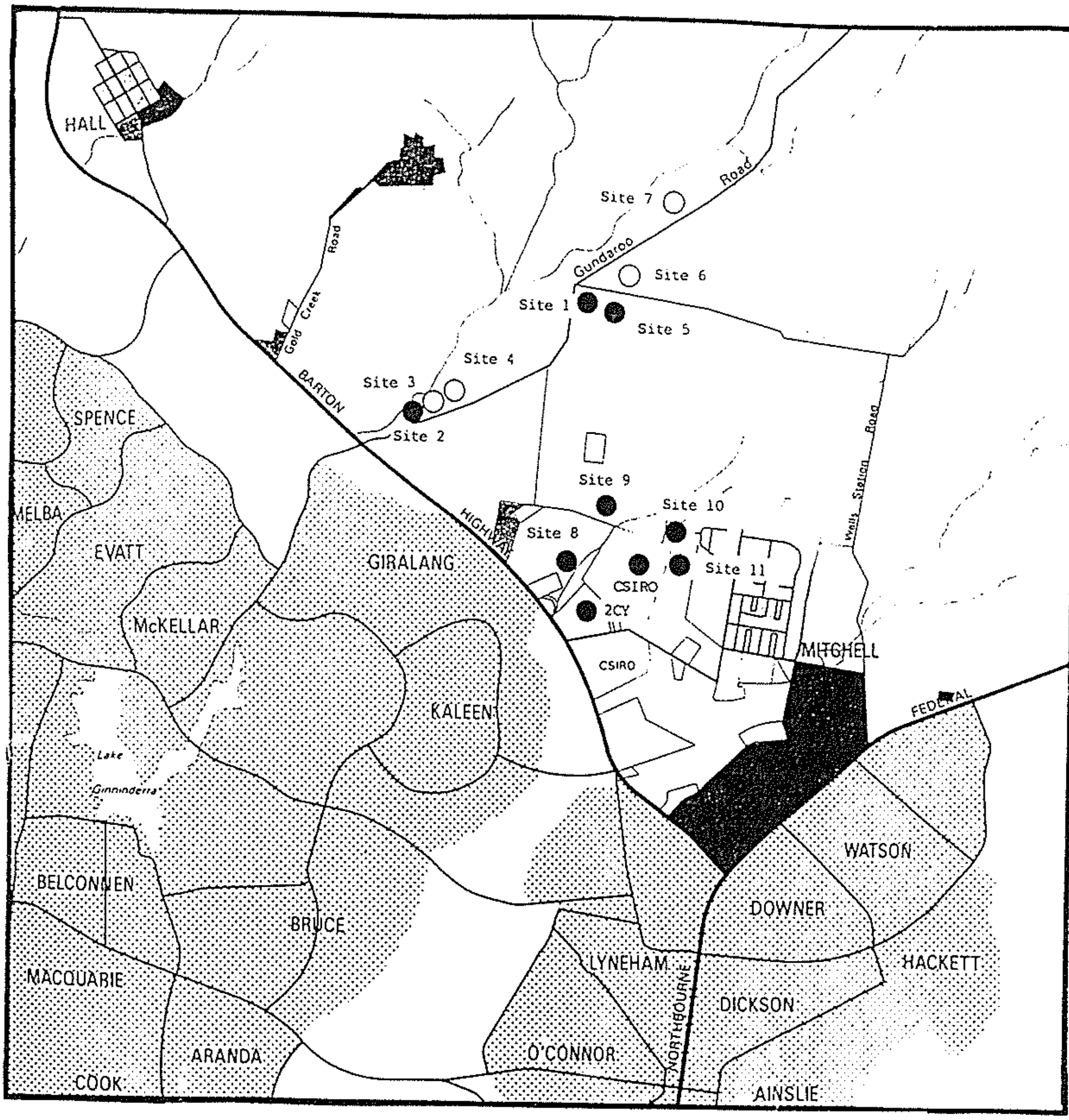


Figure 5. **Map of Gungahlin lowlands showing November 1990 - February 1991 pitfall survey sites.**
Closed circles indicate locations where *Delma impar* were caught.
Open circles indicate other pitfall survey sites.

Scientific Name	Common Name
Reptiles	
Delma impar	Striped Legless Lizard
Delma inornata	Inornate Legless Lizard
Menetia greyii	Grey's Skink
Morethia boulengeri	Boulenger's Skink
Amphibians	
Limnodynastes tasmaniensis	Spotted Grass Frog
Limnodynastes dumerilii	Eastern Banjo Frog
Limnodynastes peroni	Striped Marsh Frog
Crinia signifera	Common Eastern Froglet
Crinia.parinsignifera	Western Brown Froglet
Uperoleia laevigata	Orange-groined Toadlet
Litoria peroni	Peron's Tree Frog
Neobatrachus sudelli	Spotted Burrowing Frog
Mammals	
Sminthopsis murina	Common Marsupial Mouse
Mus domesticus	House Mouse

NB The Whistling Tree Frog (*Litoria verreauxii*) was recorded only during frog call surveys.

A total of 35 vertebrate species (18 reptiles, 9 amphibians, 7 mammals and 1 monotreme) have been recorded so far from the whole of the Gungahlin area using various survey methods.

Table 3. List of reptiles, amphibians and mammal species found in Gungahlin grasslands during the 1990-91 pitfall trapping surveys.

Results and Discussions

A total of eight amphibians, four reptiles and two mammal species were caught in pitfall traps in the Gungahlin grasslands during the 1990-91 surveys (Table 3). The numbers and species of animals caught at all surveyed sites were found to be highly variable, depending to some extent on the time of sampling, and the prevailing climatic conditions before and during the surveys.

Amphibians

During February-March 1990 amphibians were common at all of the sites surveyed with different species being found in association with their preferred habitats (Table 4). The two native grassland sites at 2CY and CSIRO had the largest number of Spotted Grass Frogs, *Limnodynastes tasmaniensis*, and 2CY was the only locality where the Striped Marsh Frog, *Limnodynastes peroni*, was found. The next most common frog recorded in pitfall traps, the Orange-groined Toadlet, *Uperoleia laevigata*, was not found in the lower altitude grassland sites, but was abundant at sites where rock cover, logs and tussock grass provided ground refuge. The capture rate of the tree climbing species, Peron's Tree Frog, *Litoria peroni*, was not expected to be high, as this arboreal species can readily climb out of the pitfall traps. Although this frog was not recorded in the grassland pitfall traps, it was heard calling at many sites in the open woodland areas near dams.

The Whistling Tree Frog (*Litoria verreauxii*) is one of the local species which over the last 10-15 years appears to have suffered a significant decline in distribution and abundance. Its presence was established by calls from a grassland dam near Gundaroo Road close to the NSW border, and from a few tadpoles dip-netted from another dam in a hilly open woodland location at the north-eastern end of Gungahlin. Another species of uncertain status in the ACT is the Spotted Burrowing Frog, *Neobatracus sudelli*. Five animals were caught in pitfalls, with three recorded from the grassland site of CSIRO. This burrowing species becomes more active and is usually found only after very wet weather in spring or summer.

Species	Sites								Total	
	2CY	CSIRO	Gung. Hill	Hall	Horse park	Oak Hill	Mull. Top	Mull. Bottom	No.	%
L. tasmaniensis	30	113	2	12	3	15	20	7	202	48.3
L. peroni	12	-	-	-	-	-	-	-	12	2.9
L. dumerilii	-	-	4	2	6	14	4	2	32	7.7
U. laevigata	-	-	4	3	3	30	85	12	137	32.8
N. sudelli	-	3	-	-	-	2	-	-	5	1.2
C. parinsignifera	9	7	-	-	-	-	3	-	19	4.5
C. signifera	4	1	-	-	-	1	-	-	6	1.4
Lit. peroni	-	-	-	2	2	-	-	1	5	1.2
Total individuals	55	124	10	19	14	62	102	22	418	
Total species/site	4	4	3	4	4	5	4	4	8	

Table 4. Amphibians caught in pitfall traps during the Gungahlin hills survey between February and March 1990.
The numbers refer to new individuals only, and do not include recaptures.

Reptiles

During the same February-March 1990 sampling period, reptiles were found to be moderately diverse in the woodland vegetation communities. Oak Hill and the Mulligans Flat "Top" sites were the most diverse with seven species recorded at each site (Table 5).

Species	Sites								Total	
	2CY	CSIRO	Gung. Hill	Hall	Horse Park	Oak Hill	Mull. Top	Mull. Bottom	No.	%
Lampropholis delicata	-	-	-	23	18	8	7	13	69	34.8
Hemiergis decresiensis	-	-	-	9	2	5	1		16	8.1
Morethia boulengeri	-	-	18	2	1	29	2	8	60	30.3
Menetia greyii	-	-	2	-	-	1	1	-	4	2.0
Ctenotus uber	-	-	-	-	-	-	1	3	4	2.0
Pogona barbata	-	-	-	-	-	8	-	1	9	4.5
Amphibolurus muricatus	-	-	-	-	1	4	19	2	26	13.1
Tiliqua scincoides	-	-	-	-	-	-	2	-	2	1.0
Delma impar	2	4	-	-	-	-	-	-	6	3.0
Pseudonaja textilis	-	-	1	-	-	-	-	-	1	0.5
Unechis dwyeri	-	-	-	-	-	1	-	-	1	0.5
Total individuals	2	4	21	33	22	56	33	27	198	
Total species/site	1	1	3	3	4	7	7	5	11	

Table 5. **Reptiles caught in pitfall traps during the Gungahlin hills survey between February and March 1990.**

The numbers refer to new individuals only, and do not include recaptures.

The lowest species diversity for reptiles was recorded from the two grassland sites where only six individuals of one species, the Striped Legless Lizard, *Delma impar*, were caught. Nevertheless, this result was significant because it confirmed the presence of one of our target species in the ACT. *Delma impar* has been nominated for inclusion on the "CONCOM List of Australian Endangered Vertebrate Fauna" as a nationally vulnerable species. In Victoria, it is now protected under the Victorian Flora and Fauna Guarantee Act.

Both of the low altitude grassland sites are covered by well-developed dense swards of native grasses. The 2CY site is dominated by Kangaroo Grass, *Themeda triandra*, and the CSIRO site is dominated by Tall Spear Grass, *Stipa bigeniculata*. These sites, while not containing the more commonly found grass and leaf-litter reptiles, at the time of the survey provided suitable habitat for *D. impar* to survive.

At the various woodland sites there was no single dominant species. The most abundant reptiles were the Delicate Skink, *Lampropholis delicata*, and Boulenger's Skink, *Morethia boulengeri*. These occurred at all of the sampled sites, except those in native grasslands and open pasture. Low numbers of the uncommon Grey's Skink, *Menetia greyii*, were captured. This leaf-litter and grassland species appears to be widespread but has a patchy and scattered distribution in the ACT.

Of particular note was the capture of *Ctenotus uber*, a member of the copper-tailed skink group. All four species were found at the two sites in the Mulligans Flat area. Each site was located in woodland with a ground cover of *Chionochloa pallida* tussock grasses and scattered quartz stones. This is only the third record of this species in the ACT with the other two records coming from Coppins Crossing near the Molonglo River and from Ginninderra Creek near the west Belconnen suburb of Latham.

The discovery of several sites with *D. impar* during the first survey changed the emphasis of subsequent surveys. Because of the pending urban development at Gungahlin and the lack of knowledge of the distribution of this significant species, site selection was concentrated around the lowland area, and aimed at sampling a range of potentially suitable habitats. A decision was also made to sample areas that were known to be the first areas to be developed, either as future suburbs or as access roads, in an attempt to obtain historical records of what was going to be lost before construction began. This sampling period was bought forward as it was suggested that *D. impar* may be more active, and therefore more catchable, during the late spring-early summer period.

The preliminary pitfall trapping results for the sampling period from late November 1990 to mid-February 1991 are summarized in Table 6. The results presented are those of new animals only and do not include recaptures or total catches. While the number of species found in these grassland sites showed an increase, the most striking feature was the significant increase in the numbers and sites where *D. impar* were caught. *Delma impar* were found to be abundant at the 2CY site, and also were found at seven out of the 12 sites sampled. The sites where *D. impar* were present generally contained large patches of *S. bigeniculata* and/or *T. triandra* with extensive and intact swards and a well-developed grass thatch. The ground cover provided by the native tussocks was estimated to range from about 30-100 per cent.

The only exception was site 11 that was dominated by exotic grass species, in particular the perennial tussock forming *Phalaris sp.* This location was near CSIRO, a known *D. impar* site, with a dense ground cover of *S. bigeniculata.* It is not known whether the legless lizards occupy the *Phalaris* habitat permanently, or disperse through the site from the nearby native grassland.

Delma impar were not found at any sites with limited ground cover or in pasture-improved areas dominated by annual exotic species. Although the surveys did not sample all habitats present the results to date show a marked preference for native grasslands.

While information on the biology and habitat requirements of *D. impar* is lacking, it does appear that the species may be capable of recolonizing areas that have been previously disturbed, if the native grass cover returns. For example, at two sites where a number of *D. impar* were captured (sites 1 and 5) the paddock had been ploughed and cultivated for a couple of years approximately 20 years ago, but had then been left to return to its "natural" state. It is obvious that the presence of a breeding population somewhere nearby was essential for the re-establishment of the species at these sites. It is somewhat ironic that sites 1 and 5 are the location of the first suburb to be developed at Gungahlin.

Amphibians were found to be relatively common at all of the grassland sites during the second survey. The Spotted Grass Frog, *L. tasmaniensis,* was again the most widespread and abundant species, with the Common Eastern Froglet, *Crinia signifera,* being found in lower numbers and at only three sites.

The overall low number of frogs at these sites, as compared with the first survey, could be directly attributed to the prevailing climatic conditions at the time of sampling. The ACT was in the middle of a drought period and experienced some of the highest early spring temperatures recorded in recent years.

Conclusion

The two pitfall trapping surveys were carried out at different times of the year and under markedly different climatic conditions. These differences were clearly reflected in the variability of the results, particularly in the differences in the numbers of amphibians caught. This variation highlights the need to undertake such surveys over at least a two year period, and to be cautious about making conclusions based on limited data.

Both native and exotic grasslands associated with swampy, low-lying areas and permanent waters, such as dams, provide important habitat and breeding sites for various frog species in the Gungahlin area, and a rich frog fauna still occurs in this region.

The relatively low species diversity of reptiles at the grassland sites may result from habitat disturbance and reduced ground cover brought about by years of grazing interspersed with periods of pasture improvement and cultivation.

Nevertheless, the results of the surveys were encouraging because of the discovery of several *D. impar* populations, which extended the known range of this species in the region. The species is, however, vulnerable to habitat disturbance and is likely to be adversely affected by overgrazing, pasture improvement and urban development. *Delma impar* is not currently present in any conservation reserve and its distribution status elsewhere in the ACT is unknown at this stage. Until such time as additional surveys are carried out, the lower altitude Gungahlin grasslands should be considered as being significant conservation areas. Seminars such as this one taking place today are the first step in raising the general level of awareness of the importance of conservation of native grassland ecosystems.

Species	Sites 2CY	1	2	3	4	5	6	7	8	9	10	11	Totals No.	%
Reptiles														
D. impar	26	7	5	-	-	6	-	-	4	2	-	4	54	90.0
D. inornata	-	-	2	-	-	-	-	1	-	-	1	-	4	6.7
M. greyii	-	-	1	-	-	-	-	-	-	-	-	-	1	1.7
M. boulengeri	-	-	-	-	-	-	-	-	-	-	-	1	1	1.7
Total individuals	26	7	8	-	-	6	-	1	4	2	1	5	60	
Amphibians														
L. tasmaniensis	-	1	3	2	-	1	11	-	1	1	16	70	106	76.3
L. dumerilii	-	-	-	3	1	-	-	-	-	-	-	-	4	2.9
C. signifera	12	-	-	-	-	-	7	-	-	-	4	-	23	16.5
C. parinsignifera	3	-	-	-	-	-	-	-	-	-	-	-	3	2.2
U. laevigata	-	-	-	-	-	-	-	-	-	-	-	1	1	0.7
L. peroni	-	-	-	-	-	-	-	-	-	-	-	2	2	1.4
Total individuals	15	1	3	5	1	1	18	-	1	1	20	73	139	
Mammals														
Mus domesticus	-	-	-	-	1	-	-	-	-	-	1	-	2	
Sminthopsis murina	-	-	1	-	-	-	-	-	-	-	-	-	1	
Total individuals	-	-	1	-	1	-	-	-	-	-	1	-	3	
No. of species/site	3	2	5	2	2	2	2	1	5	2	4	5		

Table 6. **Reptiles, amphibians and mammals caught in pitfall trap during the Gungahlin grasslands survey between November 1990 and February 1991.** The numbers refer to new individuals only, and do not include recaptures.

Responses to Questions/Comments

- It is indeed difficult to observe fauna reactions to cyclical weather patterns when all fieldwork is done in the summer, but there was government pressure to complete the study quickly because of the implications of the occurrence of the endangered *Delma impar* in relation to freeway and other development plans for Gungahlin, We could only do a species count, not a full ecological study, and also, the legless lizards are only active when it's hot, and it would be much harder to locate them in other seasons.
- Although exact figures are not available, it is known that there has been a significant decline in the number of invertebrate species in Gunghalin through settlement, burning off, clearing and pasture development since the 1850s when it was native woodland and savannah. (See Lyall Gillespie's History of Gungahlin.)

SYNEMON PLANA - A GRASSLANDS CASE HISTORY

Dr Ted Edwards, CSIRO Division of Entomology

Transcript

This morning I would like to talk about a single species of moth, and to give you some details concerning its biology and conservation. The purpose of the talk is to illustrate in a very brief and incomplete way some of the intricacies of the biology of an invertebrate, and the effects these have on conservation proposals.

While this talk is very much about a single species in a single grassland community type, I would ask you to bear in mind that *Synemon plana* is a figure-head species, an example that we happen to know something about. The grasslands are home to many other invertebrate species — hundreds — each making its own contribution to the stability and diversity of the grassland. Of these other invertebrates we know very little. Some can be expected to be as yet undiscovered, many will be known but their biology and their association with the grassland will be as yet unknown. Many of these species may be in much the same situation as *Synemon plana*. What I have to say applies to them in a general way as well.

Synemon plana is an endangered species. In historical times, it occurred in a wide belt of south-eastern Australia from Bathurst in NSW to Bordertown, just into South Australia. Today it is known from some 8 to 10 sites, all except one of which are very small, in the inner urban areas of the ACT (Figure 6), and a single site in western Victoria (beside the railway line at Salisbury).

In the ACT it survives only in the remnant patches of *Danthonia carphoides* (wallaby grass) grassland. Other grassland types are unsuitable and are not inhabited by the moth. The very small remnants of *Danthonia* grassland are scattered about the inner city with the largest remaining area at the Belconnen Naval Station.

Let me tell you something about the moth. It has a wingspan of about 5 centimetres and is entirely day flying. The adult moths are active during the period from mid November to early December depending on the aspect and warmth of the season. On a northern slope or in a warm Spring, the moths will fly earlier than in other situations.

The adult moths cannot feed or drink, and have no mouth parts. All the feeding is done at the caterpillar stage. Because they cannot drink, the adults do not live long and probably usually die on the day following emergence. The females emerge from their pupae with all their eggs fully developed. Their task is to mate and lay their eggs into the grass tussocks during the day or the following day. Little is known of the caterpillar stage, but from related species we can infer that they feed underground on the roots and other underground parts of the *Danthonia.*

Synemon plana belongs to a family of moths called the Castniidae. There are about 160 species in Central and South America, and about 50 species in Australia. This distribution leads us to believe that the family had a Gondwanan origin, and constituted part of the original fauna of this continent when it separated from Antarctica. The family also has a suit of structural features which attest to its great age.

Within the family, *Synemon plana* has several unique features. The females have much smaller wings than would be expected for a moth of similar body size. Normally the female with a weight of eggs to carry has larger wings than the male. In this case the normal situation is reversed because the females rarely fly. They can fly and will do so if disturbed but they do not do so voluntarily. They spend their time scuttling from one tussock to another laying their eggs. This is one reason why they need a grassland dominated by their food plant to survive.

One result of their sedentary behaviour is that the females do not seek their mates. The males seek the females by patrolling the grassland about a metre from the ground, in the heat of the sun searching for the flash of the yellow hind wing of the female. She briefly exposes the bright hind wing to attract a male. The females with the orange hind wings are very differently coloured to the male, and this difference between the sexes is the second unique character of this moth and its family.

The basic structure of the *Danthonia* grassland and the moth have survived the onslaught of heavy agricultural grazing last century and this century. *Danthonia* grassland is one of the more resistant native grasslands to heavy grazing. The tussocks and the shoots in the tussocks are low to the ground. By the same token, the grass is easily shaded and weakened by competition from taller and more vigorous introduced grasses and clovers.

The introduction of improved pasture plants on a huge scale to agricultural areas in the 1950s has almost eliminated the natural *Danthonia* grassland. The known sites for the moth are mostly in areas excluded from agricultural use before the improved pasture revolution began. This is the reason why populations are in the older urban parts of Canberra and not in the newer suburbs or the agricultural areas of the ACT.

Several attributes of the moth suggest that it might survive well in small reserved areas. It is a very common moth. Where the grassland survives the moths are plentiful. The moth is endangered not because it originally had a restricted distribution or occurred in low numbers. It is endangered because its whole life support system, the grassland, is endangered. Some of the smaller populations of the moth inhabit an area measured in tens of square metres. These have survived for 10 years or more after being cut off from larger populations.

This makes us believe that the moth would be a robust survivor given half a chance. One of the most likely disasters to occur to a small reserve is fire. Over vast areas fires rarely burn the total area but leave small patches untouched to provide a source for re-colonisation. In small reserves, total destruction is likely. The moth spends almost all the year underground and so, while we have no experimental proof of this, it is likely to be very fire resistant. In addition, the *Danthonia* pastures provide sparse fuel and fires are likely to be cool and very transient.

One disadvantage the moth has is the low vagility of the female, which means that it is not able to colonise areas not contiguous with areas already inhabited. This is illustrated by a site near Bungendore, a perfect *Danthonia* pasture uninhabited by the moth. The best explanation seems to be that the area was not originally a *Danthonia* pasture but the pasture has been created by heavy grazing eliminating taller natives, but the area has not been "pasture improved". Possibly originally there were no colonies of the moth nearby and the area has not been colonised because of the low vagility of the female.

The principal threats to the survival of the moth are urban and suburban development and the invasion of the grassland by introduced weeds. Development is the most immediate threat with the two largest sites already earmarked for office blocks or housing development. Planning authorities are aware of these sites and the moth is receiving consideration. There remains however, no site, anywhere, where the grassland or the moth has any statutary protection from development. The second threat, invasion of weeds, is a serious one. Many areas of *Danthonia* have been overrun by paspalum, wild oats, Phalaris, rye grass and so on.

This threat can be minimised by management of the grassland. On larger areas the best management practice is to prevent as much as possible the disturbance of the grassland. Increased water run on, planting of trees causing shading, and frequent traffic of vehicles will all fatally disturb the grassland, giving invasive weeds a foothold. Weed invasion may also be prevented, slowed or even reversed by judicious high mowing of the grassland. High mowing disproportionately damages the weeds, leaving the lower growing *Danthonia* largely intact.

One is frequently asked can a grassland be created by sowing the constituent plants in a site more suitable for conservation. In theory, establishing such an assemblage of plants may be possible. Perhaps a few of the conspicuous faunal elements could be introduced. However, the diverse invertebrate fauna of the grassland, as yet largely unknown, but probably essential for the long term ecological balance of the grassland, cannot be so easily created. Re-creation is not a practical proposition. Using astute management to increase the size of existing areas is a more practical proposition.

What needs to be done?

Clearly at least two adequate reserves are necessary. In order to decide on areas and to manage these areas,we need more information. We have to do what we can on existing information but we must also plan to obtain further information. In the short term the only research option is to survey the ACT thoroughly for grassland sites and moth sites.

In the longer term, many features of the biology of the moths need to be understood. For instance, we have never counted the number of individuals in a population. Counting flying adults is feasible, but we do not know how long the period from egg to adult lasts. Is it one, two, or three years? Or is it variable?

Counting the males will not tell us how many females there are, or if we are counting the whole population, half of it or a third of it. How many individuals comprise a viable population anyway? What sort of year to year fluctuations in numbers can we expect? What effects do droughts or wet spells have on population numbers? There is circumstantial evidence that populations increase during droughts but that is all. All these parameters have a bearing on the size of reserve which is necessary.

Even more of an unknown quantity is the future stresses to which the grassland will be exposed, particularly by weed invasion and climatic fluctuation. We also need to do thorough studies to find out what invertebrates are present in the grasslands and which are endangered. While all this information would make decisions much easier, we can and need to be able to make decisions on existing knowledge.

I would like to conclude by stressing again that while I have spoken only about the moth, this serves as a figurehead or indicator for the many invertebrates as yet unstudied which are also confined to the grassland and play an essential role in the balance of the grassland.

Responses to questions/comments

- The moths are too fragile for any attempt to transport them to any new sites, such as Bungendore or Hall.
- It would be too difficult to count the other moths associated with the *Danthonia* day pastures, but the night flyers would come to a light trap at night.
- It is not very likely that males stray away from their own *Danthonia* patch, even though the females are sedentary. The males seem to have a very sensitive appreciation of the *Danthonia* boundaries, and to mate just with their resident females. But in the very long term, perhaps some males could mate out, and genetic changes could occur.
- The males fly as high as a metre, usually during the latter part of the day.
- The importance of preservation of small grassland species is vital for invertebrates and maybe for vertebrates.
- Somehow, there must be management decisions to encompass the conflicting requirements of flora and the smaller fauna components (daisies v. moths!)
- Fire (and burning off for bushfire prevention) management is also a hazard — in winter the invertebrates are in the most sensitive phase of their life.

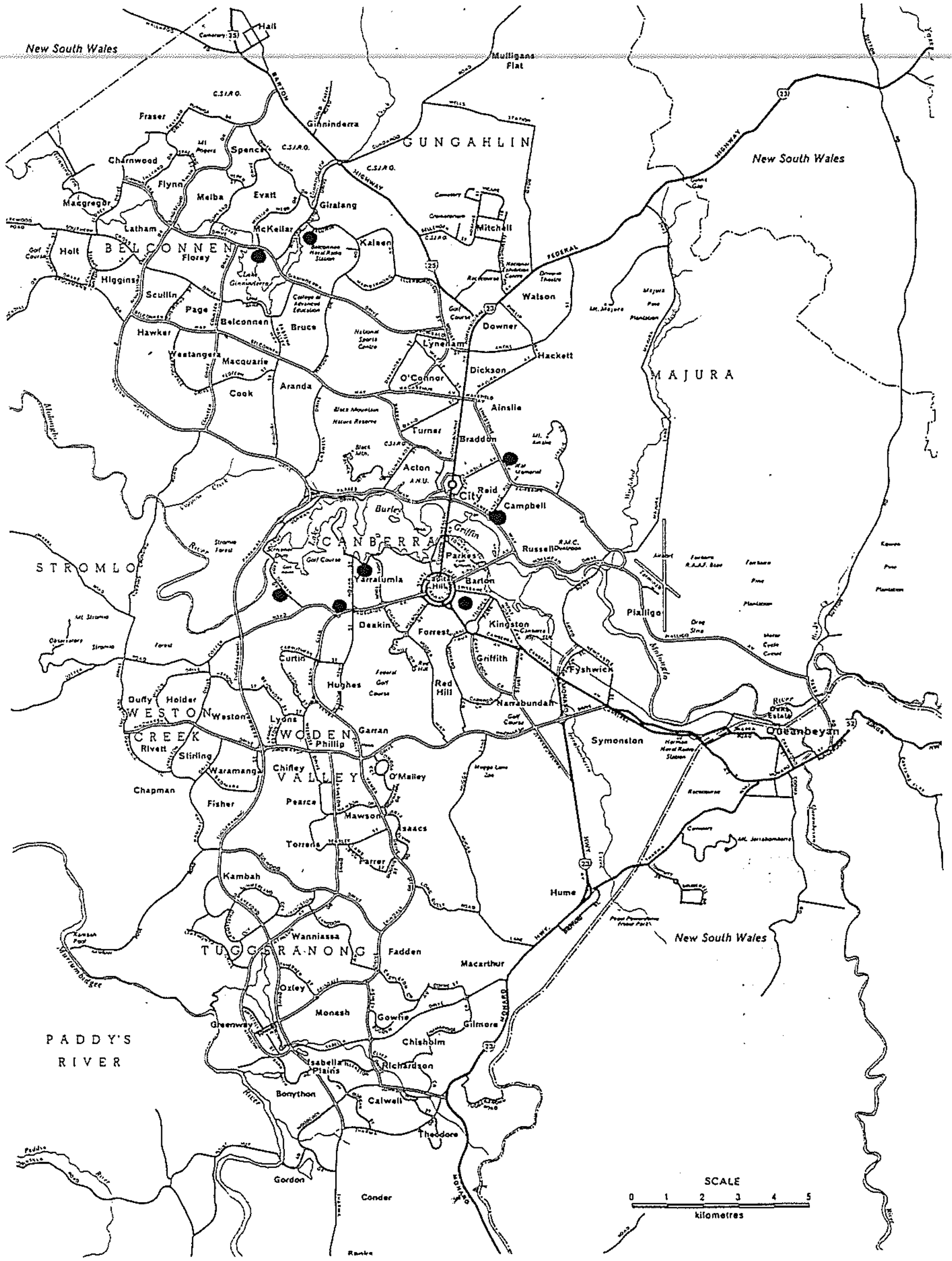


Figure 6. **Distribution of *Synemon plana* in Canberra**

Closed circles show moth locations

THE 1990s - A CRUCIAL DECADE FOR ACT NATIVE GRASSLANDS

Dr Kevin Frawley, National Parks Association, ACT
Rodney Falconer, Director of the Conservation Council

Dr Kevin Frawley's presentation derived from a report to the National Parks Association (ACT) Inc on The Conservation of Remnant Woodland and Native Grassland in the ACT, to be published in March 1991. This is a study collating published or otherwise available information for the purposes of the NPA making representation to government for the protection of these natural resources.

Dr Kevin Frawley

Summary and Transcript

The essential problem for protection of native grassland is that it is generally "invisible" to the community and so there is limited public pressure for its conservation.

The study is concerned only with low altitude tussock grassland (*Stipa* spp. community) in the ACT (Figure 7) as higher altitude communities are well protected in Namadgi National Park. The low altitude community has been reduced by cultivation, grazing, urban development and other works to tiny fragments of its original extent. Chan (1980) identified eight associations within the community in the ACT. Associations of *Themeda triandra* (Kangaroo Grass), *Stipa bigeniculata* (Tall Spear Grass), and *Danthonia* spp. (Wallaby Grass) represent original communities while those containing *Bothriochloa macra* (Red Grass) are considered to be results of uncontrolled grazing.

As well as constituting a grassland formation, the four genera are also found as components of the ground cover of savannah woodland, particularly the *Eucalyptus melliodora* — *E. blakelyi* alliance. They also occur in open forest areas, such as Black Mountain.

Forty locations of remnant native grassland were documented in NCDC (1984) and these were reassessed by Hogg (1990). In the decade since the data was compiled upon which the 1984 summary was made, three locations had been totally developed, some partly developed and others degraded by pasture improvement. Many sites remain under threat from urban and other development. The most significant potential change is the use of rural land and some other current specialist uses for urban and industrial development and service provision.

None of the currently identified areas of native grassland are formally protected. They are located mainly in:

- Rural areas (under short or long term lease)
- Land under agistment or licence
- Territory use areas.

The larger and best preserved sites have remained intact largely because of land uses which have not required substantial disturbance to the site — e.g. Belconnen Naval Communications Installation, the radio transmitter site at Gungahlin (Barton Highway/Bellenden Street). One of the best remaining sites is at Yarramundi (western end of Lake Burley Griffin) — the planned site for the Museum of Australia.

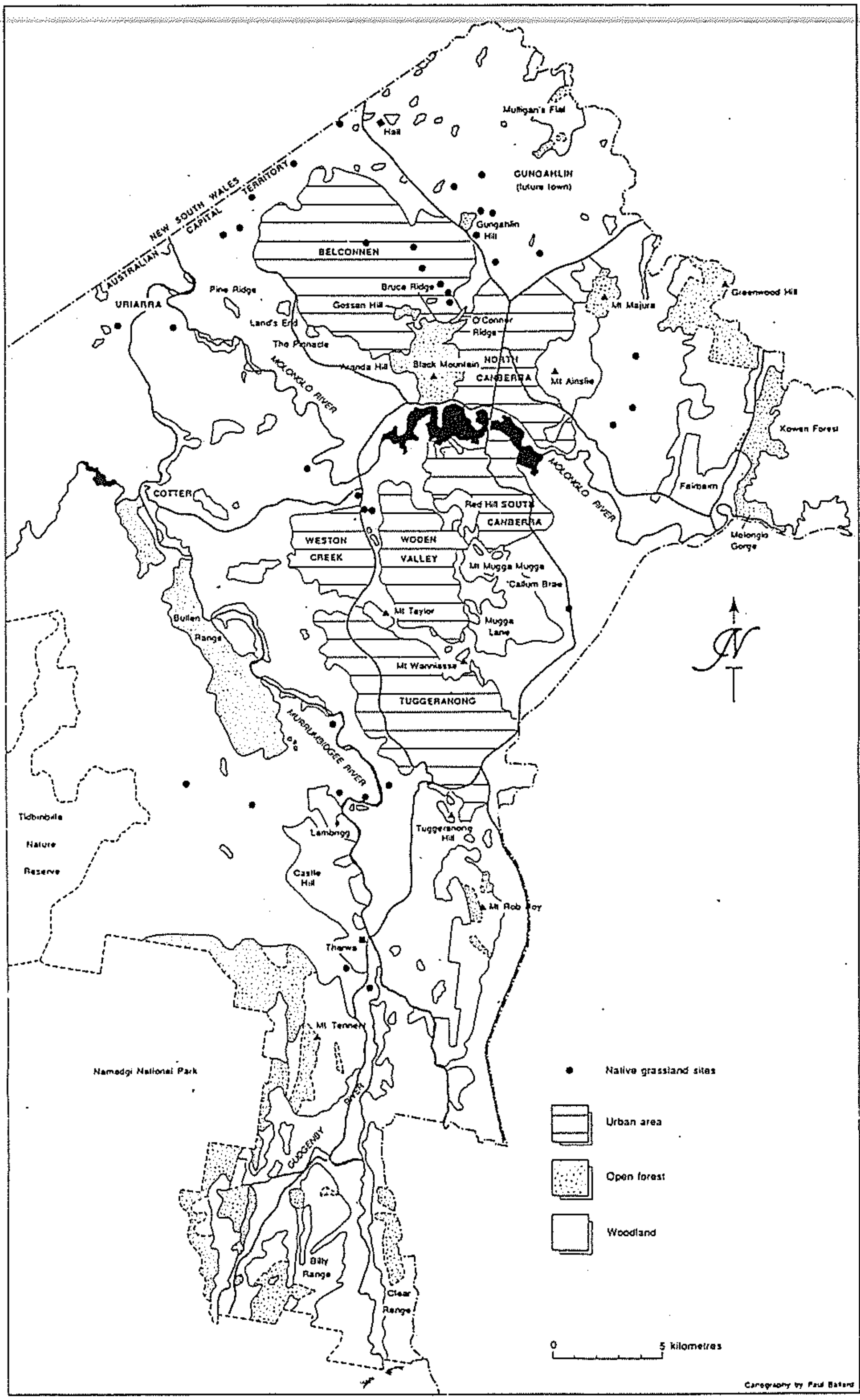


Figure 7. **Native grassland and woodland communities in the ACT**
(with permission of Dr Kevin Frawley and the National Parks Association ACT)

ACT NATIVE GRASSLAND AND LAND USE 1990	
42 SITES (7 ASSOCIATIONS)	
Present Land Use	**Proposed or Potential Land Use**
Rural (25)	Rural (18, inc. 5 affected by VFT?)
Open Space (10 incl. 7 in NCOSS)	
	Urban, industrial services (12)
Radio facilities (3)	
Roads (3)	Open Space (11, incl. 7 in NCOSS)

Ecological Values

The remaining native grasslands have a number of ecological values:

1. They represent the last vestiges of the original non-tree communities worthy of preservation in their own right. Even sites which have suffered some degradation (e.g. through invasion by exotic species) are of some scientific interest;
2. They are a biological (genetic) resource with horticultural potential. It is anticipated, for example, that Wallaby Grass (*Danthonia* spp.) seed will be commercially marketed in 1992 (R. Groves, pers. comm.). They have potential landscaping value especially in large scale restoration works (such as road easements) which provide an ideal opportunity to restore native species to the environment;
3. They have an aesthetic value providing particular colours and form to the landscape and are a part (often overlooked) of the landscape setting of the ACT;
4. Some species continue to grow during summer and are less prone to wildfire than exotic annual winter growing species;
5. They are better adapted to local conditions and require less maintenance;
6. They provide particular habitat values and in the ACT, grasslands are important for the conservation of rare flora and fauna.

Some Recommendations for Native Grasslands

1. Native grassland is poorly conserved in the ACT with little formal protection except as groundcover or in association with tree communities in reserves.
2. There is an urgent need for a comprehensive survey of low altitude native grassland to assess its remaining extent, location and integrity
3. In considering the ecological resources of the ACT, the habitat values of native grassland need inclusion
4. In drawing reserve boundaries, lower slopes with native grassland and savannah woodland should be included. An example is the proposed reservation of Mulligans Flat - Oak Hill area.
5. Following a re-inventory of native grasslands, detailed and clear management prescriptions are needed for each important grassland site. There is already a model for this. A conservation plan prepared for the native grassland at Yarramundi contained management prescriptions which could be applied elsewhere. For areas under rural lease, for which formal reservation is not feasible or appropriate, the possibility of site management, in co-operation with the rural lessee and, if necessary using lease provisions, should be explored.

6. Measures to increase recognition of native grassland and its values in the community, and amongst landholders and government agencies would be valuable. Currently, for example, the Agriculture and Landcare Section of the Department of Environment, Land and Planning has no brief to manage in any particular way. There is scope also to bring attention to native grasslands in agricultural extension work and activities such as the Landcare program. One measure to assist in this would be a local field guide.

References:

Chan, C., 1980 — *Natural Grasslands in Canberra: Their Distribution, Phenology and Effects of Mowing* (M.Sc. Thesis, ANU, Canberra).

NCDC, 1984 — *The Ecological Resources of the ACT* (NCDC, Canberra)

Hogg, D.McC, 1990 — *The Ecological Resources of the ACT: A review of recent information* (Report to NCPA, Canberra)

Rodney Falconer

Summary

Rodney Falconer showed a series of slides:

- Attempts to reconstruct native grassland ecosystems in Willandra National Park, near Ivanhoe in western NSW (regeneration very difficult due to past grazing and prolific competition from weed and pasture species).
- Emus at Tidbinbilla Nature Reserve — excepting the poplars, a view across the Kangaroo Grass lowlands of what much of the pre-European Limestone Plains might have resembled. Emus, brolgas and rock wallabies have become extinct in the ACT. The emus shown here are the result of re-introductions. Maybe these emus (of uncertain ancestry) should be replaced with more birds of more local genetic stock, say, from Kosciusko National Park, where a few pairs still remain. But Tidbinbilla and other reserves are not managed to promote grasslands, and so we need some hard policy decisions. Should sites be **actively** managed to prevent re-colonisation by shrubs and trees ?
- More native grassland at Tidbinbilla, dominated by Kangaroo Grass (*Themeda triandra*) being invaded by scattered woody shrubs. Lack of active management is a serious threat to native grasslands even in well established conservation reserves.
- Herbaceous components within relatively lightly managed native grassland, here in the vicinity of the now defunct Ainslie Waste Transfer Station. Many herbaceous species such as the silvery *Helichrysum apiculatum*, are integral parts of grassland and woodland ecosystems, and have great potential for use in landscaping, .
- Understorey of grassland, including Red-anther Wallaby Grass (*Danthonia pallida*), within regenerating open forest of Red-spotted Gum (*Eucalyptus mannifera*), Inland Scribbly Gum (*Eucalyptus rossii*) and Red Stringybark (*Eucalyptus macrorhyncha*) and Red Box (*Eucalyptus polyanthemos*), Black Mountain.
- Patches of native grassland scattered over steep ridges and slopes among woodland and open forest near Ginninderra Falls. Among the dominant tree species are scribbly gum, stringybark, cypress pine and red box. In many woodland and forest associations, grassland is limited by competition with shrubs and by shading from the canopy.
- A solitary and isolated old specimen of Yellow Box (*Eucalyptus melliodora*) by a country roadside amid heavily grazed improved pasture. Lowland woodland and grassland communities such as these are poorly represented in conservation reserves and are threatened with local and, in some cases, regional extinction.
- Kosciusko National Park — grassland has been invaded by vigorous weed species, including Paterson's Curse, bracken and blackberries.

- Burgan (*Kunzea ericoides*) thickets on a previously disturbed slope in native woodland. This species of native shrub is generally kept under control in forested situations by virtue of intolerance to canopy shading. Once that control is removed, burgan relentlessly spreads across open areas, often invading adjacent grassland. It is tenacious, having extensive lignotubers, it is resilient, suckering and a prolific producer of long-lived seeds.
- A major source of grassland disappearance in the ACT, and also a source of cultural vandalism. Sheep in a historic graveyard near Hawker. Note the damage to gravestones, unpalatable weed growth and the intensely-grazed improved pasture.
- Grasslands on a hillside in the ACT. Many of the ACT's native grasslands, even within Canberra Nature park, are being steadily replaced by exotic grasses such as Phalaris, Wild Oats and Rats-tail Fescue. In this case, unpalatable weeds, such as Paterson's Curse are increasing along this overgrazed slope. Note that most of the trees in this picture are isolated from each other and are suffering from varying degrees of dieback.
- Eucalypt die-back in the ACT. A number of causes are likely for the poor condition of these yellow box trees, including intensive defoliation associated with understorey removal, isolation and pasture improvement. This species is often less prone to dieback in the ACT than species such as stringybark, red box and Blakely's red gum, especially where they have been isolated in partial clearing operations, such as in parks and paddocks.
- New urban area, Bonython — erosion is a big problem, due to prevailing techniques involving scraping of the site by heavy machinery, with or without stockpiling of topsoil. Some large trees are spared, but shrubs, native herbs and grasses are invariably locally exterminated by this most intensive form of land disturbance. Developers appear little concerned and poorly informed — there are sediment traps to contain siltation rather than prevent soil loss. These are not always practically effective, nor is current legislation effective.
- Isolated yellow box (with decomposing tree house) in otherwise totally cleared and gouged area in the proposed Calwell supermarket, preserved by action of local residents. Although a few of these trees were saved, the understorey has been completely removed.

IN SUMMARY:

- Attempts have been and continue to be made in several parts of Australia to restore specific areas of native grassland, though weed invasion is invariably a difficult problem.
- Hard decisions are needed in the short term to balance management objectives for native grassland, fauna and other considerations in reserves in the ACT and elsewhere.
- Areas of existing native grassland may reflect their past as understorey to an extinct woodland overstorey. Decisions need to be made as to whether shrubs are allowed to alter these grasslands and if they are to be restored as grassland or woodland.
- Many native herbaceous annuals and perennials ("wildflowers") form an integral part of grassland ecosystems in the ACT; they are frequently very attractive and have real landscaping potential though are scarcely utilised by landscape architects and others in the ACT.
- Active management of native grasslands is needed to ensure their continued survival in order to promote vigour and eliminate competitive and overshading species such as introduced weeds, exotic pasture grasses, woody shrubs (such as burgan) and shady trees.
- Grazing by stock is a major cause of the disappearance of native grassland ecosystems in the ACT.
- The restoration of native understorey communities, including grasses, may contribute to the protection of certain woodland trees from dieback, and thus help prevent tree loss.
- Farmers and land developers utilise widespread practices such as pasture "improvement" and topsoil removal which threaten the viability of native grasslands, even where they are not directly used for grazing or urban development.
- Much of the attention given to the protection of remnant species has only been given to large and mature trees, and then only superficially; many of such specimens are never allowed to replace their genetic stock; the understorey is generally completely ignored in urban and rural situations.

Native grasses can be used for:—

- retention of habitat
- landscaping around offices, etc
- home gardens
- roadside verges
- rural areas/pastures
- understorey planting in urban areas
- soil conservation
- restoring degraded and dry land and salinity areas
- Canberra Nature Park
- restoring some heritage areas, e.g. Limestone Plains
- railway verges
- wild life conservation
- kangaroo and stock fodder
- Parliament House

Some areas containing native grassland in the ACT, which are in need of urgent attention may be listed as follows:

- National Museum Site
- West Belconnen
- Gungahlin
- Mount Painter
- Mount Taylor
- Mount Ainslie
- Yarralumla
- Cullum Brae
- Paddys River
- Grace Hill
- Canberra Nature Park
- Lake Ginninderra
- Avonley
- Dove Cottage
- Uriarra Crossing
- south Tharwa
- Monaro Highway near Jerrabomberra Creek
- Oak Hill
- York Park

Where do we go from here?

See Table 7 on action required from various authorities. The institutions listed can do so much about all this, especially by public education, consultation and a broader policy.

Response to Questions/Comments

- Improvement in public awareness is needed to resolve any superficial apparent conflict between different policy objectives, such as the tension between development and conservation, and the proximity of new building sites to grassland clusters.

- A small working group is needed to keep feeding information to the community, and to allow public consultation and promote the cause of grasslands to the authorities. The Environment & Conservation Bureau, CSIRO, NTPA, NCPA all need to be involved.

Action required:	By:
Research priorities, funding, co-ordination	CSIRO, Parks and Con., ANU, Dept. of Ag.,Soil Con., NPWS, botanic gardens
Policy formulation, co-ordination	ACT Govt., TPA, NCPA, Con Council, Dept. of Ag., Soil Con., NPWS, Federal Govt., local Govt.
Maintenance Weed control, fire management, mowing/grazing	Parks and Con., Soil Con., local Govt., NPWS,Dept. of Ag., landholders, consultants, private sector
Identification mapping, taxonomy	TPA, Parks and Con, CSIRO, ANU, NPWS, Soil Con., Dept. of Ag., botanic gardens, NCPA, SGAP
Horticulture selection, collection, propagation, distribution, marketing	nurseries, CSIRO, botanic gardens, Parks and Con., Dept. of Ag., SGAP
Education institutions, public awareness, politicians and administration	Dept. of Education, media, con. groups, SGAP, Parks and Con.,TPA, NCPA, Govt. Depts. in general

Table 7. **Summary of actions required by various authorities**

AN ACT GOVERNMENT PERSPECTIVE

Mr Norm Jensen, MLA, Executive Deputy for the Environment, ACT Legislative Assembly

Transcript

Thank you for the opportunity to talk to your seminar this afternoon. At this stage, I would also like to acknowledge the presence of John Langmore with his Joint Parliamentary Committee hat on. It is important that both arms of government responsible for planning in the ACT are talking on these issues. There is a role for both of us and I welcome John's presence.

Once again the Conservation Council is taking a lead role in providing an opportunity for issues affecting the diverse environment of the ACT to be discussed. This of course is one of the reasons why we continue to provide funds to allow the Council to operate not only as a source of advice for government but also the excellent resource centre and library where Canberra residents can research the many issues relating to the environment — an issue already addressed today by Kevin Frawley. While acknowledging that the Council will never be happy with the total amount we provide we certainly see your role as an important one and will continue to include you as a priority in our funding of community organisations and programs.

It is also fitting that this seminar is being conducted in a building surrounded by an important part of the native grasslands of the ACT. I seem to recall Rodney Falconer telling me that the day he took me on a visit of the problems of retaining the *Danthonia* and its related ecosystem, in the Yarralumla area which provides the home and important part of the limited breeding cycle of *Synemon plana* the rare moth we have heard about today. During that field trip a number of issues regarding the future of these related communities took up much of the time. As I was preparing these notes for today, it seemed likely that Rodney and Kevin would be posing some questions for me to answer during their remarks about the future management of these important parts of the territory. Accordingly I reduced the length of my prepared notes so that I could provide some response to Rodney's comments. Of course I would also be happy to answer any questions at the appropriate time.

Last weekend, the Council sponsored a seminar to discuss the planning, heritage and land administration legislative package. This package is also related to the subject we are discussing today because it provides the legislative framework for the way in which the remnant native grasslands in the ACT can be protected. All five bills will play some part in the protection of such areas, including the development of appropriate management plans. A very important part of all these bills is the provision in them for community consultation and participation and of course appeals before the final decisions are made. This afternoon I will be attending a meeting to discuss problems that may not have happened if appropriate appeal process for planning decisions had been in place.

The *Environment Assessment and Inquiries Bill* is an important part of this mechanism as it will ensure that all possible environmental impacts are assessed before development takes place and that significant natural areas are conserved. The bill will be directly related to the Territory Plan which will locate areas of the different categories of public land which have been defined in the Land Administration Bill which is also part of the package.

The Government is committed to producing a balance between retaining and enhancing ecosystems and meeting the needs and aspirations of all residents of the ACT. It is our intention to maintain the best of the Australian lifestyle with environmental quality together with the "Bush Capital" atmosphere that is important in the planning and management of Canberra. The maintenance of representative examples of native ecosystems is part of that intention. There is a place for the use of native grasses as we develop our parks in the new areas, moving away from the expensive irrigated parks of earlier days. I note from some of the information provided today that this was first started back in 1972-73.

The fact that we are considering these important issues surrounded by remnant native grasslands within minutes of the city, should remind us of the importance the community places on the protection and maintenance of such areas. Any suggestion that self government would somehow threaten this concept does not take account of the fact that there are some of us in the Assembly who are committed to ensuring that the Assembly and its members do not forget that.

What then is the role of government in this process? The excellent National Capital Development Commission reference paper on the ecological resources of the ACT was produced using the notable report by Dr David Shorthouse who has already spoken to us today. I also acknowledge the participation today in this seminar of Dr Richard Groves from the CSIRO who spoke to us about the flora of our native grasslands who also participated in the preparation of that report. I have no doubt that there are others here today who are also listed at Appendix C (of the Report). Thank you for your involvement which is indicative of the degree of expertise that we in government can call upon for advice and assistance.

Such publications play a major role in developing a greater understanding of the environment in which we live, and governments must ensure that such studies continue to be funded. One thing I did note about this excellent publication is the fact that the extent of native grasslands identified on the plant communities map is minute compared to the area identified in a much lighter yellow colour as "extensively modified species composition — pasture, cultivated areas, urban and other disturbed areas" — European farmers have certainly played a major role in the extent of this modification since they first arrived on the limestone plains with their hard-hoofed animals.

It is important for us all to work together to ensure that the area marked in dark yellow is no smaller when the next edition is produced. I seem to recall that Bolton in his book *Spoils and Spoilers* tells us that it only took about ten years for the extensive native grassland around Port Jackson to disappear.

In that context the Government, through the ACT Parks and Conservation Service, is seeking Commonwealth funds to undertake surveys of remnant native grassland ecosystems and of the specific fauna of grasslands like the endangered Pink-tailed Legless Lizard, mentioned earlier by Dr Keith Williams.

Further study of areas of native grassland fauna and flora is needed to understand the conservation needs of those ecosystems. We must continue to build on the knowledge already gathered so that informed planning and management decisions can be taken on a sound basis and not guesswork. Flora and fauna can be lost because the management techniques we used were insufficient or unsatisfactory, not because we did not care or did not want to fix the problem, but because we do not understand the needs of that particular ecosystem and the interrelationship, not only within but with other ecosystems.

It is for this reason that the Government supports the survey and research studies underway and planned by the Department of Environment, Land and Planning. I am also well aware of the many dedicated staff within the Environment and Conservation Bureau and the Interim Territory Planning Authority, some of whom are here today and helped organise this seminar, who are also committed to this ideal.

I do not need to spell out the fact that resources are limited and we must make the most of what we have. I am very encouraged that the Conservation Council, recognising the importance of a small but very important part of the ecosystem, has held this seminar today. It provides an opportunity for the further development of the existing co-operative arrangements between Government, non-government organisations, agencies and individuals, and enables us all to build on the already large networking arrangements in Canberra.

From my own personal point of view as a member of the Assembly and the Government with some responsibility in the area of environmental policy and its implementation, I see my attendance here today as an important part of my education. While I have an understanding of some of the basic principles of what we are trying to achieve as a community in the management and protection of our natural environment, it makes it much easier to argue the case within government when I have a greater understanding of the problems and issues as well as specific details of the environments that we are seeking to maintain and protect.

I have no doubt that if I had been more aware of the issue, reference to native grassland would have been included in the Government's environment policy. Some of you may well be aware that both my own party's and the Government's environment policy drew heavily on the policy of the Conservation Council.

I would like to thank you all for helping in that process today and I look forward to other opportunities to improve my knowledge even further. This will ensure that I will be able to ask the right questions if I feel some factors have been left out of the briefing process.

Responses to questions/comments

- The Government realises that it does take time to do the scientific work needed as a basis for environmental policy decisions, e.g. to complete a data base on the fauna and flora of a region.
- The Government itself has limited administrative resources, and will have to rely on the co-operation of other research and non-government agencies.
- I will ensure that consideration of grasslands is included in the next issue of the Government's environmental policy.

During Mr Jensen's session, TV Channel WIN arrived and filmed a part of the proceedings, which was broadcast that evening.

Dr Mike Dallwitz, Division of Entomology CSIRO, demonstrated throughout lunchtime a computer-aided taxonomy reference system which he has developed to assist the identification of species. He can be contacted on (06) 246 4075 or Fax (06) 246 4000.

WHERE DO WE GO FROM HERE?

Summary of discussion of co-ordination, research, education, policy.

Graeme Evans

It is clear that we have competing pressures in various ways e.g., development/conservation and even health issues (potential allergies, hay fever) when considering policies for native grasslands. We also need to consider the implications of thousands of years of Aboriginal heritage.

We also need to address the community's aesthetic conceptions when it comes to promoting native grasses for landscaping in private gardens.

Do we need a less specialised seminar for a wider audience?

Mark Horn

We need to query the objectives for preservation of grasslands. Is it appropriate for governments of the future to spend considerable sums just to preserve small pockets? The government needs to see the grasslands system working as part of an urban entity.

So, we have to look at the preservation of native grasslands within a "human needs" format.

Is it practical to do so? How do we set standards?

Keith Williams

The concept of a "spectre of community involvement" as an undesirable element should be avoided. Lobby groups are important in decision making and government and the scientific community should respond to community input to strategic plans.

Bernadette O'Leary

Decision making should be related to the "ownership of process" — it is very important to involve local people in the process, especially when we are looking at small areas.

Graeme Evans

Referring to Mark Horn's warning on standards — do we settle for and accept the rapacious pressure of developers?

Ian Lawrence

Native grasslands are definitely an issue because of proximity to urban areas, hence there are big development pressures. We'll need a strong community stance to withstand this.

Bill Willis

We'll need well researched arguments — remember that the NSW Pollution Control Commission has had to compromise on standards so that it can function.

Because of the pressure on grasslands, it is often not practicable to provide 5 acres to sustain a species, and half an acre may not be enough.

Graeme Evans

We are looking not just for ecological sustainability, but for "human effort" sustainability.

Jo Vandermark

There is a conflict of managerial priorities. Different sorts of resources have different priorities. We should help people to acquire grasses to grow at home, and assist with advice.

Bernadette O'Leary

We need a seed bank facility, but who should do it, and how?

Richard Groves

Three recommendations for action:

1. We need a guide book on grasses, like Kevin Frawley's book on trees, to tell people about the beauty of grasses, and the need to help preserve them.
2. We need to revise and update the Chan et al 1979 Inventory — to do more field surveys.
3. The record of this seminar must be distributed to a much wider audience.

Graeme Evans

How should this be done?

1. Would the National Parks Association help with a guide book? (Yes, replied Kevin Frawley, the NPA could start up but would need financial help for the first printing — once established, the second printing would be self financing.)
2. The Conservation Council, through Rodney Falconer, could organise a public seminar (NCPA's Anne Lyons Wright would help too.)
3. Could the NCPA mount a survey? Ian Lawrence commented that there are various surveys and re-surveys underway. There is a growing recognition in the administration of the importance of research, and that money will be needed for this.

Graeme Evans

But who should co-ordinate this?

Norm Jensen

As a result of today's seminar, I have decided to see if the ACT Government could be involved in a co-ordinating role. For example, next year (it's too late for this year) the Environment & Conservation Bureau 's exhibition at the Royal Canberra Show could provide more information on grasslands to the community.

On the handbook proposal, we could also have a computer base for this, which may include identification data (like Mike Dallwitz', which is quite easy to use, even at a primary school level) as well as horticultural information and clear graphics on the screen.

Mike Dallwitz

Would be prepared to help — at present, his program is used by taxonomists, but the system could be extended to various public uses. The data base can either be used on-line, or can be printed out in hard copy periodically.

Doug Waterhouse (NSW Soil Conservation Service, Cowra, Tel. 063 42 1811)

The Department of Agriculture has laminated samples of plants to increase recognition, which they take to shows and field days etc, and which are very popular and successful.

The Soil Conservation Service can provide commercial quantities of grass seeds — 30 species are planned to be propagated over the next few years — there are opportunities to collaborate.

Bernadette O'Leary

The Society for Growing Australian Plants wants to produce a publication, linking together with the NSW body for publishing.

The local chapter of the Society for Environmental Education is very keen to help.

Volunteers, even if not previously experienced, will be needed to help with research for the project.

Tom Baker

The Monaro Conservation Society is also interested in helping with the research for the National Parks' projected pocket size Field Guide to Grassland Species by Kevin Frawley.

David Shorthouse

In the United Kingdom, sites of special scientific interest became a focus for scientific examination by amateurs — we should think of adapting that idea.

Some of the ACT sites are owned by private bodies, e.g. the Church of England owns the Barton site — they should be encouraged to think of a management plan for the future — they have a trustee role for the future.

Kruno Kukolic

We saw this with Telecom — they had no idea of the significance of the Gungahlin site. It was almost too late, but we did negotiate a ploughed firebreak between their site and some public land.

Liz Dovey

Conflict over grasslands will continue, particularly as sites shrink. So it is very important to work out a co-ordinated management regime for sites. How should we set this up? Which agencies should do this? Who has the final management responsibility? How are values to be developed?

Kruno Kukolic

You need to know a lot of detail first.

Norm Jensen

The question of responsibility will come up in the debate on the Territory plan.

It is difficult in regard to requirements for existing leasehold land, but we can take account for the future, as we do in Heritage management — ITPA could require management undertakings to be written into leases.

Graeme Evans

Do we want to replicate Aboriginal patterns of burning etc?

Richard Groves

There is no point in trying to revise specific burning practices which we don't know — the main changes in vegetation are the result of changes in drainage patterns, etc. The bush burns every three or four years on average anyway.

David Hogg

There are areas which are not very easy to sustain, e.g. valleys etc. In nature, grasslands are not in a vacuum but in a continuum. If the Canberra Nature Park concept is considered, we should want to see rare plants and vulnerable areas getting a chance.

Tom Baker

We need to explain to people where and what the grasslands are, especially to people moving into new areas, e.g. is there a case for native grasses versus exotics?

Kevin Frawley

Heritage Week this year (20-27 April) is focused on remnant vegetation — we could organise a walk featuring grassland areas. (Carolyn Foster, who organises walks via NPA, would be the contact.)

Sarah Sharp

How will this report be disseminated?

Rodney Falconer

Where will the money come from for the publication?

Keith Williams

We need first to determine the standard of the publication. It should then be produced fairly cheaply (i.e., not a glossy).

Jody Moore

To make people more aware we should send out a copy of the report to people in the 43 designated areas.

Bernadette O'Leary

We need a short snappy document for that audience.

Keith Williams

There is already a co-ordinating Group on Natural Resources, the Interdepartmental Committee on the Environment's Sub-Committee on natural resources. We do not need another committee.

Graeme Evans

What about extending its membership to non-government organisations?

Ian Lawrence

It would be useful to have a wider range of skills and knowledge — suggest that in line with the ACT Government's co-ordinating role, it may be appropriate for that area to convene a body to test different options as they evolve.

Doug Waterhouse

In our district (Cowra), many people don't usually come to meetings over these topics — there is not a big public role for grasslands

Rodney Falconer

We could approach Greening Australia, Landcare and Park Care groups for help, and also the Grasslands Study Group of the Society for Growing Australian Plants (Leon Faulkner and Dermott Kelly, Adelaide).

Tom Baker

We should include the Shires and Authorities about railway verges. Note also that ACT Administration has a Landcare co-ordinator.

Norm Jensen

We should circulate a contact list, and get a group together within six months.

Rodney Falconer

The Conservation Council will do this.

Liz Dovey

Endorsed this suggestion, and requested that a list of participants, including their phone numbers, should be circulated.

The following people volunteered for the group — Rodney Falconer, CC; Jody Moore, ITPA; Anne Lyons Wright, NCPA — there will also be someone from Environment and Conservation.

There was a call for donations.

Sarah Sharp

We must put together a bibliography of publications related to the area.

Tom Baker

We should have on the Agenda for the next meeting:

- the relation of ACT environmental legislation to the native grasslands
- discussion of any relevant sections of planning or heritage legislation.

A map of the region's grasslands should be included in the proceedings. (Attached)

A few copies of Chan's map are available from the NCPA in Brisbane Avenue.

Bernadette O'Leary

Parks & Conservation has a grasslands data base.

Liz Dovey

Can the Conservation Council complete the network details?

Graeme Evans (Closing the workshop)

We agree that we will meet again in 6 months time.

We have succeeded today in raising the consciousness on grasslands issues. It is clear that there are three limitations to management planning — time, knowledge, and value systems, and we must work to overcome these.

Thank you, Norm Jensen, for attending and addressing us on behalf of the Legislative Assembly.

Thank you to all speakers and to all representatives of government departments, research institutions, and the voluntary sector who have attended.

Thank you again to Rodney Falconer for all your hard work in organising today's proceedings.

THE MEETING CLOSED AT 3.15 PM.

LIST OF THOSE ATTENDING

Atkinson, Charles	ACT Herpetological Assoc	291 0471
Baker, Tom	Monaro Conservation Society	297 4920
Calkovics, Mike	Mt Jerrabomberra Preservation Society	
Clark, John	Technical Service Unit, ACT P&C Service	288 4211
Crawford, Isobel	Grass Identification Survey	257 1860
Dallwitz, Mike	Entomology, CSIRO	246 4075
Davis, Maxine	David Hogg Pty Ltd	251 3885
Dovey, Liz	NSW N.P.W.S.	297 6144
Edwards, Ted	CSIRO	246 4257
Evans, Graeme	Conservation Council	251 1294
Falconer, Rodney	Conservation Council	247 7808
Frawley, Kevin	NPA (ACT)	271 2820
Godkin, Al	City Parks, ACT P&C Service	293 5116
Green, Kevin	Technical Service Unit, ACT P&C Service	288 4211
Greenslade, Penny	Entomology, CSIRO	254 4704
Groves, Richard	Plant Industry, CSIRO	246 5028
Hogg, David	David Hogg Pty Ltd	251 3885
Holland, Jack	Canberra Ornithologists' Group	288 7840
Horn, Mark	UWG, Conservation Council	275 0922
Jensen, Norm	ACT Legislative Assembly	275 8120
Kukolic, Kruno	Wildlife Research, ACT P&C Service	246 2490
Langmore, John	Chair Joint Parliamentary C'tee on ACT	248 5222
Lawrence, Ian	Interim Territory Planning Authority	246 8655
Lodder, Mark	ACT Landscape, ACT PWSG, DUS	246 8648
Lyons Wright, Anne	National Capital Planning Authority	271 2888
Metcalf, Rosemary	Herpetologist Society	247 3612
Moore, Jody	Environment Section, ITPA	246 8613
Nielsen, Robin	ACT City Parks	293 5164
O'Leary, Bernadette	ACT Parks & Conservation	283 5327
Ormay, Peter	ACT Parks & Conservation	251 2428
Sharp, Sarah	Environment Centre	257 5619
Shorthouse, David	Ecological Resources of the ACT	247 5816
Smith, Meredith	Minutes	251 2473
Taylor, Anne	ACT National Parks Association	258 9668
Vandermark, Jo	ACT Herpetological Society	247 7963
Veerman, Philip	Canberra Ornithologists' Group	231 4041
Waterhouse, Doug	NSW Soil Conservation Service, Cowra	063 42 1811
Williams, Keith	Wildlife Research, ACT P&C Service	246 3187
Willis, Bill	Monaro Conservation Society	297 5615

POSTSCRIPT — Spring 1991

Rodney Falconer, Director of the Conservation Council

Since the Workshop held at the National Museum in February, several significant and/or pertinent events have occurred which should be noted:

1. A **Native Grasslands Working Group** has been established by the ACT Environment and Conservation Bureau, consisting of representatives of several of the organisations mentioned above, specifically:

    - Liz Dovey/Ian Pulsford — N.S.W. N.P.W.S.
    - Rodney Falconer — Conservation Council
    - Kevin Frawley — National Capital Planning Authority
    - Richard Groves — Plant Industry, CSIRO
    - Gary Richards — ACT Planning Authority
    - Keith Williams — Wildlife ResearchUnit, ACT P&C Service
    - Sarah Sharp — University of Canberra

2. Several **studies of native grasslands** in the ACT and the Canberra Region are either underway, or in preparation. These include:

    - ongoing investigations by the ACT Parks and Conservation Service, Wildlife Research Unit into grassland species, including *Delma impar*;
    - preparation of a recovery plan for ACT grasslands by ACT Parks and Conservation, Wildlife Research Unit (ANPWS grant);
    - plantation a small trial plot of *Poa labillardieri*, *Themeda triandra* and *Danthonia richardsonii* near Lake Tuggeranong by ACT Parks and Conservation;
    - continued successful trials with roadside plantings and seeding of native grasses by the CSIRO;
    - research by post graduate students in Resource Management, Faculty of Applied Science of the University of Canberra in projects including:
        - — survey and dynamics of vascular plants and selected invertebrates, including interrelationships between these and site conditions
        - — investigation of *Aprasia parapulchella* habitats
        - — recovery plan for the endangered plants *Swainsona recta* and *Rutidosis leptorhynchoides*;
        - — production of *Information Requirements for Native Grassland Conservation in the ACT* for the ACT Parks and Conservation Service;
    - studies of the floristics of lowland grasslands in NSW, Victoria, Tasmania and South Australia through grants from the World Wide Fund For Nature (*World Wide Fund for Nature Temperate Grasslands Project).* The NSW project involves a study of the Monaro Grasslands carried out by the NSW National Parks and Wildlife Service;
    - locating areas of native grassland in the Gungahlin area of the ACT with a view to determining the potential for establishing reserves in this large area of future urban development, by several groups and individuals in association with the ACT Territory Planning Authority;
    - in preparation (grant application) is a study of the flora and fauna of cemeteries of the Southern Tablelands by the Conservation Council of the South-East Region and Canberra, pending funding from the Save the Bush grants scheme.

3. **A further site of *Synemon plana*** has been identified at York Park, opposite new Parliament House in Canberra. The site was previously known by Ted Edwards, who thought that the moths had disappeared some time ago. The site is likely to be developed in the near future as part of Commonwealth Offices. The National Capital Planning Authority has been coordinating possible management schemes for this site and an adjacent stand containing several species of native grasses. There are some problems with this site in terms of practicability of design and viability of the moth and grassland populations. Despite these discussions, the grass was mowed to lawn in early winter.

4. **Other sites of *Synemon plana***, though clearly identified and known to relevant senior officials in the ACT, have been similarly mown at low heights during autumn. These include several sites at Yarralumla, one of which has been planted out with Pin Oaks (*Quercus palustris*), a densely shading exotic tree.

5. Site of Significance Number 1 in Gungahlin, **Hall Cemetery**, was classified because of the population of ***Keyacris scurra*** that it contained. This wingless grasshopper is regarded as remaining only in a few isolated patches of ungrazed native grassland containing *Themeda triandra* tussocks (refugia) and *Helichrysum apiculatum* or *Helichrysum semipapposum* (food plants). Such locations are mostly cemeteries, railroad cuttings and a few previously lightly grazed horse paddocks. Hall Cemetery was regarded as a classic site for the species, but was low mowed late in 1990 as part of a cleanup associated with the unveiling of a commemorative plaque by an ACT minister. After several subsequent visits, Dr Key of the CSIRO's Entomology Division has concluded that *Keyacris scurra* is now extinct in this location (personal communication).

6. Site of Significance Number 13 in Gungahlin is **Mulligans Flat**, an area containing a rich mosaic of lowland woodland, open forest and native grassland. It is regarded highly by ornithologists, having populations of uncommon or declining birds, such as the Hooded Robin and Painted Button Quail. Birds such as the Little Friarbird have been recorded nowhere else in the ACT and the area is also valued as supporting ground nesting species which have been eliminated elsewhere close to urban areas. It is possible that the area may be recognised and managed for its high natural values, having high potential as a Nature Reserve. Several conservation groups are preparing submissions to ACT politicians and government authorities regarding the delineation and management of this area. It is, unfortunately, subject to heavy grazing pressure and the understorey has been reduced to patchy lawn over about two thirds of the Flat. I have been informed by the ACT Agriculture Section that stock numbers are likely to be controlled in the immediate future, and that we should be able to tell by December whether stock levels are appropriate. Some conservationists have expressed the view that December may be too late.

7. Work has commenced on the preparation of a **guidebook** to non-tree plant species in the ACT, through the National Parks Association (ACT branch) and Dr. Kevin Frawley.

8. Several **Victorian grasslands revegetation schemes** have been established, including efforts by Friends of the Organ Pipes National Park, the Department of Conservation and Environment and the Australian Trust for Conservation Volunteers and by Bushland Flora, a private organisation specialising in revegetation with indigenous flora (See Appendix 3).

Mulligans Flat is not unique in Gungahlin, as many of previous long-term leases have been subject to short-term lease conditions for several years. This has resulted in heavy grazing pressure on the hills surrounding Gungahlin to the extent that a high proportion of them have little apparent biological potential as the future areas of Canberra Nature Park or other public open spaces outlined in broad scale plans for Gungahlin. It seems ironic that much of the area intended for nature conservation and visual amenity is in what appears to be very poor repair, while many areas of woodland and grassland still remaining in Gungahlin are likely to be lost under urban development.

The area between Oak Hill and Mulligans Flat, mentioned by Dr Kevin Frawley, includes a particularly large stand of *Themeda* grassland, with vigorous regrowth of *Eucalyptus blakelyi*. It seems that this may have been an artefact of sorts. I have been informed by members of the Territory Planning Authority that the area was badly managed in the past, leading to some gullying. As a result, dams were built and stock were fenced out. The recovery over perhaps seven years has been dramatic, and the area now appears to warrant inclusion in the reserve system, logically linking Mulligans Flat with Oak Hill. Unfortunately, horses have been reintroduced and most of the area has been earmarked for urban development. Some members of the Agriculture Section of Parks and Conservation disagree with the history outlined above, and maintain that stock were never previously removed.

Some controversy remains unresolved regarding the best management of these grassed and wooded areas. Some sections of the ACT bureaucracy maintain that, in order to reduce fire risk (and insurance payments) to NSW, all adjoining areas of grassland should be grazed. This is in line with views expressed by the rural leaseholders. Such a scenario provides difficulties beyond the consequences for biodiversity recovery in native grasslands. Stock and neighbouring urban areas are not always compatible and the conservation role of substantial portions of Canberra Nature Park would be heavily compromised.

This brief resumé highlights real cause for both optimism and pessimism over the fate of the ACT's grasslands. It is clear that native grasslands have been recognised by academics, wildlife authorities and some planners as being in urgent need of attention and needing plans for recovery and management. But it is also clear that the message of one authority is not always taken up by another authority that manages an area. Certainly, little impact seems to have occurred at the level of the bulldozer driver, lawn-mower operator and grazier. There has even been some pressure from different groups in the community to remove or reduce native grasslands on the grounds of perceived fire danger to habitation or of the possibility of tall grass affording shelter to undesirable characters.

The appalling scenario of Hall Cemetery highlights the devastating effects of poor communication, coordination and education, despite noble intentions. It highlights the requirement for concerned individuals and groups not to assume that government publication of the significance of an area will necessarily ensure its protection. Fortunately City Parks is beginning to address part of the problem as it affects them. A register of significant grassland sites is being formed, and several sites have been delineated for exclusion of mowing pending more detailed management recommendations in line with conservation considerations.

Recent surveys have significantly altered Chan's 40 or so mapped grasslands, many of which have been subsumed by urban developments or by encroaching exotic pasture and weed species. One such site has been buried under extensions to William Slim Drive in Gungahlin, while one of his better sites at Yarramundi Reach was long ago buried beneath a roadway. The responsible authority could have stockpiled topsoil containing seeds of this community to be replaced along the new verges, but we are not aware that this has taken place. But other areas of grassland are also being added to the list.

It is apparent that the ACT's lowland grassland communities are still vanishing and this is often due to neglect. But it is also clear that there is a renewed resolve by some government authorities, research institutions and community groups to recover portions of what was once the dominant vegetation (or understorey) of the Limestone Plains.

The prognosis for our grasslands is still a matter for speculation. With urgent attention it may not be too late to rescue and even restore significant samples of these ecosystems, but the urgency is real.

APPENDIX 1

Bimberi Views by Rodney Falconer

Farewell to the Limestone Plains

Very few people can imagine what Canberra was once like.

When Joseph Wild explored between 1819 and 1821, he found the Molonglo and Murrumbidgee Rivers, limestone plains and lots of fires. But he didn't meet the people who were already there.

The Ngunawal nation hunted bustards and rock wallabies; they picked wild cherries and ground grass seeds into flour. They used sophisticated fire management techniques to retain the open woods and grasslands. They no longer walk through this place.

The farmers of the 19th century looked across the land they called the Limestone Plains over thickly grassed, sparse woodlands. The native grasslands have almost vanished.

The yellow grasslands of, say, Mount Painter reflect the dried colours of exotic grasses brought in to 'improve' the native pasture. Wild oats, prairie grass, rats-tail fescue and scores of other species from other countries have spread over the hills and plains, usually replacing the native grasses of the unimproved soils.

Our summers were tan, pink and silver with wallaby grass, redleg grass, kangaroo grass and spear grass. Their spring greenness was interspersed with swathes of yellow paper-daisies, purple pea-flowers, blue devils and bluebells, pink bindweeds, white early nancies and small orchids.

New suburbs threaten to sprawl into the domain of the 40 or so larger patches of remaining native grassland in places like West Belconnen. Smaller pockets still hang on in the open spaces of older suburbs, like Yarralumla and Barton.

The brolgas, bustards and rock-wallabies are gone. Emus and trout cod have been re-introduced. Once common species are now rare or vulnerable. They may be reflect the crippling of ecosystems — a wingless grasshopper, two species of legless lizard and a moth that can barely fly 100 metres. The plants have few common names, like the little yellow daisy charmingly called button wrinklewort.

But CSIRO researchers are finding ways of cultivating our native grasses and government authorities are becoming aware of lawns that don't need water and fertiliser, and only the occasional lawn-mower. Perhaps some portions of the Limestone Plains landscape might be rescued or recreated in the nick of time.

APPENDIX 2

See attachment for "Australian Grasses in Landscape Architecture — a Research Project" (Landscape Australia 4/1990, pp. 446 to 448) courtesy of Landscape Australia.

APPENDIX 3

Bushland Flora

POSTAL ADDRESS:
P.O. BOX 312,
MT. EVELYN
VICTORIA 3796

OFFICE PHONE NUMBERS:
FERNTREE GULLY 758 5416
BLACKBURN 877 3041
BURWOOD (A.H.) 889 3703
NURSERY 736 4364
FAX (COPY CAT) 729 6212

REVEGETATION OF WALLABY GRASSES

(Danthonia spp.)

INTRODUCTION

These guidelines have been prepared to help in the establishment of Wallaby Grasses (Danthonia species) from seed supplied by Bushland Flora.

SITE SELECTION

There are two important aspects of site selection:

1. The site must be completely weed free. Wallaby Grasses are not as vigorous as most exotic grasses and herbs and will not be able to establish if they have to compete with them. Sites which are poor in nutrients, with low moisture levels (like under trees), sunny north-facing, and few existing weeds, are best suited to Wallaby grasses.

2. The site must not be invaded by weeds within 3-4 months. Wallaby Grasses are slow to establish and if the site is initially weed free, but weed seeds germinate within 3-4 months then it is likley that the young Wallaby Grass seedligns will be smothered.

For these reasons we recommend Wallaby Grasses be sown only onto virgin subsoil which is free of weed seeds, or that extensive site preparation works are undertaken to eliminate all weeds and weed seeds.

Wallaby Grasses are suited only to low wear situations, and do not tolerate large amounts of foot or vehicle traffic.

SEEDBED PREPARATION

Sites which contain weeds should be sprayed (when the weeds are actively growing) with "Roundup" (Glyphosate) several times at 3-4 week intervals to kill existing growth and subsequent weed regrowth.

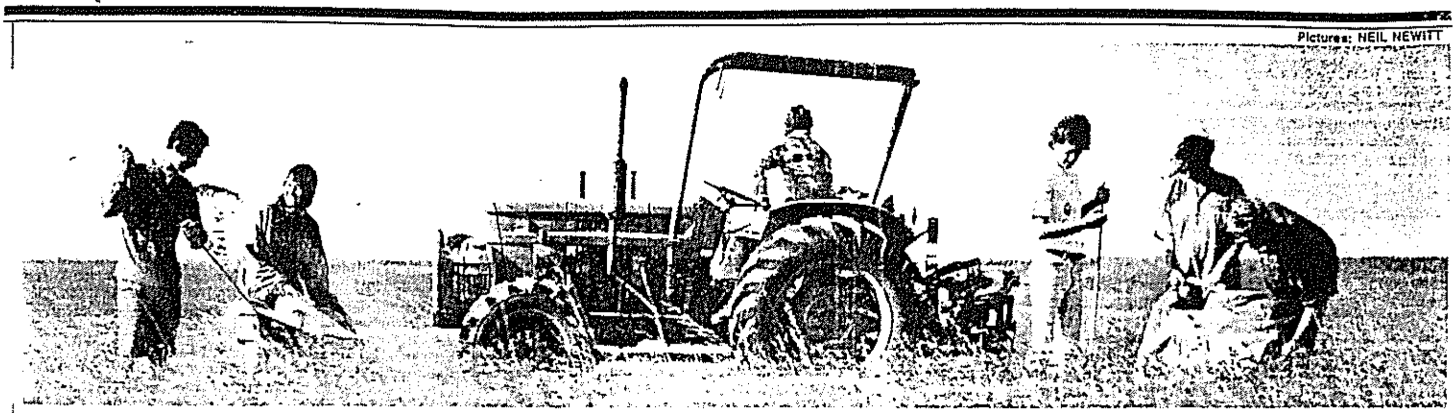
The seedbed for lawns need to be properly prepared for best results, including rotary hoeing and raking. For sites such as embankments it is best to scarify the soil surface to enable the seed to get a good hold into the soil, but rotary hoeing is normally impossible.

SOWING

Wallaby Grasses require cool temperatures and high moisture levels for germination, and must be well established to survive the first Summer. For these reasons we recommend sowing in Autumn (March onwards), after the first major rains, or Winter (upto the end of July). These times enable the seeds to germinate well, and give the seedlings enough time to establish before their first Summer.

THE AGE, Saturday 29 December 1990

Pictures: NEIL NEWITT



The harvest: Volunteers use a tractor with a sickle-bar and rakes to gather kangaroo grass on the site of a new housing estate at Taylors Lakes.

Conservationists reap a golden harvest

The sowing: Emma Kimball, of Chichester, England, scatters handfuls of the precious grass in the wind at the Organ Pipes National Park.

By KAY ANSELL

There was a time when the plains west of Melbourne were covered in kangaroo grass, a rust-colored sea rippling in the wind, stretching all the way to Bendigo.

But this scarce native grass, once considered a weed by farmers, is now a precious crop, one that is harvested at Taylors Lakes and sown in the Organ Pipes National Park.

Yesterday a group gathered at a new housing estate at Taylors Lakes to continue the annual harvest, using a tractor with a sickle-bar and rakes. The project is a combined effort by the Friends of Organ Pipes National Park, the Department of Conservation and Environment and the Australian Trust for Conservation Volunteers.

The trust harnesses volunteers throughout Australia and overseas to give practical help in conservation projects. Three young volunteers from Britain and one from the United States took part in yesterday's harvest.

It takes imagination to visualise the Keilor Plains before the white man's arrival. But if you block your ears to keep out the noise of cars, planes and trains, and avoid noticing power lines and the encroaching houses, you can almost see kangaroos grazing, along with many smaller species that have since disappeared.

Farming and the creep of housing and industrial development have led to the decline in native grasses, an environmental issue that lacks the appeal of rainforest logging and endangered marsupials. The area being harvested will also soon be swallowed up by Melbourne's urban sprawl.

Mr Matt De Luc, the senior ranger at the Organ Pipes National Park, says that recognising the value of these areas and protecting them is the challenge the community faces.

"The Keilor Plains are the third-largest lava plains in the world. We think of it in terms of the great plains of Africa. There would have been large macropods, kangaroos and wallabies.

"Here we are, 25 kilometres from the GPO — we could have massive areas of kangaroo grass ... In the long term, by sowing the grass and providing the habitat, we hope to see reptiles such as the endangered legless lizard, quails and ground-dwelling birds return."

The ground at the national park has been burnt in preparation for sowing, to eliminate competition from exotic weeds. Bales of the kangaroo grass, *Themeda triandra*, are opened and it is scattered in the wind.

Rain brings an ingenious survival mechanism into play. An awn on each seed absorbs water and coils into a corkscrew that drills the seed into the ground, where it remains dormant until spring. Barbs hold the seed in the soil to protect it from bushfires or the winds that sweep the plain.

INDEX

ARCHIVAL RECORD

REFERENCE No. 19

Edwards, T 1993
'Golden sun moth'
Australian Natural History
Vol 24(6), pp. 16-17

Will Osborne

Introduced plants rapidly displaced native grasslands, destroying the animal communities they supported.

GOLDEN SUN MOTH

BY TED EDWARDS

N PAST DECADES ENDANGERED species conservation has concentrated heavily on vertebrates. Invertebrates were poorly understood and knowledge about them was lacking. Today, for a very few, information is becoming available that indicates many are in danger of extinction.

One such species is the Golden Sun Moth (*Synemon plana*). It belongs to an ancient family of moths, the Castniidae or sun moths, which are day-flying and, like butterflies, have well-developed clubbed antennae. Adult Golden Sun Moths have a wingspan of about five centimetres and are active in the hottest part of sunny days between mid November and mid December. They inhabit grasslands dominated by certain species of wallaby grass (*Danthonia spp.*). In Canberra this is Short Wallaby Grass (*D. carphoides*). The males patrol the grasslands flying rapidly and searching for females. When a patrolling male flies over an unmated female she flips her cryptic dark grey forewings forward exposing her golden orange hind wings to which the male responds by alighting beside her. After mating the females scuttle from tussock to tussock inserting their eggs deep into the bases. The wings of the females are reduced in size so, although they can fly, they rarely do so unless frightened and then they only fly for a short distance. In this respect the species is unique in its family.

The adult moths have no mouthparts and so cannot feed or drink. They do not live long and probably die within a few days of emergence. All the feeding is done by the caterpillars which, after hatching from the eggs, tunnel in the soil feeding on the underground parts of the wallaby grass. How long they remain caterpillars is unknown but two years is the most likely period. When fully grown they prepare a vertical tunnel to the surface through which the pupa travels just before the moth emerges.

At the time of European settlement suitable grasslands inhabited by *Synemon plana* were found from Bathurst (New South Wales) through central Victoria to the South Australian border. These grasslands were prime areas for agriculture and were quickly occupied. Fortunately wallaby grass was one of the native grasses most resistant to heavy grazing by introduced stock and the grasslands survived, although probably in an altered state.

In the 1950s the use of chemical fertilisers and more vigorous introduced pasture grasses and clovers became almost universal in the areas where suitable *Danthonia* grasslands grew. These introduced plants rapidly displaced the grasslands, destroying the animal communities they supported. *Synemon plana* was once very common in the grasslands but today is known from only ten sites in the inner urban areas of the ACT, and two sites in Victoria. The largest known surviving site is the Belconnen Naval Station in Canberra, an area of some 100 hectares now under imminent threat of development, but some of the sites are no larger than a few hundred square metres.

The Golden Sun Moth is a robust survivor and can be common in these tiny

TED EDWARDS

areas, some of which have been isolated and at their present size for several decades. Nevertheless the moth is endangered because the grassland it inhabits is endangered.

None of the known sites is in a national park or part of a large reserve, and all are vulnerable to various threats. Housing and office development in Canberra threaten some of the surviving sites and invasion by introduced weeds is another major threat. *Danthonia carphoides* grassland survives best where it is lightly grazed or occasionally subject to high mowing. Without grazing or mowing the low-growing natives can become shaded and eventually choked out by taller exotic plants. Clearly at least two adequate reserves are necessary, and these would need to be carefully managed with minimum disturbance except for grazing or mowing, if the moth is to survive. Much more needs to be known of the biology of the moth and the characteristics of the grassland if they are to be successfully conserved.

The female's wings are reduced in size so, although they can fly, they rarely do.

The Golden Sun Moth is a species of some scientific interest. It was once an extremely successful moth, common over a large area of south-eastern Australia. It has the advantage of being relatively resistant to grazing and mowing, and possibly also resistant to fires. It has the disadvantage of being confined to a single plant community suited to and vulnerable to modern agriculture. It has the further disadvantage of being unable to recolonise an area distant from an inhabited site because of the relative immobility of the female. These characteristics have brought it to the edge of extinction.

Although this article is about one conspicuous species, it is important to stress that it serves as a figurehead or focus for the many invertebrates as yet unstudied that are also confined to these grasslands and also in danger of extinction. All these invertebrates play an essential role in the balance of the grassland. While many of the individual plant species in the grassland are not yet endangered, the grassland community itself is. ■

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CSIRO Report to the Wildlife Research Unit, ACT Parks and Conservation Service, Canberra

Will Osborne

CSIRO
AUSTRALIA

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Report to the

Wildlife Research Unit,
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E. D. Edwards

October 1994

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INTRODUCTION

Synemon plana is a day flying moth belonging in the family Castniidae. It is considered an endangered species. In the ACT it is found only in the lowland grasslands dominated by *Danthonia carphoides*. Some information about the moth may be found in Cook and Edwards, 1993, 1994, Douglas, 1993, Edwards, 1989, 1990, 1991a, 1991b, 1993a, 1993b, and Falconer, 1991. These references contain usually general information with not much background information. To provide this background a more extensive coverage is given in Appendix1.

Current Distribution.

The historical distribution of *S. plana* is treated in some detail in Appendix 1. The current known distribution is a series of sites in central Canberra and a few sites in Victoria. The Canberra sites are the Belconnen Naval Station which is by far the largest site, York Park, a site off Maiden St, Yarralumla, a site off Dudley St Yarralumla,and four very small sites, one off Lady Denman Drive, one near the corner of Anzac Parade and Constitution Avenue one at the eastern end of Ainslie Avenue and one near Lake Ginninderra off the western branch of Diddams Close. In Victoria populations are listed by Douglas, 1993, and are known from the Salisbury Bushland Reserve near Kiata, a minute population in the streets of Nhill, beside the Hume Highway 1 km N of Tallarook and at the base of Mt Piper near Broadford. There is a single record of a female from Bordertown, S. A. The only N.S.W. records are from last century and refer to Bathurst and Yass Plains.

Options for Research.

There are many ecological investigations which desperately need attention. Priority should go to studies to determine the fecundity of females, a simple experiment, some preliminary results of which are found in Appendix 1. Equally important is work to determine the length of the life cycle as the interpretation of all the population work carried out at York Park depends upon it. Very important is work to determine the density of *Danthonia* needed to support a healthy population. One of the principal risks to existing *Danthonia* grasslands is invasion by taller growing plants particularly introduced weeds. To what extent this invasion can occur without eliminating the moth presumably depends on the density of *Danthonia* required. These last two projects would require much time and effort.

Valuable information could also be obtained in surveying sites surrounding the city of Canberra which had not previously been looked at. All earlier information on sites was from casual observation of likely looking spots while driving around Canberra.

Use of the survey of Chan, 1980, of lowland grasslands and the recent surveys conducted by Sarah Sharp made it practicable to visit the most likely sites expeditiously. It seemed that this survey option could produce the most valuable information most quickly.

AIM

To survey as many sites in the ACT surrounding Canberra as possible in a single season to determine if *Synemon plana* was present.

METHODOLOGY

Site Selection.

Clearly a limited number of sites could be visited. Talks were held with Sarah Sharp to assess the most useful sites to visit. These were determined as having a high probability of containing stands of *Danthonia carphoides*. Some sites were included because they were of particular interest to the Wildlife Research Unit and the National Museum site was included as there was a single record of *S. plana* from that site. The following sites were visited.

Mulligans Flat
Beside Cooma Road NW of Woden Homestead
Horse Park
The Poplars, Jerrabomberra in NSW.
Campbell Park
The National Museum Site
Army Firing Range
Gungahlin Town Centre
West Belconnen.

Counts.

The survey was to establish the presence or absence of *Synemon plana* at the sites and to record some general observations about quality of the vegetation, current management and other impressions of the site. These observations are subjective but objective assessment requires far greater resources of time than was available. Nevertheless some counts were made but great caution must be exercised in interpreting them. Counts were made by standing in one spot but looking all around for a fixed period and counting all the males seen. When a male was seen the observer quickly looked away so as not to follow it. The method gives no indication of the actual number of males as one may be recorded several times but it does give an indication of the density of flying males.

Limitations of Counts.

Figure 1, taken from Edwards and Cook, 1994, shows the numbers of males captured during monitoring at York Park. It shows considerable daily fluctuation but in general there was a rough plateau in numbers extending from 25 November until 16 December. Ideally sites should be visited during this period. In practice there are many problems with this. Not all sites would match the timing at York Park. Figure 2 also taken from Edwards and Cook, 1994, shows how timing varied from one end of the site to the other even on a small site like York Park.
It can be expected that the dates of the flight period at any site will depend upon many factors, none with an exactly predictable effect.
Sites with a northern aspect will have moths flying earlier than those with a southern aspect.
Sites with light ground cover will have moths flying earlier than sites with a heavy ground cover.
Drier sites will be earlier than moister ones.
These factors will combine to exert greater differences than each singly.

The activity of the moths on each day is not necessarily the same which also made comparisons difficult and of questionable validity. The size of the male population each day and their activity will depend on several factors.

The time of day is most important. Males will not fly before about 11 am and many do not fly much after 2 pm. Even within this period probably not all males are equally active. All visits and counts had to be made between 11 am and 2pm.

Wind also affects the activity of the males. A light warm wind probably has little effect but winds over about 20km/h will have an influence. Many males will fly less in stronger winds. Those that do fly will tend to accumulate near a down-wind boundary of the site. This is a very noticeable pattern of behavior. Males that cease flying will bias the counts down, those that accumulate at an extremity of the site will bias counts down over most of the site and up in the area of accumulation.

The temperature also exerts an important effect on flight activity. Presumably the reason males will not fly before about 11 am has to do with body temperature but this holds even on very warm days. The males bask to warm up so sunshine as well as

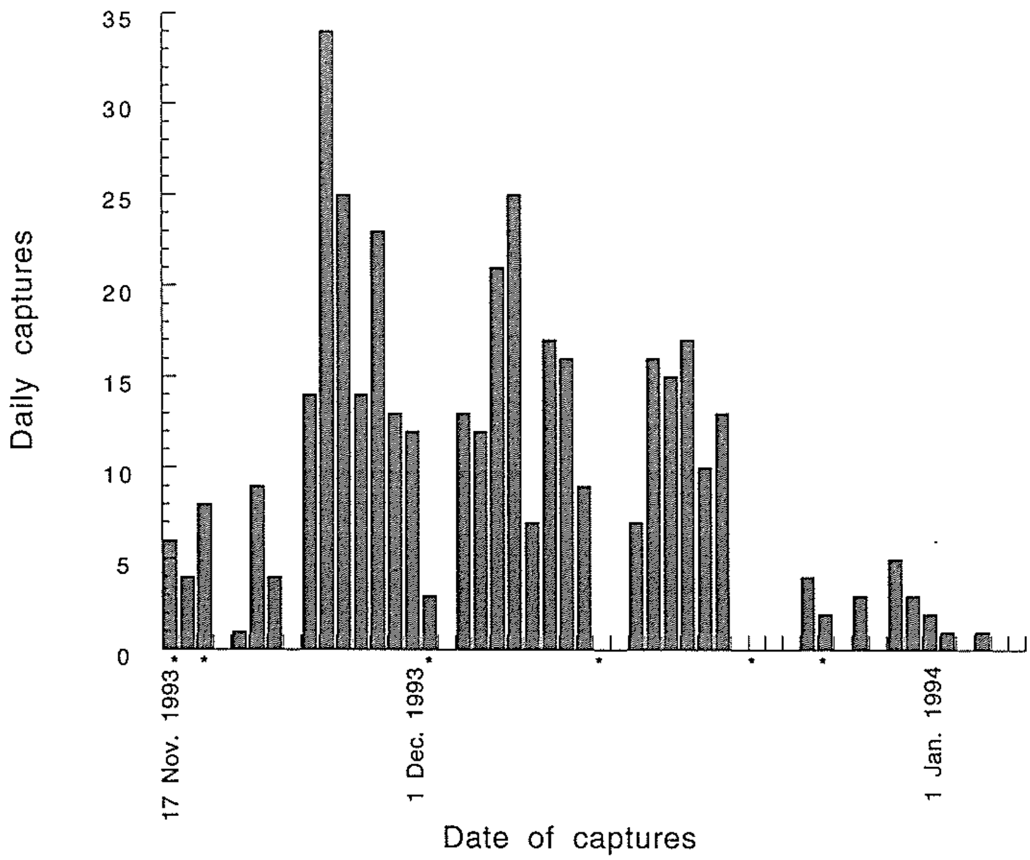

Figure 1. The number of males of *Synemon plana* captured each day. * indicates rain From Cook and Edwards, 1994

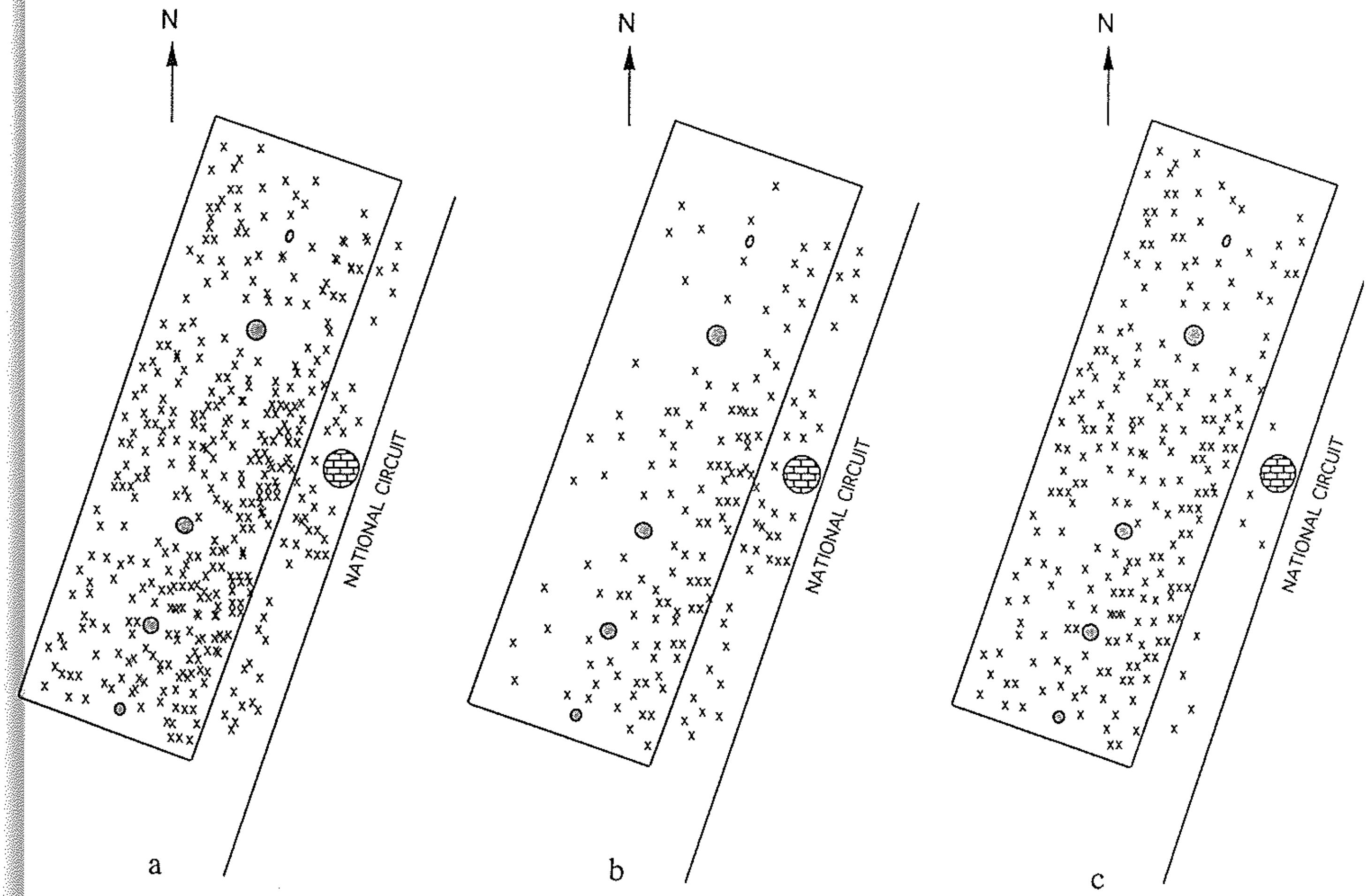

Figure 2 (a) The distribution of captures of all males of *Synemon plana* during the study period from November 16th, 1993 to January 6th, 1994. (b) The distribution of captures of males of *Synemon plana* during November 1993. (c) The distribution of captures of males of *Synemon plana* during December 1993.

tree bus shelter From Cook and Edwards, 1994 temperature is important. Once the ground becomes warm enough they may warm up by pressing close to the ground as well as basking. The first flying males are always a little slower in flight. Many Lepidoptera will fly as soon as the thoracic muscles are warm enough to function but with *S. plana* one gets the impression that they could fly earlier than they do. Many factors could be involved and no work to evaluate them has been done. It does seem probable that males wait until they can fly at almost maximun speed before attempting to fly. The most likely reason for this is pressure from predators who may find slower males much easier to catch. In any case under cold conditions male activity can be expected to be less and probably the emergence of moths from the pupae is less than in warm conditions.

Cloud cover will greatly reduce activity. As mentioned above males bask and also obtain warmth from the sun-heated ground. It sometimes happens that a very hot day is partially cloudy. In these conditions a few males may fly but many more will fly on a hot sunny day. On a sunny day if many males are flying and a cloud covers the sun even for a minute or two the males cease flight and will fly again shortly after the sun appears again. Clearly for any survey it would be a waste of time to visit a site except in full sun. The problem is firstly that counts will be clearly meaningless unless all are made in full sun. Secondly, that in a survey, a negative observation can only be made under perfect conditions. In the 1993 season we were most fortunate to have much sunny weather. In the 1991-92 season only two days would have been suitable.This does not mean that such a season is disastrous for the moths. They can fly in what short bursts of sun there are but in a survey nearly all ones time would be spent waiting for the weather and then doubting if the conditions were good enough to rely on an observation of no specimens at a site.

Rainfall may also cause a brief change in population activity. Figure 1 shows the effect of rainfall at York Park. Possibly involved is a lowering of soil surface temperature affecting the emergence of moths.

None of the sites visited were uniform and all had patches of habitat which were more suitable and other patches that were unsuitable for the moth. This is discussed for each site. Counts were made in the most suitable areas unless otherwise recorded.

Effects of different seasons.

We did not have to consider differences between seasons because the monitoring at York Park gave us a benchmark. The lenghth of the life cycle is discussed in Appendix 1. In theory a species with a two year life cycle could develop large population differences in alternate years because of the lack of mixing of odd and even year populations. In an extreme case where the 2 year cycle is strict the situation could develop where the species occurs only in odd or even years. At present we have no knowledge that this is happening. There may be enough mixing to prevent it or the species may have an annual life cycle.

Comparisons with known sites.

There are no comparisons with the previously known sites in inner Canberra. Each old site visited would have meant one less potential new site visited.

RESULTS

Mulligans Flat.

Visited. 26 November 1993. Weather full sun, warm, not windy.

Description. Mulligans Flat is a very large area which could only be surveyed by a walk across it visiting likely places. Across the area runs a fenced track/ right of way approximately W-E. North of this the vegetation is mostly woodland or open woodland with considerable open areas. In three spots across this area single males were observed. No substantial populations were seen.
South of the fenced track woodlands dominate the ridges but grasslands with scattered trees extend towards the valley floor. Next to the woodlands the grasslands are dominated by *"Chionochloa" pallida*. Downslope from this are *Danthonia* grasslands in the drier spots and *Themeda* in wetter spots. These *Danthonia* patches contained populations of *S. plana* but not large or extensive populations. Downslope from these the grasslands were dominated by *Themeda*. The *Danthonia* grasslands contained almost pure *Danthonia* and few herbaceous species were present.

Counts. Counts made in the *Danthonia* areas were 0/10mins, 1/10mins and 2/10mins.
Males were in good condition. Only one female was seen.

Management. The area south of the fenced track was lightly grazed by cattle.

Comments. The area contains small populations of*S. plana*. Most of these are south of the fenced track. To the north of the track are the only spots where I have seen the moth in patches of *Danthonia* within a woodland in the ACT. Figure 1 shows that on this date the population at York Park peaked at the beginning of the optimal survey period. However the grassland areas at Mulligans Flat are on south and east facing slopes and in 1993 generally moister than York Park. The visit may have been a bit too early for maximum numbers.

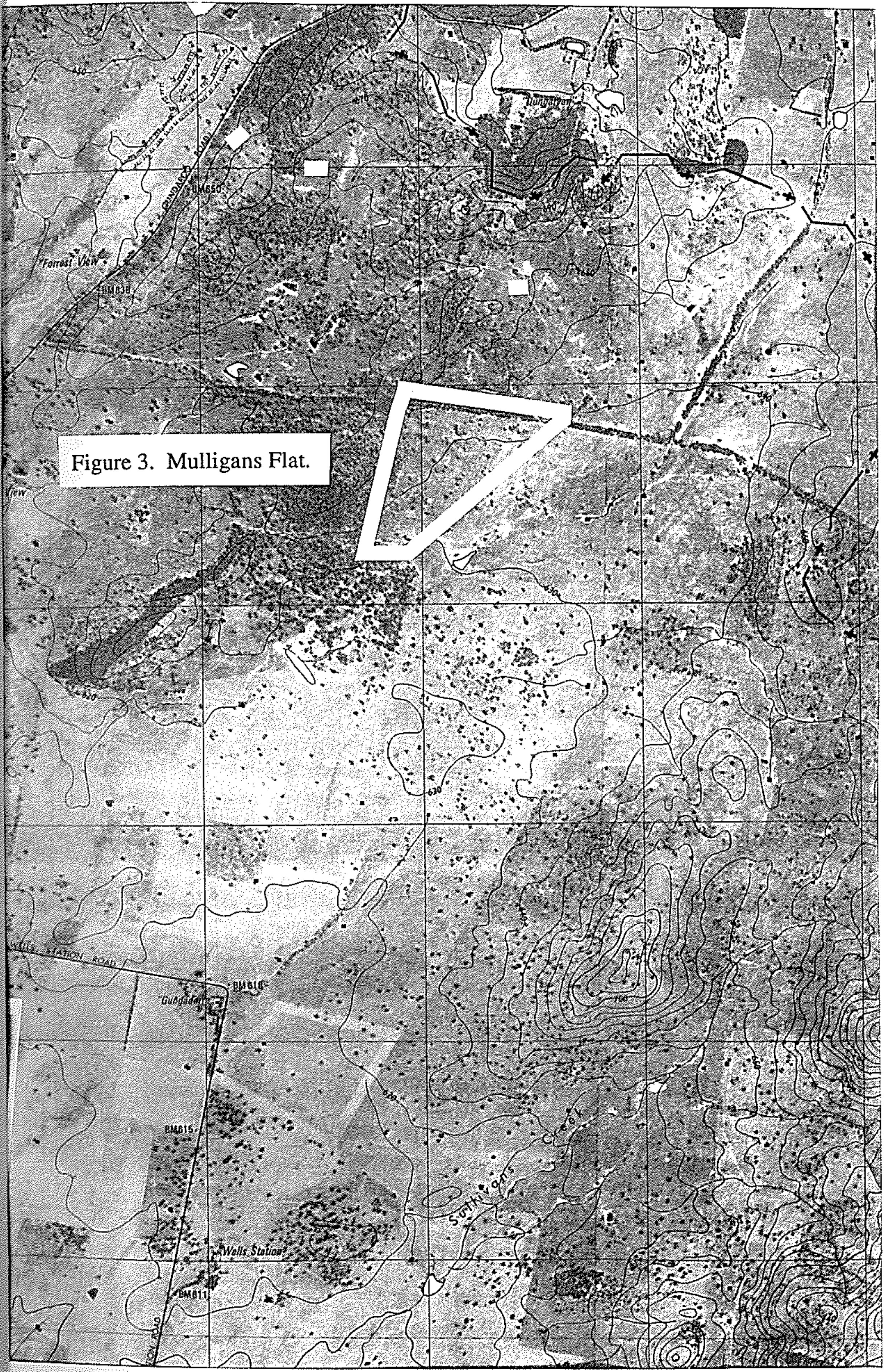
Figure 3. Mulligans Flat.
Gungahleen
BM650
Forrest View
BM630
WELLS STATION ROAD
BM618
Gungaderra
BM615
Sullivans Creek
Wells Station
BM611

NW of Woden Homestead.

Visited. 29 November 1993. Weather warm, sunny but some scattered cloud, light wind.

Description. The area examined was from the Cooma road up to the peaks of some treeless rocky knolls to the south. Behind these the ground rose further to wooded ridges.
Most of the area was a dense *Stipa bigeniculata* grassland. The *Stipa* was so dense that little *Danthonia* was growing amongst it. In some patches on the knolls and on the higher parts abutting the road there were stands dominated by *Danthonia*. In some of these patches no *S. plana* were seen but in others populations existed. The moister drainage lines near the road were heavily weed invaded.

Counts. Several counts of 1/10mins were made. In one place a count of 3/10mins was made and in another 5/10mins. These were all in *Danthonia* patches.
Males were in good condition and several females were seen. One female was taken for egg counts.

Management. The area has at times been lightly grazed by sheep. It is almost unfertilized and has never been cultivated.

Comments. The area has grasslands in excellent condition and except for weed invasion in the wettest places is very clean. While the area is managed as at present the populations should be safe. As I understand it the area is inhabited by the earless dragon which probably preys on the moth. Robberflies were also present in large numbers. Several other interesting Lepidoptera were observed here. The hesperiid butterfly *Trapezites luteus,* a widely distributed species, which feeds on *Lomandra filiformis* and is found in grasslands, woodlands and occasionally in forest but which is never very common.The anthelid moth *Pterolocera* sp.was present. This is a purely grassland species, with wingless females and a restricted distribution. It will feed on a wide range of grasses however.
This is a significant site for *S. plana* but not a densely populated one.

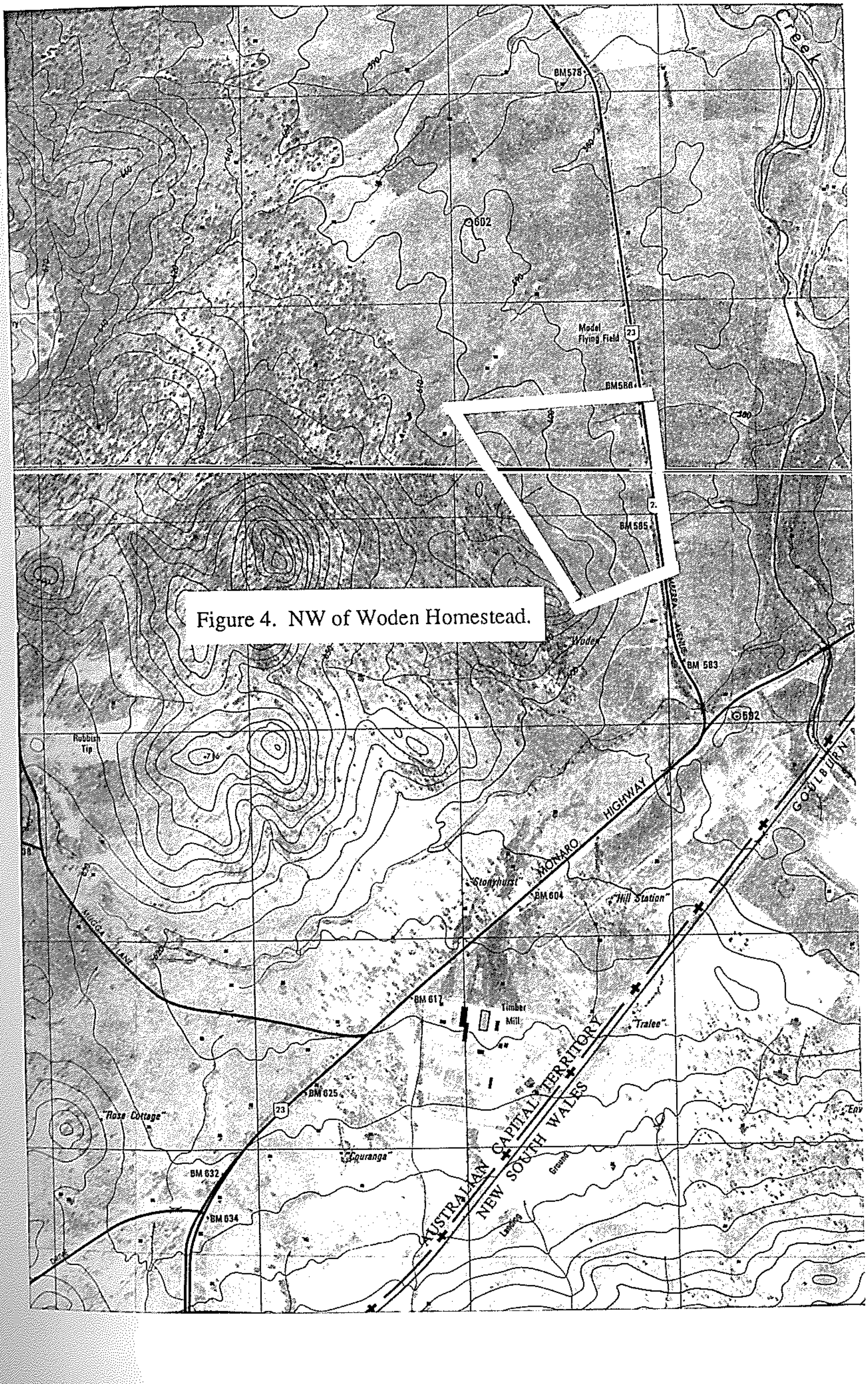
Figure 4. NW of Woden Homestead.
BM578
602
Model Flying Field
BM586
BM585
"Woden"
BM 583
602
Rubbish Tip
MONARO HIGHWAY
"Stonyhurst"
BM 604
"Hill Station"
BM 617
Timber Mill
"Tralee"
BM 625
"Rose Cottage"
"Couranga"
BM 632
BM 634
AUSTRALIAN CAPITAL TERRITORY
NEW SOUTH WALES
Creek

Horse Park.

Visited. 30 November 1993. Weather hot, cloudless, light wind.

Description. This was a large area consisting of several paddocks. Much of the area was heavily grazed and much of it was heavily infested with introduced weeds. One small paddock was less heavily grazed and consisted of a somewhat grazed *Themeda* grassland with large patches of *Danthonia*. This paddock contained grassland with a good representation of herbaceous plants and was in excellent condition but the surrounding areas were very poor. Although heavily infested with weeds the surrounding areas were so heavily grazed that *Danthonia* was common and a moderate population of the moth was widespread in the area. The paddock in the best condition contained the highest populations of any areas surveyed. This site is another illustration that moderate grazing probably increases the suitability *Danthonia* grassland to the moth but would not be ideal for many other species. The site was lightly S sloping and quite dry. Further downslope in wetter areas introduced grassy weeds like *Phalaris* and *Holcus* dominated the grassland In the degraded areas inhabited by the moth cluster clover was the main weed.

Counts. In the better paddock 18/min, 11/min and 6/ min. In the heavily degraded areas but with *Danthonia*, cluster clover and annual grasses 3/min.
Males were in good condition a series of females were seen and three taken for egg counts. Several mated pairs were seen.

Management. The area is heavily grazed by sheep and the better paddock lightly grazed. There is no sign that the area has been pasture improved by the deliberate sowing of exotics.

Comments. The small paddock was by far the most densely populated site surveyed. The surrounding areas were well populated but unimpressive as grasslands. The site must be considered significant for *S. plana* but its conservation value for other fauna is problematical. It is an important object lesson in the tolerance of *Danthonia* and *S. plana* to grazing provided this is not accompanied by cultivation or pasture improvement.

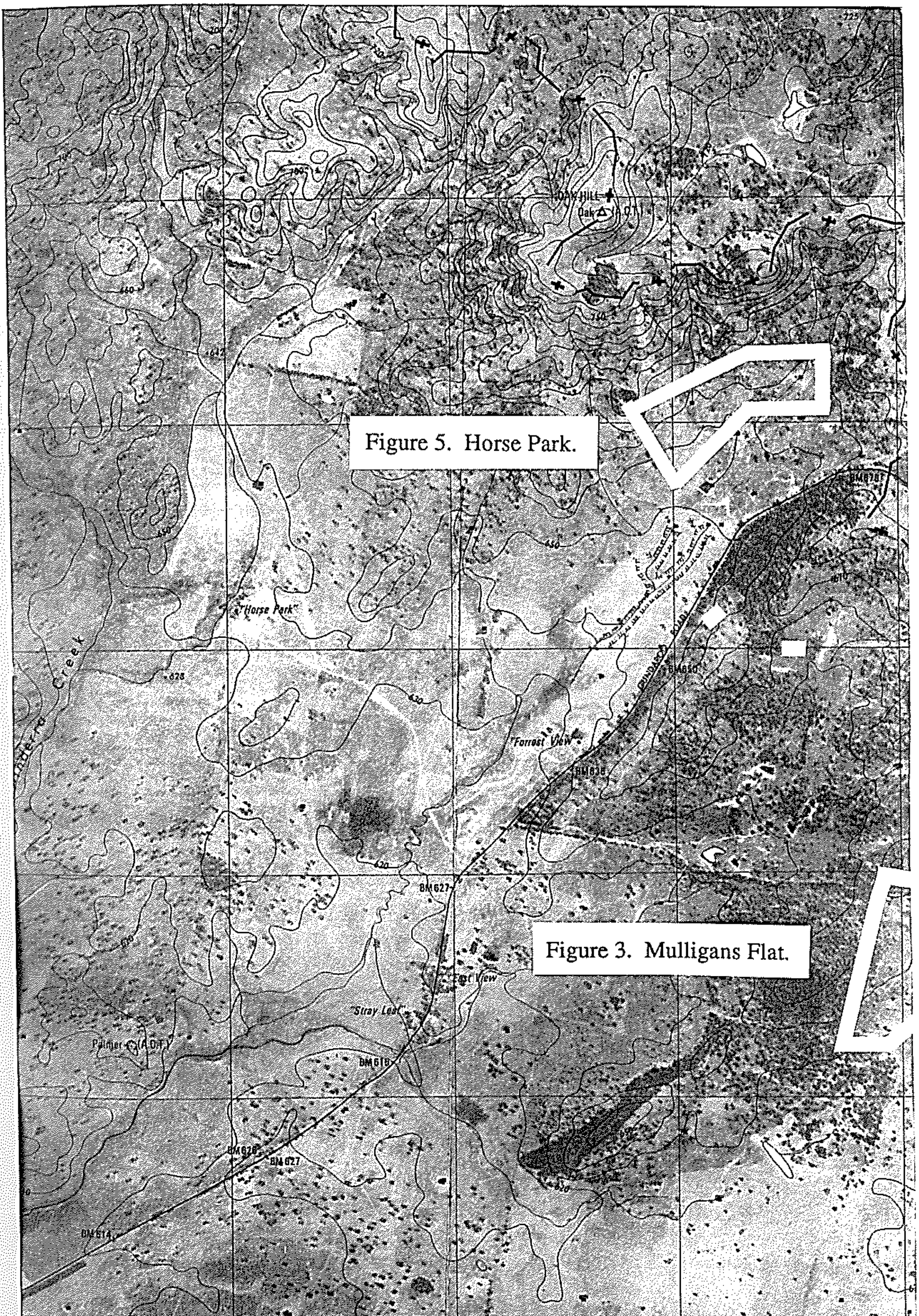
Figure 5. Horse Park.
Figure 3. Mulligans Flat.
"Horse Park"
Creek
"Forrest View"
"Stray Leaf"
BM627
BM618
BM614

The Poplars, Jerrabomberra.

Visited. 1 December 1893 Weather Sun without cloud, hot with a moderate developing to strong NW wind.

Description. The area visited is in NSW to the east of the Monaro Highway and to the north of the main Jerrabomberra entrance road. The northern boundary abutts the road serving houses at the SW foot of Mt Jerrabomberra. A graded waterway runs across the northern part of the site but there is a little grassland and some woodland to the north of this. The southern part is a grassland hill and the eastern part of the hill has an air beacon and the surrounding corner is heavily infested with *Phalaris*. The remainder of the site is mostly dense *Stipa bigeniculata* grassland. In patches in this,particularly at and towards the crest of the hill there is *Danthonia* grassland in good condition. *S. plana* was observed in all the *Danthonia* patches including those next to the woodland at the northern boundary. The main area was along the crest of the hill and for a hundred metres on each side. Some patches of *Danthonia* had very dense stands of *Chrysocephalum* and some were rather invaded by *Vulpia*.

Counts. In a patch of *Danthonia* 2/3 of way up hill 10/min, near crest of hill 4/min, 6/min, 6/min and 6/min
Males were in good condition and 3 females were seen.

Management. The area appeared never to have been cultivated or pasture improved. The SE corner was greatly disturbed as was some of the waterway. There does not seem to be significant current grazing by stock and none were present at the time of the visit. A large (30) resident kangaroo herd was grazing the area.

Comments. This is the only known population of the moth in NSW. The area is at present very healthy and represents a very useful grassland site. The moth populations present are fairly large as is the general area. Adjoining areas to the south and the west would be worth looking at but time was not available to visit them this season.

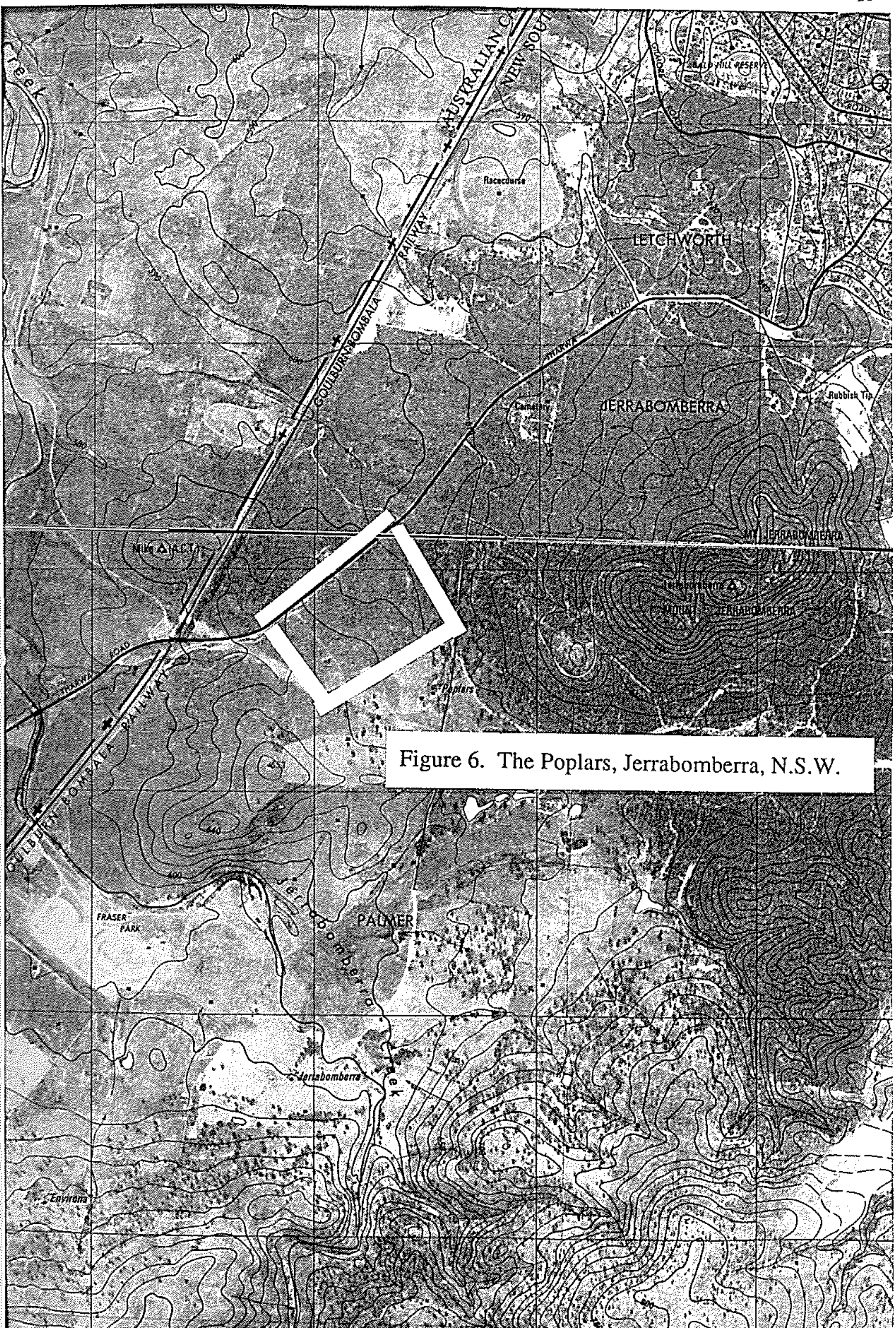

Figure 6. The Poplars, Jerrabomberra, N.S.W.

Campbell Park.

Visited. 6 December 1993. Weather partially cloudy, cool. Visit curtailed by cloudy conditions. The area was again visited on 16 December 1993.

Description. The area visited is due east of the Campbell Park offices and a little to the north. The area consists of a number of small paddocks and the grassland is very patchy. There are some patches of good *Danthonia* and some with thick *Stipa bigeniculata*. There is some invasion by exotic weeds particularly *Hypochoeris*. The area has an easterly slope and the Offices represent approximately the lower limit of the original woodland. Further to the east towards Majura Lane the areas has been more heavily used agriculturally. The area was moister than some sites. Later in December grasslands to the north up to about 1km were visited. Some areas of *Danthonia* were observed but no moths.

Counts. Three counts were made of 1/min, three of 2/min, three of 3/min and one of 5/min.
Males were in good condition and no females were seen.

Management. The proliferation of small paddocks suggests that the area was once more intensively used. At present it is lightly grazed by cattle.

Comments. The site contains reasonable populations of the moth but is heavily invaded by weeds in places. Under its present management the weed invasion will probably continue or the *Danthonia* will have to compete with *Stipa*. With appropriate management the site could become significant but at present it is best regarded as significant but minor.

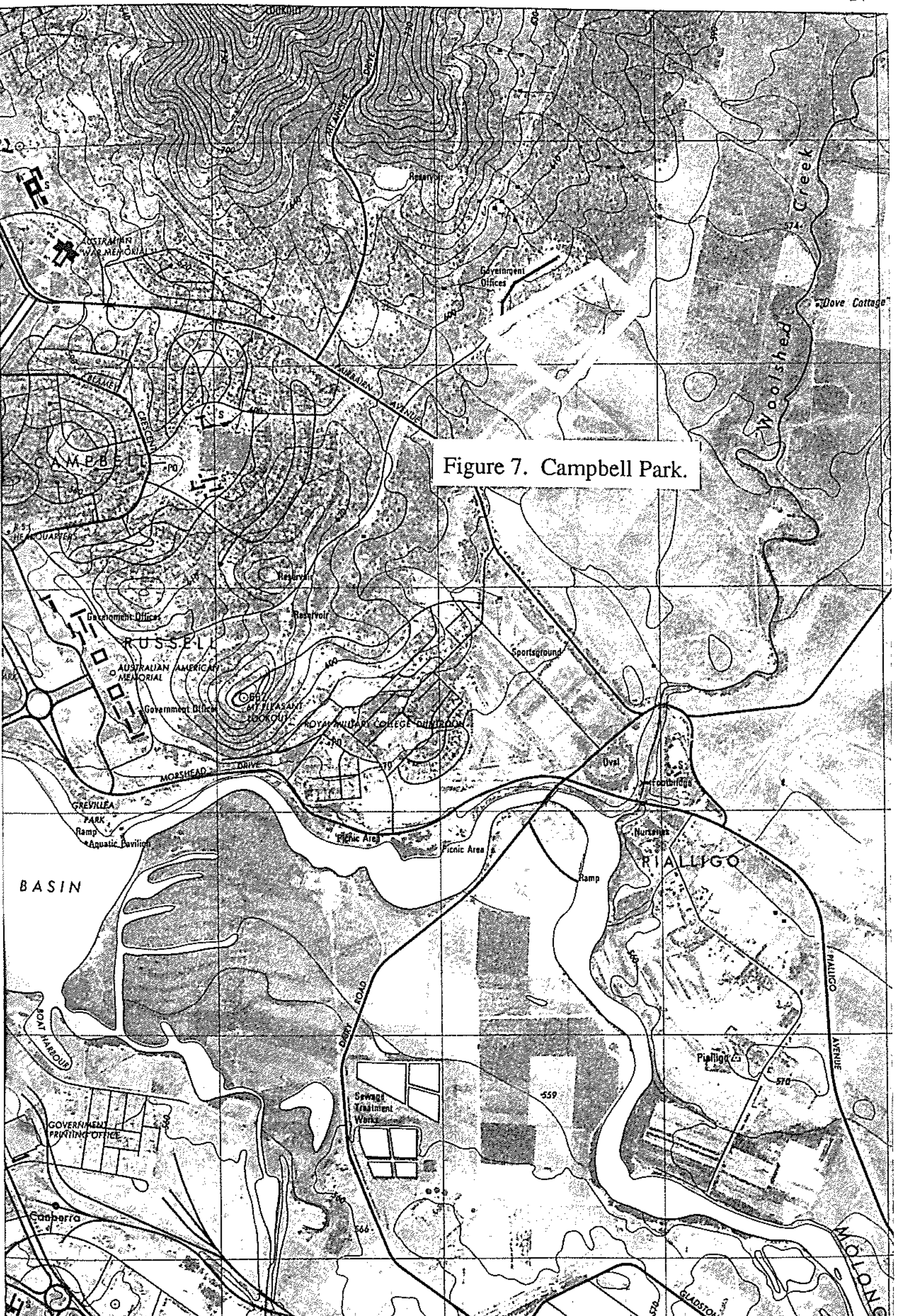

Figure 7. Campbell Park.

National Museum Site.

Visited. 9 December 1993. Weather warm some scattered cloud, light E wind.

Description. This is a fairly small site generally E sloping down to the lake. Most of the area is within an area that cannot be built on due to the possibility of flood. All the area within 10 m of the lake is overgrown with weeds. The area is mostly *Themeda* grassland and in parts this is in good condition. This site was visited because it is a high profile grassland site with the Museum authorities interested in it and interested in using it as a backdrop to museum exhibits. It was also visited because several years ago a single female *S. plana* was collected there and more information on the population was required. Now there is no *Danthonia* grassland remaining on the site and there were only a few scattered plants of *Danthonia* observed. No moths were observed in a fairly thorough search. What were previously *Danthonia* grasslands have now been overrun by *Themeda* or by introduced weeds. These weeds include *Avena, Paspalum, Festuca, Hypericum* and *Hypochoeris*.

Counts. No moths were observed.

Management. The area has not been grazed nor mown for some years and this has probably contributed to the rapid expansion of the introduced weeds.

Comments. The area is probably one of the best documented examples of the end result of no management. While the site was never large it is a pity it has degraded as it had the potential to be a useful site for education and research.

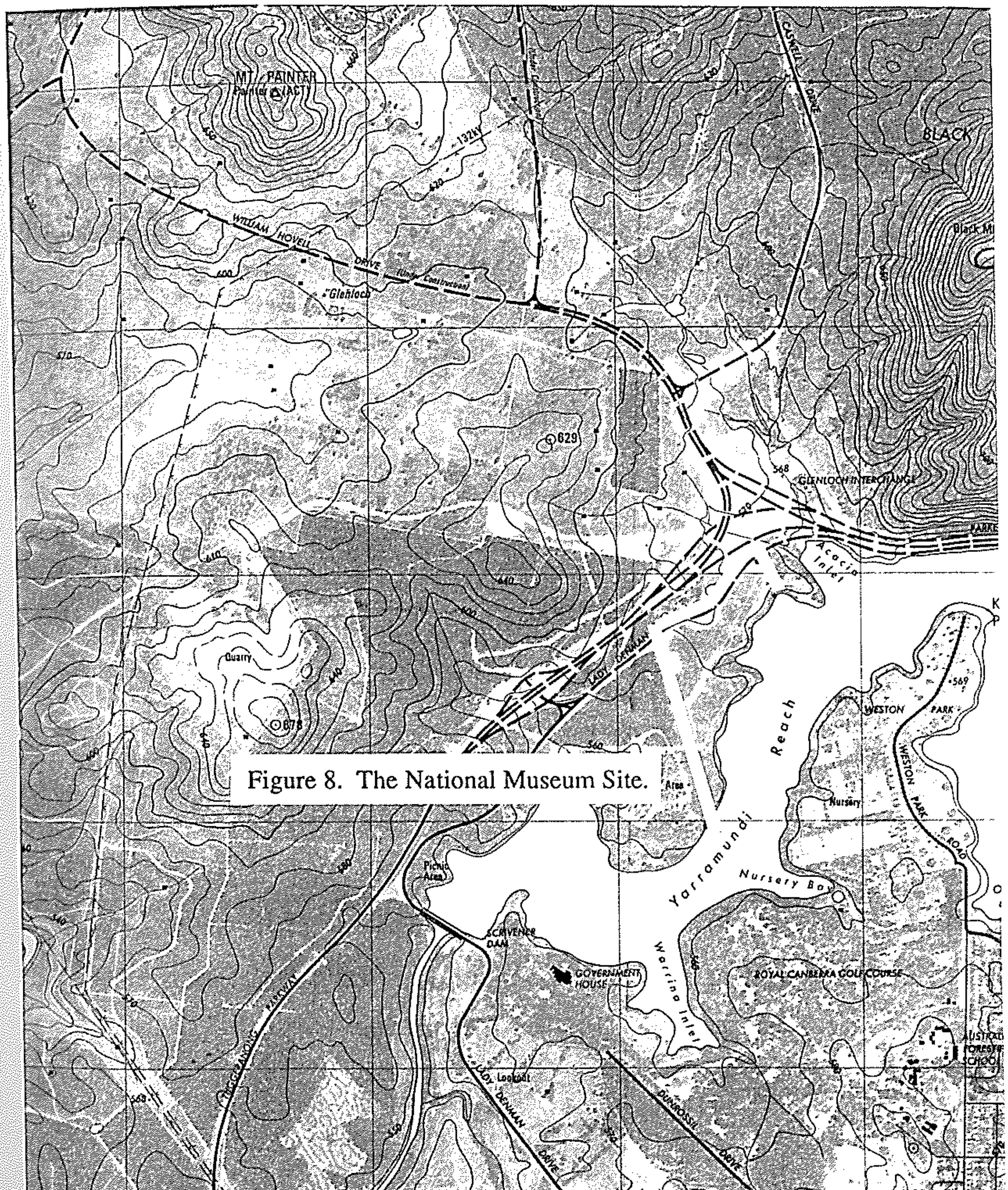

Figure 8. The National Museum Site.

Army Firing Range.

Visited. 7 December 1993. Weather partial sun some high cloud wind moderate to strong E cool.
Army authorities were most helpful in providing access to this site. Nevertheless because of other activities the site was only available on limited occasions. Hence the site was visited in less than ideal conditions. The moths were active however and the counts are probably fairly useful.

Description. This is a very large site. The area investigated was to the N and S of the access road for about 400m and from the entrance for about 1km in towards the firing range. That is from the entrance east to the first trees and the power lines. In the lowest lying areas there is a heavy invasion of introduced weeds as there was along the margins of the entrance road. Much of the area was *Stipa bigeniculata* but on the rises and small hillocks there were extensive areas of *Danthonia*. These were often quite weedy with *Hypochoeris* and saffron thistle.There was a small line of hillocks to the north of the road and one to the south near the entrance and others well into the site. These held the *Danthonia* patches except for an area along the southern boundary around a soil quarry.

Counts. Counts were made only in the *Danthonia* patches and suggested a large range of population sizes. There were two counts of 0/min, two of 1/min, one of 2/min. one of 3/min, one of 5/min, one of 7/min, and two of 9/min. The males were in good condition but no females were seen.

Management. This site has in the past been managed with light grazing mostly as a fire prevention excercise. One corner is a gravel pit and parts of the area may have been used at times in Army excercises. Because of its proximity to roads and the airport the area essentially acts as a buffer zone for the Army activities on more remote parts of the site. In the last two years the area does not appear to have been grazed.

Comments. The overall impression of this site is its large size and its great potential. It is a very varied site of great conservation value. The *S. plana* populations on the *Danthonia* patches are variable in size but some are in very good condition. The patches are all close enough together for *S. plana* to be able to move fairly freely between them. The area must be regarded as a very important site. The principal problem at present is the lack of grazing. There is every sign that introduced weeds are spreading rapidly and without some control could quickly overrun much of the area. There are conflicts of interest here as there are lizard sites in the area where heavy grazing would be detrimental. However it seems necessary to consult with the Army and to establish a management program which can be monitored for its effect on the lizards and on the moths. From an overall view point this is probably the most promising site for moth conservation of all the sites discussed in this report.

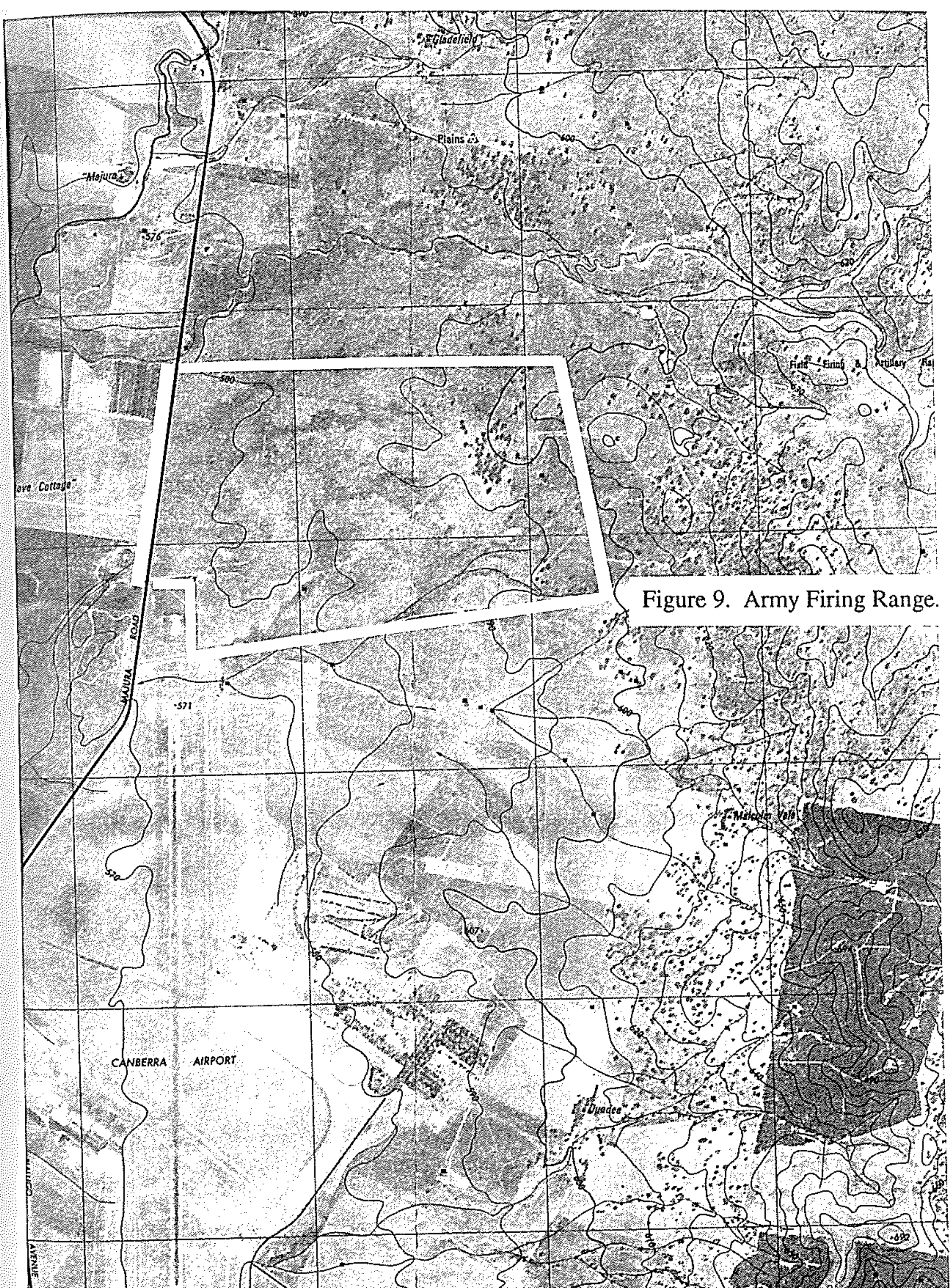

Figure 9. Army Firing Range.

Gungahlin Town Centre.

Visited. 15 December 1994. Weather sunny, cool, windy.

Description. The area is mostly a *Stipa bigeniculata* grassland with patches of *Danthonia*. In places there are heavy weed infestations. This is the same general area in which the lizard surveys have been carried out. There are several patches of *Danthonia* particularly on the higher ground. *S. plana* was present in the *Danthonia* patches in moderate numbers.

Counts. Fifteen counts of 1/min and one count of 2/min were made.

Management. Prior use seems to have been sheep grazing. It is now involved in the construction of the Gungahlin Town Centre.

Comments. This is a useful site for *S. plana* with moderate populations whose future will depent on the future land use and management of the area. It may be under threat from weed invasion if too long is taken to institute management processes.

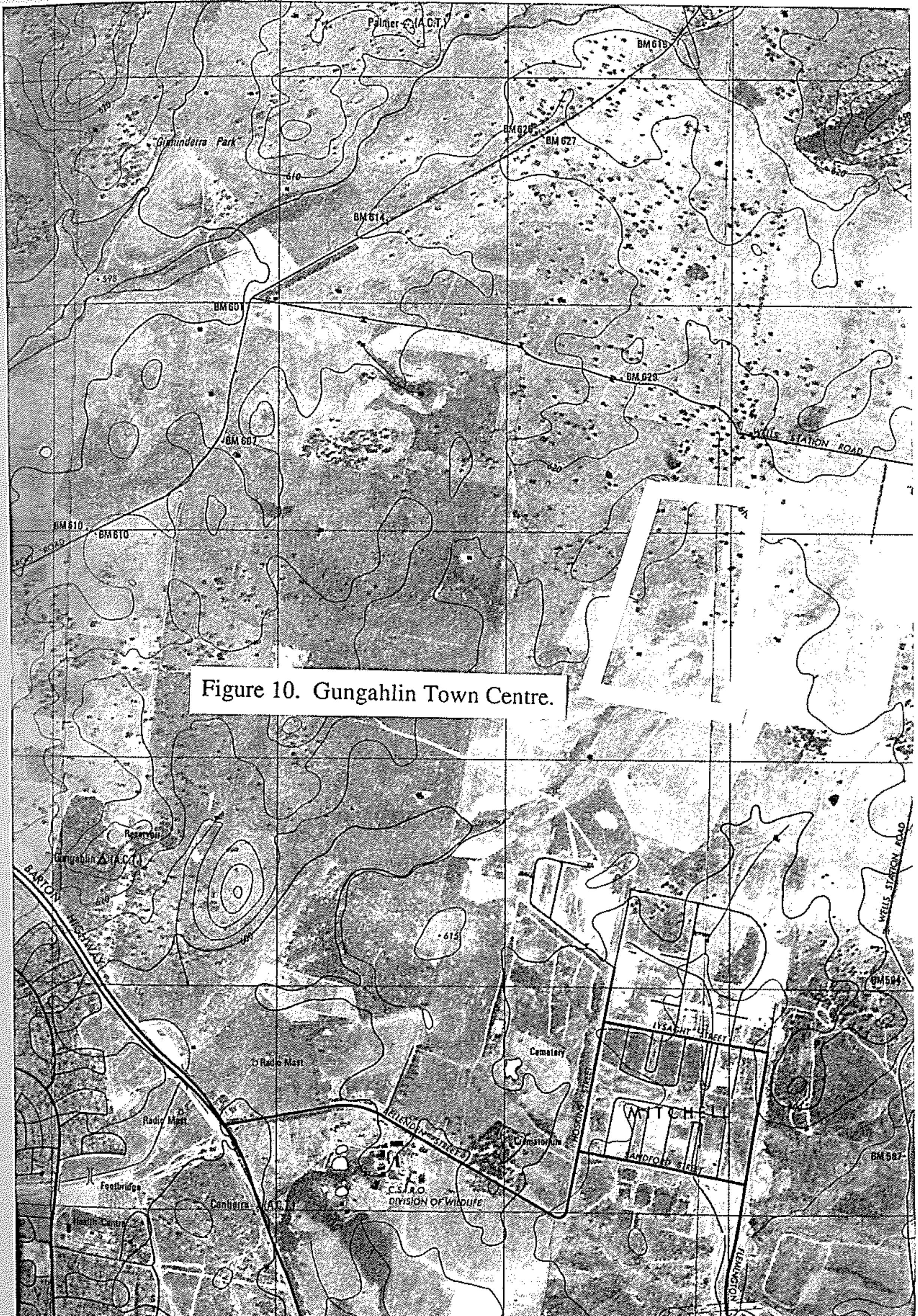

Figure 10. Gungahlin Town Centre.

West Belconnen.

Visited. 10 December 1993. Weather scattered cloud, cool, and strong wind.

Description. This is s small site surrounded by grasslands heavily infested with introduced weeds. These weedy grasslands contain *Themeda* and *Stipa* but also lots of *Bromus, Vulpia, Phalaris, Hordeum* and *Hypochoeris*. There was an area of *Danthonia* grassland under power lines along a rough track on a ridge. These power lines run close to the border between the ACT and NSW.

Counts. There were seven counts of 1/min, two counts of 2/min, one count of 3/min and one count of 5/min.

Management. The area is generally grazed by sheep but currently little grazing is occurring.

Comments. This is a small population of no outstanding conservation value. Nevertheless it is present and being so close to the border is under no immediate threat. It is mostly at risk through uncontrolled growth of introduced weeds. Occasional use of the track is probably an advantage.

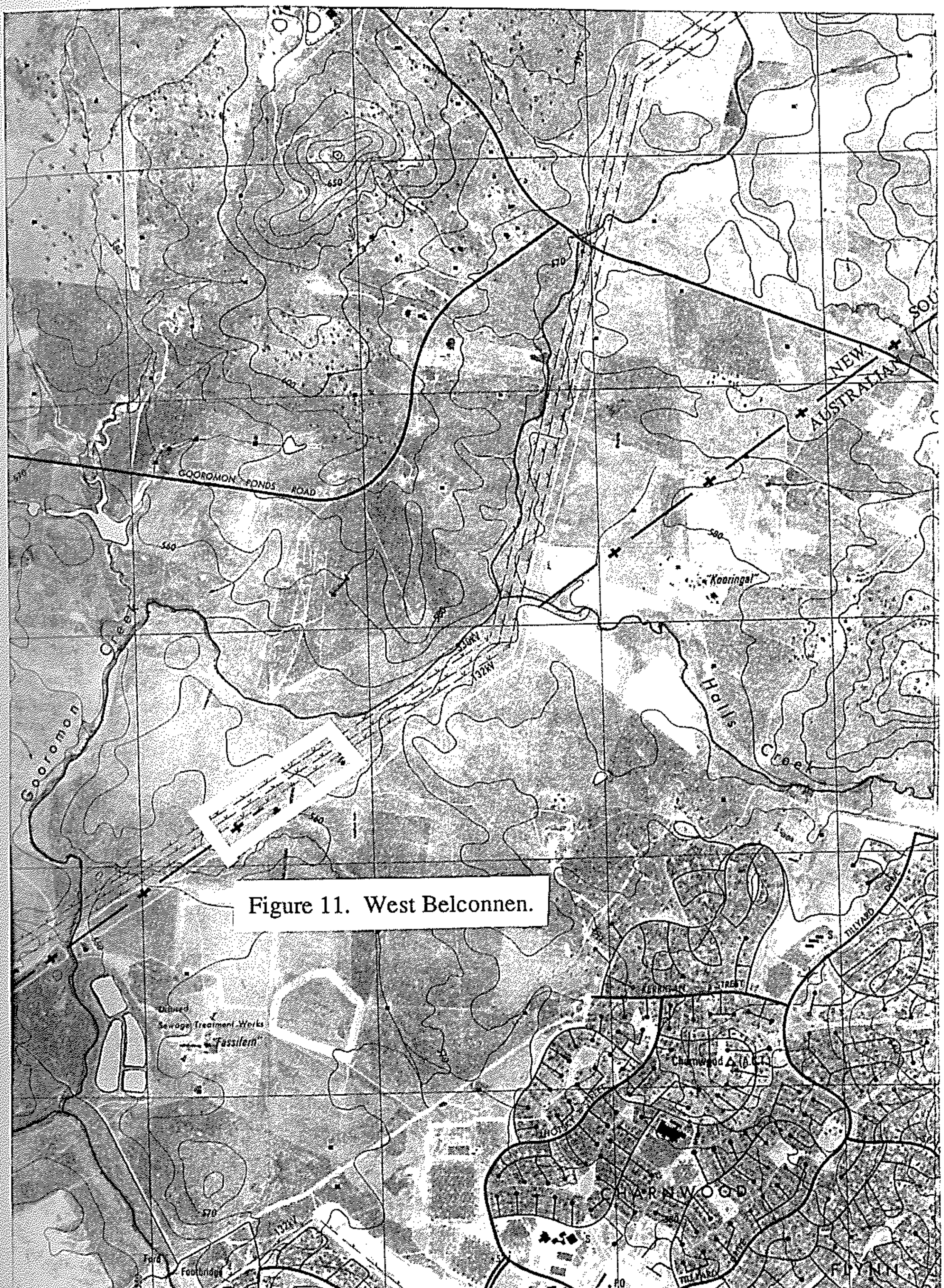

Figure 11. West Belconnen.

DISCUSSION

Not a random survey.

The survey was not a random survey and the most likely sites based on vegetation evidence were visited. Moths were found at 8 of the 9 sites. On this evidence moths could be expected to occur on further likely sites not visited. However it does not suggest that the moths are everywhere. The majority of likely sites were covered.

Counts.

The counts given are not strictly comparable, the reasons were discussed under methodology, nor is any statistical analysis appropriate. They were all made during the period when the York Park population was in full flight. They were also all made under reasonably favourable weather conditions and at appropriate time of day. This being so they do give a vague basis on which some comarisons are possible with the exception of the Mulligans Flat one where it may have been too early in the season. It is fair to say that the most dense populations were at Horse Park and the Army Firing Range and at the Poplars, Jerrabomberra.

Plant Associations.

Danthonia grasslands existed as patches in *Stipa bigeniculata* grasslands at Woden Homestead Site, the Poplars Jerrabomberra, Campbell Park, Army Firing Range, West Belconnen and at Gungahlin Town Centre. At Mulligans Flat and at Horse Park the *Danthonia* grassland was in patches associated with *Themeda* grassland.

Topography.

There was a distinct tendency for most sites to be on low ridges, hillocks or low hills. there were a few sites where *Danthonia* grasslands occurred in moister areas but almost always moist, low areas were heavily invaded by introduced weeds. Clearly any sites for reservation should contain low hills or hillocks

Management.

The elimination of *S. plana* at the National Museum site seems to be due entirely to the lack of light grazing or high mowing at the site. This has permitted the unrestricted dominance of taller growing introduced weeds. This can be contrasted with the site where *S. plana* had the most dense population which was heavily grazed, so much so that the site probably had little other conservation value. For *S. plana* to survive a grazing or mowing management program is considered essential. This will conflict with the requirements of some other fauna, particularly lizards, which benefit from the availability of thick vegetation cover. There are only two answers to this. Areas may be managed in a small scale mosaic pattern so that some areas are suitable for each at different times. Or separate areas can be managed separately each aimed at conserving different elements of the fauna. An essential component of any management program is monitoring so that it can be seen if the management scheme is working and altered if it is not.

Ranking of Sites.

1. **Army Firing Range.** This was ranked the most important site because of its size and extensive populations. It is also a more practicable proposition for conservation than some sites. Its nearness to the airport means that it is under less development pressure. Its current function as a buffer zone for army activities is compatable with its use for conservation. It urgently needs some grazing or mowing management as the weed problem seems to be intensifying.

2. **The Poplars, Jerrabomberra.** This was the next most impressive site but it must be stressed that it is in NSW and not under ACT control. The site is large and in very good condition overall with some ares very clear of weeds and other patches with moderate weed invasion. Some of the *S. plana* populations were very healthy.

3. **NW of Woden Homestead.** This was mostly in very good condition and is also a site of some importance for the earless dragon lizard. The site is of sufficient size to be viable if managed sensitively. The populations of *S. plana* were not large and in a few apparently suitable patches of *Danthonia* the moths were inexplicably absent but even so overall the populations are significant. An advantage of the site is that it seems to be under no immediate threat of development.

4. **Horse Park.** This area was richly inhabited by *S. plana* recording the highest population densities. However the site appears to have no other conservation values because if the fairly heavy grazing it is subjected to. Except for the one small paddock it is also heavily weed infested but the effects of this are subdued by the heavy grazing.

5. **Gungahlin Town Centre.** This area has substantial populations of *S. plana*. It is also a site important to lizard conservation. However the area has been considered for other land use purposes and must have a very high development value.

6. **Mulligans Flat.** This area has been set aside for conservation. The *S. plana* populations are in tiny patches in the northern parts and over larger areas in the southern parts. But the populations are much less dense than in other sites. It is possible that sampling was too early in the season. Even so it is a significant area and

given its current land use for conservation will be valuable in the conservation of *S. plana*. As the area is primarily a woodland and grassy woodland conflicts over management could be even more difficult than in purely grassland sites.

7. Campbell Park. An area with good but patchy *S. plana* populations and where weed invasion is a problem. The site is not a high priority but should be kept in mind.

8. West Belconnen. A small site, not at present under threat except by weed invasion. Again not a high priority but should be kept in mind.

9. National Museum Site. *S. plana* has probably been eliminated from this site by weed competition. Even if it is still present in such low numbers that it was not found there is insufficient *Danthonia* grassland left for survival. It is a useful lesson in the importance of management.

Other sites. In the discussion above only the sites surveyed have been ranked. Of the other sites the Belconnen Naval Station must be considered a very important site because of its size and the very dense and extensive populations of *S. plana* it contains. Because of its past grazing and mowing history the management conflicts possible on sites that support both moths and lizards could be avoided.
York Park should also be considered an important site because of its nearness to the seat of government, because it has had much work done on it, and because it now has high educational value. Its population size (and this has been measured) is such, that it is important to monitor it long term and see how viable it is. It is a site that may give early warning of problems that may occur on other larger sites. The previously known sites in suburban Canberra are shown in Figure 12.

Possibility of further sites.

It is probable that further survey work may reveal further sites and extend those already known. There is considerable potential for further sites in the Mulligans Flat area and in the northern headwaters area of Gininderra Creek. There is also potential in areas to the west and south of the Poplars site. There must be a lot of potential in NSW particularly immediately to the N and NW of the ACT.

Further Work.

The potential for further survey work is considered above.
The highest priorities for further biological work have also been discussed under options for reaseach in the introduction.
Further taxonomic and general distributional and status work is currently in hand.
There are other species of *Synemon* that should also be considered endangered.

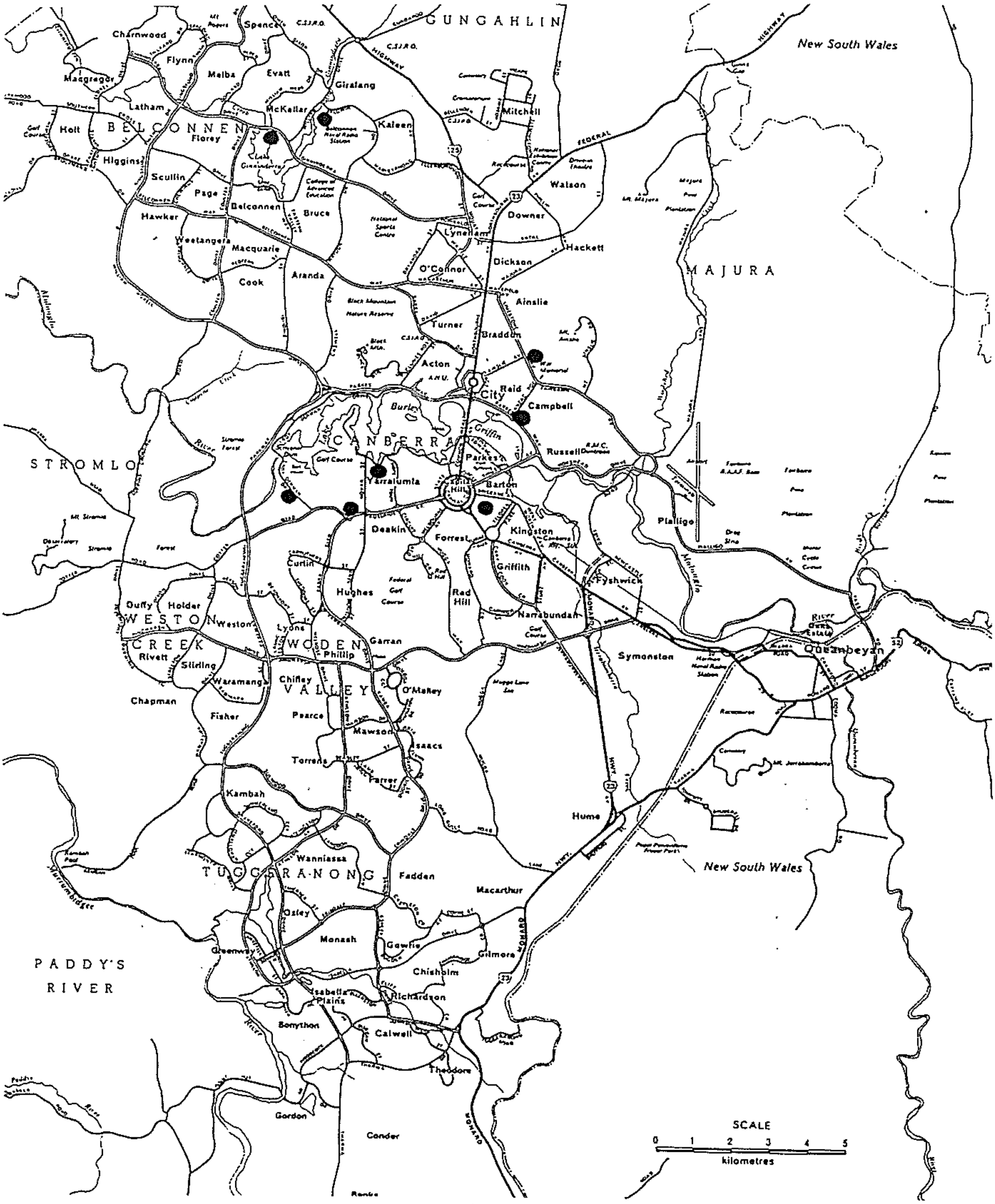

Figure 12. **Distribution of *Synemon plana* in Canberra**
Closed circles show moth locations From Edwards, 1991a

There is a lot of scope for work on management of the *Danthonia* grassland. In particular the possible strategies with mowing and grazing should be looked at to evaluate the effects on weed invasion. The Recovery Plan research program is looking at some aspects of management and this is to be welcomed.Research on management must progress to the use of different treatments on areas populated by the moths combined with close monitoring.

APPENDIX 1.

Family distribution.

Synemon plana belongs in the family Castniidae. This family has one of the classical gondwanan distributions so there is little doubt that it is of gondwanan origin. The family contains approximately 160 species in central and South America, about 43 species in Australia and three species in South East Asia. The Australian species are more closely related to the South American ones than they are to the South East Asian species. The family is not known from New Guinea nor is it known from Tasmania.
In Australia the greatest number of species are known from southern Western Australia where two or three species can often be found flying together. Not only are there more species in southern Australia but these species tend to have more limited distributions. The species in tropical areas are more widespread. Only one species inhabits Cape York Peninsula occurring as far north as Iron Range and it also occurs near Darwin. Of 43 species some 32 do not extend much north of 28 S and most occur entirely south of 28 S. Five species are known entirely between 20 S and 28 S. There are six species found entirely north of 28 S. Only 3 species occur on both sides of the Great Australian Bight. There are 3 species extending across northern Australia. There are 22 species confined to Western Australia south of the Pilbara and 15 species confined to eastern Australia including South Australia.

Early observations.

The first Australian castniid to be discovered was described by Adam White in 1841 from two specimens collected by George Grey in 1839 at Albany W.A. during his period as Government Resident there following his explorations in W.A. It was called *Synemon sophia.* This species occurs only along the southern coast in the Albany area in W.A. and is very poorly known. All subsequent references to this species are misidentifications in which it is confused with other similar species common around Perth.

Synemon plana was first described in 1854 when Francis Walker descibed two females from "Australia". In 1856 L. J. Newman recorded T. R. Oxley's description of the flight behavior of a species which was probably *S. plana* in the Victorian goldfields near Bendigo. Then G. R. von Frauenfeld, naturalist on the Austrian frigate "Novara", called at Sydney from 5 November to 7 December 1858 and was given many moths and butterflies by A. W. Scott and possibly also by W. J. Macleay. A male *S. plana* was taken back to Austria on the "Novara" and was described as a new species, *Synemon hesperioides,* by Rudolf Felder in 1874. The place of origin of this specimen was incorrectly given as "Sidney". That these are the sexes of the one species was not recognised until Tillyard published "Insects of Australia and New Zealand" in 1926 and then only implicitly.

Early Localities.

The early localities given for the moth were either vague or incorrect. Boisduval in 1875 gave only "Nouvelle Hollande" and Westwood in 1877 gave "Nova Hollandia, Hunter River". The basis for this latter locality is unknown and no specimens are known from the Hunter area. The oldest specimens known in collections are probably a short series in the Macleay Museum, Sydney, from "Yass Plains" but there are probably equally old specimens in the Museum of Victoria from a range of places north of Melbourne.The only known series from central N.S.W. was collected by Edward Meyrick near Bathurst on 14 November 1885.

From about 1890 on specimens were labelled with more precise localities and dates and from 1890 until 1950 specimens are known from the following localities (See Fig. 13).

N.S.W. None.

A.C.T. Canberra

Victoria. Alexandra, Altona, Ararat, Bendigo, Bright, Broadmeadows, Burrumbeet, Castlemaine, Dunsworthy, Eildon, Gisborne, Glenroy, Hamilton, Keilor, Kiata, Mansfield, Maryborough, Monbulk, Moolort, Nagambie, Salisbury, Riddell's Creek, Romsey, Tallarook, Tatong, Treacy, Wannon Divide, and Woodend.

Incorrect localities.

Several published localities are probably incorrect. Sydney given by Felder and Hunter River given by Westwood are two. There is a series purporting to come from Blue Lake Kosciusko National Park but intensive search has failed to produce any sign of the species at this altitude which is so at variance with other localities.

Taxonomy.

At present all Australian species are placed in the genus *Synemon* although a group of three species feeding on *Lomandra* are morphologically distinct.

The species may most easily be grouped on their foodplant requirements. There is a group feeding on *Lomandra* (Dasypogonaceae)

Lepidosperma (Cyperaceae)

Ecdeiocolea (Ecdeiocoleaceae)

Danthonia (Poaceae)

tropical grasses, *Cymbopogon, Chrysopogon, Sorghum, Eragrostis (Thellungia)* (Poaceae)

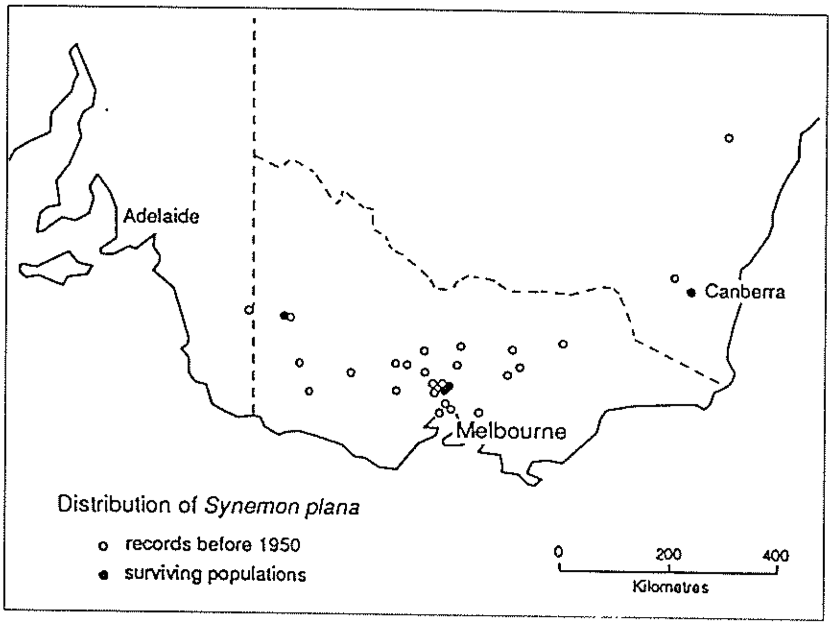

Figure 13. *Distribution of Synemon plana showing distribution before 1950 and surviving populations*

From Edwards, 1993b

Synemon plana belongs to the *Danthonia*-feeding group. This group contains the following. *S. plana*

S. selene

a parthenogenetic population which may be distinct from *S. selene*

S. nais

S. near *collecta*

S. theresa

an undescribed species from Kosciusko National Park.

Of these *S. plana* is endangered. *S. selene,* at least the bisexual population, is probably extinct. *S. selene*, the parthenogenetic population, is known from 4 sites in western Victoria. *S. nais* is known from only one surviving site in Victoria but may be extensive and secure between Ceduna S.A. and Madura W.A. *S.* near *collecta* is known from a single site in Victoria, no sites in southern or central N.S.W. but many sites on the New England Tableland of N.S.W. *S. theresa* has not been seen since 1947 but may still exist on Mt Lofty, S.A. or near Castlemaine, Vic. The undescribed species from Kosciusko National Park is at least in a reserve but is known from only one tiny population on less than a hectare beneath power lines.

Biology of *Synemon plana*.

Foodplants.

The foodplant is known to be *Danthonia*. The genus *Danthonia* is currently used as a convenience term. The application of the name to the Australian species is not taxonomically correct and *Rhytidosperma* should be used. There are several Australian grass genera more closely related to *Rhytidosperma* than is *Danthonia*. *Danthonia* in its strict sense is a European genus. There is evidence that at least three species are involved. Pupal shells have been found beside and emerging from *D. carphoides* and *D. laevis* in Canberra. Near Kiata in western Victoria they fly in stands of *D. setacea*. In determining the foodplant digging to find the pupa among grass roots is the surest method but not possible in rare plant communities. Finding protruding pupal shells within and between tussocks is the next most reliable method. Gravid females will probe many grasses with their ovipositor and it is usually difficult to determine if an egg has been deposited. The behavior of the female is not considered a good indicator of the foodplant. The best clue as to which grasses to dig under, or search for pupal shells in, is the local distribution of the adults, particularly females.

Egg.

Eggs are laid deep in the leaf bases of the culms of the host grass or between the grass and the soil by the females probing deeply with their long extensible ovipositors. It is probable that only a single egg is laid at a time.

Larva.

The larvae are underground feeders but the proportion of roots to rhizomes and culm bases eaten is not known. Certainly in the later instars the larvae tunnel in the soil and when full grown construct a vertical shaft to the surface, to permit the emergence of the pupa prior to eclosion. The larva pupates deep in this tunnel and the pupa is equipped with backwardly directed spines so that rotation causes the pupa to move forwards in the shaft.

Pupation.
When the adult is ready to emerge the pupa emerges from the top of the shaft and then the adult breaks clear of the pupal shell. This leaves the pupal shell protruding where it may be found with a thorough search.

Length of life cycle.

The length of the life cycle is unknown. The egg stage is probably about a month in duration, the pupal stage probably about 6 weeks and the adult lives from 1 to 3 days. However the larval stage could be 42, 94 or 146 weeks. It is important to know the length of the larval stage. The size of the population, as measured by counts during the flight period, may represent the whole population, half the population or one third of the population, so it is important in determining population size. It also has an important influence on gene flow in the population. A species with a very strict 2 year life cycle can behave as two isolated populations and indeed eventually become two species. In practice 2 year life cycles do not seem to be that strict and the populations behave as a single species.

Fecundity.

Adult females of *S. plana* emerge with all the eggs fully developed and almost ready to lay. In insects fully developed eggs are dosed by the female with a small quantity of seminal fluid as they are laid. The female is able to store the sperm, in some species for very long periods, and control this store adding a small volume of seminal fluid to the micropylar region of each egg as it is laid. In this way eggs may be fertilized even though the outer coating is fully developed. Actual fertilization proceeds after laying.

As the freshly emerged female has all eggs almost ready to lay then the number of eggs carried will be a measure of the potential fecundity. Three females, apparently freshly emerged, were collected and preserved at Horse Park, A.C.T. on 30 November 1993. They contained 124, 196, and 133 eggs. Clearly some females are capable of laying up to 200 eggs.

Mobility.

Males fly rapidly over the grassland searching for females. Males flying away from the grassland sometimes fly for 50 m or so but most of them quickly turn back to their grassland habitat. This implies that males can recognize suitable habitat. Males are very active fliers and given continuous habitat could cover considerable distances. Genetic interchange will be extensive given nearly continuous habitat but with the current situation with most remaining grasslands small and isolated by several kilometres the the populations will be effectively isolated. The females have reduced wings and are reluctant to fly. They will do so when disturbed but only for distances of a few metres. Whatever the mobility of the males, the females relative immobility means that grassland patches where the species has disappeared cannot be recolonised from populations more than a hundred metres away.

Feeding.

Adults of both sexes have no functional mouthparts and so can neither feed at flowers nor drink.

Longevity.

The longevity of the males has been measured by Cook and Edwards, 1993, 1994. The majority of males survive for only one or two days. The maximum age of a recaptured male was 5 days and this was in cool weather. The longevity of the female is unknown as they have not been recaptured on subsequent days. There is no reason to suppose it is any longer than that of males.

Structure of grassland.

It is not known if enough material is present beneath a single average tussock of *Danthonia* for a larva to complete development. If not (as seems most likely) then the larva needs to be able to migrate from one tussock to another. This would suggest that a grassland dominated by *Danthonia* is necessary for the species. *Synemon nais* which feeds on *Danthonia setacea* and/or *Danthonia caespitosa* occurs in a habitat where plants are more widely spaced (Douglas, 1993). *S. nais* is a much smaller moth and it is possible that the availability of a single host tussock is one reason for this. Even if development can be completed on a single tussock the fact that females probe the wrong grasses means that a high proportion of *Danthonia* needs to be present for the female to lay her complement of eggs. The development of reduced wings in the female also suggests that the normal habitat contains a high proportion of *Danthonia*. It is relevant here that all other Castniidae, including *S. nais*, have fully winged and active females. It is not known what density of *Danthonia* is necessary for the survival of *S. plana* and experiments to determine this would be most useful as weed invasion of the grasslands is a major problem and some knowledge of how far it can proceed without irreversible effects would be valuable. The presence of bare ground between tussocks may also be important as the moths bask to increase body temperature. The pattern on the procryptic forewings of *S. plana, S. nais* and *S. selene* suggest that they are adapted to resting between spaced tussocks while the pattern of others, like *S. collecta*, with forewings patterned with longitudinal lines, suggests that they inhabit denser grass.

Population density.

Estimates of the size of the population present on York Park have been made in two consecutive years (Cook and Edwards, 1993,1994). The male population was estimated at 520 in the first year and 456 in the second year. This is the population on 3500 sq.m. or one third of a hectare. Such numbers should be viable from a genetic perspective but it is not known how much the population size may fluctuate between good and bad years. There is no information on the sex ratio in nature. There is no reason to suppose anything but a 1:1 ratio but the captures of females at York Park, even allowing for their inconspicuous behavior, was very low. The sex ratio in adults needs investigation. In addition not knowing if the species has a one, two or three year life cycle means that we cannot determine the population density. York Park, assuming a 1:1 sex ratio and a two year life cycle, may support something like 1592 individuals concurrently or very approximately one for every two square metres.

Parasites and predators.

There are no records of parasites or parasitoids attacking *S. plana*. There is every reason to suppose that this is due to lack of knowledge. A number of predators have been observed. Cook and Edwards, 1994, record the willy wagtail (*Rhiphidura leucophrys*), magpie lark (*Grallina cyanoleuca*) and implicate the starling (*Sturnus vulgaris*). The robber flies (*Colepia abludo* and *Brachypogon* sp.) were also recorded.

At sites shared with the earless dragon (*Tympanocryptis lineata*) the lizards may well be predators. Predators before white settlement would have included many birds and mammals not now present. The Australian Bustard, emus and ibis are likely candidates.

Soil factors.

There has been no research on the effects of soil texture. The majority of species are found in areas of sandy or lightly textured soils. There is a species from the western Darling Downs area which inhabits heavy black cracking clays where it feeds on *Eragrostis (Thellungia) advena*. Light soils are usually better drained than heavy soils and also warm up more quickly in the spring.

Flight period.

In Canberra males at York Park were first observed on 24 November in 1992 and on 17 November in 1993. Both years were moist. In dry years the moths start flying earlier in the season in early November and possibly even at the end of October. In most years they probably start somewhere between 10 and 20 November. In 1993 the last specimen was recorded on 30 January and in 1994 on 4 January. The year 1992-3 was exceptionally wet and it is unusual for adults to be present well into January. At any one site moths from the higher drier parts fly before those from lower and moister areas. So the synchronisation of flight is probably closer in a very limited area than over a large varied site. Cook and Edwards (1994) present evidence that few moths are present on days following rain.

The flight period within the day depends upon sunshine. On a cloudless day males will start flying at about 11 am and are usually active until 2 pm. Females are rarely found before midday but their activity may extend later into the afternoon. Males are dependent on sunshine to warm up the body prior to flight and are very rarely seen in cloudy conditions.

Effects of fire.

There are no observations on the effects of fire. *Danthonia* grassland in a natural condition would only support a very cool low intensity fire. Fire, more than any other management tool, has the potential to cause a disaster to natural ecosystems. All the known populations in the ACT have survived well without any history of fire in the last 50 years. There is thus no evidence that any fire regime would aid *S. plana* populations. Timing of fire is also important. Fires undoubtedly occurred naturally very occasionally and probably most of these would have been in the hotter months. It is politically easier to burn outside this period for management purposes but it must be remembered that nearly all invertebrates will be in their most vulnerable stages during the cooler months and there will be few that are not vulnerable at some stage. Fires should never be used in management without thorough preliminary studies to a depth that has never yet been attempted in Australia. It must be remembered that before white settlement native ecosystems were much more extensive and probably the major strategy for animals to 'survive' fire was one of reoccupation of areas from surrounding unburnt areas. With the current fragmentation of habitats and their rarity this is often no longer an option. The effect of a fire is often local extinction.

In the case of *S. plana* with the larval and pupal stages underground they can probably survive fire well. However the adult and egg stages may be vulnerable, although the eggs may also survive the rapid, low intensity, fire of a *Danthonia* grassland.

Nevertheless this may be only a superficial assessment. Some of the *Synemon* that live in more frequently burnt situations are present in considerable numbers in the season after a fire, clearly having survived the fire itself, but the population in subsequent years may decline. The larvae after all live on the underground root or rhizome reserves of the plants and the mobilisation of these following fire may create a considerable food shortage for the larvae. These populations survive but, contrary to the initial impression of a healthy population immediately after the fire, there may be a longer term population crash.

ACKNOWLEDGEMENTS

I would like to thank Sarah Sharp for much helpful advice on the lowland grasslands of the ACT and advice on the most promising grassland sites to visit.
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