Australian Capital Territory

Nature Conservation (Threatened Ecological Communities and Species) Action Plan 2005 (No 1)

Disallowable instrument DI2005—84

made under the

Nature Conservation Act 1980, s 42 (Preparation of action plan)

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1 Name of instrument

This instrument is the Nature Conservation (Threatened Ecological Communities and Species) Action Plan 2005 (No 1).

2 Details of instrument

I have prepared Action Plan No 28 (ACT Lowland Native Grassland Conservation Strategy) as attached to this instrument.

This Action Plan incorporates the Action Plan requirements for the following declared items and supersedes the Action Plans previously published for the items listed below.

- Natural Temperate Grassland
- Striped Legless Lizard (*Delma impar*)
- Grassland Earless Dragon (*Tympanocryptis pinguicolla*)
- Golden Sun Moth (*Synemon plana*)
- Perunga Grasshopper (*Perunga ochracea*)
- Button Wrinklewort (*Rutidosis leptorrhynchoides*)
- Ginninderra Peppercress (*Lepidium ginninderrense*)

3 Commencement

This instrument commences the day after notification.

4 Instruments revoked

This instrument revokes the following instruments for Action Plans.

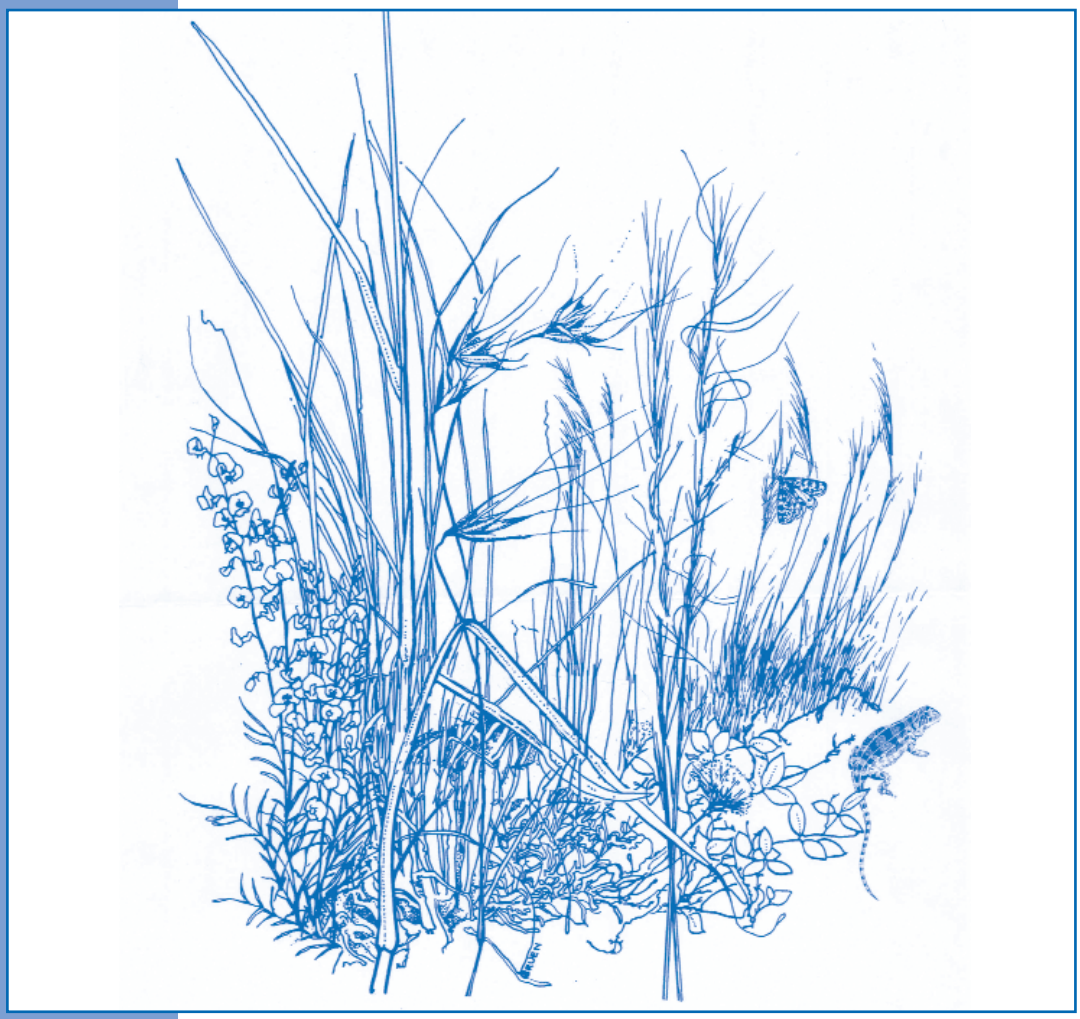
- Nature Conservation (Threatened Ecological Communities and Species) Action Plan 2004 (No 2) DI2004-44.
- Nature Conservation Action Plans for endangered species 2003 DI2003-149.

Maxine Cooper
Conservator of Flora and Fauna
5 June 2005

Action Plan No. 28

Vision Splendid of the Grassy Plains Extended

ACT Lowland Native Grassland Conservation Strategy



ACT Government

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Authorised by the ACT Parliamentary Counsel–also accessible at www.legislation.act.gov.au

Action Plan No. | **28**

A Vision Splendid of the Grassy Plains Extended

ACT Lowland Native Grassland Conservation Strategy

ISBN: 0 642 60338 3

Published by Arts, Heritage and Environment (AHE 05/1466)

Enquiries: Phone Canberra Connect on 13 22 81

Website: www.cmd.act.gov.au

Note on the title:

A Vision Splendid of the Grassy Plains Extended

With an apology to Banjo Patterson and the line from his poem 'Clancy of the Overflow':
'And he sees the vision splendid of the sunlit plains extended'.
(*The Bulletin* 21 December 1889)

Vision

The Australian Capital Territory makes an outstanding contribution, regionally and nationally, to conservation of lowland native grassland and grassland flora and fauna.

Before European settlement, the temperate grasslands of the ACT and region, and their associated flora and fauna, were part of an extensive band of grasslands in south-eastern Australia. Occurring across broad plains and in low elevation areas subject to cold air drainage, they formed a mosaic with lowland woodland and riparian and wetland communities. These grasslands and associated grassy woodlands were the natural resource base for the development of the Australian pastoral industry from the early 1800s. Their accessibility and productivity resulted in their almost complete transformation by the new pastoral economy. In the ACT, the development of Canberra in the valleys and on the plains during the 20th century destroyed most of the grassland that remained.

Natural temperate grassland is one of Australia's most threatened ecosystems. In south-eastern Australia, 99.5% of the estimated pre-European natural temperate grassland has been destroyed or grossly altered. Some form of degrading disturbance threatens all grassland remnants, even those in permanent reserves. Loss of grassland habitat and the fragmentation and degradation of the remaining areas has had a severe impact on plants and animals that are dependent on grasslands. Characteristic species of grasslands such as the Grassland Earless Dragon and the Striped Legless Lizard now survive only in small and disconnected populations. The once extensive 'wildflower' displays provided by species of inter-tussock forbs are restricted to remnants of relatively undisturbed grassland.

The *ACT Lowland Native Grassland Conservation Strategy* builds on more than ten years of survey, monitoring, research, conservation planning and management in relation to lowland native grasslands in the ACT and region. From a slim knowledge base in 1990, a good understanding has been developed of the remaining grasslands in the ACT and some of their component species. Some grasslands have been placed in reserves and there are good prospects for conserving other areas. The *Strategy* provides the strategic context for the ongoing protection, management and restoration of this unique Australian ecosystem.

Acknowledgements

The *Strategy* was prepared for the Conservator of Flora and Fauna by the Wildlife Research and Monitoring Unit of Environment ACT. The team comprised: Mark Dunford (data management and mapping), Murray Evans, Marjo Rauhala, Sarah Sharp and David Shorthouse. David Wong assisted Sarah Sharp in the 2003–04 surveys.

Assistance by contract staff, consultants and researchers in undertaking flora and fauna surveys and analyses over the past 10 years has contributed greatly to the preparation of the *Strategy*.

Kevin Frawley prepared drafts of the report and managed its compilation.

Progress in preparing the *Strategy* was reported to the ACT Flora and Fauna Committee, and individual members provided expert comment and advice.

Cover illustration modified from illustrations by Bev Bruen and Liz Faul.

Figure 2.1 provided by NSW Department of Environment and Conservation.

THIS DOCUMENT SHOULD BE CITED AS:

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).

FURTHER INFORMATION

Further information on this Action Plan or on threatened species and ecological communities can be obtained from:

Environment ACT
(Wildlife Research and Monitoring)
Phone: (02) 6207 2126
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1 Introduction

1.1

A New Focus for Nature Conservation in the ACT

In 2002 the ACT Government introduced a *New Focus for Nature Conservation in the ACT*, which includes a program to establish strategies for priority species/ecological communities. This is to ensure that resources are directed to achieving maximum effect in conservation activities. To implement this program, Environment ACT initiated a three-year review of existing Action Plans for threatened species and ecological communities.

The first review in 2002–03 resulted in *Woodlands for Wildlife: ACT Lowland Woodland Conservation Strategy* covering endangered Yellow Box–Red Gum Grassy Woodland, other lowland woodlands and the species dependent upon these woodlands (ACT Government 2004a). This *ACT Lowland Native Grassland Conservation Strategy* is the product of the second review covering natural temperate grassland (an endangered ecological community), other native grasslands, and plant and animal species dependent upon these. In 2004–05, Action Plans for aquatic species (and the riparian zone) were reviewed and a new integrated strategy prepared. These three strategies are complementary and recognise that ecological communities are dynamic—evolving and intergrading with each other, and sharing the more mobile of their constituent fauna.

Coincident with this ACT Government program, a *Planning Framework for Natural Ecosystems of the ACT and NSW Southern Tablelands* has been completed (Fallding 2002). The document was prepared through close cooperation between ACT agencies, NSW local and state government agencies and the ACT Housing Industry Association. The framework provides the basis for a more coordinated approach to threatened species conservation in the region. The *Planning Framework* does not cover all the Southern Tablelands. It includes the ACT and areas to the north-west, north-east and east of the ACT, and south to the southern border of the ACT.

The *Planning Framework* compares the pre-1750 and current distributions of the broad native vegetation types found within the ACT and NSW Southern Tablelands region. About 45% of the region supported grassy ecosystems (native grassland, grassland–woodland mosaic, box–gum woodland) pre-1750, compared to about 13% in 2000. Native grassland has been reduced from 11% of the region pre-1750 to about 1% in 2000. Only a very small proportion of the remaining grasslands are in good condition (i.e. floristically and structurally intact and having a low weed cover). Of the pre-1750 natural temperate grassland in the Southern Tablelands as a whole (i.e. extending south to the Victorian border), there is less than three percent remaining that retains a level of ecological integrity justifying recognition as having high conservation value and warranting protection.

The *Planning Framework* concludes that remnants of many vegetation types in good structural and floristic condition are relatively rare. The grassy ecosystems, including lowland native grassland 'can be regarded as the most important from a conservation planning point of view because of their extremely restricted extent following development and agricultural land use' (p. 15). Grassland sites of high biodiversity value are rare, isolated and fragmented, and with the exception of reserves established in the ACT, are poorly represented in the regional reserve network (p. 17).

1.2

Scope of the *Lowland Native Grassland Conservation Strategy*

Reflecting Government policy, the *Lowland Native Grassland Conservation Strategy* takes an integrated, territory-wide approach within a regional context, to the protection of the remaining lowland native grasslands.

The *Strategy* seeks to maintain and improve the natural integrity of the remaining lowland native grassland ecosystems. Within the grassland remnants, this means maintaining and improving the viability of the grassy ecosystem. Externally, it means maintaining and improving connectivity to other native vegetation, avoiding further fragmentation, and minimising harmful effects from adjacent land uses.

The *Strategy* recognises that in addition to natural temperate grassland, which has been declared an endangered ecological community, there are also areas of native pasture (see Chapter 2) and secondary grassland (included in the *ACT Lowland Woodland Conservation Strategy* as it is derived from cleared woodland). Lowland native grassland also exists as part of the grassland–woodland mosaic that covers about 3% of the region (Fallding 2002, p. 20). The *Strategy* encompasses the conservation of grassland flora and fauna, including those species declared as 'vulnerable' or 'endangered' under the *Nature Conservation Act 1980* (ACT).

The *Lowland Native Grassland Conservation Strategy* supersedes seven separate Action Plans previously published for the natural temperate grassland ecological community, four threatened animal species associated with lowland grassland, and two plant species—all declared threatened under the *Nature Conservation Act 1980* (ACT) (Table 1.1). The statutory requirement for the ACT Conservator of Flora and Fauna to prepare Action Plans for declared threatened species and ecological communities remains and this *Strategy* incorporates this requirement in an integrated way. While the legal authority of the *Strategy* is confined to the Australian Capital Territory, management considerations are addressed in a regional context. Should any other species associated with lowland native grassland be declared threatened in the future, the *Strategy* will require amendment to incorporate the details and requirements for that species.

The focus of the *Strategy* is lowland native grassland, including the endangered natural temperate grassland ecological community, across the ACT, regardless of tenure and land use. In this way, it differs from a management plan applied to a particular area or areas. A central purpose of the *Strategy* is to inform decision-making with regard to land use planning, and the development and management of land in the ACT.

Specifically, the *Strategy*:

- identifies the remaining areas of natural temperate grassland and other important areas of lowland native grassland in the ACT;
- identifies the floristic associations found in lowland native grassland areas in the ACT;
- outlines the values of the remaining lowland native grassland areas focusing on the conservation values of the ecological communities and component flora and fauna (recognising that areas may also have social and cultural values e.g. recreational, aesthetic, Aboriginal and European heritage);

Table 1.1: Ecological Community/Species Included in the *Lowland Native Grassland Conservation Strategy* and Existing Action Plans

Species/Ecological Community	Status	Action Plan No. Date	Declaration Date (in accordance with section 21 of the *Nature Conservation Act 1980 (ACT)*)
Natural Temperate Grassland	Endangered	No. 1, 1997 (ACT Government 1997a)	15 April 1996
Striped Legless Lizard (*Delma impar*)	Vulnerable	No. 2, 1997 (ACT Government 1997b)	15 April 1996
Grassland Earless Dragon (*Tympanocryptis pinguicolla*)	Endangered	No. 3, 1997 (ACT Government 1997c)	15 April 1996
Golden Sun Moth (*Synemon plana*)	Endangered	No. 7, 1998 (ACT Government 1998a)	15 April 1996
Perunga Grasshopper (*Perunga ochracea*)	Vulnerable	No. 21, 1999 (ACT Government 1999)	19 May 1997
Button Wrinklewort (*Rutidosis leptorrhynchoides*)	Endangered	No. 8, 1998 (ACT Government 1998b)	15 April 1996
Ginninderra Peppercress (*Lepidium ginninderrense*)	Endangered	No. 25, 2003 (ACT Government 2003b)	4 September 2003

- outlines conservation goals, objectives and actions for lowland native grassland and grassland dependent species, including those declared as threatened under the *Nature Conservation Act 1980* (ACT);
- outlines principles on which to base conservation actions;
- incorporates the Action Plans for listed species and communities which are required by the *Nature Conservation Act 1980* (ACT);
- provides a basis for planning and land management decisions with regard to areas containing lowland native grassland;
- encourages community participation in the conservation of lowland native grassland and component species;
- satisfies the requirement under section 23(2) of the *Nature Conservation Act 1980*, that an Action Plan includes proposals for the identification, protection and survival of a threatened species or ecological community, or, in the case of a threatening process, proposals to minimise its effect.

1.3

Definition of Natural Temperate Grassland

Natural temperate grassland is a native ecological community that is dominated by native species of perennial grasses. There is also a diversity of other native herbaceous plants (forbs) present. An important characteristic of the community is that it is naturally treeless, or has less than 10% projective foliage cover (see Glossary) of trees, shrubs and sedges in its tallest stratum (Moore 1964; Kirkpatrick 1993). In the ACT, natural temperate grassland occurs up to an altitude of 625 m.

The ecological community is described in greater detail in Chapter 2.

1.4

Role of the ACT Flora and Fauna Committee

The ACT Flora and Fauna Committee is established under amendments to the *Nature Conservation Act 1980* that were enacted in 1994. It is comprised of seven members with expertise in biodiversity or ecology. It advises the ACT Minister for the Environment in relation to nature conservation.

Since its establishment in 1995 the Flora and Fauna Committee has received and assessed nominations of species or ecological communities that may be threatened with extinction. The Committee is required to make assessments on nature conservation grounds only and is guided by specific criteria set out in its publication *Threatened Species and Communities in the ACT: Criteria for Assessment* (July 1995) (ACT Flora and Fauna Committee 1995). In making its assessment of natural temperate grassland and the listed plant and animal species included in this Strategy, the Committee concluded that each nomination satisfied these criteria.

As a group of experts in biodiversity, the Committee is asked to draw on its knowledge and experience of the region's flora and fauna during preparation by Environment ACT of draft and final Action Plans and to advise the Conservator of Flora and Fauna on progress in implementing them. These reviews are published in the Committee's Annual Reports. The Committee is also asked for its views on topical nature conservation issues as they apply to the ACT and it regularly provides such advice to Environment ACT. Thus the Committee is a valuable source of technical expertise, independent of Environment ACT and the Conservator of Flora and Fauna.

ACTION PLAN REVIEWS

The Flora and Fauna Committee conducts annual reviews of progress in implementing Action Plans for threatened species and communities. In 2003 the review comprised assessment of Action Plans for Natural Temperate Grassland, Striped Legless Lizard, Grassland Earless Dragon, Golden Sun Moth, Button Wrinklewort and Perunga Grasshopper, A Leek Orchid, Small Purple Pea and A Subalpine Herb.

The Committee's assessment used the following performance indicators:

- completion of commitments that can reasonably be expected to be finalised within the review timeframe (e.g. introduction of a statutory protection measure for a species; development of a management plan);
- completion of a stage in a process with a time line that exceeds the review period (e.g. design or commencement of a research program);
- commencement of a particular commitment that is of a continuing nature (e.g. design or commencement of a monitoring program for population abundance); and
- expert assessment of achievement of conservation objectives of the Action Plan.

The Flora and Fauna Committee reported in October 2003 to the Conservator of Flora and Fauna

recommending that the species included in the review (with the exception of A Subalpine Herb *Gentiana baueuerlenii*) be incorporated into this *Lowland Native Grassland Conservation Strategy*. A Leek Orchid (*Prasophyllum petilum*) and the Small Purple Pea (*Swainsona recta*) are found in grassy woodland and have been included in the *ACT Lowland Woodland Conservation Strategy*. The Committee noted that the protection and management of lowland native grassland areas (and associated threatened species) would become increasingly important because of development pressures in areas such as the Majura and Jerrabomberra valleys. The Committee recommended that greater priority be given to education of the Canberra community about grassland conservation, and expressed concern that no Memorandum of Understanding had been negotiated with Canberra Airport in relation to the protection of native grasslands.

1.5

Relevant Legislation

1.5.1 ACT Planning and Land Management

The *Australian Capital Territory (Planning and Land Management) Act 1988* provides for two categories of land in the ACT:

- National Land—used by or on behalf of the Commonwealth, and managed by the Commonwealth; and
- Territory Land—all the remaining land of the ACT. The ACT Government manages this land on behalf of the Commonwealth.

Important areas of natural temperate grassland on National Land occur in the Majura Valley, Jerrabomberra Valley (HMAS Harman) and at the Belconnen Naval Station.

The *National Capital Plan* (NCA 2003) sets out general land use policies for the Territory as a whole and may specify areas of land that have the special characteristics of the National Capital as Designated Areas. The Plan may set out detailed conditions of planning, design and development in Designated Areas. The National Capital Authority has planning responsibility for these areas, which may be either National Land or Territory Land. This *Lowland Native Grassland Conservation Strategy* accords with relevant objectives of the *National Capital Plan* (p. 5), and principles and policies in the *Plan* for the National Capital Open Space System (Ch. 8), Rural Areas (Ch. 9) and Environment (Ch. 11).

Planning for areas that are not Designated Area is the responsibility of the ACT Planning and Land Authority and planning policies are set out in the *Territory Plan* (ACTPLA 2003).

1.5.2 Legislation Applying to the Conservation of Flora and Fauna in the ACT and Region

The following legislation applies to the conservation of flora and fauna in the ACT and region:

***NATURE CONSERVATION ACT 1980* (ACT)**

The *Nature Conservation Act 1980* provides authority for the Conservator of Flora and Fauna to manage Public Land reserved for conservation of the natural environment. Activities that are inconsistent with management objectives for nature conservation are controlled. Special measures for conservation of a species or community of concern can be introduced in a reserved area, including restriction of access to important habitat. Provisions of the *Nature Conservation Act 1980* are applicable to National Land (which is land used by, or intended to be used by the Commonwealth).

Part 1 of the Act establishes the ACT Flora and Fauna Committee with responsibilities for assessing the conservation status of ACT flora and fauna and the ecological significance of potentially threatening processes. Where the Committee believes that a species or ecological community is threatened with extinction or a process is an ecological threat, it is required to advise the responsible minister, and recommend that a declaration be made accordingly.

Parts 4 and 5 of the Act provide for protection of native plants and animals. Section 21 of the Act authorises the declaration of (a) a vulnerable or endangered species, (b) an endangered ecological community, and (c) a threatening process, based upon the advice and recommendation to the responsible Minister by the ACT Flora and Fauna Committee.

Native plants and animals may also be declared as ‘protected’ (s. 17) or as having ‘special protection status’(s. 16) in recognition of a particular conservation concern that warrants additional protection. Increased controls apply to declared species and licensing constraints are specified. Species declared as endangered under the Act, or threatened with extinction, must also be declared as having special protection status. This is the highest level of statutory protection that can be conferred on a species in the ACT. Further information on these matters can be obtained from Environment ACT by phoning the Arts, Heritage and Environment Helpline on 6207 9777.

Under s. 47 of the Act, the Conservator of Flora and Fauna may give the occupier of land, directions for protection or conservation of native plants and animals. This provision is relevant to the management of threats to a species or ecological community of concern that occurs on leased land. Conservator's directions were issued in January 2004 to lessees in the Jerrabomberra Valley to ensure that natural temperate grassland and a population of the Grassland Earless Dragon are protected while consideration is given to the pattern of future land use in the valley.

Part 9 of the Act allows the Conservator to enter into a Management Agreement with an agency where its activities have potential to conflict with nature conservation objectives. This provision is relevant to management of conservation threats on unleased land and applies to utilities (e.g. gas, electricity), navigation and communication facilities, and land development.

LAND (PLANNING AND ENVIRONMENT) ACT 1991 (ACT)

The *Land (Planning and Environment) Act 1991* is the primary authority in the ACT for land planning and administration and establishes *The Territory Plan*. One of the goals of the *Plan* is 'to promote ecologically sustainable development, protect biodiversity, and provide for high standards of environmental amenity, urban design and landscape' (ACTPLA 2003). The *Plan* identifies nature reserves, national parks, wilderness areas and special purpose reserves within the Public Land estate. The Act requires that management plans be prepared for areas identified as Public Land under *The Territory Plan*.

The Act provides for *The Territory Plan* to incorporate a Heritage Places Register. Places of natural heritage significance may be included in the Register and conservation requirements specified. The Act also provides for environmental assessments and inquiries to be initiated in relation to land use and development proposals. This is included in *The Territory Plan* environmental planning policies.

It should be noted that Part IV (Environmental Assessments and Inquiries) and Part V (Land Administration) of the *Land (Planning and Environment) Act 1991* apply to all Territory Land. This includes Territory Land within Designated Areas under the *National Capital Plan* (see s. 1.5.1) that is subject to regulations under the Act. In circumstances where the regulations do not apply, collaborative solutions are sought between the Territory and the Commonwealth.

The Canberra Spatial Plan (ACT Government 2004b) was released in March 2004 and provides a clear strategic direction for the development of Canberra over the next 30 years and beyond, but with the flexibility required to respond to change. It sets the framework for spatially based decision making in the future and outlines the actions needed to achieve the strategic direction for Canberra over the next 30 years. *The Spatial Plan* does not replace the *Territory Plan*, but will inform changes to both the *Territory Plan* and the *National Capital Plan*.

The *Spatial Plan* contains key principles to guide the future growth of Canberra. Protection of the natural environment is one of these key principles. The *Plan* states that the location of future residential development will ensure that areas identified as having significant biodiversity values, such as threatened species and ecological communities and habitat for threatened species, are protected from development. In particular, the *Spatial Plan* notes that development in the new employment corridor in Majura, Symonston and Jerrabomberra, including around the airport, will take into account the areas of native grassland and habitat for threatened species that are of significant nature conservation value.

ENVIRONMENT PROTECTION AND BIODIVERSITY CONSERVATION ACT 1999 (COMMONWEALTH)

The *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) is the primary Commonwealth legislation for environment protection. Under the EPBC Act, an action will require approval from the (Commonwealth) Environment Minister if the action has, will have, or is likely to have a significant impact on a matter of national environmental significance and it is not subject to certain specified exceptions. Exceptions include actions taken in accordance with Commonwealth accredited management plans. The Act also promotes ecologically sustainable development through the conservation and ecologically sustainable use of natural resources, the conservation of biodiversity, and a cooperative approach to the protection and management of the environment involving governments, the community, landholders and indigenous peoples.

Matters of national environmental significance trigger the Commonwealth's environmental assessment and approval responsibilities. The matters are: World Heritage and National Heritage properties, Ramsar wetlands of international importance, nationally listed threatened species and ecological communities, migratory species protected under international agreements, Commonwealth marine environment and nuclear actions.

'Natural Temperate Grassland of the Southern Tablelands of New South Wales and the Australian

Capital Territory' and several of the plant and animal species included in this *Strategy* are listed as threatened under the EPBC Act. There is also potential application of the EPBC Act in the ACT to nationally listed threatened species (see Table 2.4, 2.5), National Land, and in relation to Commonwealth actions (see http://www.deh.gov.au/epbc/index.html).

The Commonwealth prepares Recovery Plans for species and ecological communities listed under the EPBC Act (e.g. *National Recovery Plan for Natural Temperate Grassland of the Southern Tablelands (NSW and ACT): an endangered ecological community* (Environment ACT 2005)). In situations where such Recovery Plans coincide with ACT Action Plans or ACT management responsibilities, every effort is made to ensure coordination, consistency and cooperation between the Commonwealth and ACT governments and their agencies.

Pursuant to s. 23 of the *Nature Conservation Act 1980*, the *Draft ACT Lowland Native Grassland Conservation Strategy* was released for public comment on 12 October 2004 for the period to 21 December 2004. Twelve submissions were received and a detailed analysis of these was presented to the Flora and Fauna Committee on 14 March 2005. The *Strategy* has been finalised, taking into account both the submissions and the advice of the Committee.

***THREATENED SPECIES CONSERVATION ACT 1995* (NSW)**

The *Threatened Species Conservation Act 1995* (TSC Act) provides for the protection of all threatened plants and animals native to New South Wales (with the exception of fish and marine plants which are covered by other laws). Under the Act, threatened species are classified as endangered or vulnerable. A recovery plan must be prepared for endangered species (other than those presumed extinct), endangered populations, endangered ecological communities and vulnerable species. For each key threatening process that is listed, the NSW Department of Environment and Conservation (Parks and Wildlife Division) is required to prepare a threat abatement plan.

One of the important features of the TSC Act is the integration of the conservation of threatened species into development control processes under the NSW *Environmental Planning and Assessment Act 1979*. The effect of a development or activity on threatened species must be considered by a consent and/or determining authority. Where there is likely to be a significant effect on threatened species, the preparation of a species impact statement is required.

The requirements of this legislation, including the preparation of recovery plans by the NSW Department of Environment and Conservation (Parks and Wildlife Division), apply to four species included in this *Lowland Native Grassland Conservation Strategy*. These are the Striped Legless Lizard (Vulnerable, TSC Act), Grassland Earless Dragon (South-eastern Lined Earless Dragon), Golden Sun Moth, and Button Wrinklewort (Endangered, TSC Act). Natural temperate grassland is not listed under the TSC Act, however the ecological community receives some protection under the Act because it provides habitat for threatened species.

***FLORA AND FAUNA GUARANTEE ACT 1988* (VIC.)**

The *Flora and Fauna Guarantee Act 1988* is the primary legislation for the protection of Victoria's biodiversity, native plants and animals and ecological communities on land and in water. Species and ecological communities can be listed as threatened under the Act, based on assessments by an independent Scientific Advisory Committee. Threatening processes may also be listed. The Victorian Department of Sustainability and Environment maintains lists of rare or threatened species in Victoria. Conservation status categories used in these lists (presumed extinct, endangered, vulnerable, rare, poorly known) are also applied to species or communities listed as threatened under the Act.

1.6

Consultation and Community Participation

A community forum was held in March 2004, to enable community groups and interested individuals to provide comment on pre-circulated draft sections of the *Lowland Native Grassland Conservation Strategy*. A range of groups and individuals with an interest in grassland conservation was represented at the forum. Matters raised by forum participants included clarification of the concept of a comprehensive, adequate and representative protected area system; the importance of ecological connectivity and prevention of fragmentation; the need for grassland rehabilitation; increasing the knowledge of native grassland and promotion of its conservation; involvement of the community; and the response to development threats.

The *Draft ACT Lowland Native Grassland Conservation Strategy* was released for public comment from 12 October 2004 to 21 December 2004. Twelve submissions were received and a detailed analysis of these was presented to the Flora and Fauna

Committee on 14 March 2005. The strategy has been finalised, taking into account both the submissions and the advice of the Committee.

There is active community interest in the ACT in the conservation of native grassland. Community groups, including the Conservation Council of the South East Region & Canberra, Friends of Grasslands, Australian Native Plants Society, Friends of Aranda Bushland and ACT Park Care and Landcare groups have been involved in advocacy, research, publication and on-ground work in support of the conservation of native grasslands. An objective of the *Strategy* (Table 4.1) is that 'landholders, community groups and others are actively involved in natural temperate grassland conservation'. As a means to further build community involvement, the *Strategy* proposes the formation of a Conservation Management Network as pioneered in other jurisdictions.

1.7

Implementation

The *Lowland Native Grassland Conservation Strategy* is not a management plan prepared under the *Land (Planning and Environment) Act 1991*, nor does it propose that management plans be prepared for each grassland area independent from existing management plans and management arrangements. The *Strategy* is a *thematic* document i.e. it deals with lowland native grassland conservation across all land tenures in the ACT. The goals of the *Strategy* will be achieved through a variety of means, relevant to the different tenures. The *Strategy* provides the strategic, ACT-wide and regional context for the consideration of lowland native grassland conservation in planning studies for specific areas of the ACT. It is in such planning studies that issues such as a buffer between native grassland and urban development will be determined.

Environment ACT has responsibility for coordinating implementation of this *Lowland Native Grassland Conservation Strategy* in partnership with relevant public and private land managers and the wider community. Building upon the existing community interest in native grassland conservation, will be an important part of achieving the goals of this *Strategy*. The remaining lowland native grassland in the ACT is mainly on Public Land (Territory Land) reserved under the *Territory Plan* and National Land, with other areas on leased and unleased Territory Land. Achievement of the objectives of the *Strategy* will require the participation of the managers of these lands, in particular in undertaking the actions set out in Chapter 4.

Primary responsibility for conservation of lowland native grassland and component species on reserved Public Land will rest with the ACT Parks and Conservation Service, with the directions of the *Strategy* expressed through management plans. For example, the *Canberra Nature Park Management Plan* (ACT Parks and Conservation Service 1999, p. 18) includes an action 'to provide assistance in the development and implementation of conservation strategies for threatened native plant species and communities and provide for long term monitoring'. Memoranda of Understanding (especially with Commonwealth landholders), Land Management Agreements (with rural lessees), and directions by the Conservator of Flora and Fauna under s. 47 of the *Nature Conservation Act 1980* in relation to activities on unreserved Public Land in the urban area are also means by which the *Strategy* may be implemented. Cooperation with NSW agencies, especially the Department of Environment and Conservation (Parks and Wildlife Division) is an important element in implementing the *Strategy*, as part of a growing regional effort to conserve the biodiversity of the ACT and Southern Tablelands.

The role of the *Strategy* in land use planning and land management in relation to ACT legislation is shown in Figure 1.1 on page 8.

1.8

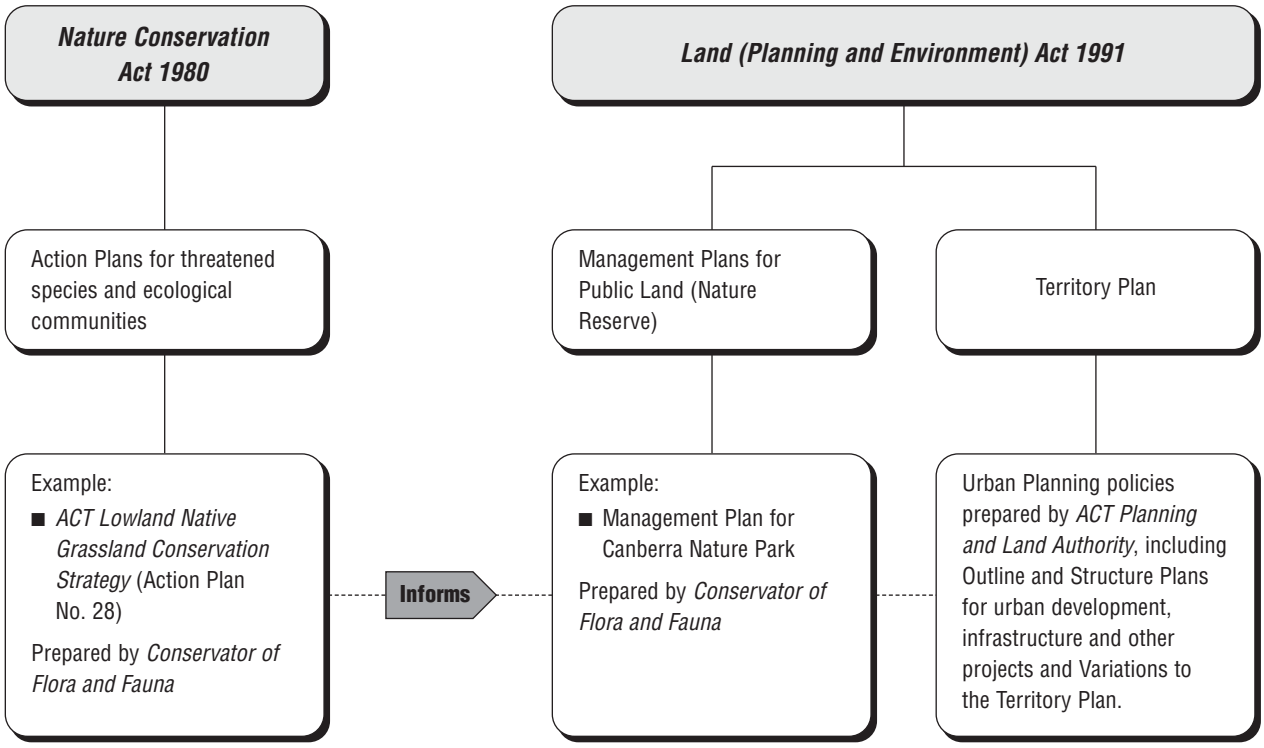
Structure of the ACT Lowland Native Grassland Conservation Strategy

The *Strategy* is structured as follows:

Chapter 1: The **Introduction** outlines the scope of the *Strategy*, the basis for declaring species threatened in the ACT and the role of the ACT Flora and Fauna Committee. It also includes a brief summary of the structure of ACT planning and land management, an outline of legislation applying to the conservation of flora and fauna in the ACT and region, and sections on community consultation and implementation of the *Strategy*.

Chapter 2: Lowland Native Grassland contains sub-sections on lowland native grassland (including the natural temperate grassland ecological community), grassland flora and grassland fauna. The first sub-section provides a description of natural temperate grassland and places the NSW Southern Tablelands distribution in its south-eastern Australian context. The sub-section outlines the surveys undertaken to compile the vegetation data for the *Strategy*. It describes other

Figure 1.1: The Role of the Lowland Native Grassland Conservation Strategy in Land Use Planning and Land Management in the ACT.



(A brief outline of the broader ACT planning framework including the role of the National Capital Plan is contained in s. 1.5.1.)

lowland native grassland communities, grassland not included in the *Strategy*, and categories of lowland native grassland in the ACT. Changes to natural temperate grassland since European settlement and ongoing threats are outlined.

The second sub-section (Grassland Flora) briefly describes the lowland native grassland flora of the ACT region. It outlines how disturbance tolerant and disturbance sensitive species have been used as indicators of levels of grassland modification. The sub-section sets out specific conservation actions for ACT threatened grassland flora species, and uncommon species found in the ACT, some of which are listed as threatened in other jurisdictions.

The third sub-section (Grassland Fauna) discusses the interdependence of fauna and grassland ecosystems, outlines threats to fauna and briefly describes grassland fauna of the ACT region. The sub-section discusses the conservation of grassland fauna in the ACT, critical habitat features for threatened species, and threats to those species. It concludes with specific actions for the conservation of grassland fauna.

The chapter includes maps showing the location in five geographic areas of the remaining ACT lowland native grassland and known occurrences of threatened species.

Chapter 3: Lowland Native Grassland: Planning and Management for Conservation considers principles underlying conservation planning for native grassland and criteria for identifying areas of highest conservation significance. Planning and management issues for each part of the ACT are outlined. The chapter also reviews aspects of the management of native grassland.

Chapter 4: The Lowland Native Grassland Conservation Strategy brings the elements of the *Strategy* together, placing the Strategy into the ACT planning and land management context and considering policy guidelines for grassland conservation. The chapter evaluates the state of protection for lowland native grassland in the ACT, outlines actions taken to improve lowland grassland conservation, future actions necessary, and determines priorities. In particular, in support of the *Strategy's* goals, the chapter (s. 4.2) sets out objectives, the actions necessary to achieve those objectives, and relevant performance criteria.

2 Lowland Native Grassland

2.1

Natural Temperate Grassland

2.1.1 Natural Temperate Grassland in South-Eastern Australia

Natural grasslands are one of the major vegetation formations in Australia. Moore and Perry (1970) recognised four basic types: arid tussock grassland (e.g. Mitchell Grass *Astrebla* spp.), arid hummock grasslands (e.g. spinifex *Triodia* spp.); coastal grasslands; and sub-humid grasslands (tropical, temperate and sub-alpine). Prior to European settlement, temperate grasslands had an irregular distribution from north of Adelaide through south-eastern Australia to northern New South Wales, and including the Tasmanian midlands (Groves and Williams 1981). The grasslands occurred throughout the fertile inland and sub-coastal plains and lower slopes of the Great Dividing Range at low elevations (100–350 m asl). In the rolling hills of the South Australian mid-north and the Southern Tablelands of New South Wales, they occurred as high as about 1000 m asl (Lunt *et al.* 1998). The changes wrought by European pastoralism and agriculture, often the complete removal of the native grasslands and woodland trees that marked the grassland–woodland interface, mean that it is no longer possible to delineate the original grassland distribution with any accuracy. It was probably a dynamic boundary, reflecting variability in temperature and rainfall, and perhaps fire regimes (Sharp, pers. comm.).

The temperate grasslands and woodlands were the home of Aboriginal people, and their activities over millennia helped to shape the plant and animal communities found by the first Europeans. When Aborigines came to Australia, the grasslands were rich in animal life, including the giant marsupials ('megafauna'), and the plains provided many edible tubers and bulbs. The tubers of Murnong or Yam Daisy (*Microseris lanceolata*), for example, were stored as a winter food (Kirkpatrick *et al.* 1995). There is no doubt that Aborigines burnt the grasslands and associated grassy woodlands. It is often assumed that the burning-off recorded in explorers' accounts was only to provide good feed ('green pick') for grazing animals, however, it also had horticultural benefit, encouraging yams and tubers (Lunt *et al.* 1998).

Prior to European colonisation, fire regimes in temperate grasslands and woodlands were probably a combination of deliberate Aboriginal burning (possibly mosaic cool spring or autumn fires that favoured the maintenance of a diverse herbaceous cover) and summer 'wildfires' that occasionally swept across the landscape (Benson 1994; Benson and Wyse Jackson 1994; Lunt *et al.* 1998). The nature of pre-European burning regimes remains largely unknown and the precise ecological effects of Aboriginal burning are unclear, but the available evidence does not support the hypothesis that it caused the evolutionary diversification of the Australian flora (Bowman 1998). Aboriginal burning followed millions of years of evolutionary adaptation in which lightning-generated fire probably played a significant part. With regard to grassland–woodland boundaries, it seems most likely that absence of trees was controlled by a combination of soil and regional climatic features, with pre-European fire regimes playing a minor role in controlling tree regeneration (Lunt and Morgan 2002).

The natural temperate grasslands and temperate eucalypt woodlands were the natural resource base for the development of the Australian pastoral industry from the early 1800s. In the 1830s, Mitchell traversed some of these lands describing them as 'Austral Felix' (Mitchell 1838). By the mid-nineteenth century, 30 million sheep, 1.7 million cattle and 32 000 horses were grazing on the grassy plains and lower open slopes of the Great Dividing Range of New South Wales and Victoria (Lunt *et al.* 1998). The productivity of the plains resulted in their early and thorough alienation and almost complete transformation by the new pastoral economy (Stuwe 1986). With few physical or institutional barriers to this expansion, it is

not surprising that the temperate grasslands are now one of Australia's most endangered terrestrial ecological communities (Kirkpatrick *et al.* 1995).

2.1.2 Lowland Native Grassland: ACT and Southern Tablelands Region—Past Distribution

Lowland native grassland in the ACT region occurs within the South Eastern Highlands Region as defined in the Interim Biogeographic Regionalisation for Australia (Thackway and Cresswell 1995; Environment Australia 2000). This bioregion includes about 80% of the ACT, the tablelands and western slopes of south-eastern NSW and extends from near Bathurst in the north, into Victoria in the south.

Forming part of this South Eastern Highlands Region, the Southern Tablelands extend southwards from the Abercrombie River to the Victorian border, from Booroowa and Jindabyne to the west and Goulburn to Braidwood and Bombala in the east. Natural temperate grassland was widespread in the Southern Tablelands at the time of European settlement as part of the woodland–grassland mosaic (Costin 1954; Benson 1994; Fallding 2002). An accurate estimate of the extent of natural temperate grassland prior to European settlement is not possible, due to lack of knowledge of the characteristics of this mosaic. For the Monaro region (extending from Canberra and Queanbeyan in the north to the Victorian border in the south, and from the Kybean Range in the east to the Snowy Mountains and Fiery Range in the west), Benson and Wyse Jackson (1993) estimated a total of 250 000 ha of the ecological community. However, this estimate appears to include two montane grassland types that are not part of the listed ecological community. For the Southern Tablelands as a whole, estimates range from approximately 386 000 ha or less (Thomas *et al.* 2000) to approximately 480 000 ha or more (Rehwinkel 1997).

Natural grassland was particularly common in areas of lower elevation, often extending across large parts of the plains and the river valleys at elevations from 560 m to about 1000 m. The Monaro Plains, Bungendore Plains, Goulburn Plains, Yass Plains and Limestone Plains (ACT) supported large areas of natural temperate grassland (Figure 2.1). Smaller areas located between Braidwood and Crookwell and from Murrumbateman to Tumut also supported natural temperate grassland on various substrates and topography (Rehwinkel 1997).

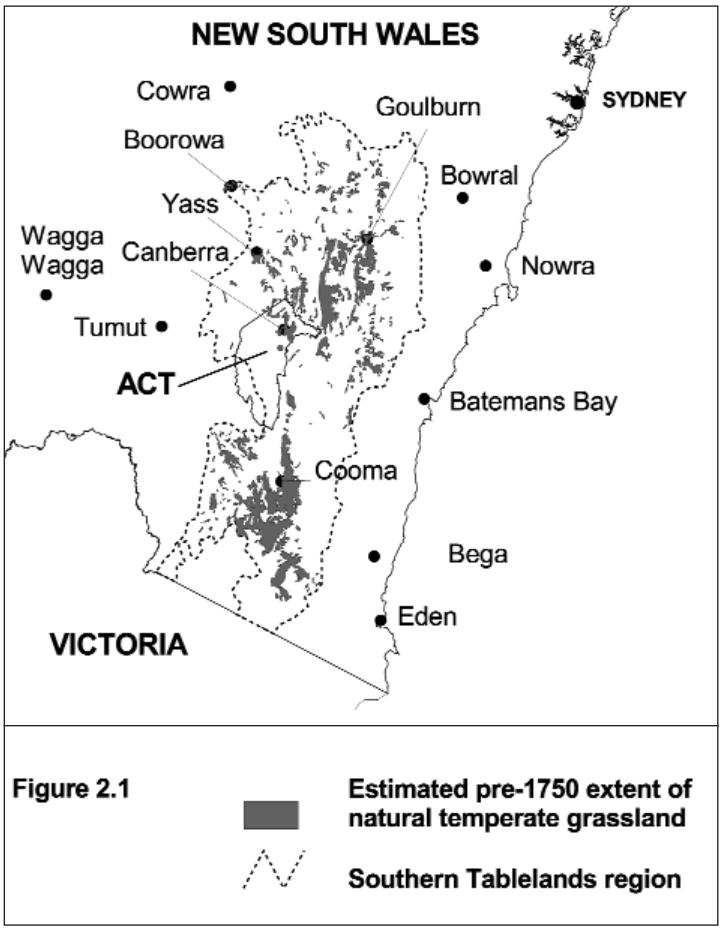


Figure 2.1: Estimated Pre-1750 Extent of Natural Temperate Grassland in the Southern Tablelands Region.

Geological formations that supported the ecological community included Cainozoic sediments, Silurian and Ordovician volcanics, mudstones, shales and limestones. Typical soils were derived from volcanic and sedimentary substrates and included red, grey and brown clay podsols and laterites (Benson 1994).

In the ACT, natural temperate grassland was the dominant ecological community in lower elevation areas in the Molonglo River Valley, which forms the central part of the Canberra region and the adjacent Jerrabomberra and Majura valleys. Natural temperate grasslands also dominated large areas of the lowland plains at Tuggeranong in the south, and the plains at Belconnen and Gungahlin to the north (Pryor 1938, Benson and Wyse Jackson 1994; Wildlife Research Unit 1994). Benson (1994) estimated that in the ACT there were 20 000 ha of natural temperate grassland present prior to European settlement.

The pre-European distribution of natural grasslands in the region is believed to have been influenced by a combination of environmental factors, including low temperatures due to cold air drainage in winter, periods of low soil moisture availability in summer associated with the heavy clay soils, and low rainfall in some areas (Chan 1980; Groves and Williams 1981; Benson and Wyse Jackson 1994; Benson 1994). Story (1969) considered the effects of seasonal burning by Aborigines to have been an important factor determining distribution of the ecological community, a view not supported by Lunt and Morgan (2002) for temperate grasslands as a whole. In environments where edaphic and climatic factors did not preclude tree growth, natural temperate grassland graded into open grassy woodlands and other vegetation formations.

In the Southern Tablelands of New South Wales and the ACT, the earliest known site of Aboriginal occupation is from Birrigai, ACT, dated at 21 000 years BP (Flood *et al.* 1987). Archaeological evidence points to the more sheltered river valleys as being the main occupation sites, with some montane valley camps and high summer camps that were probably associated with exploitation of the Bogong Moth and associated social and ceremonial activities. The lowland grasslands, woodlands, and river valleys provided mammals, reptiles, ducks and other birds and vegetable foods (e.g. Yam Daisy, ferns, fruits and seeds) as well as a seasonal abundance of fish (Flood 1980, pp. 61–82, 97–100). There is little evidence for year-round occupation of the treeless tablelands, an inhospitable location in winter. While grass seeds are known to have been part of the diet on the western plains of New South Wales, seed grinding of the now less common Kangaroo Grass (*Themeda australis*) and Hairy Panic Grass (*Panicum effusum*) does not appear to have been part of the economy on the Monaro (Flood, 1980, pp. 97–8).

It is not possible to establish with any certainty the nature of Aboriginal and lightning induced fire regimes in the grasslands of the Southern Tablelands and the ACT. While early European explorers such as Throsby, Kearns, Cunningham, Hume and Hovell recorded Aboriginal fires, these may have been signal and campfires as well as burning-off (Lunt *et al.* 1998). The botanist Alan Cunningham provided an account of burning at Tuggeranong, ACT, in April 1824 (quoted in Flood, 1980, p. 20):

> *These interesting Downs had been burnt in patches about two months since, and as the tender blade had sprung up, these portions, having assumed a most lively appearance, formed a striking contrast with the deadened appearance of the general surface, still clothed with the vegetation of the last year. It was common practice of the aborigines, to fire the country in dry seasons where it was wooded and brushy; to oblige game of the kangaroo kind to quit their covery and subject themselves to be speared.*

By the mid-1820s after Capt. Mark Currie had ridden south of the Limestone Plains and discovered the high plains of the Monaro (Hancock 1972), the grasslands of the Southern Tablelands were known to Europeans and the pastoral advance followed. Squatting runs and land grants superimposed a new map over the Aboriginal tribal boundaries and transformation of the country began. By 1840, only fifteen years after Europeans had settled on the Monaro, P.E. de Strzelecki, in a report to Governor Gipps expressed concern about the effects that drought, cropping and over-grazing were having on soil erosion (Hancock 1972).

2.1.3 Lowland Native Grassland: ACT and Southern Tablelands Region—Present Distribution

European land uses, particularly grazing, pasture improvement, cropping, the introduction of exotic species (including pasture species) and changes to the pattern of burning, have greatly reduced the extent and integrity of natural temperate grassland in the region. Tree planting on natural temperate grassland also threatens its integrity. Urban development has contributed significantly to the further loss of this ecological community in the region, particularly in parts of the ACT associated with the establishment and expansion of Canberra.

Disconnected areas of native grassland of varying conservation significance are all that remain of the pre-European distribution of the natural temperate grassland community in the ACT and region (Environment ACT 2005). It is found along roadsides and railway easements, and in urban areas, churchyards, cemeteries, special purpose sites (e.g. radio transmission tower areas), travelling stock reserves and privately owned or leased rural land. Many remaining sites are small (less than 10 ha). Some of the largest sites are on private land and on Commonwealth occupied land in the ACT, including areas managed by the Department of Defence.

REGIONAL GRASSLAND SURVEYS

The Southern Tablelands have not been uniformly surveyed for the presence of native grassland. Ecological surveys were initially focused on the ACT (which has been comprehensively surveyed) and the Monaro sub-region. More recently, the north-western and eastern sub-regions (in NSW) have been the subject of survey effort. Private land in NSW is inadequately surveyed across all sub-regions and information regarding the location and boundaries of sites across all land tenures is incomplete. In the NSW portion of the Southern Tablelands, over 400 sites on both public and private land (covering more than 7 000 ha) have been identified as containing natural temperate grassland in moderate to good condition. A similar amount, as yet unsurveyed, is likely to exist on private land (Environment ACT 2005).

SURVEYS IN LOWLAND NATIVE GRASSLAND IN THE ACT

In 1938 Pryor modelled the natural distribution of natural temperate grassland in the ACT based on the valley landform occurring in the altitude range of up to 600 m (Pryor 1938). This mapping has formed the basis of all subsequent work. However, prior to 1990, knowledge of natural grassland remnants in the ACT was limited to a small number of incomplete botanical surveys (e.g. Chan 1980, who identified and mapped the location of native grassland sites and their dominant grasses). The need to survey and document the remaining grasslands was identified in a proposal for a *Recovery Plan for Lowland Native Grasslands in the Australian Capital Territory* prepared by the Wildlife Research Unit of the ACT Parks and Conservation Service in 1991. In 1992 the Plan was approved for funding under the Commonwealth's Endangered Species Program (see s. 3.1).

In the period 1991 to 1996, comprehensive surveys were undertaken, resulting in a major increase in knowledge of the distribution and ecology of natural temperate grassland and component plant and animal species in the Territory. The surveys identified all the remaining grassland sites and formed the basis for the assessment of their conservation value. This information provided the foundation for the 1997 Action Plan for natural temperate grassland prepared pursuant to the *Nature Conservation Act 1980* (ACT Government 1997a).

Evaluation of the conservation significance of native grassland must be done in a regional context. Complementary to the ACT grassland survey work in the 1990s, was the Monaro and Southern Tablelands Native Grasslands Conservation Project (Rehwinkel 1996c) which followed up on the survey work on the Monaro by Benson (1994), Jones (1995) and Rowell (1994). The project included grassland floristics, fauna habitat and grassland conservation ratings, but noted that 'the faunal values of native grasslands on the Monaro are poorly known (Rehwinkel 1996c, p. 9). The project focussed on ways to ensure that the best grassland sites would continue to be managed in ways that preserved and enhanced their conservation values, but also included the recording and survey of new grassland sites. A summary of the grassland floristic survey work for the South-Eastern Highlands region (including the ACT) is contained in Rehwinkel (1997, pp. 33–35).

In 2003–4 the vegetation in all known grassland sites was again surveyed as part of the preparation of this *Strategy*. The same methods that were developed to survey woodland sites in the ACT were applied (ACT Government 2004a). The ACT Rapid Assessment Technique has been developed to provide information about the species present, habitat features, condition, ecological communities and floristic associations. The survey specifically aimed to provide accurate mapping and assessment of the spatial extent of areas of grassland of natural temperate grassland and native grassland of varying condition and containing the different floristic associations. Each grassland area was mapped as polygons of vegetation that reflected homogeneity of vegetation composition and structure. Contiguous polygons of natural temperate grassland, native pasture and small areas of connecting exotic grassland or vegetation could then be combined to identify discrete native grassland sites.

The surveys of polygons do not provide a complete species inventory. These surveys aim to provide an overall description of the species present and types of species likely to be present as a result of the level of disturbance that is evident at the sites. As is described in the *ACT Lowland Woodland Conservation Strategy* (ACT Government 2004a) studies undertaken by Prober and Thiele (1995), and Dorrough (1995) have

described which species occur more frequently in grazed and ungrazed areas. In addition, an analysis of the frequency of all species surveyed in over 700 sites across the Southern Tablelands region has been used to identify species that appear to have declined as a result of site disturbance. Appendix 1 lists examples of species categorised by their sensitivity to disturbance.

Comparisons of grassland distribution, species diversity and condition at all ACT sites when first surveyed (between 1991 and 1996) and subsequently (in 2003/4) were undertaken (s. 3.3.1, Appendix 2). The Strategy is open to the addition of new areas of native grassland in the ACT, should further areas be located.

PRESENT ACT DISTRIBUTION OF LOWLAND NATIVE GRASSLAND

The distribution of lowland native grassland in 2004, including natural temperate grassland, in the ACT, together with the estimated distribution of entirely treeless grassland prior to European settlement, is shown in Figure 2.2. Grassland sites outside the treeless area identified by Pryor (1938) occur where records, visual estimation and presence of cold air drainage areas indicate that projective foliage cover of trees was probably less than 10% prior to European settlement. On this basis it has been estimated that natural temperate grassland occurs in the ACT at elevations less than 625 m (Sharp 1997).

In the ACT lowland region, remnant lowland native grassland has been recorded at 47 sites (2172 ha) (Figure 2.2, Table 3.2). Sites are defined as areas that have separate land uses or ownership, or are separated by a 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.

Native grassland sites that contain a substantial proportion of natural temperate grassland are regarded in this *Strategy* as the endangered ecological community. They may also contain areas or patches of native pasture, degraded native pasture or exotic vegetation. However, as they are managed in their entirety, the whole site is considered to be the community. Many sites identified as containing natural temperate grassland contain several or more floristic associations. These sites also may contain threatened flora and/or fauna species.

There are also other native grassland sites that contain no natural temperate grassland (or very small patches, less than 0.25 ha), being dominated by native pasture, degraded native pasture or exotic vegetation. These sites are included in the *Strategy* if they support threatened grassland species.

2.1.4 Description of the Ecological Community: Natural Temperate Grassland

Native grassland communities in those parts of the south-east of the continent and Tasmania with a mean annual rainfall of 500 to 1000 mm are referred to as **natural temperate grassland**, or lowland native grassland. The ecological community is defined by the vegetation structure thought to have been present at the time of European settlement. While the definition of natural temperate grassland is expressed in terms of the vegetation, the ecological community comprises both the flora and the fauna, the interactions of which are intrinsic to the functioning of grassy ecosystems.

Sites that meet the defining characteristics of natural temperate grassland encompass those that clearly demonstrate the natural ecological function of grasslands and those that may be deficient in some respects, but are considered recoverable. However, the distinction between what constitutes the ecological community and what are degraded remnants that are beyond recovery may not always be readily apparent. Ecological survey and assessment of individual sites is necessary to clarify which sites warrant protection or recovery action.

DEFINITION OF NATURAL TEMPERATE GRASSLAND

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 asl.

COMPOSITION

Plants

In addition to a wide variety of grasses, native grasslands in their natural state contain a high diversity of forbs including sedges, rushes, orchids, lilies and broad-leaved herbs such as daisies. About 700 species of native herbs have been identified in grasslands of south-eastern Australia, the majority of which are not grasses (Eddy 2002). ‘Bare ground’ in grasslands may be covered by a layer of lichens and mosses (the ‘cryptogamic crust’). An important characteristic of the community is that it is naturally treeless, or has less

than 10% projective foliage cover (2–20% crown cover density) (see Glossary) of trees, shrubs and sedges in its tallest stratum (Moore 1964; Kirkpatrick 1993). To simplify assessment, Lunt *et al.* (1998) estimated that this cover is equivalent to a tree cover of less than one mature tree per hectare. The degree of tree cover remains a contentious attribute in defining the range of native grasslands (Carter *et al.* 2003).

Natural temperate grassland intergrades on slopes at slightly higher elevations with grassy woodland (defined as having a tree cover greater than 10% projective foliage cover). Yellow Box–Red Gum grassy woodland is declared an endangered ecological community in the ACT under the *Nature Conservation Act 1980* (see ACT Government 2004a). Natural temperate grassland may contain poorly drained areas, and at lower elevations, wetlands or drainage lines with a characteristic flora (including wetland species such as sedges and rushes) (Moore 1964). These wetlands and the fauna associated with the moister conditions are a component of the grassland community. River Tussock (*Poa labillardieri*) frequently dominates grassland along drainage lines.

Animals

An integral part of this community is the grassland fauna ranging from large herbivores such as kangaroos to a multitude of invertebrates (see s. 2.3). Many small mammals (e.g. bandicoots, bettongs, rat kangaroos, rats) are known to have occupied the grasslands and may have been important agents of disturbance (Whalley 2003). The rapid transformation of the grasslands by pastoral activity from the early 1800s resulted in the decline or extinction of many species (Lunt *et al*. 1998).

The fauna found in natural temperate grasslands of the Southern Tablelands typically includes a rich diversity of invertebrates, reptiles, amphibians and birds (including several specialist grassland species). The more common grassland species include the Delicate Skink (*Lampropholis delicata*), Spotted Marsh Frog (*Limnodynastes tasmaniensis*), Spotted Burrowing Frog (*Neobatrachus sudelli*), Richard's Pipit (*Anthus novaeseelandiae*), Brown Quail (*Coturnix ypsiliphora*) and Stubble Quail (*C. pectoralis*). Latham's Snipe (*Gallinago hardwickii*), a species protected under migratory bird agreements with Japan (JAMBA) and China (CAMBA), utilises wetlands in native grassland sites (ACT Government 1997a). Generalist species such as the Australian Magpie (*Gymnorhina tibicen*) and the Eastern Grey Kangaroo (*Macropus gigantea*) use the grassland community for foraging. Some characteristic grassland fauna species are no longer found within native grasslands including the Emu (*Dromaius novaehollandiae*), Australian Bustard (*Ardeotis australis*) and Little Button-quail (*Turnix velox*) (Frith 1984).

Little is known about the past and present distribution and ecology of many of the grassland fauna, particularly invertebrates, though some species have been the subject of detailed studies in recent years (especially the Grassland Earless Dragon (*Tympanocryptis pinguicolla*), Striped Legless Lizard (*Delma impar*), and Golden Sun Moth (*Synemon plana*)). Further studies are required to investigate abundance, distribution and habitat use of a range of grassland faunal species. Appropriate management strategies also need to be developed to ensure the species are adequately conserved as part of the grassland community.

Given the lack of information on distribution and abundance of the wide range of grassland fauna, the diversity of plants and structure of the community is taken to be an indicator that the typical native grassland fauna may still be present.

STRUCTURE

Perennial tussock grasses impart a characteristic structure to natural temperate grassland. The tussocks are often closely spaced, forming an upper stratum of loosely interlacing leaf canopies (Costin 1954; Sharp 1997). This upper canopy stratum generally varies in height from mid high (0.25–0.5 m) to tall (0.5–1.0 m), and in cover from open to dense (greater than 70% ground cover) (Walker and Hopkins 1984).

A second, lower stratum may be discernible, typically comprising shorter perennial and annual grasses, and forbs, growing between the tussocks. At ground level, there may also be a third discontinuous stratum of dwarf forbs and grasses, with occasional mosses and lichens also present on 'bare ground' forming a 'cryptogamic crust' (Costin 1954; Lunt *et al*. 1998). The community sometimes includes areas of embedded rocks, which provide habitat for animals.

FLORISTICS

The characteristic dominant genera of natural temperate grassland in Australia include *Themeda, Poa* and *Austrostipa* (Groves and Williams 1981). In the Southern Tablelands (including the ACT), dominants include Kangaroo Grass (*Themeda triandra*) wallaby grasses (*Austrodanthonia* spp.), spear grasses (*Austrostipa* spp.), Red Grass (*Bothriochloa macra*) and tussock grasses (*Poa* spp.) (Benson and Wyse Jackson 1994; Benson 1994; Sharp 1997).

Most natural temperate grassland has been subject to grazing by domestic stock or by rabbits, which has

modified its species composition and structure. Exotic plant species are common in natural temperate grassland, which may vary from a semi-natural state with few exotic species, to a highly modified state in which exotic species form a dominant component of the community (Groves and Williams 1981; McIntyre 1994; Sharp 1997). Surveys show that exotic species comprise over 35% of the flora at most native grassland sites in the Monaro region (Benson 1994; Sharp 1997). The majority of these exotic species are annuals (Sharp 1997). Exotic species have either invaded through natural processes, often assisted by human activity, or have been sown as pasture species e.g. clovers and Phalaris (*Phalaris aquatica*).

Five floristic associations have been defined for natural temperate grassland in the ACT (Sharp and Shorthouse 1996; Sharp 1997). This is a sub-set of eight floristic associations described for natural temperate grassland in the broader Monaro region (Benson 1994). The ACT floristic associations comprise both wet tussock grasslands including 'Wet *Themeda*' Grassland and '*Poa labillardieri* ' Grassland, and dry tussock grasslands including '*Austrodanthonia*' Grassland, 'Dry *Themeda'* Grassland and '*Austrostipa*' Grassland (Sharp 1997).

Surveys of threatened fauna indicate a strong correlation between these floristic associations and habitat for certain species. The presence of these associations is related to both intrinsic site factors and land use practices since European settlement. In particular, drainage patterns related to slope and landform, soil characteristics, and intensity of land use appear to influence these floristic associations (Sharp 1997). These factors also affect the plant species present in sites, their characteristic life and growth form, and the degree of invasion by exotic species (Sharp 1997).

The following descriptions of the ACT floristic associations are based on detailed studies by Benson (1994) and Sharp (1997). Appendix 3 contains a list of common names for the species mentioned.

- **Wet *Themeda* Grassland**

  Wet *Themeda* grassland is a tall, dense, closed tussock grassland. It is often degraded, with a low native species diversity and high weed content. It occurs in moist to poorly drained sites.

  Dominant native grasses: *Themeda triandra, Poa labillardieri, Poa* spp. and *Austrodanthonia* spp.

  Other characteristic native species: *Carex inversa, Juncus* spp., *Asperula conferta, Bulbine bulbosa, Wurmbea dioica*.

  Common exotic species: *Trifolium glomeratum, Trifolium campestre, Vulpia myuros, Tragopogon dubius, Hypochaeris radicata, Cerastium glomeratum, Bromus hordeaceus, Holcus lanatus, Phalaris aquatica.*

- ***Poa labillardieri* Grassland**

  Poa labillardieri grassland is a tall, dense, closed tussock grassland. It occurs in the ACT as small, often degraded remnants that are part of larger grassland sites. It is found in poorly drained areas and along seepage lines, drainage lines and creeks.

  Dominant native grasses: *Poa labillardieri, Themeda triandra.*

  Other characteristic native species: *Carex appressa, Carex inversa, Juncus* spp., *Haloragis heterophylla, Hydrocotyle laxiflora.*

  Common exotic species: *Poa pratensis, Rumex crispus, Trifolium repens, Trifolium dubium, Cirsium vulgare, Holcus lanatus, Phalaris aquatica.*

- ***Austrodanthonia* Grassland**

  Austrodanthonia grassland is a mid-high, open tussock grassland found in well drained areas with shallow or skeletal soils. Despite moderate to high levels of disturbance, it exhibits high native species diversity, and often includes low growing species not found in other floristic associations.

  Dominant native grasses: *Austrodanthonia carphoides, A. caespitosa, A. laevis, Austrostipa bigeniculata, A. scabra* spp. *falcata, Bothriochloa macra.*

  Other characteristic native species: *Chloris truncata, Elymus scaber, Triptilodiscus pygmaeus, Panicum effusum, Oxalis perennans, Goodenia pinnatifida, Vittadinia muelleri, Chrysocephalum apiculatum, Plantago varia, Wahlenbergia* spp., *Solenogyne dominii.*

  Common exotic species: *Hypochaeris radicata, Trifolium* spp., *Aira elegantissima, Vulpia* spp., *Tolpis umbellata*.

- **Dry *Themeda* Grassland**

  Dry *Themeda* grassland is a tall, dense, closed tussock grassland generally found on well drained, loamy soils. In the ACT, this association is now only found on sites where there have been low levels of past disturbance. Dry *Themeda* grassland sometimes includes species no longer found in other grasslands due to their higher levels of disturbance.

  Dominant native grasses: *Themeda triandra, Austrostipa* spp., *Poa sieberiana, Austrodanthonia* spp.

  Other characteristic native species: *Leptorhynchus squamatus, Plantago varia, Stackhousia monogyna.*

Common exotic species: *Avena* spp., *Centaurium erythraea, Tragopogon porrifolius, Trifolium* spp., *Bromus hordaceous*.

- ***Austrostipa* Grassland**

  Austrostipa grassland is a tall, open tussock grassland. Most sites are likely to have been previously dominated by *Themeda triandra*. Sites are usually degraded, with a low diversity of native species. The association often includes shorter grasses interspersed between the tussocks.

  Dominant native grasses: *Austrostipa bigeniculata, A. scabra* ssp. *falcata, Elymus scaber, Austrodanthonia caespitosa, Enneapogon nigricans.*

  Other characteristic native species: *Austrodanthonia* spp., *Bothriochloa macra, Themeda triandra, Wahlenbergia* spp., *Chrysocephalum apiculatum.*

  Common exotic species: *Trifolium arvense, Vulpia myuros, Hypochaeris glabra, Hypochaeris radicata, Carthamnus lanatus, Paronychia brasiliana, Aira caryophyllea, Dactylis glomerata, Arctotheca calendula.*

Since European settlement, these floristic associations have all been modified to varying degrees (see Table 2.1 and s.2.1.8).

2.1.5 Other Lowland Native Grassland Vegetation Included in the Strategy

Other lowland native grassland vegetation bears some resemblance to the structure and species composition of natural temperate grassland but is not considered to be part of the endangered ecological community, based on the loss of species diversity and high levels of disturbance. These areas are unlikely to have the soil seed-store that would allow them to rehabilitate naturally. However, the distinction between what constitutes the ecological community and what are degraded remnants that are beyond recovery may not be readily apparent. Further ecological survey and assessment may be necessary to clarify those sites that warrant protection or recovery action. If such sites indicate a more diverse flora as a result of recovery they should be re-classified as containing the endangered ecological community.

Whatever the classification, the more degraded sites may still have a role in landscape function (e.g. erosion and groundwater management, salinity control and resistance to weed invasion), provide habitat for some threatened species, buffers to more diverse grassland stands, and connectivity in the landscape.

NATIVE PASTURE

About five percent of the pre-European extent of natural temperate grassland in the Southern Tablelands now exists as native pastures with a high cover of native grasses, but very low to no forb diversity. They contain a low cover of exotic species (Table 2.1). Previously, these grasslands may have been intensively grazed, but are unlikely to have undergone extensive pasture 'improvement' (sowing of introduced species including crops, legumes or perennial pasture species, continuous application of fertiliser). Native pastures may have economic, social and biodiversity values. These sites may provide important habitat for threatened animal species and with appropriate management may have some capacity for ecological restoration, particularly as habitat for threatened species tolerant of such modified vegetation. Native pasture may also provide buffers to remnants of higher value native grassland or connect remnants of native vegetation.

DEGRADED NATIVE PASTURE

Large areas of the Southern Tablelands contain degraded native pasture (Environment ACT 2005). Degraded native pastures are at the other end of the continuum from high quality natural temperate grassland that retains its ecological integrity (Table 2.1). These grasslands contain one or more native grass species (which may not have been the original dominants), but have very few or no native forbs. Such pastures have a high content of introduced perennial species (both weeds and pasture species), in particular, persistent or invasive species such as Phalaris (*Phalaris aquatica*), African Lovegrass (*Eragrostis curvula*), Serrated Tussock (*Nassella trichotoma*) and Chilean Needlegrass (*Nasella neesiana*).

Typically, these grasslands have been subject to pasture improvement (species introduction and/or fertiliser addition) in the past or to intense grazing pressure over a long period.

2.1.6 Native Grassland Communities Not Included in the Strategy

SECONDARY (DERIVED OR DISCLIMAX) GRASSLAND

Secondary grasslands are derived from lowland grassy woodlands or forests that have been extensively cleared of trees since European settlement, through intentional removal, dieback or prevention of natural regeneration (Benson 1996). They are found on hillslopes beyond the normal extent of natural temperate grassland to which they have a superficial resemblance. Species composition in secondary grassland is often very similar to natural grasslands, but they may also contain shrubs and herbaceous

species more characteristic of the former woodland community. Native species diversity ranges from very high to low, similar to that of natural grasslands. Secondary grasslands have important ecological values (which may include habitat for threatened species) and may warrant consideration for protection, management and rehabilitation.

Reflecting their origins, secondary grasslands in the ACT are considered to be part of the Yellow Box–Red Gum Grassy Woodland endangered ecological community and are included in the *ACT Lowland Woodland Conservation Strategy* (ACT Government 2004a).

Sub-Alpine and Alpine Grassland

Sub-alpine grassland or sod tussock grassland occurs at higher elevations in level or gently undulating terrain on alpine humus soils (Costin 1981). It is common in 'frost hollow' valleys in upland areas such as the mountainous western portion of the ACT. The main dominants are Snow Grass (*Poa* spp.), Alpine Wallaby Grass (*Austrodanthonia nudiflora*), Spreading Rope-rush (*Empodisma minus*), with some local occurrences of Kangaroo Grass (*Themeda triandra*). *Poa* spp. may be dominant also in some higher elevation alpine herbfield areas e.g. the Brindabella Range.

Grassy 'Glades'

Above about 625 m, patches of grassland occur in grassy woodland often at locally lower elevations and near creek lines that are subject to cold air drainage ('frost hollows'). These areas are too small to map separately as natural temperate grassland. Their presence indicates how natural temperate grassland and grassy woodland intergrade to form a vegetation mosaic, though there are now few intact examples of this.

2.1.7 Changes to Natural Temperate Grassland Since European Settlement and Ongoing Threats

Some form of degrading disturbance threatens all grassland remnants, even those in permanent reserves. As noted previously, natural temperate grassland has been reduced to small and disconnected fragments across its former range throughout south-eastern Australia. An estimated 99.5% has been destroyed or grossly altered since European settlement (Kirkpatrick *et al.* 1995). In most areas the grassland has been replaced completely by plant introductions associated with the European pastoral and agricultural economy or by urban and infrastructure development. In other areas, it has been partly transformed both intentionally and inadvertently (e.g. through weed invasion) and survives with varying levels of degradation. There are small remnants that give an indication of the presumed character of natural temperate grassland prior to European settlement, commonly in cemeteries, churchyards, on roadsides or in travelling stock reserves. A shared feature of these places is that they have been fenced off from continual grazing and have not been subject to intensive pasture improvement or cropping (Benson 1994). Characteristically, they have rich forb diversity and grasses intolerant of continuous grazing pressure are present.

A key issue for natural temperate grassland conservation is the maintenance of grassland fauna as a part of the ecological community. Invertebrates are the dominant faunal element in lowland grasslands and are involved in most ecological processes. However, they have a history of being largely unrecognized or thought of mainly in terms of control of pest species (Yen 1995).

Following European settlement, a number of factors have been responsible for the loss of natural temperate grassland and degradation of the remnants in the ACT and region. These factors generally remain as ongoing threats. The changes and threats may be categorised as follows:

- **Pastoral and agricultural development:** Natural temperate grasslands in the Southern Tablelands were carved up into grazing runs from 1830. Small-scale pasture improvement began in the 1860s and clovers were first sown in the 1920s. Intensive pasture improvement involving the use of subterranean clover and application of superphosphate was undertaken after the Second World War (Benson and Wyse Jackson 1994). This accelerated the loss of native grassland. However, some of the ACT rural lands held on short-term leases were not subject to intensive pasture improvement and retained significant components of their native vegetation cover.

  Where native grassland has not been completely replaced by sown crops or 'improved pastures', the ecological effects of grazing depend upon its intensity and timing, and length of time that the area has been grazed. Most of the impacts of stock grazing have been inferred by comparing the vegetation at sites protected from grazing (or known to have been only lightly grazed), with more intensively grazed sites. Grazing can affect grassland species and the ecological community through the removal of biomass, trampling, nutrification, increased weediness (through creation of bare ground, dispersal of seeds, introduction of

weeds through fodder), destruction and modification of faunal habitat, soil erosion, and loss of soil moisture (Sharp 1994). Plant species sensitive to grazing become less common as the ecological community is simplified.

Changes in species composition and loss of floral diversity are two of the significant changes that occur in heavily grazed grasslands. An early observation in 1862 by grazier James Litchfield on the Monaro was the problem with infestations of 'corkscrew grass' (speargrasses *Austrostipa* spp.) (Hancock 1972). This probably replaced more palatable species such as Kangaroo Grass as they were grazed out. Speargrasses now dominate many native pastures, especially on the Monaro (Eddy et al. 1998). Perennial grasses such as Red Grass or Red-leg Grass (*Bothriochloa macra*), wallaby grasses (*Austrodanthonia* spp.) and speargrasses (*Austrostipa* spp.) become more prominent as grazing intensity increases (Story 1969; Frawley 1991; Benson 1994). Decades of pasture improvement have contributed to changes in the floristic composition of natural temperate grassland.

Much of the biodiversity of native grasslands is made up of species other than grasses (see s. 2.1.4). As well as being trampled, lilies, orchids and forbs are less likely to survive under heavy grazing due to their palatability and failure to set seed (especially upright forbs from which grazing removes the flower stalks). Palatable forbs can be lost, even at low grazing intensities, with little obvious effect on the dominant grasses (Lunt 1991).

It should be noted that there has been a significant improvement in knowledge of and recognition of native grasslands in the last 15 years, and interest on the part of landholders in conserving remnant native grassland on their properties (Lunt 2005). This is reflected, for example, in the establishment of Conservation Management Networks, four of which are currently established in grassy ecosystems of south-eastern Australia (Thiele *et al.* 2003).

- **Urban and Infrastructure Development:** This is particularly relevant to the ACT where the most extensive areas of natural temperate grassland (Figure 2.2) have been destroyed during the development of urban Canberra. Some fragments of the former grasslands remain, with the larger remnants located in areas set aside for special purposes such as radio beacons, the airport and military uses. Other smaller areas remain on land originally set aside for future government uses and on current and former rural leases. Some of these grasslands remain on Public Land within the urban fabric while others have been reserved as part of Canberra Nature Park. The setting aside of areas for public institutions and government offices resulted in small grassland areas remaining in the Central National Area of Canberra (Frawley 1995). Examples include the Australian Centre for Christianity and Culture (ACCC) Barton (1.9 ha) containing very high quality *Themeda* grassland, and York Park, Barton (0.4 ha), an *Austrodanthonia* grassland containing a population of the endangered Golden Sun Moth *Synemon plana*.

  In recent years, the conservation values of the remaining native grassland areas in the ACT have been recognized in land-use planning, resulting in significant planning changes. Grassland reserves have been established in Gungahlin (1995) and Dunlop (1997), announced for the Jerrabomberra Valley (July 2004), and proposed for Lawson (Belconnen Naval Station).

  Threats to remaining grassland areas from urban and infrastructure development are of two types: direct loss of grassland, and deleterious impacts on the natural integrity of grassland from adjacent urban areas. Urban edge threats can be lessened at the planning stage (e.g. by allowing adequate buffers and not permitting housing on the outer edge of perimeter roads) and by effective management of reserves involving the local community.

- **Weed Invasion:** Grassland vegetation appears particularly prone to weed invasion, probably due to its location on fertile soils (Kirkpatrick *et al.* 1995). In the ACT, even the remaining grassland considered to be in moderate to good condition may have more than 20% cover of exotic plants. Many weeds are indicative of levels of past disturbance and now function as part of the grassland vegetation without apparently threatening the integrity of the surviving native plants e.g. hairgrasses (*Aira* spp.) and Quaking Grass (*Briza minor*) (Kirkpatrick *et al.* 1995; Eddy *et al.* 1998). However, they may be replacing or out-competing annual or spring flowering native species and could be critical in terms of native species richness and diversity (Sharp 1995). Weeds are favoured by soil disturbance, changes to drainage and nutrient levels (sites that become wetter are often subject to increases in nutrients from upslope fertiliser application) and in some instances, fire. For example, Chilean Needlegrass (*Nassella neesiana*) a Weed of National Significance has spread dramatically in abundance and distribution in the last decade and is promoted by fire, which creates bare ground and reduces competition from other species (Muyt 2001).

Categories of plants that have become established as weeds in natural temperate grassland include: annual grasses (e.g. Rat's Tail Fescue and Squirrel Tail Fescue *Vulpia* spp., barley grasses *Hordeum* spp.); annual and biennial forbs (e.g. Viper's Bugloss *Echium vulgare*, Great Mullein or Aaron's Rod *Verbascum thapsus*); perennial grasses (Sweet Vernal Grass *Anthoxanthum odoratum*, Yorkshire Fog *Holcus lanatus*, Chilean Needlegrass *Nassella neesiana*, Serrated Tussock *N. trichotoma*, Phalaris or Canary Grass *Phalaris aquatica*, Bulbous Bluegrass *Poa bulbosa*); perennial forbs (e.g. St John's Wort *Hypericum perforatum*); and shrubs or woody weeds (e.g. Hawthorn *Crataegus monogyna*, African Boxthorn *Lycium ferocissimum*, Sweetbriar *Rosa rubiginosa*) (Rowell 1994; Sharp 1995; Rehwinkel 1996a,b,c; Eddy *et al.* 1998; Sharp and Rehwinkel 1998; Eddy 2002).

Weeds are a major threat to all grassland remnants. Weed invasion is encouraged by disturbance to grassland sites and the small size of remnants; which makes them vulnerable to the spread of weeds from adjacent land. The following perennial and highly invasive weed species are of particular concern and are all the subject of weed control activities by land management agencies in the ACT, coordinated through the ACT Weeds Working Group:

(a) African Lovegrass (*Eragrostis curvula*). This is an aggressive, tenacious, drought and frost tolerant species capable of dominating the ground flora on lighter low-nutrient soils (Muyt 2001). The ACT African Lovegrass Management Plan (2002) focuses on control of new and scattered infestations while undertaking management of existing heavy infestations.

(b) Serrated Tussock (*Nassella trichotoma*). A Weed of National Significance, Serrated Tussock is a major weed of the Southern Tablelands. In this region it is widespread, but may have occupied only 20% of its potential range. It has broad site tolerance and is highly invasive. Mature plants develop a drooping, smothering form eventually excluding other ground flora and are capable of producing 100 000 seeds annually with some remaining viable for 10–15 years (Parsons and Cuthbertson 1992; Muyt 2001).

(c) Chilean Needlegrass (*Nassella neesiana*). A Weed of National Significance, Chilean Needlegrass is one of the most threatening invasive plants of grassy ecosystems in south-eastern Australia and has spread rapidly since 1990. Its adaptability to a wide range of conditions, large persistent seed bank, ease of seed dispersal, and tolerance of various treatments make control extremely difficult. Plants tolerate periodic inundation, extended dry periods, fire and heavy grazing and are adapted to low or high fertility soils, moderate shade or sunny locations (Muyt 2001). The species was surveyed in the ACT in 2000 and 2002 and found to be present in or adjacent to 85% of natural temperate grassland sites.

(d) St Johns Wort (*Hypericum perforatum*). This species is a major weed of grasslands, grassy woodlands and forests in south-eastern Australia. It forms extensive infestations excluding most other ground flora and impeding overstorey regeneration. Perennial crowns develop from shallow rhizomes and produce new aerial growth each year. It also reproduces from seed (Muyt 2001). It is widespread in lower elevation areas of the ACT.

- **Changed and Inappropriate Fire Regimes:** While it is known that fire regimes have changed, it is not exactly clear what they changed from and what the results have been. It is generally accepted that natural temperate grassland was adapted to a fire regime derived from Aboriginal burning (probably consisting of a mosaic of patchy, low intensity fires in spring and autumn) and occasional high intensity fires in summer (most probably caused by lightning strike). With European settlement, the dominant disturbance agent changed from burning under low grazing pressure by native species to grazing by stock with little burning. At local scales, however, areas such as roadsides and railway easements were burnt frequently. Increasingly, this burning has been phased out in favour of other means of defoliation (Lunt and Morgan 2002).

  The timing of fire in relation to the life cycles of plants, the intensity and frequency of fires, all have a strong influence on the long-term results of a fire regime. The primary threats posed to native grasslands by fire are that the grassland is burnt too frequently, too hot or at the wrong time in the life cycles of the plants, and that the whole of a grassland remnant is burnt leaving no escape for native animals. In the absence of other defoliation, fire can also be too infrequent allowing native grassland to become overgrown with consequent loss in biodiversity. This is due, in particular, to the decline of inter-tussock perennial forbs that appear to need open conditions for seed production and germination (Eddy 2002; Lunt and Morgan 2002).

The effects of grassland fire regimes on fauna have been poorly studied, however, frequent burning is widely perceived as having negative impacts on many animals, particularly small species that are relatively immobile and live in small grassland fragments. The challenge for managers of small grassland remnants that contain a diverse flora and threatened fauna is to maintain an open vegetation structure to maintain plant diversity while also maintaining viable animal populations (Lunt and Morgan 2002). In these circumstances, defoliation by mowing or intermittent, light grazing may be more appropriate.

In their review of fire regimes in temperate lowland grasslands, Lunt and Morgan (2002) highlight the complexity of the subject and note that burning regimes should be tailored to individual grassland remnants. They suggest that experience with *Themeda* grasslands points to the need to regularly burn productive grassland remnants to prevent further declines in biodiversity. While few fire studies have been conducted in grasslands dominated by *Austrodanthonia* and *Austrostipa*, these have less biomass and shorter lifespans than *Themeda triandra* or *Poa* spp., so litter accumulation and competitive exclusion do not present the same threat to plant diversity. A significant issue is that fire opens the ground surface to opportunistic post-fire colonisation by exotic annual weed species that have a large soil seed bank and to exotic perennial grasses e.g. Chilean Needlegrass. Incorporating fire into the management of native grasslands remnants is difficult where off-site spread is a danger. These areas are also vulnerable to unplanned fires (e.g. bushfires, arson) from surrounding areas. There are a number of reasons, therefore, why other forms of defoliation are now used instead of burning in grassland remnants.

- **Other Forms of Disturbance**

Grazing by feral animals: Loss or degradation of natural temperate grassland has also resulted from grazing by feral animals (particularly rabbits), soil disturbance, soil fertility change, altered drainage, traffic and trampling, and stockpiling and dumping of materials (Eddy 2002). Grazing by rabbits puts pressure on more succulent species that are less tolerant of regular or heavy grazing. The rabbit plague that engulfed south-eastern Australia in the second half of the 19th century reached the Monaro in the early 20th century, having devastating effect on both the vegetation and the pastoral economy (Hancock 1972). Eddy (2002) suggests that a significant proportion of the change in native grasslands has been the result of grazing by rabbits, rather than grazing by domestic stock.

Physical disturbance: Physical disturbance of the soil has occurred through activities such as cultivation, ripping rabbit burrows, laying pipes and cables. These activities remove or kill the existing vegetation, often releasing soil nutrients and creating a favourable environment for weed invasion. Soil moisture is a major determinant of plant community structure and composition. Alteration of drainage patterns by the construction of dams, roads and other earthworks, for example, has resulted in increased water flows on to grassland sites often bringing extra nutrients and allowing exotic species to out-compete the original vegetation. Traffic and trampling result in bare, compacted ground that is vulnerable to weed invasion, increased run-off and erosion, and cause the loss of cryptogams from naturally occurring bare patches. Vehicle traffic assists in weed seed dispersal. Grassland has been lost from road verges and public land areas following dumping, stockpiling and spreading of soil and gravel which smothers the vegetation and creates bare areas vulnerable to weed invasion.

Use of fertilisers and other soil ameliorants: Changes in soil fertility (e.g. by application or drift of superphosphate, gypsum or lime) can alter the competitive relationships between plants to the point where species composition in the community changes.

Mowing and slashing: Mowing and slashing can be a threat to native grassland if it prevents flowering and seed production by being undertaken too frequently or at the wrong time. Mowing and slashing equipment can also transfer weed seeds and this is thought to be one of the means by which African Lovegrass and Chilean Needlegrass have been spread (Eddy 2002). A major concern with mowing is that cut material left on site acts as mulch and inhibits inter-tussock forb growth. Mowing and slashing may also affect animal habitat.

Tree planting: Natural grasslands are treeless or contain only scattered trees and this characteristic is important to their ecology. Tree planting in or near grasslands can have detrimental effects through shading, effects on soils, attracting birds that are vectors of weed seeds, and giving rise to the spread into the grassland of wildings (e.g. Radiata Pine *Pinus radiata*). For example, forward tree planting in what is now the Crace Nature Reserve has affected the grassland and habitat for the Striped Legless Lizard and will need to be managed to ensure habitat is not lost permanently.

Herbicide use: While herbicides are essential for the control of weed species, such application or spray drift has the potential to affect grassland native species (Eddy 2002).

Collection of grass seed: There is increased interest in collection and propagation of native seed for use in revegetation work. Harvesting seed without considering recruitment requirements of the source community is a potential threat. Concern has also been raised about the genetic effects of the introduction of plants or seeds of the same species from another area (Eddy 2002). This is the subject of ongoing research.

Salinisation of soils: There is a medium-term likelihood of salinisation of soils becoming a threat to natural temperate grassland in parts of the Southern Tablelands. When remediation works are undertaken, it is important that the characteristics of the grassland are not compromised, especially by extensive tree planting (Environment ACT 2005).

2.1.8 Condition of Lowland Native Grassland in the ACT

The remaining areas of lowland native grassland can be considered on a continuum from those that appear largely intact (similar to their estimated pre-1750 state though there are likely to be changes in component species) to those in a substantially modified state with only a few elements representing their origins. For the purposes of the *Strategy*, the remaining lowland native grassland in the ACT has been classified in relation to its assessed degree of modification since European settlement, the corollary of which is the degree to which it retains its natural integrity. This categorisation of grassland is adapted from a similar conceptual framework developed for lowland woodland in the *ACT Lowland Woodland Conservation Strategy* (ACT Government 2004a), which itself is based on a means of conceptualising human modification of woodland landscapes presented by McIntyre and Hobbs (1999) and McIvor and McIntyre (2002).

Because annual exotic species fluctuate in their cover and diversity between seasons and years, they are not used in the evaluation of the degree of disturbance, although generally there is a greater cover of annual exotic species in the more disturbed sites. However, grasslands almost invariably now contain annual and perennial plant species.

Categories of remaining lowland native grassland reflecting varying degrees of modification are shown in Table 2.1, and discussed on page 22.

Table 2.1: Condition of Lowland Native Grassland in the ACT

Degree of Modification	Vegetation Cover (predominant cover, may also contain small patches of more or less disturbed vegetation)	Grassland Category	↓↑
Unmodified (pre-1750 composition	Native cover only, reflecting biological diversity prior to European settlement. Community dominated by perennial tussock grasses with wide variety of other herbs. Treeless or less than 10% projective foliage cover.	Natural Temperate Grassland	↓
Partially Modified	High diversity and cover of native species, including disturbance sensitive species and/or moderately sensitive species. Includes high diversity of forbs (BSR 1–2).	Natural Temperate Grassland (endangered ecological community)	↓
Moderately Modified	Moderate diversity and cover of native species, including disturbance tolerant species (but excluding disturbance sensitive or moderately sensitive species) (BSR 3).	Natural Temperate Grassland (endangered ecological community)	↓↑
Highly Modified	Low diversity of native species (mostly disturbance tolerant native grasses), very low native forb diversity, low cover of introduced perennial species (BSR 4).	Natural Temperate Grassland (endangered ecological community)	↓↑
Substantially Modified	One or more disturbance tolerant native grass species, few or no native forbs, low cover of introduced perennial species (BSR 5).	Native Pasture	↓
Severely Modified	Dominated by exotic annual and/or perennial species, but may contain some native species (E).	Degraded native pasture or exotic pasture	↓
Destroyed	Exotic pasture, crops, urban or other development.	Not applicable	

Natural Temperate Grassland (endangered ecological community) declared under the Nature Conservation Act 1980 (ACT).

↓↑ Areas of grassland may change levels depending upon land use, management and disturbance factors.

BSR: Botanical Significance Rating: see s. 3.2 and Appendix 1.

- **Unmodified (pre-1750 composition and structure): Natural Temperate Grassland**

  Although grassland in this category no longer exists, estimation of the features of the pre-1750 natural temperate grassland provides a basis against which to consider the type and extent of subsequent modification. The characteristics of this grassland are outlined in s. 2.1.4. The key features are considered to have been dominance by native species of perennial grasses, a high diversity of other herbs especially forbs, and the absence of trees or only scattered trees. Though floristic composition varied geographically, Kangaroo Grass (*Themeda triandra*) is thought to have been dominant over extensive grassland areas on the Southern Tablelands with River Tussock (*Poa labillardieri*) dominant in wetter areas. Higher areas of the Monaro underlain by basalt were almost certainly dominated by Poa Tussock (*Poa sieberiana*) (Benson and Wyse Jackson 1994) and still are today (Eddy *et al.* 1998). On drier sites, speargrasses (Corkscrew *Austrostipa scabra* and Tall Speargrass *A. bigeniculata*) and wallaby grasses (*Austrodanthonia* spp.) were probably dominant. Speargrasses and wallaby grasses have subsequently expanded their range, replacing Kangaroo Grass under grazing pressure. The grasslands were maintained by a disturbance regime involving regular burning, grazing by native herbivores and some physical disturbance to the soil by Aboriginal digging for edible roots where these were present and digging by an abundance of small mammals (Whalley 2003). As well as the mammalian fauna, the grasslands supported a rich diversity of invertebrates, reptiles, amphibians and birds (including several specialist grassland species).

- **Partially Modified: Natural Temperate Grassland (endangered ecological community)**

  These are lowland grassland areas that are considered to have had the least amount of change from the pre-1750 ecological community. In particular they have a high diversity and cover of native species (including perennial grasses thought to have been the original community dominants), a high diversity of forbs, and species sensitive or moderately sensitive to disturbance. In the ACT, these are sites containing natural temperate grassland with a botanical significance rating (BSR) of 1–2 (for explanation see s. 3.2), where particular land uses have resulted in lower levels of disturbance. These sites may contain threatened plant and/or animal species.

- **Moderately Modified: Natural Temperate Grassland (endangered ecological community)**

  Moderately modified lowland grassland differs from partially modified grassland in regard to the loss of species diversity and likely changes in the dominant perennial grasses. These changes have often resulted from grazing practices and there is evidence that some changes occurred early in the European pastoral period (Benson and Wyse Jackson 1994). There is still a moderate diversity and coverage of native species, including disturbance tolerant species, but few or no disturbance sensitive species. In the ACT, these are sites with a botanical significance rating of 3 (see s. 3.2). The majority of areas of natural temperate grassland in the ACT are of this rating. These sites may contain threatened plant and/or animal species.

- **Highly Modified: Natural Temperate Grassland (endangered ecological community)**

  Areas of highly modified natural temperate grassland contain the characteristic features of natural temperate grassland, but have lost much of the diversity present in less modified sites. The reduction in diversity is largely a result of the loss of many forbs and some of the more disturbance sensitive grasses (for example Kangaroo Grass). These sites still contain, however, a high cover of native species. It is unclear on the basis of existing evidence whether these sites are likely to gain a higher level of diversity as a result of changes to management practices, but are defined as a component of the ecological community on the basis that there may be adequate species remaining to provide the basis for natural regeneration and enhancement of diversity. These sites have a BSR of 4 and may contain threatened plant and/or animal species.

- **Substantially Modified: Native Pasture**

  These sites are characterised by a high cover of native grasses, especially Spear grasses (*Austrostipa* spp.), and lack the more disturbance sensitive grasses such as Kangaroo Grass. At most they contain only several native forbs that are the most disturbance tolerant species (particularly Sheeps Burr *Acaena ovina*, Swamp Dock *Rumex brownii*, some Bluebell species *Wahlenbergia* spp. and Wattle Mat-rush *Lomandra filiformis*). The sites contain a low cover of exotic perennial species. Evidence from surveys and monitoring indicate that these sites are so modified that they are unlikely to increase in diversity as a result of natural regeneration. These sites have a BSR of 5 and may contain threatened plant and/or animal species.

- **Severely Modified: Degraded Native Pasture**

  Degraded native pasture contains a small cover of native species, but is characterised by a high cover of exotic species that may have been deliberately introduced or have invaded as a result of significant levels of modification of the site (e.g. cropping followed by uncontrolled regrowth of weeds, some deliberately introduced species and some native species, particularly speargrasses). These sites are indicated in the *Strategy* by the notation 'E'. Threatened plant and/or animal species have been found in some of these sites.

- **Destroyed**

  Exotic pasture, other exotic vegetation or infrastructure has now replaced most of the natural temperate grassland existing at the time of European settlement. The grasslands were affected initially by grazing or cropping prior to the establishment of the National Capital and during the course of its development. The total destruction of natural temperate grassland over much of the ACT (see s. 2.1.3) has been mainly due to the development of the city of Canberra in the valleys where natural temperate grassland was naturally distributed.

2.2

Grassland Flora

2.2.1 Natural Temperate Grassland Flora

Natural temperate grasslands and other native grasslands are characterised structurally by grass species, particularly Kangaroo Grass, spear grasses, wallaby grasses, Red Grass and *Poa* grasses, and grasses usually dominate in terms of cover. However, the term 'natural temperate grassland' can disguise the fact that a characteristic of this grassland in a relatively undisturbed condition is the presence of large number of non-grass species (forbs), which are not obvious in all seasons and all years. One of the most attractive features of natural temperate grassland is the extensive 'wildflower' display, in particular by representatives of the lily and daisy families. These displays are a window to the floral diversity of the spaces between the grass tussocks where may be found also a variety of orchids, peas and gentians and, in moister areas, rushes and sedges (Eddy *et al*. 1998), amongst many more plant families. Many of these plants disappear from grasslands as disturbance increases (Table 2.1).

For much of the year many of these species are not readily noticeable, because they emerge from rootstock, flower, set seed and then die back to rootstock in autumn or earlier. The winter monotones of brown and grey are replaced in early spring by greens, whites, yellows and blues, as the plants respond to the onset of warmer weather. Spaces in the grasslands provide opportunities for many of the smaller, more delicate species such as orchids and lilies to grow and reproduce. The white Early Nancy, a small lily, is one of the first species flowering, a promise that spring is coming. Orchids are rarely visible for more than several weeks, and over spring there is a constant change over of species. Especially prevalent in early spring are various species of *Caladenia*, white and purple Wax-lipped orchids and Yellow-flowered *Diuris* species. Even where the ground appears bare, there may be 'soil crust' lichens and bryophytes forming an extensive ground-surface covering. This is often less easy to see in dry periods when many species desiccate as a protective response.

In surveys undertaken in ACT lowland native grasslands since 1991, 50 species of grasses, over 200 species of native forbs (including sedges and rushes, lilies and orchids), and about 150 introduced species have been identified. Dominant grasses, other characteristic species and common exotic species of ACT lowland native grasslands are listed in s. 2.1.4. Many of these and/or related species are illustrated in Eddy *et al*. (1998).

Partially modified sites (Table 2.1) contain species that are uncommon, rare or non-existent in more disturbed sites. These species include orchids, some lilies and other more palatable forbs. However, many moderately disturbed sites still retain a high diversity of species, although they tend to be those that are common throughout many sites. Even the least disturbed sites contain a significant proportion of introduced species.

2.2.2 Threatened and Uncommon Grassland Flora Species in the ACT: Threats, Conservation Objectives and Actions

Eleven plant species found in natural temperate grasslands in the Southern Tablelands region are listed as threatened under Commonwealth, New South Wales or ACT legislation (Environment ACT 2005). Seven of these species are known to occur in the ACT (Table 2.2). Many other grassland plant species are rare or uncommon, or have suffered dramatic declines in their frequency and abundance, occurring either in low density within sites, or in very few sites in the region. The abundance and distribution of many of

these is poorly known. Unpublished data from recent studies are revealing more species with very low population densities in natural temperate grassland in the region (R. Rehwinkel pers. comm.; S. Sharp pers. comm.). These data will need to be kept under review to assess whether targeted conservation actions are required for these species.

Three plant species of grassland/grassy woodland listed as threatened under ACT and/or Commonwealth legislation are included in the *ACT Lowland Woodland Conservation Strategy* (ACT Government 2004a). These species are the Hoary Sunray (*Leucochrysum albicans* var. *tricolor*), Tarengo Leek Orchid (*Prasophyllum petilum*) and Austral Toadflax (*Thesium australe*) (Table 2.3).

Button Wrinklewort (*Rutidosis leptorrhynchoides*) and Ginninderra Peppercress (*Lepidium ginninderrense*) are included in this *Lowland Native Grassland Conservation Strategy*. While *Rutidosis leptorrhynchoides* is generally considered to be a herb of natural temperate grassland, in the ACT it occurs on the margins of Yellow Box–Red Gum Grassy Woodland. The largest population at Stirling Park occupies open areas within the woodland, especially previously disturbed areas and patches with skeletal soils. Action Plans pursuant to the *Nature Conservation Act 1980* were adopted for these species in 1998 and 2003 (ACT Government 1998b, 2003) and are subsumed into this Action Plan. Declarations by other jurisdictions of these species are summarised in Table 2.2.

Threatened Species: Button Wrinklewort (*Rutidosis leptorrhynchoides*)

Button Wrinklewort was declared an endangered species in 1996 under the *Nature Conservation Act*

Table 2.2: Plant Species listed under Commonwealth, State and Territory Legislation that occur in Natural Temperate Grassland of the Southern Tablelands

Species	Common Name	C'wlth	ACT	NSW	Vic
Calotis glandulosa [3]	Mauve Burr-daisy	V		V	
Dillwynia glaucula [3]	Michelago Parrot-pea			E	
Diuris pedunculata	Golden Moths	E		E	
Dodonaea procumbens [3]	Creeping Hopbush	V		V	
Lepidium ginninderrense [1]	Ginninderra Peppercress	V	E (SPS)		
Leucochrysum albicans var. *tricolor* [2]	Hoary Sunray (white form)	E			
Prasophyllum petilum [2]	Tarengo Leek Orchid	E	E	E	
Rutidosis leiolepis [2]	Monaro Golden Daisy	V		V	
Rutidosis leptorrhynchoides [1]	Button Wrinklewort	E	E (SPS)	E	T
Swainsona sericea	Silky Swainson-pea			V	
Thesium australe [2]	Austral Toadflax	V		V	

E: endangered; **V**: vulnerable; **T**: threatened (as defined under Victorian legislation); **(Nom.)**: nominated; **SPS**: Special Protection Species.

Notes:

1. ACT declared threatened species included in this Strategy
2. Species included in the *ACT Lowland Woodland Conservation Strategy* (ACT Government 2004a)
3. Species not known to occur in the ACT

Legislation:

Commonwealth: *Environment Protection and Biodiversity Conservation Act 1999*

ACT: *Nature Conservation Act 1980*

NSW: *Threatened Species Conservation Act 1995*

Vic: *Flora and Fauna Guarantee Act 1988* (Note that under this Act, species are listed as 'threatened' rather than being assigned to categories)

1980 (ACT) and is listed as endangered under the *Environment Protection and Biodiversity Conservation Act 1999* (Cwlth). It is a slender perennial forb, 25–35 cm tall, with bright yellow button flowers (2 cm wide) from December to April. Formerly widespread in south-eastern Australia, the species has a disjunct distribution with 18 known populations in the ACT region and nine in Victoria. The species' habitat is both native grassland and native woodland in the ACT and the region. Populations at Red Hill, Stirling Park and State Circle are found within grassy woodland, and at West Block in a very small grassy woodland remnant (less than 0.25 ha). These sites are considered in the *ACT Lowland Woodland Conservation Strategy* (ACT Government 2004a). Another small population occurs at the Baptist Church in Currie St, Parkes, in degraded native grassland over-planted with eucalypts and exotic trees including pines. This population has been indicated in Figure 2.7 as habitat only. Further details of the species including ACT listing, distribution and abundance, habitat and biology are contained in Appendix 4.1.

Under existing circumstances, the species is considered to be reasonably secure in the ACT region. With the exception of the ACCC (Barton) site and West Block (Parkes) all populations are increasing in size. The location of each known occurrence of this species is shown in Figures 2.3–2.7 (at end of Chapter 2).

THREATS

Threats to the populations of *Rutidosis leptorrhynchoides* in the ACT and region are primarily:

- **Habitat loss or degradation:** While habitat loss is an ever-present threat, it should be noted that the majority of ACT sites are in reserves or adequately protected by other means. The largest populations in the ACT are on National Land at Stirling Ridge and Majura Training Area. These areas are not in reserves, but MOUs between Environment ACT and the respective Commonwealth land managers generally provide an adequate level of conservation management. The small area occupied by the Majura population increases its vulnerability to damage (Crawford and Rowell 1996).
- **Competition with other vegetation, including weeds:** *Rutidosis leptorrhynchoides* prefers an open habitat and is a poor competitor amongst tall, dense sward-forming grasses. Sites may need specific defoliation measures to reduce this competition. Grazing is not recommended as a routine management method, as it can have an adverse effect on *R. leptorrhynchoides* and its habitat. Occasional slashing in late summer may be used on sites where other factors (e.g. fire risk to property) make burning undesirable. Patch burning may be appropriate on other sites, but its effects should be monitored. Burning should not be used as a broad-scale management tool on *R. leptorrhynchoides* sites in the ACT until it has been established by experimentation that the benefits (seedling establishment) are likely to outweigh the costs (mortality of adult plants).

  Woody weed invasion and native tree and shrub regeneration may also affect *R. leptorrhynchoides* especially in grassy woodland sites. Older woody weeds should be cut and removed, and the stumps dabbed with herbicide. Seedlings and suckers should be controlled annually by hand-pulling and spot-spraying with herbicide (no spot spraying of herbicide should be used within 2 metres of any *R. leptorrhynchoides* plant).

  Native trees and shrubs not indigenous to the ACT (e.g. Cootamundra Wattle *Acacia baileyana*, Knife-leaved Wattle *A. cultriformis*) should be treated as woody weeds in grasslands. In the absence of fire, slashing or grazing, regeneration of eucalypts and some native shrubs such as *Cassinia quinquefaria*, Bitter Pea (*Daviesia mimosoides*), Silver Wattle (*Acacia dealbata*) and Green Wattle (*A. mearnsii*) may shade out *R. leptorrhynchoides*. Where necessary, a selection of these should be removed (cut and dabbed) annually, to maintain open mixed-age/species woodland.
- **Heavy grazing:** (See s. 2.1.7 and s. 3.7.4) Under heavy grazing *R. leptorrhynchoides* disappears because it is a tall herb palatable to stock. However, intermittent grazing in late summer may not be detrimental.
- **Erosion of genetic diversity and increased inbreeding:** This may compromise both short and long-term population viability by reducing individual fitness and limiting the gene pool on which selection can act in the future. The species has been the subject of considerable genetic research aimed at understanding the factors that limit population viability (Young *et al.* 2000). Research has indicated that populations of fewer than 200 plants are experiencing low seed set as a result of loss of genetic variation (CSIRO Plant Industry 2001).

CONSERVATION OBJECTIVE

1. Conserve in perpetuity, viable, wild populations of *Rutidosis leptorrhynchoides* in the ACT.
2. Support local, regional and national efforts towards conservation of the species.

Key elements in achieving this objective are protecting and managing major sites where significant populations occur, and developing an understanding of the requirements for the genetic conservation of the species as a basis for management.

CONSERVATION ACTIONS

Conservation actions for this species (mostly undertaken by Environment ACT) identified for this *Strategy* (Table 2.3) are mainly adapted from those included in Action Plan 8, Button Wrinklewort *Rutidosis leptorrhynchoides* (ACT Government 1998b). However, there are also some new actions that better reflect activities being undertaken or proposed with regard to this species. Table 2.3 contains notes on progress with actions undertaken in the period 1998–2003.

Table 2.3: Conservation Actions for Button Wrinklewort (*Rutidosis leptorrhynchoides*)

Actions (adapted from Action Plan 8 and new actions)	Notes on Progress with Actions 1998–2003
INFORMATION (SURVEY, MONITORING, RESEARCH)	
Maintain alertness to the possible presence of the species while conducting surveys in appropriate habitat.	1. Increase in number of known populations in the ACT. 2. New sites found in ACT since the preparation of Action Plan 8 are: ■ Crace Grassland Reserve (150 plants in 1998; 4000 plants in 2000); ■ Baptist Church, Manuka (50–100 plants in 2000); ■ Tennant St, Fyshwick (100 plants in 2000); ■ Harman (203 plants and 782 plants in two locations in 2003 (HLA-Envirosciences 2004)). 3. Additional populations were found at Stirling Ridge in 2000 and 2003 and at Campbell Park in 2002.
Review research by the CSIRO directed towards understanding how genetic variations influence the viability of small populations, for its potential to be applied to the conservation management of the species in the ACT.	1. A report commissioned by Environment ACT on issues and options for genetic conservation of small populations of threatened plants in the ACT outlines factors to be considered in, and directions for, genetic conservation of the species (CSIRO Plant Industry 2001). 2. Seed has been collected from several populations and is being stored at the Australian National Botanical Gardens. 3. Options are being considered for translocating plants from large populations to populations of less than 200 plants.
Maintain a monitoring program for the species with particular attention to seedling establishment and inspection for site damage. Coordinate this program with National Recovery Team efforts.	1. Populations are included in annual monitoring programs and site inspections are undertaken as required. Seedling establishment is generally healthy. 2. Ongoing contact has been maintained with researchers from the CSIRO and the Australian National University. There is close liaison with NSW Department of Environment and Conservation (DEC) (Queanbeyan) with regard to the regional conservation of *R. leptorrhynchoides*.
PROTECTION	
Protect *R. leptorrhynchoides* in native grassland habitat through the provisions of the *Land (Planning and Environment) Act 1991*, the Territory Plan and Memoranda of Understanding with the Commonwealth and the Anglican Church.	1. Most populations are under conservation management. 2. All *R. leptorrhynchoides* sites (except Australian Centre for Christianity and Culture (ACCC), Barton and Baptist Church, Manuka) are under the control of either the ACT or Commonwealth Governments. 3. MOUs have been signed for the Stirling Park–Attunga Point site (National Capital Authority) and Majura Training Area (Department of Defence). An MOU for the ACCC site remains under negotiation. *(Continued)* ▶

Table 2.3: *(Continued)*

Actions (adapted from Action Plan 8 and new actions)	Notes on Progress with Actions 1998–2003
PROTECTION *(Continued)*	
Through the National Recovery Team, promote complementary protection through reservation in NSW.	A consistent regional approach is established. This is the subject of on-going liaison with NSW Dept of Environment and Conservation.
Manage as a component of the grassy community, any conservation area established primarily for *R. leptorrhynchoides*.	1. Habitat for the species is being maintained. 2. Conservation management arrangements provide for the maintenance of the populations in their natural habitat.
Work with the ACT Planning and Land Authority and the National Capital Authority to ensure that land uses adjacent to sites supporting *R. leptorrhynchoides* are compatible with conservation objectives to minimise any adverse impacts.	1. Standard guidelines for the protection of the populations is provided to all land agencies as required. 2. Site by site advice has been provided as required. 3. Threats from adjacent land uses have been identified and minimised.
MANAGEMENT	
Develop an appropriate management regime for each site, in the form of a Management Plan or agreed management under the terms of a Memorandum of Understanding.	Draft management plans have been prepared for the majority of the ACT sites. Ongoing liaison is required to ensure that management is adequate.
Take an adaptive management approach, liaising with the National Recovery Team, CSIRO Centre for Plant Biodiversity Research and other regional researchers, and incorporating the results of research into management prescriptions for ACT *R. leptorrhynchoides* sites.	Adaptive management is implemented on sites. Management approaches have taken into account the results of monitoring and research work on the species.
Explore possibilities for horticultural effort being applied as a conservation measure for *R. leptorrhynchoides*.	1. Issue raised with National Recovery Team for consideration in consultation with relevant organisations. 2. This action is not considered to warrant a high priority.
COMMUNITY/LANDHOLDER INVOLVEMENT	
In consultation with the National Recovery Team, compile and distribute management guidelines and maintain contact with land managers responsible for areas on which populations of *Rutidosis leptorrhynchoides* occur.	1. Guidelines for management have been prepared in conjunction with the National Recovery Team. 2. Close liaison occurs with land managers and management advice has been provided to them. 3. Land managers are now aware of *R. leptorrhynchoides* populations on their land and management requirements.
Encourage community groups including the Friends of Grasslands and appropriate Park Care Groups to assist in the conservation of native grasslands and their component species including *R. leptorrhynchoides*.	1. Information on the species is provided to community groups and other stakeholders. 2. The community was involved in the (unsuccessful) translocation of plants at the Australian Centre for Christianity and Culture, Barton. There is strong community involvement in the management of the species in Red Hill Nature Reserve.
Promote the conservation of *R. leptorrhynchoides* through suitable information signs, community liaison and public education.	Actions to date include: information signs at ACCC, Barton; factsheet on the ACT Government website; inclusion in grassland field guide (Eddy *et al.* 1998); displays and talks at public events.

Threatened Species: Ginninderra Peppercress (*Lepidium ginninderrense*)

Ginninderra Peppercress was declared an endangered species in 2001 under the *Nature Conservation Act 1980* (ACT) and listed in 2005 as vulnerable under the *Environment Protection and Biodiversity Conservation Act 1999* (Cwlth). It is a perennial herb to a height of about 20 cm, with one to six branched stems arising from a rootstock. The inflorescence is an elongating raceme with small flowers appearing in late spring. The only known population of *Lepidium ginninderrense* occurs at the Belconnen Naval Transmission Station in the suburb of Lawson, ACT. Further details of the species including ACT listing, distribution and abundance, habitat and biology are contained in Appendix 4.2. The location of the known occurrence of this species is shown in Figure 2.6 (at end of Chapter 2).

THREATS

It is unlikely that the species exists anywhere else in the ACT. The issues for protecting the species, therefore, are related specifically to the need to preserve the single extant population.

The main threat to the survival of *L. ginninderrense* is likely to be urban infill, and deliberate or unintended actions associated with visitor and/or land management activities in the local area.

Observations by Avis (2000) suggest that the species grows well in locations where competing grass tussocks and other plant growth are short and open, and consequently there is little competition for space and light. Thus, inappropriate management leading to loss of such habitat may be also a threat to the species. It is important to determine management practices that are most conducive to the maintenance of the population at the only known site in Lawson.

CONSERVATION OBJECTIVES

1. Preserve the existing ACT population of *Lepidium ginninderrense* as it is the only known population of the species.
2. Conserve and manage the habitat of *Lepidium ginninderrense* so that natural ecological processes continue to operate.

CONSERVATION ACTIONS

Conservation actions (mostly undertaken by Environment ACT) are adapted from actions identified in Action Plan 26, Ginninderra Peppercress *L. ginninderrense* (ACT Government 2003) (Table 2.4). Table 2.4 contains notes on progress with actions identified in Action Plan 26.

Table 2.4: Conservation Actions for Ginninderra Peppercress (*Lepidium ginninderrense*)

Actions (adapted from Action Plan 26)	Notes on Progress with Actions
INFORMATION (SURVEY, MONITORING, RESEARCH)	
Monitor the population of *L. ginninderrense* annually and encourage research into the species.	Monitoring occurs annually.
Advise field workers, interested naturalists and conservation groups of the presence of the species to increase the potential that any other existing populations are identified.	1. Field workers in ACT grasslands are aware of the species, its habitat and identifying characteristics. 2. No other populations have been identified.
Liaise with NSW Dept of Environment and Conservation to encourage surveys of potential habitat outside the ACT.	
PROTECTION	
Support reservation under the *Land (Planning and Environment) Act 1991* (ACT) of the Lawson grassland including the area containing *L. ginninderrense* as part of the planning for the new suburb of Lawson.	1. The area in which the population of Ginninderra Peppercress occurs is within the Belconnen Naval Transmission Station, which is shown as National Land in the *National Capital Plan* (NCA 2003) and the *Territory Plan* (ACTPLA 2003). 2. The closure of the Belconnen Naval Transmission Station in the near future and development of the suburb of Lawson will require the protection of the Ginninderra Peppercress in a reserve. 3. Preliminary planning for Lawson has recognised the significance of this species and the need to protect it *in situ*. *(Continued)* ▶

Table 2.4: *(Continued)*

Actions (adapted from Action Plan 26)	Notes on Progress with Actions
MANAGEMENT	
Facilities such as walking tracks will not be developed near the site, with the aim of discouraging visitor access to the area.	Tracks near the population are currently in low use; the species grows to the edge and in places, across the tracks.
Consider actions relevant to protection of the population from adjacent activities.	1. This is not an issue until closure of the Belconnen Naval Station brings a potential for increased utilisation of the area. 2. A 'low profile' will be maintained for the site where the species is located.
Statements of conservation objectives and intended management actions for the species will be placed in relevant management plans and strategies.	To be undertaken when the Belconnen Naval station is closed.
Expert advice on best practices for management of the species will be sought, particularly (a) maintenance of an open habitat, and (b) actions considered desirable based on the results of monitoring (as part of an 'adaptive management' approach).	1. Current management is to maintain the open vegetation structure and otherwise provide minimal impact to the site. 2. Advice is incorporated into management guidelines for the species.
GENETICS AND *EX-SITU* CONSERVATION	
The following actions will be undertaken on the advice of CSIRO Plant Industry (2001): (a) Collect open-pollinated seed from a wide range of individuals. (b) Use some of the seed to establish new populations at other apparently suitable locations. (c) Store remaining seed under appropriate conditions (e.g. at the Australian National Botanical Gardens) to act as a core for *ex-situ* genetic conservation.	1. Existing plants of *L. ginninderrense* support high seed set, allowing opportunities for translocation and *ex-situ* conservation (CSIRO Plant Industry 2001). 2. Seed collection is already underway and seed is stored at the Australian National Botanical Gardens.
COMMUNITY/LANDHOLDER INVOLVEMENT	
Explore opportunities to involve the local community in Park Care activities as part of the management of the proposed reserve.	Under the current land use (Belconnen Naval Transmission Station) there is no public access to the *L. ginninderrense* site. However, with the development of the new suburb of Lawson recreational use of open spaces in the area will increase.

Uncommon Grassland Flora Species in the ACT

Species not listed under legislation as vulnerable or endangered may be also of conservation concern and it is important that their status be monitored over time and threats minimised, especially those species listed as threatened under other State or Commonwealth legislation (see Table 2.2). Some plant species in native grassland are naturally rare or have become uncommon due to clearance or disturbance. Some species may also be considered to be 'declining', if there is a suspected or recorded decrease in numbers (population decline). Decline also alludes to a potential or actual loss of vigour within the population (Crawford and Rowell 1996). For reasons such as the inconspicuous habit of some species, seasonal variation, and lack of historical knowledge of abundance and distribution, considerable uncertainty may surround these assessments. The conservation status of species needs to be considered in a regional context. The ACT has been comprehensively surveyed, but coverage of the Southern Tablelands region as a whole is variable with private land, in particular, being inadequately surveyed (Environment ACT 2005).

From surveys at the ten most diverse grassland sites in ACT Crawford and Rowell (1996) identified 28 species that they assessed as uncommon or declining. Of these, one has been described as a new species and declared endangered (Ginninderra Peppercress), and another is the threatened Button Wrinklewort, dealt with in the previous section. Several others of these species were probably under-surveyed in the past, as the more

recent surveys have found populations to be more common than previously thought (e.g. Blue Devil (*Eryngium ovinum*) and Wiry Dock (*Rumex dumosus*)).

Of the more uncommon species, the status of several is of particular concern:

- *Amphibromus nervosus* is a small forb occurring in swampy ground at low elevations and in valleys (Burbidge and Gray 1970). It has been found in two grassland locations in the ACT (Dunlop Nature Reserve and 'Woden Station' in the Jerrabomberra Valley) (Crawford and Rowell 1996). More recently, it has been found at two woodland sites, including Mulligans Flat Nature Reserve. Collections of the species from the ACT are lodged with the National Herbarium.
- *Burchardia umbellate* (Milkmaids) was found at one grassland location (Dunlop Nature Reserve) (Crawford and Rowell 1996) and has been found subsequently at two woodland sites, including Mulligans Flat Nature Reserve. It is also known from Hall Cemetery, in habitat of the Tarengo Leek Orchid. The species is widespread in other parts of temperate Australia, but is uncommon on all but the north-western parts of the Southern Tablelands region (Eddy *et al.* 1998).
- *Microseris lanceolata* (Yam Daisy) is known to have declined since European settlement. The species is described as being common in the ACT and widespread in temperate Australia (Burbidge and Gray 1970), however, it is seldom recorded in surveys. It occurs in one grassland site (Australian Centre for Christianity and Culture, Barton), and has been recently recorded in Mulligans Flat and Farrer Ridge nature reserves.
- *Ophioglossum lusitanicum* (Adder's Tongue) is probably frequently overlooked as it is a tiny one or two leaved fern (up to 25 mm tall) with an inconspicuous green fertile spike. Crawford and Rowell (1996) found it at six grassland sites (Canberra International Airport, Gungahlin Grassland Reserves, Majura Training Area, Dunlop Reserve and 'Woden Station').
- *Stuartina muelleri* (Spoon Cudweed) is one of the few annual herbaceous species found in ACT grasslands. It occurs in grassland, woodland and sclerophyll forest, and is relatively widespread (Crawford and Rowell 1996). This is a very small plant, which is easily missed in surveys, particularly as it has inconspicuous tiny flowers and is only present in spring (Eddy *et al.* 1998). The species was found by Crawford and Rowell (1996) at the Belconnen Naval Station and Gungahlin Grassland Reserve. More recently it has been recorded at Yarramundi Reach and Mulligans Flat Nature Reserve.
- *Swainsona sericea* (Silky Swainson-pea) is a grassland and grassy woodland species listed as vulnerable in NSW. The species flowers from October to December, but quickly dies back to rootstock after flowering. It was recorded on the Monaro at four locations (Benson 1994), at three ACT grassland sites in 1996 (Gungahlin Grassland Reserve, Majura Training Area and 'Woden Station') and at four ACT woodland sites (Crawford and Rowell 1996).
- *Zornia dyctiocarpa* var. *dyctiocarpa* (Zornia) is recorded as being widespread in grassland and open forest in a number of biogeographic regions (Crawford and Rowell 1996). In the ACT, however, it is less commonly found, but is known to occur in grassland at Dunlop Grassland Reserve (Crawford and Rowell 1996) and at 'Woden Station' and in woodland on Tuggeranong Hill and Wattle Park, Lyneham (S. Sharp, pers. comm.).

THREATS

Threats to uncommon species are those previously discussed for the ecological community generally (see s. 2.1.7). An additional threat is the lack of botanical and ecological knowledge of these species, as they do not have the same 'profile' as listed threatened species.

CONSERVATION OBJECTIVES

1. Conserve populations of known uncommon plant species in ACT natural temperate grassland as viable populations in perpetuity.
2. Conserve the full range of habitat diversity to maintain a range of species in suitable habitat.

CONSERVATION ACTIONS

Conservation actions (Table 2.5) for uncommon grassland flora species (mostly undertaken by Environment ACT) are framed within the actions for the Strategy as a whole in Table 4.1. Table 2.5 contains notes on activities currently being undertaken in relation to these actions.

Table 2.5: Conservation Actions for Uncommon Grassland Flora Species

Actions	Activites Completed or Currently being Undertaken in Relation to these Actions
INFORMATION (SURVEY, MONITORING, RESEARCH)	
Maintain alertness to the possible presence of uncommon grassland plant species when undertaking surveys in appropriate habitat.	1. Field workers in ACT and regional grasslands are aware of the need to record occurrences of a range of species of concern. 2. A survey for 53 species considered uncommon or declining in ACT grasslands and grassy woodlands has been undertaken (Crawford and Rowell 1996). Surveys of all ACT grasslands include records of these species.
Maintain a database of known occurrences and abundance of uncommon grassland plant species to enable analysis of changes in distribution and abundance.	The ACT vegetation database contains records of all species identified in all grassland plant surveys undertaken in ACT since 1991.
Maintain a watching brief on ACT populations of uncommon grassland plant species and evaluate their conservation status in a regional context.	Field workers are aware of the need to look out for occurrences of a range of species that may be declining.
Facilitate and encourage research that will provide information on the status of uncommon grassland plant species and management requirements.	
PROTECTION	
Ensure known populations of uncommon grassland plant species are protected from inadvertent damaging actions (e.g. by advising landholders of their presence).	The presence of populations is taken into account in the management of grassland sites.
MANAGEMENT	
Prepare management guidelines for uncommon grassland plant species where necessary.	
Manage sites, and provide advice to other landowners and managers, to maintain optimum habitat (where known) for uncommon grassland flora species.	
Consider nomination for ACT listing if uncommon grassland flora species show evidence of local decline in extent and abundance.	
REGIONAL AND NATIONAL COOPERATION	
Liaise with interstate agencies involved in protection and management of uncommon grassland flora species with the aim of increasing knowledge of their biology, and habitat and conservation requirements.	Liaison with NSW Dept of Environment and Conservation threatened species officers includes information exchange about the status of particular species of concern.

2.3

Grassland Fauna

2.3.1 Fauna as part of the Grassland Ecosystem

Animals are intrinsic to the overall functioning of ecosystems, including grassy ecosystems. Animals are essential for pollination and dispersal of many grassland plants and are involved in nutrient recycling and maintenance of soil condition. Grasslands provide habitat for animals and are a source of food for both herbivores and predators. Invertebrates are particularly important though it is not known what constitutes a natural invertebrate community for grasslands (Driscoll 1994). However, they are the dominant faunal element in grasslands and are involved in most ecological processes (Sharp and Dunford 1994; Yen 1995).

Australian grasslands have evolved under grazing from a range of animals, including kangaroos, wallabies, wombats and other herbivores such as termites. The population sizes (or densities) of grazing animals are determined largely by seasonal abundance of the grassland plants upon which they feed. In turn, plant species composition and abundance of grassland vegetation are affected by the population size of grazers (grazing intensity) and seasonal conditions (rainfall and temperature). Thus grazers and grasslands are linked in a complex feedback loop driven by fluctuating seasonal conditions.

Loss of native animal species or introduction of exotic animal species can alter ecosystem processes and may lead to a change in the composition of grassland vegetation (such as a shift in the dominant plant species following removal of grazers or after sustained heavy grazing). There may be adverse affects also on the health of the ecosystem (such as the loss of native plants following loss of their insect pollinator or increased erosion due to loss of vegetation cover through heavy grazing). The well-known phenomenon of rural tree dieback that affects woodlands and isolated paddock trees in grasslands is a notable example of an altered ecosystem process that has resulted in widespread impact at the landscape level. One of the possible explanations for the increasing occurrence and severity of insect-mediated dieback is a reduction in the abundance and efficacy of natural controls of damaging insects, in particular the decline in insectivorous birds and insect parasitizers of pasture scarabs (Reid and Landsberg 2000; Martin and Green 2002).

2.3.2 Threats to Grassland Fauna

The main threat to fauna in native grasslands in Australia, and the primary reason for the decline of many grassland animal species, is the widespread removal, modification and fragmentation of grassland habitat since European settlement. Other threats include increased predation by introduced predators, competition from introduced herbivores and human disturbance. These threats to grassland fauna are described in more detail in the following sections.

CONTINUED REMOVAL AND FRAGMENTATION OF HABITAT

The decline of grassland fauna is related to the history of land clearing and conversion of grasslands to agriculture, including cropping of introduced plants and grazing by introduced animals largely on introduced pastures. Clearance of native vegetation, including native grassland, still remains the most significant threat to terrestrial biodiversity despite apparently tight legislative controls (Australian State of the Environment Committee 2001) and is listed as a key threatening process in NSW and nationally. Expanding urban development increases pressure on remnants of native vegetation, whereas construction of roads and other urban infrastructure leads to increased fragmentation of habitat. There is an extensive literature on the effects of fragmentation on animals, especially birds and mammals (Andren 1994). Whilst much of this literature relates to removal of shrub and tree layers, the effects can also be extrapolated to fragmentation of habitat for grassland fauna.

The size and isolation of a remnant is critical for the long-term persistence of many animal species within the remnant. Minimum patch size to support a viable population of larger animals such as Eastern Grey Kangaroos is likely to be greater than for some smaller mammals or reptiles, and all species are likely to require larger patch sizes in poor quality or degraded habitat than in good quality habitat. Animal populations too small to be viable in the long term may persist for some time in remnants following habitat fragmentation, resulting in a time lag (in some cases years or decades) between habitat disturbance and species decline (Recher and Lim 1990; Saunders *et al.* 1991; Traill 2000). Such time lags can occur if individuals are long-lived (but may not be breeding) or if the habitat is sufficient to satisfy the requirements of the species during good conditions, but not during or following major environmental disturbances such as drought or fire.

Habitat fragmentation is of particular significance for many invertebrates whose populations can fluctuate dramatically, often related to the prevailing weather. Species whose populations fluctuate in size will frequently exist only in small populations and their persistence may derive from repeated recolonisation following local extinction, involving immigration from other populations (Driscoll 1994). Some invertebrates have limited mobility. Populations of the threatened Golden Sun Moth (*Synemon plana*) separated by more than 200 m are effectively isolated but the lack of genetic differentiation between closely located populations may indicate that these were all historically connected and have only recently undergone fragmentation (see Appendix 5.3). Management of grassland fragments for invertebrate conservation is particularly difficult given the lack of knowledge and the isolation of fragments. Timing and type of biomass reduction, for example, is critical to the life cycle of many species.

The degree of isolation or connectivity of a remnant determines its potential for recolonisation and is a critical issue for fauna conservation. Connectivity has been defined as 'the degree to which the landscape facilitates or impedes movements among patches' (Bennett 1999). Movement between patches can be impeded by unsuitable habitat between patches (e.g. cultivation or urban development) or by barriers such as major roads and traffic. Although there are possible disadvantages to linking habitats (e.g. corridors might serve as conduits for disease or fire), connectivity is generally regarded as desirable in conservation planning (Saunders and Hobbs 1991). Lack of connectivity in highly fragmented ecosystems is clearly a threat to the long-term viability of some animal populations (Smith and Hellmann 2002), though the best means of rebuilding connectivity is subject to debate and depends upon the species in question. For example, it is not known whether species such as the Grassland Earless Dragon or Striped Legless Lizard are able to cross a major road and what structures would assist such crossing.

The value of corridors has been debated on the basis of adequate width, high cost and edge effects. An alternative is closely spaced patches forming 'stepping stones' (Beier and Noss 1998; Martin and Green 2002; Freudenberger 2001). Stepping stones are likely to benefit species that are sufficiently mobile to cross areas of unsuitable habitat (such as some birds and kangaroos) but may not benefit less mobile species such as many reptiles. Even amongst highly mobile species, fragmentation can result in the necessity to move greater distances between resources, such as between feeding and shelter (e.g. kangaroos moving between shelter trees and open feeding areas). Movement between fragments can also increase exposure to risks such as predation or road collision (e.g. kangaroos in the Canberra urban area and migrating Eastern Long-necked Turtles (*Chelodina longicollis*)).

DEGRADATION OF EXISTING HABITAT

The major threat to animals in existing habitat, even where the habitat may have sufficient area and connectivity, is the modification or degradation of habitat. Habitat modification can be through a change in plant species composition (e.g. exotic species replacing native species), habitat structure (e.g. short grass as opposed to tall grass, or tussocks replaced by non-tussock species, trampling of grass, removal of rocks), plant species diversity (e.g. loss of diversity in a monoculture) or quality (e.g. loss of organic matter, loss or addition of nutrients, change in soil characteristics). Such changes can be brought about through grazing by stock at an intensity that reduces plant diversity of the ground layer, planting of crops or exotic pastures, invasion by weeds, addition of fertilizer, use of chemicals, removal of rocks, dumping of soil, gravel or rubbish, and altered fire regimes. Each of these modifications may reduce the suitability of habitat for certain animal species. Removal of bush rock, invasion by exotic perennial grasses, and high-frequency fire regimes are listed in NSW as key threatening processes. Grazing by stock and use of exotic pasture plants and fertilizer (i.e. 'pasture improvement') have caused the most extensive modifications to existing grasslands. Improved pastures are of little conservation value.

INTRODUCED PREDATORS

Foxes, cats and dogs are known to prey on grassland fauna, which can form a substantial proportion of the diet of these introduced predators. The native prey of foxes, and feral, stray and domestic cats includes mostly insects, small mammals, reptiles and birds commonly found on the ground or in lower understorey (Coman 1995; Newsome 1995; Dickman 1996). The impact of this predation on population sizes of grassland fauna has not been well quantified. It is evident, however, that some species have been highly vulnerable to predation by introduced predators. Mammals in the weight range between 35 g and 5.5 kg have shown disproportionate decline since European settlement, and this occurred prior to extensive agricultural clearing. Thirteen of the 27 species of native mammals that disappeared from western NSW were last collected in 1857 or earlier (Bauer and Goldney 2000). Dickman (1994) concluded that cats

played an important role in the demise of these species. Feral cat and fox predation on native wildlife are listed as key threatening processes in NSW and nationally. The uncontrolled roaming of domestic cats, and in some cases dogs, in grassland nature reserves close to urban areas is likely to contribute to increased predation on wildlife. Conservation of susceptible fauna in these areas will depend on responsible pet ownership or stronger controls.

DIRECT HUMAN IMPACTS

Threats from direct human impacts include trapping, hunting, disturbance to grassland areas used for recreation, impacts of vehicle traffic and construction of urban infrastructure (e.g. drains, trenching for cables). Hunting is considered to have placed pressure on animal populations in the past and resulted in serious declines or extinction e.g. the Brush-tailed Rock Wallaby (*Petrogale penicillata*) in central western NSW (Bauer and Goldney 2000). Human disturbance to habitat is likely to be exacerbated in small grassland fragments close to population centers.

2.3.3 Grassland Fauna in the South Eastern Highlands Region

At the time of European settlement, lowland grasslands of south-eastern Australia supported a rich vertebrate fauna, including emus, kangaroos, bustards, rat kangaroos, predatory birds as well as less obvious animals including small marsupials, rodents, birds, bats, reptiles and frogs (Osborne *et al.* 1995). The grasslands also contained a diverse invertebrate fauna (Driscoll 1994) among which insects are a dominant and relatively conspicuous class involved in most ecosystem processes (Farrow 1999). With widespread clearance and modification of grasslands (s. 2.3.2), many grassland animal species have declined, including some of the larger vertebrates, though many of the smaller animals still remain common in grasslands that are in good condition. A few species, such as the Eastern Grey Kangaroo, Australian Magpie and Eastern Blue-tongue Lizard, show some tolerance to the modification of grasslands since European settlement and may even have benefited from some changes.

A variety of data sources were used to compile composite information on grassland fauna of the ACT region. These sources include scientific papers and books, reports and/or records of observations by Environment ACT staff, consultants, other government agencies including the NSW Department of Environment and Conservation, and community groups such as the Canberra Ornithologists Group (COG). The detail and accuracy of this data vary within the region, depending upon the locations and methods of surveys and the inclusion of opportunistic observations. Surveys for certain fauna groups (such as reptiles) and specific studies have been conducted in many grasslands and adjacent grassy woodlands. Opportunistic sightings of species provide valuable information for areas where detailed surveys have not been conducted.

INVERTEBRATES

Insects, other invertebrates and micro-organisms account for more than 90 per cent of the biodiversity in ecosystems such as grasslands and are vital for healthy ecosystem function. Invertebrates live in the soil, near the ground surface and in the grass and forb canopy. They are essential for pollination and reproduction of many plants, are involved in nutrient recycling through the breakdown of dead plant and animal material and are the main food of many grassland animals such as birds, reptiles and amphibians. Less information, however, exists on the composition, biodiversity and ecological requirements of invertebrates than for other fauna groups. Consequently, conservation of most invertebrate species falls under the umbrella of habitat protection for vertebrates and vegetation communities. It is evident, however, that more than just the dominant plant species are important habitat determinants for invertebrates. Vegetation and litter structure, soil types, soil and plant nutritional properties and topography are important factors, as are the type and timing of management interventions (Driscoll 1994; Farrow 1999; Greenslade 1994).

Management activities affecting grassland invertebrates include defoliation (grazing, mowing, burning), pasture improvement, and use of fertilizers and chemicals (Driscoll 1994). Grazing of livestock alters the species composition and abundance, and may reduce the diversity of invertebrates in grasslands. To best conserve invertebrates, mowing is considered to be preferable to grazing, in part because it is more flexible. The effects of fire on invertebrates are not well understood but are known to depend upon the season and intensity of fire, the size of the fire, the habitat upon which the life history stages of the invertebrates depend, and if relevant, the proximity of sources of recolonisation (Yen and Butcher 1997) (see s. 3.5.1). Sowing of grasslands with exotic pastures has major effects on grassland invertebrates. For example, abundance of Collembola (Springtails) has been shown to increase and introduced species become dominant (King 1991 in Driscoll 1994). A decline in ant diversity and replacement of native earthworms by exotic lumbricid worms has also been noted (Lee 1985 in

Driscoll 1994). Application of fertilizers and biocides (often associated with pasture improvement) has been shown to affect species composition and abundance as well as ecosystem function. For example, Titlyanova *et al.* (1990, in Driscoll 1994) noted changes in the biomass of a number of invertebrate Orders, and concluded that fertilizers decrease species diversity, simplify the trophic structure of animal populations, increase the rate of organic matter decomposition and decrease the regulatory functions of heterotrophs.

Two threatened insect species found in the ACT region, the Perunga Grasshopper (*Perunga ochracea*) and Golden Sun Moth (*Synemon plana*), are grassland specialists and are described more fully in Appendix 5.3 and 5.4 and in s. 2.3.5. Many other insect species and invertebrates in general may have undergone similar declines, but there is insufficient baseline data for such an assessment.

Insect species known to have declined include:

(a) The Canberra Raspy Cricket (*Cooraboorama canberrae*). This is a rare grassland insect found only in the ACT region with a raspy call made by rubbing the sides of the abdomen against the inside of the hind legs. Adults were formerly found in the gardens of new suburbs but the species has become more rare with urban expansion. It has been recorded at Gungahlin Grasslands, Majura Training Area, Jerrabomberra Valley and Belconnen Naval Base.

(b) Lewis's Laxabilla (*Laxabilla smaragdina*). This tiny wingless grasshopper has not been recorded for many years in the ACT (Farrow 1999). It was common on the lower slopes of Tuggeranong Hill before suburbs replaced the native grassland (Greenslade and Rentz c. 1998)

(c) Key's Matchstick Grasshopper (*Keyacris scurra*). This flightless grasshopper was formerly common in grasslands and grassy woodlands in south-eastern Australia but is now uncommon in the ACT region. There are records from near Hall, Mulligans Flat Nature Reserve, Crace Nature Reserve, near the Murrumbidgee River, Tidbinbilla Nature Reserve and the railway line easement near Royalla (NSW) (Rowell and Crawford 1995). Local abundance of the species is correlated with known and potential food plants (especially *Chrysocephalum apiculatum*) growing between tussocks of Kangaroo Grass (*Themeda triandra*) (Rowell and Crawford 1999). The species has an unusual life history for a grasshopper in that eggs hatch in autumn, juveniles grow over winter, and adults are found in spring. Even light grazing or mowing may destroy populations and, being flightless, the animals are very slow to recolonise areas from which they have been eliminated (Greenslade and Rentz c. 1998).

Australia has approximately 100 000 described invertebrate species and possibly twice that number undescribed (Yen and Butcher 1997). An unknown number of these are found in grasslands. An example of a new undescribed species from grassland is Whiskers Springtail (Tomoceridae new genus, undescribed species). Springtails are tiny, little known, soil and leaf litter insects usually about a millimetre or two long. Not obvious to the casual observer, they are common throughout Australia on grasses and other plants, as well as being especially abundant in soils and leaf litter. About one-tenth of Australian springtail species are restricted to very small areas of just a few hectares. The Whiskers Springtail comes from a single small grassland locality near Captains Flat (NSW). Springtails play an important role in maintaining the grassland ecosystem as they improve soil fertility by feeding on bacteria and fungi which decompose dead plant material, so increasing the availability of nutrients for plant growth (Greenslade and Rentz c. 1998).

BIRDS

Compared to more structurally diverse habitats such as woodlands and forests, grasslands are not particularly rich in bird species. However, about fifty bird species occur as residents or summer migrants in grassy woodlands and for many of these species nearby grasslands are an important component of their habitat. Five bird species are grassland specialists and are considered to be dependent on this habitat, namely Stubble Quail (*Coturnix pectoralis*), Brown Quail (*Coturnix australis*), Singing Bushlark (*Mirafra javanica*), Brown Songlark (*Cinclorhamphus cruralis*) and Richard's Pipit (*Anthus novaeseelandiae*). Stubble Quail are widely distributed in the ACT region though uncommon. Brown Quail are rare in the ACT region and within the ACT most records are from open paddocks on the western edge of the city and in the native grasslands of the Upper Cotter and Upper Naas catchments. Singing Bushlarks are rare in the ACT region and the few ACT records come from mainly the Lake Tuggeranong area and Point Hut silt trap. Brown Songlarks are widely distributed though rare in the ACT region, whereas Richard's Pipits are widely distributed and common in the ACT and region.

Latham's Snipe (*Gallinago hardwickii*), a species protected under migratory bird agreements with Japan (JAMBA) and China (CAMBA), utilises the wetter grasslands (R. Rehwinkel pers. comm.) and wetlands in native grassland (ACT Government 1997a). It has been recorded in wet grassland at HMAS Harman and

Gungaderra Nature Reserve. However, in the ACT most of the Snipe's habitat is now in exotic grassland. Two lowland woodland species, the Diamond Firetail (*Emblema guttata*) and Superb Parrot (*Polytelis swainsonii*) forage is grasslands. In the past ACT lowland grasslands supported good populations of Emu (*Dromaius novaehollandiae novaehollandiae*), Bush Stone-curlew (*Burhinus grallarius*) and Bustard (*Ardeotis australis*), now locally extinct.

Species often seen on or near the ground in open grassy habitats include Australian Magpie (*Gymnorhina tibicen*), Magpie Lark (*Grallina cyanoleuca*), Masked Lapwing (*Vanellus tricolor*), Rufous Songlark (*Cinclorhamphus mathewsi*) and to a lesser extent Golden-headed Cisticola (*Cisticola exilis*). Birds of prey such as Australian Kestrel (*Falco cenchroides*), Brown Falcon (*Falco berigora*) and Black-shouldered Kite (*Elanus notatus*) often hunt in grasslands, and insectivores such as Martins and Swifts are frequently seen flying and feeding above grasslands.

Introduced bird species commonly seen in grasslands include Starling (*Sturnus vulgaris*), Skylark (*Alauda arvensis*) and Goldfinch (*Carduelis carduelis*).

MAMMALS

Native mammals typically associated with native grasslands of the ACT region include the ubiquitous Eastern Grey Kangaroo (*Macropus giganteus*) and Common Wombat (*Vombatus ursinus*). Echidnas (*Tachyglossus aculeatus*) are also widespread in the ACT region and are occasionally seen in grasslands. Many species more typically associated with grassy woodlands often occur in nearby grasslands or where scattered trees or other suitable shelter exist in or close to grasslands, and include Swamp Wallaby (*Wallabia bicolor*), Common Brushtail Possum (*Trichosurus vulpecula*), Common Dunnart (*Sminthopsis murina*) and native Bush Rat (*Rattus fuscipes*). At least ten bat species occur in ACT open grassy woodlands and are likely to use adjacent grasslands and areas where isolated trees provide suitable roosting sites. These bats are the Lesser Long-eared Bat (*Nyctophilus geoffroyi*), Gould's Long-eared Bat (*N. gouldi*), White-striped Freetail-bat (*Nyctinomus australis*), Chocolate Wattled Bat (*Chalinolobus morio*), Gould's Wattled Bat (*C. gouldii*), Common Bentwing-bat (*Miniopterus schreibersii*), Little Forest Bat (*Vespadelus vulturnus*), Southern Forest Bat (*V. regulus*), Large Forest Bat (*V. darlingtoni*) and Southern Freetail-bat (*Mormopterus planiceps*).

All native mammal species found in ACT grasslands also occur in other habitats such as woodlands, forests, riparian zones and the ecotones between them. The Southern Freetail-bat is considered to be uncommon whereas the Common Bentwing-bat, although still reasonably abundant, is listed nationally under the *Environment Protection and Biodiversity Conservation Act 1999* (Cwlth) as being 'conservation dependent' because of the need to protect major roosting caves. The other mammal species occurring in ACT grasslands are considered to be common throughout most of their distributions (Strahan 1995) and are not listed as threatened in the ACT or NSW, although population sizes of many have declined since European settlement.

More recent additions to mammalian fauna found in grasslands include the Dingo, which was brought to Australia by humans around 3500–4000 years ago (Corbett 1995), and several domestic and feral species that were introduced either deliberately or inadvertently following European settlement. Domestic species include cattle, sheep and horses, whereas feral animals include pigs, rabbits, hares, cats, foxes, dogs and mice.

REPTILES AND AMPHIBIANS

Native grassland in the ACT region provides habitat for many lizard species and three snake species, and their abundances vary geographically. Two threatened reptile species found in the ACT region, the Grassland Earless Dragon (*Tympanocryptis pinguicolla*) and Striped Legless Lizard (*Delma impar*), are grassland specialists and are described more fully in Appendix 5.1 and 5.2 and in s. 2.3.5. The Pink-tailed Worm Lizard (*Aprasia parapulchella*) is listed as threatened nationally. This species is very rare in New South Wales but locally common in parts of the ACT (Osborne *et al.* 1991). In the ACT the species is found in grasslands with outcrops of rocks of volcanic origin, particularly areas near the Murrumbidgee and Molonglo Rivers (s. 2.3.5).

Reptiles that are widespread and common in native grasslands of the ACT region are the Delicate Skink (*Lampropholis delicata*), Three-toed Skink (*Hemiergis decresiensis*), Garden Skink (*Lampropholis guichenoti*), Olive Legless Lizard (*Delma inornata*), Striped Skink (*Ctenotus robustus*), Copper-tailed Skink (*Ctenotus taeniolatus*) (particularly in rocky areas) and Eastern Blue-tongue Lizard (*Tiliqua scincoides*).

Less commonly seen lizards include the Shingleback (*Trachydosaurus rugosus*) and Bearded Dragon (*Pogona barbata*). The Shingleback is primarily an inhabitant of the drier inland and in the ACT occurs in grasslands and woodlands north of Canberra, which marks the easterly limit of its distribution. Specimens from the ACT and region are black or

very dark brown in colour (Bennett 1997). Bearded Dragons are occasionally seen in grasslands of the ACT and region, though their numbers may have declined in recent years.

The Eastern Brown Snake (*Pseudonaja textilis*) and Red-bellied Black Snake (*Pseudechis porphyriacus*) are both widespread and common in grasslands of the region, with the latter species more frequently seen near dams and other waterbodies. The Blind Snake (*Ramphotyphlops nigrescens*) is also widespread in the region though less frequently seen, possibly due to its cryptic habits. This species tends to occur in relatively undisturbed environments, including native grasslands that have not been ploughed or heavily grazed for long periods (Bennett 1997).

The Eastern Snake-necked Turtle (*Chelodina longicollis*) is found throughout the ACT, including native grassland habitats, wherever there is a water source such as a creek, swamp or farm dam.

Frogs occur in wetter areas or at waterbodies within grassland and may use burrows and cracks in the soil, logs, rocks and thick grass for shelter. Species recorded in ACT native grassland include Spotted Grass Frog (*Limnodynastes tasmaniensis*), Whistling Tree Frog (*Litoria verreauxii*), Plains Froglet (*Crinia parinsignifera*), Common Eastern Froglet (*Crinia signifera*), Eastern Banjo Frog (*Limnodynastes dumerilii*), Brown-striped Frog (*Limnodynastes peronii*), Spotted Burrowing Frog (*Neobatrachus sudelli*) and Smooth Toadlet (*Uperoleia laevigata*). The Brown Toadlet (*Pseudophryne bibronii*) has declined in numbers in the ACT region and is no longer found within grasslands of the ACT. The Green and Golden Bell Frog (*Litorea aurea*) is listed as threatened in NSW and nationally and is now locally extinct in the ACT.

2.3.4 Conservation of Grassland Fauna in the ACT

Consistent with the requirements for threatened species in the *Nature Conservation Act 1980*, one of the two goals adopted for the *Lowland Native Grassland Conservation Strategy* is to:

> *Conserve in perpetuity, viable, wild populations of all lowland native grassland flora and fauna species in the ACT and support regional and national efforts towards conservation of these species.*

The major threat to native grassland fauna in the ACT region and the apparent reason for decline of some species is the loss and modification of grassland habitat (s. 2.3.2). The premise of this *Strategy* is that protection in nature reserves and off-reserve conservation management of grassland habitat provides the foundation for long-term conservation of grassland fauna, including threatened species. For this reason, objectives and actions in the *Strategy* for conservation of fauna relate largely to grassland habitat. In general, the *Strategy* takes an ecosystem approach to the conservation of grassland fauna rather than treating each species separately. Exceptions are threatened species, for which there is a legislative requirement to prepare Action Plans and some threatened species have specific recovery requirements.

From the general threats to grassland fauna previously discussed, it is evident that all grassland fauna will be advantaged by the conservation of large areas of grassland in sound ecological condition that are connected to other grasslands, grassy woodland, forest or wetland. This habitat is further enhanced where introduced predators can be controlled and deleterious human disturbance such as incompatible adjacent land uses can be managed.

Actions undertaken to conserve threatened, declining or uncommon animal species and their habitats (see s. 2.3.5) will also benefit the more abundant grassland animal species. For example, retention of adequate grass cover and structure for Grassland Earless Dragons and Striped Legless Lizards will also benefit the numerous other reptile species that inhabit grasslands. Actions that help conserve the Perunga Grasshopper and Golden Sun Moth will also benefit a diversity of grassland invertebrates. Any key conservation requirements for non-threatened species that do not fall under the umbrella of protection of natural temperate grassland or habitat protection for threatened species need to be explicitly identified. For example, water bodies (creeks, wetlands and dams) with good water quality and fringing and aquatic vegetation are habitat for amphibians, long-necked tortoises and some birds, and so should be conserved.

Objectives and actions for the *Strategy* related to grassland fauna, including threatened species, are shown in Table 4.1. The actions are not designed to prescribe every detailed task needing to be undertaken. Detailed actions will be developed by responsible agencies, often with community involvement and will be refined over time as more information is gained (as part of 'adaptive management'). With regard to threatened species, objectives and actions in this *Strategy* must be integrated with state and national conservation efforts. Information in the next section provides a guide to more detailed or specific actions related to the conservation of threatened species.

Conservation of the Grassland Earless Dragon, Striped Legless Lizard, Golden Sun Moth and Perunga

Grasshopper in the ACT provides a major contribution to the conservation of these threatened species at regional and national levels. Importantly, two of the three extant populations of the Grassland Earless Dragon are located in the ACT. The Striped Legless Lizard is known to occur in only scattered locations in south-eastern Australia, of which the ACT is a stronghold. The Perunga Grasshopper has been recorded from scattered locations in south-eastern Australia, with most of the recent records from the ACT and surrounding areas. Distribution of the Golden Sun Moth has contracted to only scattered locations in south-eastern Australia, most of which are in the ACT region. Conservation of grassland habitat also substantially contributes to the regional conservation of several uncommon grassland animal species. The long-term viability of these threatened and uncommon species across their range at regional or national levels is dependant on appropriate conservation measures both within and outside the ACT.

2.3.5 Threatened and Uncommon Grassland Fauna Species in the ACT

Grasslands in the ACT provide critical habitat for four animal species (two reptiles and two insects) declared as threatened in the ACT under the *Nature Conservation Act 1980* (Table 2.6). These species are described further in Appendix 4 and 5. The Pink-tailed Worm Lizard (*Aprasia parapulchella*) (listed as threatened nationally) also occurs in grasslands of the ACT. This species does not occur in the low lying grasslands on valley floors, but is associated with river corridors and adjacent hill slopes at some sites.

The Pink-tailed Worm Lizard is included in the conservation strategy for aquatic species and the riparian zone (*Action Plan 29*) (in preparation).

Grassland species that are uncommon in the ACT region include Canberra Raspy Cricket, Lewis's Laxabilla, Key's Matchstick Grasshopper, Shingleback Lizard, Stubble Quail, Brown Quail, Singing Bushlark and Brown Songlark.

Threatened Species: Grassland Earless Dragon (*Tympanocryptis pinguicolla*)

The Grassland Earless Dragon (*Tympanocryptis pinguicolla*) is listed as threatened in the ACT, NSW, Victoria (where it no longer occurs) and nationally (Table 2.6). This small, cryptic lizard is a grassland specialist, with the three remaining populations occurring in the ACT region. Two of these populations occur in the ACT, with one population extending into nearby NSW. The third population is located near Cooma in NSW (Smith *et al.* 1999). Environment ACT has supported post-graduate research at the Australian National University (Nelson, 2004) into the biology and ecology of the Grassland Earless Dragon, including an analysis of the genetic differences between the ACT and Cooma populations. These were found to be consistent with species-level differences, suggesting these populations should be considered separate taxonomic units (Scott and Keogh 2000). A more detailed description of the species and its ecology is given in Appendix 5.2. The locations of the two ACT populations of this species are shown in Figures 2.3 and 2.4 (at end of Chapter 2).

Table 2.6: Conservation Status Nationally of ACT Threatened Animal Species of Native Grassland

Species	ACT	NSW	Other
Striped Legless Lizard	V	V	E (Cwlth), T (Vic)
Grassland Earless Dragon	E (SPS)	E	E (Cwlth), T (Vic), E (Qld)
Golden Sun Moth	E (SPS)	E	CE (Cwlth), T (Vic)
Perunga Grasshopper	V	—	—

CE: Critically Endangered; **E**: Endangered; **V**: Vulnerable; **T**: Threatened; **SPS**: Special Protection Species

Legislation:

Commonwealth: *Environment Protection and Biodiversity Conservation Act 1999*

ACT: *Nature Conservation Act 1980*

NSW: *Threatened Species Conservation Act 1995*

Vic: *Flora and Fauna Guarantee Act 1988* (Note that under this Act, species are listed as 'threatened' and specific conservation status (e.g. endangered) is applied in lists prepared by the Victorian Department of Sustainability and Environment.)

Qld: *Nature Conservation Act 1992*; *Nature Conservation (Wildlife) Regulation Act 1994*

THREATS

In common with other threatened grassland animal species, the main threats to the Grassland Earless Dragon are the continued loss and fragmentation of its grassland habitat due to agricultural, urban and industrial development and degradation of habitat through changed grazing intensity, pasture improvement, weed invasion, changed fire regimes and impacts of stock. Other threats include the impacts of predators and direct human disturbance.

The habitat of the Grassland Earless Dragon is extremely fragmented, such that the probability of unassisted movement between the three remaining populations (Majura Valley, Jerrabomberra Valley and Cooma) is now very unlikely. In NSW, populations are protected in reserves near Cooma and at Letchworth, near Queanbeyan. Species with small and isolated populations and extremely restricted distributions, such as the Grassland Earless Dragon, are more vulnerable to environmental disturbances such as wildfires and drought.

Areas of habitat for both populations of the Grassland Earless Dragon in the ACT are subject to development proposals. In the Majura Valley, proposals include airport taxiway extensions and new road and railway routes, all of which are located within Grassland Earless Dragon habitat. In the Jerrabomberra Valley planning studies have identified grassland habitat suitable for nature reserves and the ACT Government is establishing these as land becomes available.

Maintenance of suitable habitat is essential for the long-term conservation of the species. Key habitat for the Grassland Earless Dragon appears to be well-drained natural temperate grassland that is relatively undisturbed and minimally pasture-improved, preferably with a grass sward that is relatively short (around 10 cm high), open in structure or patchy. The species has also been recorded in adjacent *Austrostipa* dominated grassland with low floral diversity that has been modified by pasture improvement and weed invasion. Even within areas of apparently suitable habitat the occurrence of the species is patchy, suggesting a more subtle relationship between the species and its grassland habitat (Robertson and Cooper 2000).

Land management practices that appear to be compatible with maintaining the habitat of the species include grazing by stock at low intensity (such as occurs in the Jerrabomberra Valley), grazing by kangaroos (Majura Training Area) and regular mowing to a height of 10 cm (Canberra Airport). Where the species has persisted despite periods of more intense grazing, it is likely that the availability of shelter such as rocks and arthropod (spider) burrows has been critical. The species has been recorded using an area the year following a fire (Nelson *et al.* 1998) and during subsequent years (Evans and Ormay 2002). It is probable that infrequent patchy burns in grassland habitat are not a threat to the species, despite some mortality that may occur during the fire. However, widespread fires that affect all or most of the habitat or a fire regime that results in long-term changes in habitat structure are likely to pose a threat to the remaining fragmented populations.

Grassland Earless Dragons shelter within grass tussocks, beneath rocks and in burrows made by arthropods. In the ACT, Grassland Earless Dragons commonly use arthropod burrows, though it is not known whether the availability of these burrows is linked to abundance of the species.

Residential developments close to Grassland Earless Dragon habitat are likely to contribute to disturbance (vehicle traffic, weeds, increased visitation in reserves by people and dogs) and increase the risk of predation by uncontrolled roaming of domestic cats. Minimization of these impacts will depend on responsible pet ownership or stronger controls and, where possible, buffer areas between residential development and grassland habitat.

CONSERVATION OBJECTIVES

1. Protect in perpetuity several viable populations of the Grassland Earless Dragon in secure native grassland habitat across the range of the species in the ACT.
2. Maintain the potential of the species for evolutionary development in the wild.

CONSERVATION ACTIONS

See s. 2.3.6.

Threatened Species: Striped Legless Lizard (*Delma impar*)

The Striped Legless Lizard (*Delma impar*) is listed as threatened in the ACT, NSW, Victoria and nationally (Table 2.6). This small, snake-like lizard is known only from scattered locations in south-eastern Australia, mostly from the ACT region and Victoria (Melbourne region). It is a grassland specialist, occurring primarily in lowland native grasslands. A more detailed description of the species and its ecology is given in Appendix 5.1. The locations of the known occurrences of this species are shown in Figures 2.3–2.7 (at end of Chapter 2).

THREATS

In common with other threatened grassland animal species, the main threats to the Striped Legless Lizard are the continued loss and fragmentation of its grassland habitat due to agricultural, urban and industrial development and degradation of habitat through changed grazing intensity, pasture improvement, weed invasion, changed fire regimes and impacts of stock. Other threats include the impacts of predators (such as cats, foxes and birds of prey) and direct human disturbance.

Prior to European settlement the habitat for the Striped Legless Lizard appears to have been mostly contiguous. This habitat is now fragmented, such that the probability of movement between the four disjunct areas supporting the species (Gungahlin, Yarramundi Reach, Majura Valley and the Jerrabomberra Valley) is low. The population at Yarramundi Reach, the smallest of these habitat areas, may recently have become extinct. Only one population is protected (Gungahlin grassland reserves). Species with small and isolated populations, such as the Striped Legless Lizard, face increased vulnerability to environmental disturbances such as wildfires and drought.

Some areas of habitat for two populations of the Striped Legless Lizard in the ACT are subject to development proposals. In the Majura Valley proposals include new road and railway routes and in the Jerrabomberra Valley areas of habitat are part of a study to identify potential future land uses, including nature conservation.

Maintenance of suitable habitat is essential for the long-term conservation of the species. Key habitat for the Striped Legless Lizard appears to be native grasslands dominated by perennial, tussock-forming grasses such as Kangaroo Grass *Themeda triandra*, spear grasses *Austrostipa* spp. and wallaby grasses *Austrodanthonia* spp. The species is also found in some adjacent areas dominated by exotic grasses. An important habitat characteristic appears to be tussock structure, though little is known about the way in which its habitat is used. Grazing by stock at low intensity (such as occurs in the Jerrabomberra Valley) or kangaroos (Majura Training Area) appears to be compatible with maintaining the habitat of the species. Some areas where the species persists are thought to have had low to moderate levels of agricultural disturbance in the past. It has been suggested (Coulson 1990; Dorrough 1995) that more intensive land-uses, such as ploughing, may be incompatible with the survival of the species.

There is a paucity of information on the effect of fire and fire regimes on this species. It is probable that infrequent patchy burns in grassland habitat are not a threat if the tussock grass structure is retained after the fires. However, widespread fires that affect all or most of the habitat or a fire regime that results in long-term changes in habitat structure (such as loss of tussock structure) are likely to pose a threat to the remaining populations.

Residential developments close to Striped Legless Lizard habitat are likely to contribute to disturbance (vehicle traffic, increased visitation by people and dogs, weed infestation, more frequent fires) and increase the risk of predation by uncontrolled roaming of domestic cats, and in some cases dogs. Minimization of these impacts will depend on responsible pet ownership or stronger controls and, where possible, buffer areas between residential development and grassland habitat.

CONSERVATION OBJECTIVES

1. Protect in perpetuity several viable populations of Striped Legless Lizard in secure native grassland habitat across the range of the species in the ACT.
2. Maintain the potential of the species for evolutionary development in the wild.

CONSERVATION ACTIONS

See s. 2.3.6.

Threatened Species: Golden Sun Moth (*Synemon plana*)

The Golden Sun Moth (*Synemon plana*) is listed as threatened in the ACT, NSW, Victoria and nationally (Table 2.6). This medium-sized moth is a grassland specialist, preferring a subset of native grasslands that have a higher proportion of short-growing wallaby grasses (*Austrodanthonia* spp.). The species derives its name from the bright orange hind-wings of the female and the flight of adults, which is restricted to sunny spring and summer days. Its distribution has contracted to only scattered locations in south-eastern Australia (Clarke and Dear 1998). Genetic differences between ACT, NSW and Victorian populations suggest historical isolation, whereas relatively less genetic difference amongst ACT populations suggests recent fragmentation (Clarke and O'Dwyer 1998). A more detailed description of the species and its ecology is given in Appendix 5.3. The locations of the known occurrences of this species are shown in Figures 2.3–2.7 (at end of Chapter 2).

THREATS

In common with other threatened grassland animal species, the main threats to the Golden Sun Moth are

the continued loss and fragmentation of its grassland habitat due to agricultural, urban and industrial development and degradation of its habitat through changed grazing intensity, pasture improvement, weed invasion, changed fire regimes and impacts of stock.

Grasses suitable for the species dominate only a subset of the remaining natural temperate grassland. The habitat of Golden Sun Moth is extremely fragmented and though the species is able to fly, movement between habitat patches is likely to be severely impeded (particularly for the less mobile female) by unsuitable habitat and urban areas. In the ACT, approximately 25% of grassland patches where the species is known to occur are protected in reserves. Some areas of habitat for Golden Sun Moth in the ACT are subject to development proposals.

Maintenance of suitable habitat is essential for the long-term conservation of the species. Key habitat for the Golden Sun Moth appears to be natural temperate grassland dominated by low-growing wallaby grasses. However, many of its habitat requirements are still not known, e.g. the proportion of suitable wallaby grasses that make natural temperate grassland suitable habitat. Invasion by weeds is likely to be a major threat to habitat quality because of the requirement for vegetation of a certain species composition. Invasion by weeds and other species has already contributed to a decline in habitat quality in some areas and in some cases has resulted in loss of habitat. Exotic species such as Phalaris or Canary Grass (*Phalaris aquatica*), Paspalum (*Paspalum dilatatum*), Serrated Tussock (*Nasella trichotoma*), Chilean Needle Grass (*Stipa neesiana*), Brome Grasses (*Bromus* spp.), Wild Oats (*Avena* spp.), Clovers (*Trifolium* spp.), Flatweed (*Hypochoeris radicata*), Fescue (*Festuca elatior*) and Plantain (*Plantago lanceolata*) pose a continuing threat to surviving areas of native grasslands dominated by wallaby grasses.

The native grasslands currently dominated by wallaby grass and harbouring the Golden Sun Moth are subject to some low intensity management activities that apparently benefit low growing wallaby grasses and hence maintain habitat quality for the species. These activities include grazing by stock or native animals at low intensity, or regular mowing (Canberra International Airport). Indeed, light grazing may have increased areas of native grassland dominated by wallaby grasses. Cessation or modification of these management regimes may lead to a change in grassland composition or structure and possibly degradation of habitat for the Golden Sun Moth. More intensive agricultural practices involving ploughing, application of fertiliser, sowing of introduced pasture species or cultivation are destructive to native grasslands.

It is probable that infrequent patchy burns in grassland habitat are not a threat to the species, particularly at times when most of the population exists in its subterranean larval stages. However, there are observations suggesting that numbers may fall in years following fire before building up again. As larvae, Golden Sun Moth feed on the underground reserves of plants and as these reserves are mobilised to produce above ground growth following fire, their availability to the larvae are likely to be reduced. Widespread fires in the habitat when the adults have emerged in spring or summer could result in high levels of mortality. Frequent fires, or fire regimes that result in loss of wallaby grasses, are likely to pose a threat to the remaining populations of Golden Sun Moth. There is a paucity of information on what factors are responsible for determining the proportions of wallaby grasses in native grasslands.

Although several bird species are known to prey on the Golden Sun Moth, including introduced Starlings, there is no evidence that predators have contributed to the decline of the species.

CONSERVATION OBJECTIVES

1. Protect in perpetuity the existing viable populations of Golden Sun Moth in secure native grassland habitat across the range of the species in the ACT.
2. Maintain the potential of the species for evolutionary development in the wild.

CONSERVATION ACTIONS

See s. 2.3.6.

Threatened Species: Perunga Grasshopper (*Perunga ochracea*)

The Perunga Grasshopper (*Perunga ochracea*) is listed as threatened (vulnerable) in the ACT (Table 2.6). The cryptic species is a grassland specialist, preferring natural temperate grassland dominated by wallaby grasses (*Austrodanthonia* spp.), kangaroo grass (*Themeda triandra*) and *Stipa* spp. and has also been recorded in open grassy woodland. This stocky grasshopper has only rudimentary wings and is flightless. In the Canberra region, it is readily identified by a distinctive pale 'X' on its back. A more detailed description of the species and its ecology is given in the Appendix 5.4. The locations of the known occurrences of this species are shown in Figures 2.3–2.7 (at end of Chapter 2).

Threats

In common with other threatened grassland animal species, the main threats to the Perunga Grasshopper are continued loss and fragmentation of its grassland habitat due to agricultural, urban and industrial development and degradation of habitat through changed grazing intensity, pasture improvement, weed invasion, changed fire regimes and impacts of stock.

The Perunga Grasshopper had been recorded from only a few of the natural temperate grassland and open grassy woodland remnants in the ACT, suggesting that only a subset of native grassland appears to be suitable habitat for the species. The habitat of the Perunga Grasshopper is extremely fragmented and movement between habitat patches is likely to be severely impeded because the species is flightless. The ability of the species to recolonise isolated patches following localised extinction is therefore likely to be limited. In the ACT, approximately 30% of grassland patches where the species is known to occur are protected in reserves. Some areas of habitat for the Perunga Grasshopper in the ACT are subject to development proposals.

Maintenance of suitable habitat is essential for the long-term conservation of the species. Key habitat for the Perunga Grasshopper appears to be natural temperate grassland dominated by wallaby, kangaroo and spear grasses with forb food plants located in the inter-tussock spaces. Grass tussocks are used also to escape predators. The importance of dense tussocks for invertebrate shelter spaces during low temperature conditions such as frost have been highlighted by Bossenbroek *et al.* (1977). Nymphs of another ACT species, the Wingless Grasshopper *Phaulacriduim vittatum*, seek shelter in tussocks from wind and low temperatures (Clark 1967). In contrast to most other grasshopper species in the ACT, including the Wingless Grasshopper, nymphs of the Perunga Grasshopper are present during winter, and grass tussocks may be essential for protection against low temperatures.

Invasion by exotic plants is a major threat to the floristic composition of natural temperate grasslands and is therefore likely to be a threat to habitat quality for Perunga Grasshopper. However, the ecological requirements of the species are still poorly understood and the effect of weed invasion on habitat and food plants of Perunga Grasshopper is unknown.

The species has persisted in areas that have been lightly grazed or regularly mown (e.g. Canberra International Airport, Belconnen Naval station), suggesting that these land management practices are compatible with the maintenance of habitat for the species. More intensive agricultural practices involving ploughing, application of fertiliser, sowing of introduced pasture species or cultivation are destructive to native grasslands. The effect of fire on the species or its key habitat parameters is not well understood. It is probable that infrequent patchy burns in grassland habitat are not a threat to the species. Frequent fires, or fire regimes that result in loss of wallaby grasses, kangaroo and spear grasses, or loss of food plants (forbs) are likely to pose a threat to the remaining populations of Perunga Grasshopper.

The effect that predators and parasites may have in reducing population numbers of Perunga Grasshopper is unknown. Parasitic wasps (*Scelio* spp.) in south-eastern Australia have been shown to regulate some populations of other acridid grasshoppers (Baker *et al.* 1996) and predators such as birds may reduce grasshopper populations as shown in other studies of grasshopper assemblages (e.g. Belovsky and Slade 1993).

CONSERVATION OBJECTIVES

1. Protect in perpetuity the existing viable populations of Perunga Grasshopper in secure native grassland habitat across the range of the species in the ACT.
2. Maintain the potential of the species for evolutionary development in the wild.

CONSERVATION ACTIONS

See s. 2.3.6.

2.3.6 Conservation Actions: Threatened Grassland Fauna Species in the ACT

The following conservation actions for threatened grassland fauna species (mostly undertaken by Environment ACT) are framed within the actions for the Strategy as a whole in Table 4.1.

INFORMATION

- Maintain alertness to the possible presence of threatened grassland fauna species when undertaking surveys in appropriate habitat. Although all large areas of potentially suitable habitat in the ACT have been surveyed, further surveys are required to determine more accurately the area of occupancy of populations.

  (Grassland Earless Dragon, Striped Legless Lizard, Golden Sun Moth)

- Collect information on the distribution of the **Perunga Grasshopper**. Limited information exists on the distribution of the species and abundance in

known sites of occurrence. Currently, no practical method exists for systematically surveying the distribution or abundance of this species and information so far has been obtained from opportunistic observations.

MONITORING AND RESEARCH

- Encourage, support, coordinate, and where practicable, undertake research into the biology and ecology of **Grassland Earless Dragon** and **Striped Legless Lizard** as the basis for managing the species and their habitats. More specifically, research and monitoring is required to better understand:
  - — seasonal home range area, habitat use (including daily shelter sites and over-wintering sites) and movements, based on sex and age;
  - — seasonal activity and behaviour, including intra-specific interactions, territoriality, dominance, reproductive behaviour;
  - — breeding requirements, oviposition sites, reproductive rates, survivorship, sources of mortality and dispersal;
  - — preferred food and availability;
  - — impact of barriers such as roads;
  - — land management practices compatible with, or required for, maintaining suitable habitat;
  - — sensitivity of habitat to trampling or other potential damage from multiple use;
  - — susceptibility to fires and seasonal effects, optimum fire regimes, value and use of firebreaks;
  - — efficient methods for monitoring abundance, absolute population size and relationship to trapping indices, long-term population trends and magnitude of seasonal/annual fluctuations; and
  - — relative importance of predation by native, feral and domestic animals.
- Encourage, support, coordinate, and where practicable, undertake research into the biology and ecology of **Golden Sun Moth** and **Perunga Grasshopper** as the basis for managing the species and their habitats. More specifically, research and monitoring is required to better understand:
  - — biology: life cycle, reproductive rates, survivorship, sources of mortality and dispersal;
  - — habitat requirements of **Golden Sun Moth**: relationship to wallaby grasses and other flora, subterranean larval stage requirements, oviposition sites;
  - — micro-habitat requirements of **Perunga Grasshopper**: relationship to floristic composition and habitat structure, oviposition sites, soil requirements, nymph stage requirements;
  - — diet and food availability for **Perunga Grasshopper**, possible competition from abundant grasshoppers such as *Phaulacridium vittatum*;
  - — ability to move between fragmented habitat;
  - — genetic variability, minimum viable population size;
  - — land management practices compatible with, or required for, maintaining suitable habitat, including grazing, mowing and soil disturbance;
  - — susceptibility to fires and seasonal effects, optimum fire regimes, value and use of firebreaks;
  - — efficient methods for monitoring abundance, absolute population size, long-term population trends;
  - — effect of predators on population sizes.
- Continue to monitor habitat (vegetation composition) and **Golden Sun Moth** populations at major sites, including impacts of management practices.
- Continue to monitor habitat (vegetation composition) at known **Perunga Grasshopper** locations, including impacts of management practices, particularly grazing.

PROTECTION AND MANAGEMENT

- Encourage management to be undertaken in an adaptive framework, and facilitate the incorporation of research results into management of species and their habitats.
- Seek protection of key habitat known to support viable populations of threatened species across their range in the ACT, noting that:
  - — at present there is insufficient known about what constitutes a viable population of **Grassland Earless Dragon**, **Striped Legless Lizard**, **Golden Sun Moth**, **Perunga Grasshopper**;
  - — information on the distribution and abundance of **Perunga Grasshopper** in the ACT is incomplete;
  - — much of the known habitat for **Grassland Earless Dragon** and **Striped Legless Lizard** is on land under Commonwealth control;
  - — some of the known habitat for **Golden Sun Moth** and **Perunga Grasshopper** is on land under Commonwealth control.
  - — some areas of degraded native pasture or exotic pasture provide habitat for **Grassland Earless Dragon** and **Striped Legless Lizard**, or serve as buffers and habitat connections.

REGIONAL AND NATIONAL COOPERATION

- Maintain links with, and participate in, regional and national recovery efforts for threatened grassland fauna species to ensure that conservation actions are coordinated with regional and national programs.
- Liaise with interstate agencies involved in protection and management of threatened and uncommon grassland fauna species with the aim of increasing knowledge of their biology, and habitat and conservation requirements

2.3.7 Conservation Actions: Uncommon Grassland Fauna Species in the ACT

Species not listed under ACT legislation as vulnerable or endangered may be also of conservation concern and it is important that their status be monitored over time and threats minimised. Some animal species in native grassland are naturally rare or have become uncommon due to clearance or disturbance. Some species may also be considered to be 'declining', if there is a suspected or recorded decrease in population numbers (population decline).

Grassland species that are uncommon in the ACT region include Pink-tailed Worm Lizard (listed as threatened nationally), Canberra Raspy Cricket, Lewis's Laxabilla, Key's Matchstick Grasshopper, Shingleback Lizard, Stubble Quail, Brown Quail, Singing Bushlark and Brown Songlark. These species are uncommon because they are either at the margin of their distribution, they occur naturally at low density or they have declined in abundance. Some of these species are of conservation concern because declines (in the ACT or elsewhere) may be continuing and because small populations tend to be more vulnerable to disturbance. The conservation status of uncommon species needs to be considered in a regional context. The ACT and areas immediately to the east near Queanbeyan and in the Yarrowlumla Shire have been better surveyed than the region as a whole (Rehwinkel 1997).

CONSERVATION OBJECTIVE

1. Uncommon fauna species in ACT natural temperate grassland are maintained in viable populations in perpetuity.

CONSERVATION ACTIONS

The following conservation actions for uncommon grassland fauna species (mostly undertaken by Environment ACT) are framed within the actions for the *Strategy* as a whole in Table 4.1.

INFORMATION

- Maintain alertness to the possible presence of uncommon grassland fauna species when undertaking surveys in appropriate habitat.
- Maintain a database of known occurrences and abundance of uncommon grassland fauna species to enable analysis of changes in distribution and abundance.

MONITORING AND RESEARCH

- Maintain a watching brief on ACT populations of uncommon grassland fauna species and evaluate their conservation status in a regional context.
- Facilitate and encourage research that will provide information on status of uncommon grassland fauna species and management requirements.

PROTECTION AND MANAGEMENT

- Seek to ensure known populations of uncommon grassland fauna species are protected from inadvertent damaging actions (e.g. by advising landowners and managers of their presence).
- Prepare management guidelines for uncommon grassland fauna species where necessary.
- Manage sites, and provide advice to other landowners and managers, to maintain optimum habitat (where known) for uncommon grassland fauna species.
- Consider nomination for ACT listing if uncommon grassland fauna species show evidence of local decline in extent and abundance.

REGIONAL AND NATIONAL COOPERATION

- Liaise with interstate agencies involved in protection and management of uncommon grassland fauna species with the aim of increasing knowledge of their biology, and habitat and conservation requirements.

FIGURE 2.2

Estimated pre-1750 and current distribution of lowland native grassland in the Australian Capital Territory

Gungahlin

Belconnen

Majura

Central Canberra

Tuggeranong insert

Jerrabomberra

Tuggeranong insert

0 15 30 Kilometres

0 1.5 3 6 Kilometres

Contact Details:
Wildlife Research and Monitoring
Environment ACT

ACT Government

building our city building our community

environment ACT

LOWLAND NATIVE GRASSLAND CONSERVATION STRATEGY ACTION PLAN 28

Natural temperate grassland

Native pasture

Exotic pasture

Estimated pre-1750 grassland

FIGURE 2.3

Majura Valley: Lowland Native Grassland and Threatened Species

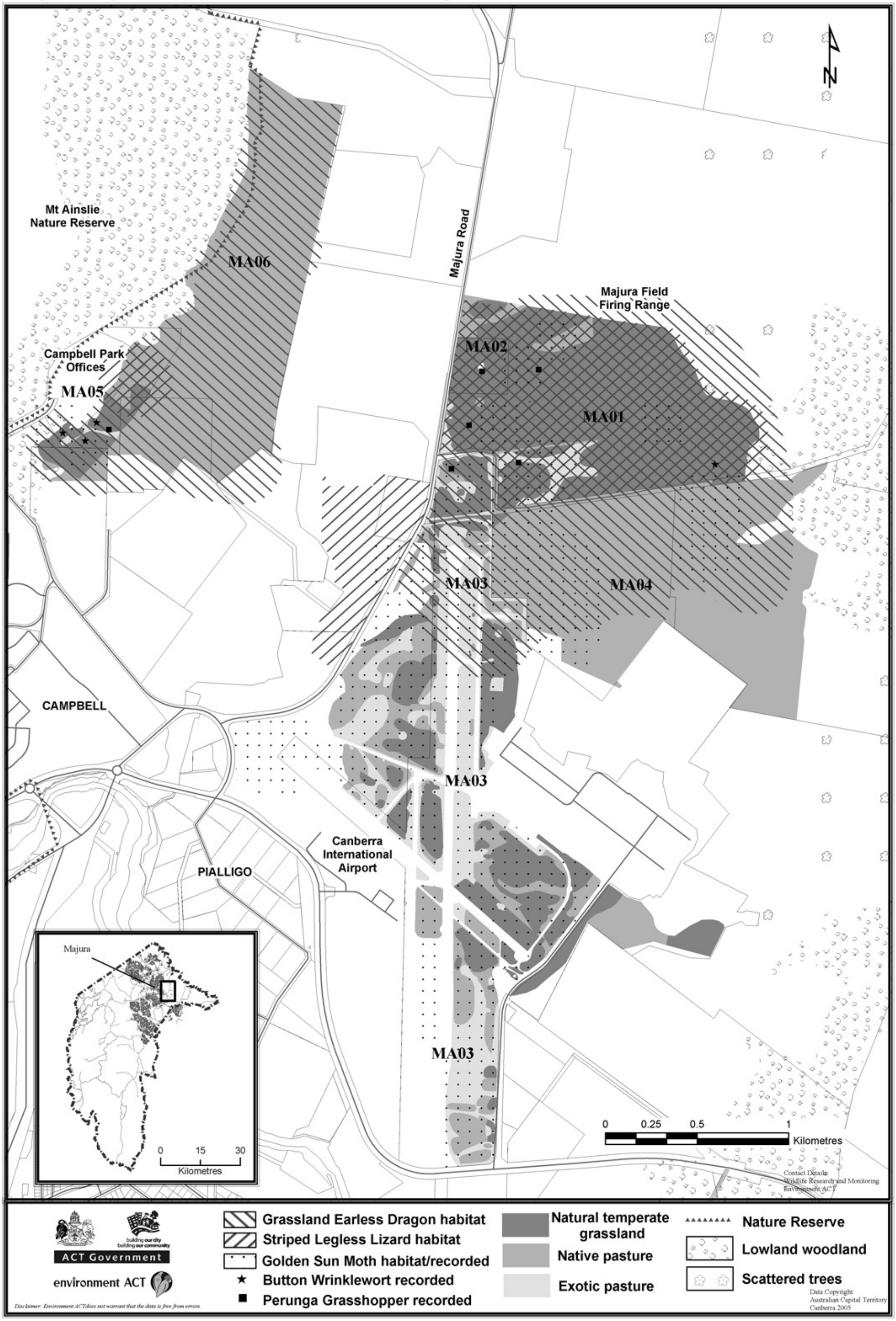


FIGURE 2.4

Jerrabombera Valley: Lowland Native Grassland and Threatened Species

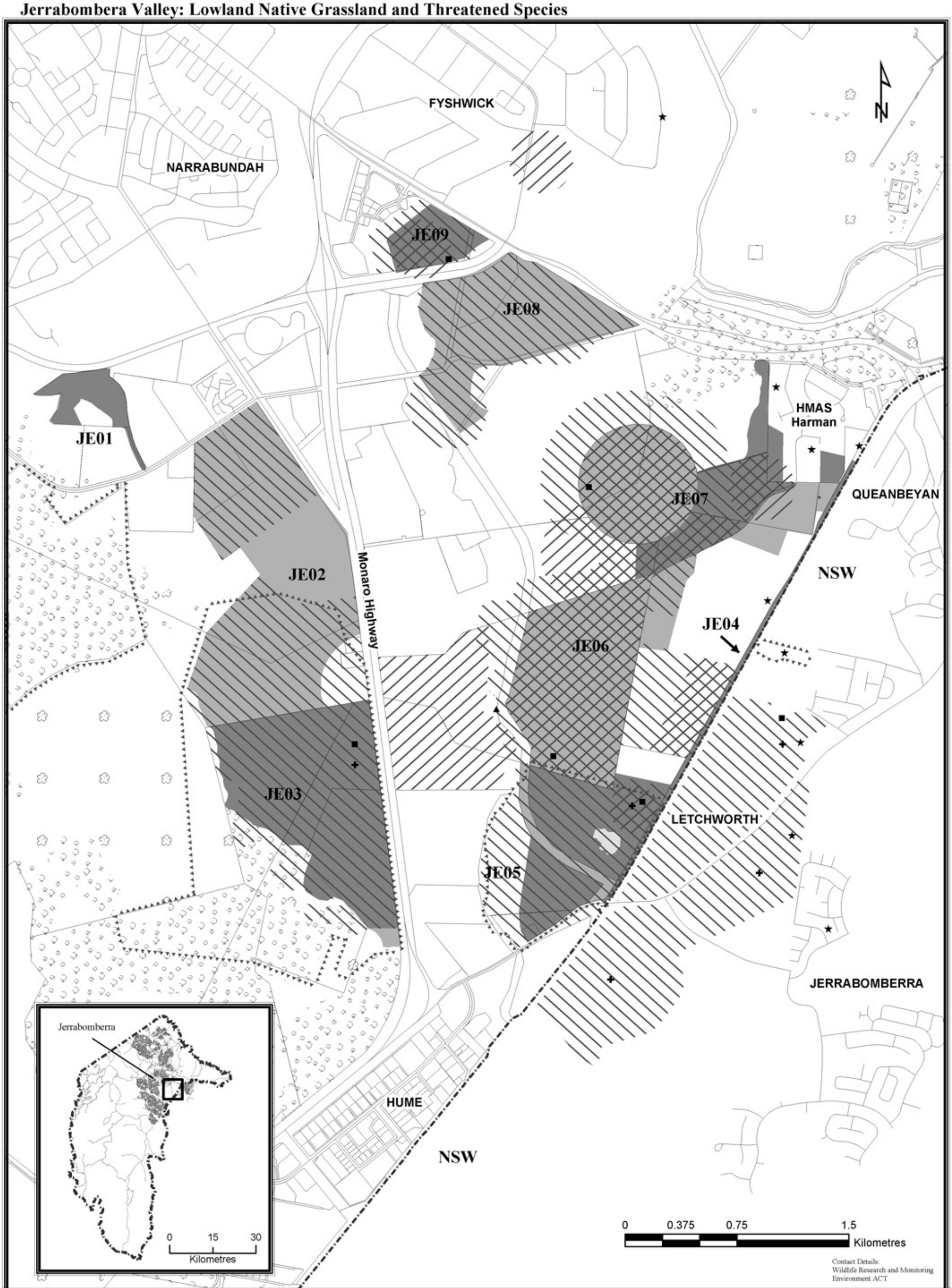
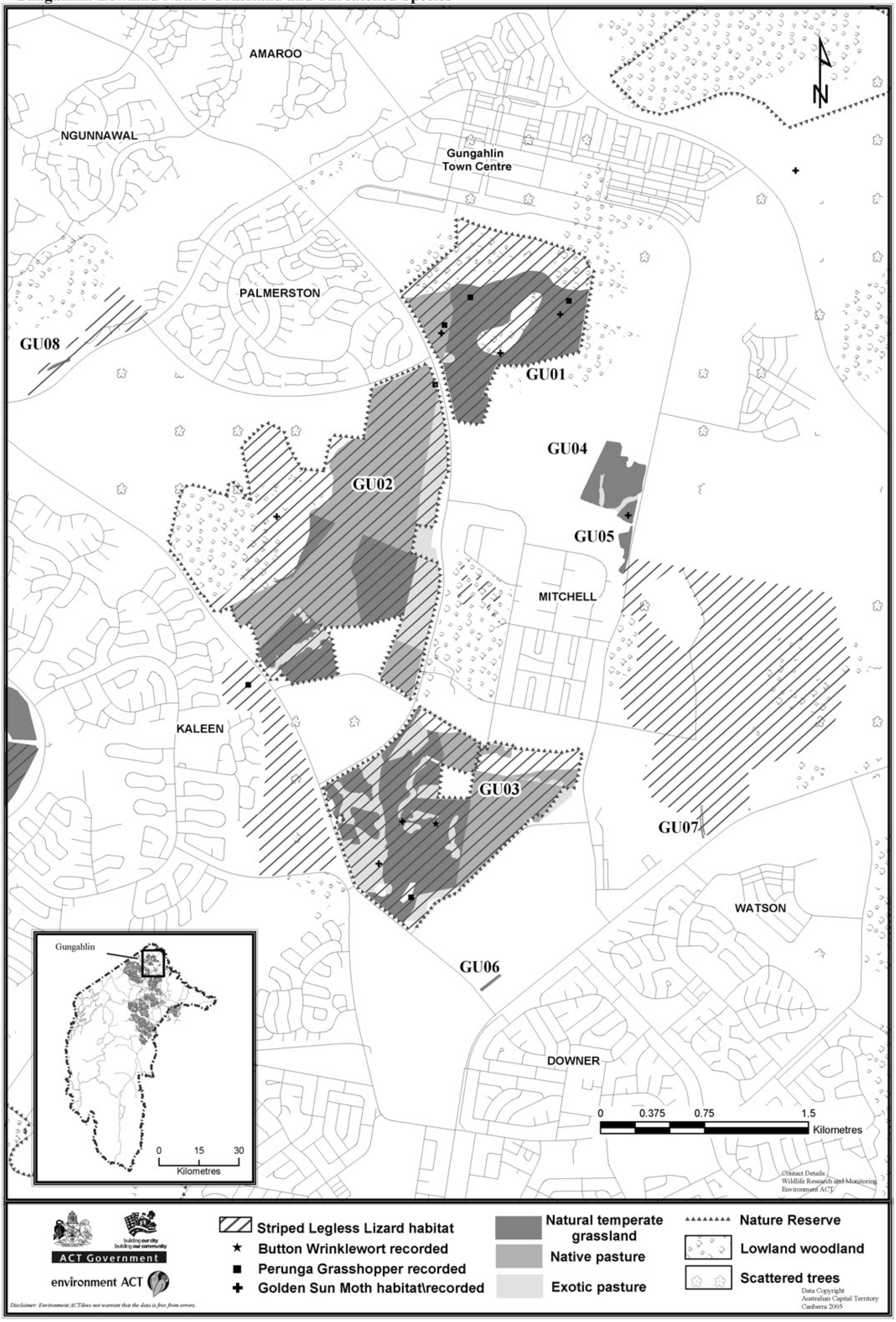


FIGURE 2.5

Gungahlin: Lowland Native Grassland and Threatened Species



Belconnen: Lowland Native Grassland and Threatened Species

FIGURE 2.6

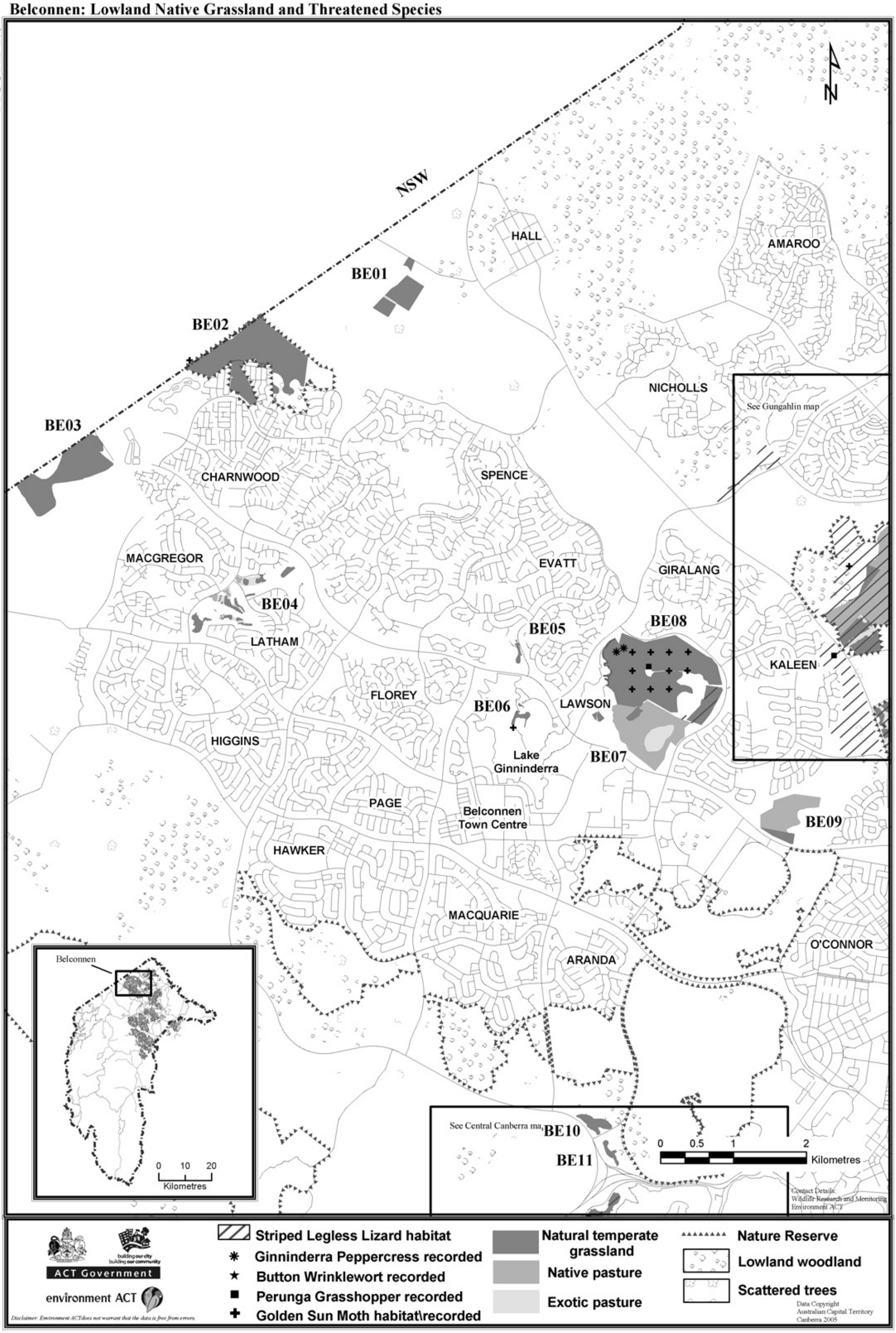
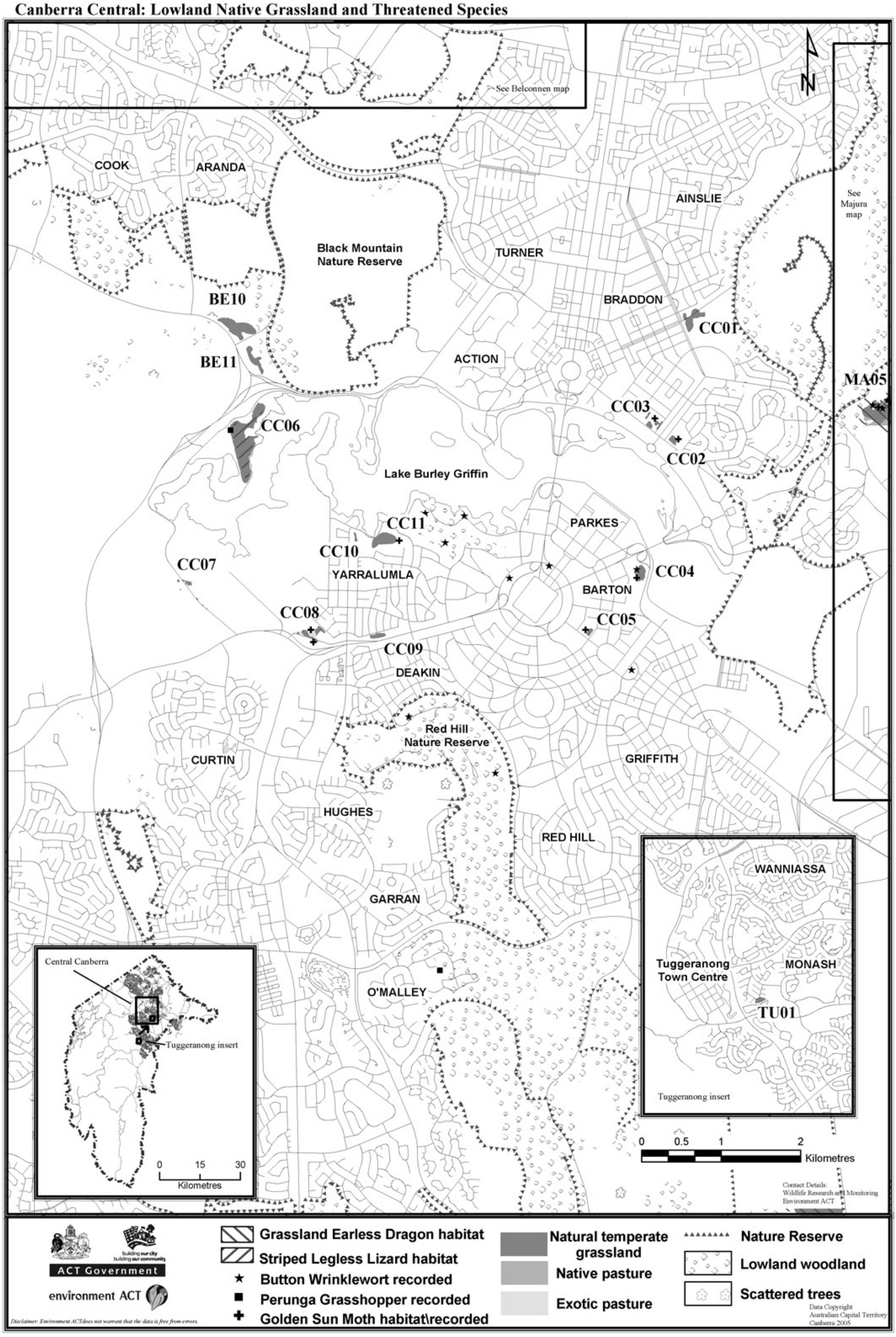


FIGURE 2.7

Canberra Central: Lowland Native Grassland and Threatened Species



3 Lowland Native Grassland: Planning and Management for Conservation

3.1

Recovery Planning for Lowland Native Grassland in the ACT

The *Lowland Native Grassland Conservation Strategy* builds upon earlier initiatives for grassland conservation in the ACT and region, and incorporates those currently underway. Implementation of a four year recovery plan for natural temperate grassland in the ACT (Wildlife Research Unit 1991, 1992) commenced in 1993 with funds from the Commonwealth Endangered Species Program and the Plan was subsequently supported for a further three years. The primary goal of that Recovery Plan was to reduce the threat to the ecological community. Achievements of the recovery program included the mapping and surveying of the floristics of ACT grasslands; ecological research on grassland floristics and some threatened plant and animal species; research on impacts of herbicides on selected native grasses; development of a management plan; establishment of a long-term monitoring program; compilation of a data base; and provision of seminars and educational materials (Sharp 1997, 1999; Sharp and Shorthouse 1996).

The management plan (Wildlife Research Unit 1994) prepared as part of the Recovery Plan process provided the first holistic management framework, guidelines and prescriptions for all the known natural temperate grassland areas in the ACT and threatened species found in the grasslands. It provided the basis for conservation management while survey, monitoring and research, in the ACT and elsewhere, built the information base to refine management approaches.

The achievements of the Recovery Plan (Wildlife Research Unit 1991) provided a substantial basis for defining the objectives of the Action Plan for natural temperate grassland prepared by Environment ACT, following declaration of the ecological community as endangered in the ACT (ACT Government 1997a). New developments under the Action Plan included establishing grassland reserves at Gungahlin and Dunlop and a Special Purpose Reserve at Mugga Mugga; signing of Memoranda of Understanding between Environment ACT and Commonwealth land management agencies in the ACT; undertaking surveys that have located new populations of threatened grassland species; completion of management plans for grassland reserves; preparation of management plans by agencies with whom Environment ACT has Memoranda of Understanding; management oriented research e.g. burning experiments; regional liaison on grassland conservation; weed surveys and weed control programs; contribution to the preparation and production of a grassland flora field guide for the Southern Tablelands (Eddy *et al.* 1998).

Regionally, Environment ACT has been closely involved with the 'Joint biodiversity survey of grassy ecosystems of the South Eastern Highlands project' (Rehwinkel 1997) that culminated in the *Planning Framework for Natural Ecosystems of the ACT and NSW Southern Tablelands* (Fallding 2002) as well as the *National Recovery Plan for Natural Temperate Grassland of the Southern Tablelands (NSW and ACT)* (Environment ACT 2005). Objectives and actions in the 2005 National Recovery Plan are complementary to those in this *ACT Lowland Native Grassland Conservation Strategy*. As a consequence of new surveys, altered management, and continuing development of Canberra, there have been a number of changes to the inventory of ACT grasslands.

3.2

Botanical Significance Rating (BSR)

A botanical significance rating system has been applied to the remaining lowland native grassland in the ACT. This system was based initially on analyses of data from Victorian grasslands (Stuwe 1986) and has been modified over time by Environment ACT (Wildlife Research and Monitoring) and relates to the responses

of plant species to different levels of disturbance (Table 3.1). This system was applied also to the understorey of woodland sites in the *ACT Lowland Woodland Conservation Strategy* (ACT Government 2004a). A more detailed description of the ratings and of the species typical of different levels of disturbance in grassy ecosystems is provided in Appendix 1. Application of the botanical significance rating to ACT lowland native grassland sites is shown in Table 3.2.

3.3

Remaining Lowland Native Grassland in the ACT

Vegetation surveys were undertaken at all ACT native grassland sites in 2003–04 as part of the preparation of this *Strategy* and the data compared with data from surveys undertaken previously. As a result, a review of the condition, diversity and spatial extent of all sites was undertaken. Further information on the survey methods is in s. 2.1.3.

Sites may contain areas of native grassland in varying condition, and may include several floristic associations, areas of native pasture and areas of exotic vegetation (such as in drainage lines that are weedy and disturbed). Sites that contain no natural temperate grassland (native pasture and/or exotic pasture) are included in this *Strategy* where they contain populations of threatened species.

In Table 3.2 the land use, total area, the area of the major floristic associations, native pasture and the botanical significance ratings are listed for each site. At some sites, patches of grassland occur that have higher or lower botanical significance ratings than the majority of the site. The botanical significance ratings of these smaller patches are indicated in brackets. Sites that do not contain natural temperate grassland, but are known habitat for threatened species are indicated in italics.

The number of sites containing native grassland (which may or may not be assessed as natural temperate grassland) is 47, totalling 2172 hectares (Figure 2.2 and Table 3.2). Of these 47 sites, 42 (totalling 1534 ha) contain 991 hectares of natural temperate grassland (Botanical Significance Rating (BSR) 1–4, see Table 3.1). This represents about 5% of the estimated original area of 20 000 hectares. These sites also contain areas of native pasture (385 ha, BSR 5) and exotic grassy vegetation (157 ha). Vegetation on the other five sites is not assessed as natural temperate grassland because it lacks the native species diversity that is a characteristic of the ecological community in the ACT (see s. 2.1.5). These areas of native pasture (639 ha, BSR 5) provide habitat for some threatened grassland plants and animals and/or may be important buffers and corridors for native grassland species. As well as the grasslands listed in Table 3.2, there are small patches (less than 0.25 ha) of native grasses and in some instances, hardy native forbs such as the Common Everlasting *Chrysocephalum apiculatum* and

Table 3.1: Botanical Significance Rating (BSR) for Native Grassland

	BSR 1 Very High	BSR 2 High	BSR 3 Moderate	BSR 4 Low	BSR 5 Very Low	Exotic E
Diversity of native species	Very high	Very high	Medium	Low	Very low	Very low to none
Uncommon native species	Several to many	Several	Few	None	None	None
Disturbance tolerant native species	Several to many	Several to many	Many	Several (including some native forbs)	Several (mostly native grasses)	None
Cover of native grasses	High	High	High	High	High	Low to none
Cover of exotic species	Low	Low	Low to moderate	Low to moderate	Low to moderate	Moderate to high
Alteration due to disturbance	Minimal alteration	Some alteration	Moderate alteration	Much alteration	Substantial alteration	Severe to total alteration
Natural temperate grassland	Yes	Yes	Yes	Yes	No	No

Common Blue Bell *Wahlenbergia communis* scattered along some roadsides and through open space areas of Canberra.

3.3.1 Changes in Lowland Native Grassland Sites Since 1997

In spring 2003 all grassland sites were resurveyed, using a method that enables a detailed comparison between and within sites in regard to composition, condition and spatial distribution. This has resulted in a revision of the status and condition of the sites since they were reported in the original Action Plan for natural temperate grassland (ACT Government 1997a). There have been significant changes to some grassland sites in terms of size, botanical significance rating and condition. Changes to the area and number of sites identified as containing natural temperate grassland results from a number of factors. These include more accurate mapping, better information to guide the discrimination between primary grassland (natural temperate grassland) and secondary grassland (modified woodland), development of better methods of survey for identifying condition, identification of previously unknown sites and the loss of sites to development. Appendix 2 provides details of the changes that have occurred in grassland sites.

Overall, the amount of identified natural temperate grassland is about the same (approximately 1000 ha in 1997 as compared to 991 ha in 2005). A further 500 ha was identified in 1997 as being lower quality natural grassland. With further surveys having been undertaken, a total of 1180 ha of native pasture and exotic vegetation containing threatened species has been included in this *Strategy*.

Since 1997, five new areas of natural temperate grassland have been found. All are small (each less than one hectare in size), and together amount to 2.5 ha (Appendix 2 (1a)). Eight sites (97 ha) have been re-assessed as containing additional areas of natural temperate grassland (Appendix 2 (1b)). This is due to changes in condition at the site and also better application of condition analysis.

One site identified in the Action Plan as containing natural temperate grassland has been developed (GAP 4) and two other sites have been partially developed (a total loss of 8 ha (Appendix 2 (2a)). Parts of several sites have deteriorated beyond recovery through weed invasion or site disturbance resulting in a reduction in the size of the natural temperate grassland area (14 ha) (Appendix 2 (2b)). Another 145 ha have been reclassified from natural temperate grassland to native pasture or exotic vegetation as a result of the improved analyses undertaken in 2003. This has resulted in the exclusion of four sites previously identified as natural temperate grassland, and reduction in area at seven other sites (Appendix 2 (2c)). This includes two areas of grassland identified in Action Plan 1 as constituting the *Poa* floristic association. In the 2003 surveys these areas were assessed as being degraded native pasture, and therefore not representing the endangered ecological community.

Several secondary grasslands (totalling 102 ha) were previously misclassified as natural grasslands and are now included in the *ACT Lowland Woodland Conservation Strategy* (ACT Government 2004a).

3.4

Conservation Planning for Lowland Native Grassland

As noted in s. 2.1, natural temperate grassland is one of Australia's most threatened ecosystems. In this context, the conservation of the remaining areas of lowland native grassland (including natural temperate grassland) is a critical task for national biodiversity conservation. The ACT retains significant remnants of the original extent of natural temperate grassland in the region; however, the small size and fragmented nature of the remaining grassland areas pose particular difficulties for conservation planning.

Canberra's growth as a city continues to exert significant development pressures on land in and around existing urban areas. Some land that is generally regarded as available for development may still retain natural features worthy of consideration for their potential contribution to the nature conservation estate or to enhancing the natural landscape of the city. Consideration needs to be given to the ecological, landscape and other values of the land so that an informed decision can be made on its future.

Management of grassland fragments to improve habitat qualities, to enhance ecological connectivity, or to increase the effective size of remnants will be an important management priority for some time to come. Linking grasslands with other natural ecological communities such as grassy woodlands, wetland areas and forests increases the overall conservation value of areas by building habitat heterogeneity in the landscape.

Planning for, and management of conservation areas in the ACT must take into account the potential impact of land uses and other activities on adjacent land and in some instances, on the same land. Compatible land uses or management practices will help to moderate

Table 3.2: Native Grassland in the ACT: List of Sites Grouped by Geographic Location

Name of each site by geographic area	Site No. (GAP)	Land use	Area (ha)	Floristic Association (NTG) Dominant grasses (native pasture)	Flor. Assn Area (ha)	BSR
GUNGAHLIN—Total native grassland area: 410.1 ha. Area of natural temperate grassland: 179.2 ha.						
Mulanggari Nature Reserve	GU01 (GAP 6)	Reserve	68.5	*Austrodanthonia* Wet *Themeda* Native pasture (*Austrodanthonia*) Native pasture (*Austrostipa*) Exotic vegetation	51.1 7.5 0.9 8.5 0.5	2(3)
Gungaderra Nature Reserve	GU02 (GAP 9)	Reserve	187.3	*Austrodanthonia* *Austrostipa* Wet *Themeda* Native pasture (*Austrodanthonia*) Native pasture (*Austrostipa*) Native pasture (*Poa*) Exotic vegetation	4.3 21.9 15.7 0.1 109.3 5.8 30.2	5 (2,4)
Crace Nature Reserve	GU03 (GAP 13)	Reserve	136.0	*Austrodanthonia* Dry *Themeda* Wet *Themeda* Native pasture (*Austrostipa*) Exotic vegetation	35.9 3.1 22.5 41.1 33.3	3(5)
North Mitchell	GU04 (GAP 10)	Vacant	15.9	*Austrodanthonia* *Austrostipa* Exotic vegetation	1.4 13.4 1.2	3(4)
Mitchell	GU05 (GAP 10)	Rural (agisted)	1.6	Dry *Themeda*	1.6	3
Belconnen Pony Club	GU06 (GAP 14)	Rural	0.3	*Austrodanthonia*	0.3	4
Wells Station Road	GU07	Roadside	0.2	*Austrostipa*	0.2	4
Nicholls	GU08 (GAP 8)	UOS	0.3	*Austrostipa*	0.3	4
MAJURA VALLEY—Total native grassland area: 641.3 ha. Area of natural temperate grassland: 208.9 ha.						
Majura Training Area	MA01 (GAP 28)	Defence	126.6	*Austrodanthonia* Wet *Themeda* Native pasture (*Austrostipa*) Exotic vegetation	106.9 6.8 5.8 7.1	2(1)
Air Services Beacon	MA02 (GAP 28)	Airport Services	10.7	Wet *Themeda*	10.7	2(4)
Canberra International Airport	MA03 (GAP 28)	Airport	203.6	*Austrodanthonia* Native pasture (*Austrostipa*) Exotic vegetation	73.6 62.9 67.1	3(1, 2,5)
'Malcolm Vale'*	MA04	Rural lease	155.4	Native pasture (*Austrostipa*)	155.4	5
Campbell Park	MA05 (GAP 27)	Defence	11.7	*Austrodanthonia* Exotic vegetation	10.9 0.8	3(2)
Majura West*	MA06	Rural lease	133.3	Native pasture (*Austrostipa*)	133.3	5
JERRABOMBERRA VALLEY—Total native grassland area: 697.1 ha. Area of natural temperate grassland: 267.4 ha.						
'Mugga Mugga'	JE01 (GAP 39)	Reserve	15.0	*Austrodanthonia* *Austrostipa*	1.4 13.7	4(3)
'Callum Brae'*	JE02 (GAP 36)	Rural lease/ Reserve	162.7	Native pasture (*Austrodanthonia*) Native pasture (*Austrostipa*)	89.3 73.4	5
'Woden Station'/ Jerrabomberra West Reserve	JE03 (GAP 36)	Reserve	116.9	*Austrodanthonia* *Austrostipa* Native pasture (*Austrostipa*)	62.8 52.4 1.7	3
Woods Lane	JE04 (GAP 37)	Roadside	10.3	Dry *Themeda*	10.3	3
'Woden Station' East/ Jerrabomberra East Reserve	JE05 (GAP 37)	Reserve	72.0	*Austrodanthonia* *Austrostipa* Native pasture (Austrostipa) Exotic vegetation	44.2 18.0 7.8 2.0	4(3)
Harman Bonshaw South *	JE06 (GAP 37)	Defence, Rural lease	105.7	Native pasture (*Austrostipa*)	105.7	5
Harman Bonshaw North	JE07 (GAP 37)	Defence, Rural lease	114.6	*Austrodanthonia* Native pasture (*Austrostipa*)	46.3 68.3	5(4)
'Cookanalla'*	JE08	Rural lease	81.5	Native pasture (*Austrostipa*)	81.5	5
Amtech	JE09 (GAP 35)	Vacant	18.0	*Austrodanthonia*	18.0	4
Tennant St, Fyshwick	JE10	Agisted	0.3	Dry *Themeda*	0.3	3

(Continued) ▶

Table 3.2: *(Continued)*

Name of each site by geographic area	Site No. (GAP)	Land use	Area (ha)	Floristic Association (NTG) Dominant grasses (native pasture)	Flor. Assn Area (ha)	BSR
BELCONNEN—Total native grassland area: 387.5 ha. Area of natural temperate grassland: 300.1 ha.						
Ginninderra Experimental Station	BE01 (GAP 2)	Research	19.4	Dry *Themeda* Exotic vegetation	18.9 0.5	4
Dunlop Nature Reserve	BE02 (GAP 3)	Reserve	81.9	*Austrodanthonia* Wet *Themeda*	77.0 4.9	3(2)
'Jarramlee'	BE03 (GAP 15)	Rural (agisted)	52.0	*Austrostipa* Wet *Themeda*	47.3 4.7	4(3)
Umbagong Park, Florey	BE04 (GAP 16,17)	UOS	15.5	*Austrodanthonia* *Austrostipa* Dry *Themeda* Native pasture (*Austrodanthonia*) Native pasture (*Themeda*) Exotic vegetation	0.8 0.2 8.0 1.2 0.6 4.7	4 (3,5)
Evatt Powerlines	BE05 (GAP 18)	UOS	1.1	Dry *Themeda*	1.1	3
Lake Ginninderra	BE06 (GAP 19)	UOS	1.9	*Austrodanthonia* Dry *Themeda*	0.1 1.7	3
Lawson Territory	BE07 (GAP 20)	Rural (agisted)	59.2	*Austrodanthonia* Dry *Themeda* Native pasture (*Austrostipa*) Exotic vegetation	2.2 1.1 46.9 9.1	5(3)
Lawson Commonwealth	BE08 (GAP 20)	Defence	120.3	*Austrodanthonia* *Austrostipa* Dry *Themeda* Wet *Themeda*	91.2 9.8 16.5 2.9	2 (3,4)
Kaleen east paddocks	BE09 (GAP 21)	Rural (agisted)	28.2	*Austrodanthonia* Native pasture (*Austrostipa*)	4.0 24.2	5(3)
Caswell Drive	BE10 (GAP 22)	UOS	5.8	Dry *Themeda* Wet *Themeda*	3.5 2.3	2
Glenloch interchange	BE11 (GAP 23)	UOS	2.2	Dry *Themeda*	2.2	2
CANBERRA CENTRAL and TUGGERANONG—Total native grassland area: 36.5 ha. Area of natural temperate grassland: 35.8 ha.						
CSIRO Headquarters, Campbell	CC01 (GAP 25)	CSIRO	3.0	Dry *Themeda*	3.0	3
Constitution Ave, Reid	CC02 (GAP 26)	UOS	0.7	Dry *Themeda*	0.7	3
St Johns Church, Reid	CC03	Urban Lease	0.9	*Austrodanthonia*	0.9	4
ACCC, Barton	CC04 (GAP 33)	Urban Lease	1.9	Dry *Themeda*	1.9	1
York Park, Barton	CC05 (GAP 34)	UOS	0.4	*Austrodanthonia*	0.4	4
Yarramundi Reach	CC06 (GAP 24)	UOS	21.2	*Austrostipa* Dry *Themeda*	16.4 4.8	4(3)
Lady Denman Drive, Yarralumla	CC07 (GAP 29)	Roadside	0.4	*Austrodanthonia*	0.4	3
Dudley St, Yarralumla	CC08 (GAP 30)	UOS	2.2	*Austrodanthonia* Wet *Themeda* Exotic vegetation	0.6 0.9 0.7	3
Kintore St, Yarralumla	CC09	Vacant	0.8	Dry *Themeda*	0.8	3
Novar St, Yarralumla	CC10 (GAP 31)	UOS	0.2	*Austrostipa*	0.2	4
Black St, Yarralumla	CC11 (GAP 32)	UOS	3.6	Dry *Themeda*	3.6	3
Isabella Pond, Monash	TU01 (GAP 38)	UOS	1.2	Dry *Themeda*	1.2	2
Total			**2172**			

Notes: (1) Site No: In the *Strategy*, site numbers have been assigned to all native grassland sites (including sites containing natural temperate grassland and native pasture) to identify the geographic region in which they occur. The 'Site No.' column shows the GAP (Grassland Action Plan) location numbers from Action Plan 1 (ACT Government 1997a). The Site Numbers supersede the GAP numbers.

(2) UOS = Urban Open Space

(3) Floristic association: for explanation, refer to section 2.1.4.

(4) Natural Temperate Grassland (NTG) contains areas with a Botanical Significance Rating (BSR) of 1 to 4. Native Pasture has a BSR of 5 and does not meet the definition of the endangered ecological community (refer to section 2.1.8, Table 3.1). Where a site contains small patches of vegetation with a higher or lower BSR than the majority of the site, these ratings are indicated in brackets.

(5) *—Denotes native grassland sites that do not contain natural temperate grassland.

adverse external influences on nature conservation values. Conservation management supported by research, monitoring and community participation are identified as key actions for this *Strategy* (Table 4.1).

3.4.1 Conservation Planning Principles

In developing a systematic approach to conservation planning and strategic options for native grassland conservation in the Gungahlin area of the ACT, Williams et al. (1995, pp. 8–18) set out a number of steps each with associated conservation planning principles.

The steps are:

- set goals and objectives;
- assess knowledge of the species, communities and sites of concern;
- delineate possible areas for conservation and consider environmental inter-linkages;
- develop strategy options and management guidelines.

The conservation planning principles include:

- areas that have the highest conservation values should be protected;
- consideration of size (viability), diversity, representativeness, distinctiveness (rarity) and naturalness is required;
- replication of conservation areas in fragmented habitats is necessary as a precaution against catastrophic and/or unpredictable local extinction;
- integration of smaller systems within broader conservation systems increases their conservation value; and
- regional conservation planning based on remnants must consider the constraints and opportunities provided by the present and future land use patterns.

The ACT Government adopted this approach in 1995 when reviewing the planning for Gungahlin Town Centre. The principles and associated methodology were used to identify high priority areas for grassland conservation, based on vegetation qualities and habitat for threatened species. Subsequently three nature reserves were established in the Gungahlin area with the primary aim of protecting natural temperate grassland and habitat for the Striped Legless Lizard (*Delma impar*). Grazing management in these reserves has been altered to promote conservation values, with some success (see s. 3.6.3).

The *Lowland Native Grassland Conservation Strategy* recognises the importance of addressing the conservation needs of threatened, declining and/or uncommon plants and animals in an integrated way, and not separated from consideration of the ecological communities of which they are a part. An understanding of the key life history properties and habitat requirements of species, the dynamic processes operating within ecosystems, and the importance of connectivity in making fragmented communities more viable across a variety of local and regional scales are accepted as being essential to sound conservation planning. For highly fragmented communities such as natural temperate grassland, connectivity can often only be considered in terms of links to other ecological communities, which together build a network.

In order to bring together the information on grassland type, vegetation condition, habitat features and occurrences of threatened and declining flora and fauna species with the relevant conservation planning and management issues, the following attributes, derived from the principles outlined above, have been incorporated into the material that is the basis for Chapters 3 and 4 of the *Strategy*:

- **Regional context:** regional biodiversity conservation significance;
- **Ecological characteristics:** vegetation condition; resident populations(s) of threatened species; habitat heterogeneity;
- **Physical data:** size; area/perimeter ratio;
- **Landscape context:** connectivity with other native vegetation; altitudinal range; and
- **Planning and management:** compatible land uses within and adjacent to sites; potential for regeneration and restoration management.

3.4.2 Survey, Monitoring and Research

Williams *et al.* (1995) list the following additional principles for sound conservation planning:

(a) knowledge of key life history properties of species and dynamic processes within the ecological communities is essential (Principle 3);

(b) spatial scale is important when assessing the value of published knowledge of species and communities (Principle 4);

(c) common as well as rare species have a bearing on conservation planning (Principle 5);

(d) the quality of available data and therefore its value to conservation planning varies depending on its taxonomic and spatial resolution, seasonal biases and temporal representation (Principle 6).

SURVEYS

As described in s. 2.1.3 extensive vegetation surveys have been undertaken in native grassland sites in the ACT since 1991. While the majority of lowland native grassland sites in the ACT have been documented and surveyed, there may be smaller sites or more degraded sites that have not yet have been investigated. If new sites are identified, they will be surveyed, information added to the database of sites and actions undertaken that are consistent with this Strategy. The majority of sites have been surveyed on several occasions, providing information about changes resulting from seasonal conditions and management. Additionally, vegetation surveys have also been undertaken in conjunction with reptile trapping sites to provide more detailed information about immediate habitat.

All known threatened plant populations have been mapped and surveyed on several occasions, providing information on fluctuations in distribution and abundance.

While many sites in the Southern Tablelands in NSW have also been surveyed, these have been mainly restricted to government land. Consequently, there is incomplete information on which to make regional comparisons. However, there have been few areas of grassland of the same size as the larger ACT sites found to date in NSW.

Extensive fauna surveys were also undertaken in this period, focussing on threatened and uncommon grassland species, particularly reptiles (summarised up to 1996 in Rehwinkel 1997, pp. 48–53). Edwards (1994) surveyed lowland grassland sites for the Golden Sun Moth (*Synemon plana*). These surveys resulted in a good knowledge base for threatened species, but there is still limited knowledge of other species, especially invertebrates. More recent surveys include those for *Keyacris scurra* (Rowell and Crawford 1999) and grassland canopy insects (Farrow 1999) (see s. 2.3.3). Surveys carried out in association with annual monitoring have found new populations of some threatened species e.g. (a) Perunga Grasshopper at West Belconnen, Yarramundi Reach, Crace Nature Reserve, Campbell Park and Jerrabomberra West; (b) Button Wrinklewort at Crace Grassland Reserve and a more extensive population at Campbell Park.

MONITORING

Monitoring is vital to understanding trends in grassland communities and is an essential component of a sound approach to conservation management of native grassland. Long-term monitoring of the flora of the ecological community in the ACT commenced in 1993 under the Recovery Plan program (Sharp and Shorthouse 1996) and continues on an annual basis. Fourteen permanent monitoring sites have been established that include the main floristic associations and the range of land uses and management practices in the ACT. This long term monitoring is designed to identify slow, largely imperceptible changes in the flora of the ecological community. The monitoring results are entered into the grassland database held by Wildlife Research and Monitoring (Environment ACT), reported to the Flora and Fauna Committee, and are essential to devising and refining the management regimes for grassland areas.

Populations of threatened plant species are monitored annually and their condition assessed. In addition, Button Wrinklewort and Ginninderra Peppercress populations are assessed for abundance and distribution at two to five year intervals.

Populations of threatened animal species are monitored for their continued presence at grassland sites. Annual monitoring surveys are conducted for Grassland Earless Dragon, Striped Legless Lizard and Golden Sun Moth. In addition to monitoring the distribution of these species in grasslands, techniques are currently under trial to assess the feasibility of quantitatively monitoring changes in abundance. The lack of a practical field method for monitoring the presence/absence or abundance of the threatened Perunga Grasshopper means that information on the distribution of this species is obtained from incidental observations.

RESEARCH

The original Action Plan for Natural Temperate Grassland (ACT Government 1997a, p. 13) noted that the emphasis of ACT grassland research to date had been to improve knowledge of the distribution and ecology of grassland and selected (plant and animal) species. Implementation of the Action Plan required management-oriented research. There was also a need for research on the basic ecological requirements of selected grassland plants and animals, including threatened species. Subsequently, some research in both these directions has been undertaken and management has also drawn on research from grasslands elsewhere. A literature review on the role of grazing for conservation management of native grasslands has been prepared (Lunt 2005).

Research has been undertaken in the ACT and region on the ecology, taxonomy, survey methodology, management and conservation of grassland threatened species, especially reptiles (Rehwinkel 1997). The following is a brief summary of the research undertaken:

- Grassland Earless Dragon (*Tympanocryptis pinguicolla*): A reasonably good, basic knowledge of this species has been developed through research over the last decade including genetics/taxonomy (Scott and Keogh 2000; Smith 1994; Smith *et al.* 1999), ecology and conservation (Benson, 1999; Langston, 1996; Nelson 2004).
- Striped Legless Lizard (*Delma impar*): There has been less research on *Delma impar* and its life history remains largely unknown (Smith and Robertson 1999). Research on the biology/ecology of the species has been mostly undertaken in Victoria (Melbourne Zoo and University of Technology). ACT studies on the ecology of the species include those by Nunan (1995) and Osmond (1994).
- Perunga Grasshopper (*Perunga ochracea*): The behaviour and biology of this species has been documented by Rentz (1996). Stephens (1998) also studied aspects of its ecology. The dietary requirements of the species are not fully understood and no research has been undertaken on population sizes or specific predators.
- Golden Sun Moth (*Synemon plana*): Edwards (1994) documented ACT populations of this species and a population at York Park, Barton was surveyed over the period 1992–3 to 1994–5 (Cook and Edwards 1993, 1994; Harwood *et al.* 1995) (see Appendix 5.3). While the life history of *Synemon plana* is not fully understood, genetic research by Clarke (1999) has helped identify and determine the conservation significance of moth populations in the ACT. This research shows that ACT populations are genetically very similar, probably reflecting recent fragmentation. Maintaining or increasing population sizes is a major conservation issue for this species and this is directly related to maintaining and increasing the cover of the larval food plant, *Austrodanthonia*. Clarke and Dear (1998) documented the regional distribution of the species and their survey has also provided insights into the ecological parameters determining that distribution.
- Button Wrinklewort (*Rutidosis leptorrhynchoides*): Due to its high conservation profile within an endangered ecosystem, and its amenability as a research model, *Rutidosis leptorrhynchoides* has been the subject of considerable ecological and genetic research aimed at understanding the factors that limit population viability. Most of this is reviewed in Young *et al.* (2000). Issues and options for the genetic conservation of the species are contained in Young (2001).
- Ginninderra Peppercress (*Lepidium ginninderrense*): Almost nothing is known about the general biology of *Lepidium ginninderrense*, and there is a need for research into this basic information. Based on extrapolation from other genetic studies of rare plants and evidence of good seed set, Young (2001) suggests that the species may still contain significant genetic variation for broadly based seed collections to form the basis of a conservation strategy.

3.4.3 Protection

A primary objective of the *Strategy* is the establishment of a comprehensive, adequate and representative system of protection for grassland in reserves or by other measures where reservation is not practicable or desirable (see s. 4.2 and s. 4.3.1). Generally these areas will be those with the highest value in terms of meeting local, regional and national objectives. Assessment of conservation value includes concepts of size (viability), diversity, representativeness, distinctiveness (rarity), naturalness and habitat value. Given the small proportion of the estimated original extent of natural temperate grassland that still remains in the ACT, it is not possible for a comprehensive, adequate and representative system to conserve a predetermined proportion of the original ecological community. However, the principles can be adapted to the circumstances regarding ACT native grasslands and used to guide decisions relating to protection.

The objective is to establish, as far as is practicable, a system of reserves and other protected areas that is:

1. **Comprehensive:** It will include the full range of the five floristic associations identified for ACT natural temperate grassland.
2. **Adequate:** It will replicate ecologically viable natural grassland communities, species and populations.
3. **Representative:** It will reasonably reflect the biological diversity of the ecological community.

The conservation planning principles derived from Williams *et al.* (1995) (see s. 3.4.1) complement the above.

MEASURES FOR PROTECTION

Adequate protection of lowland native grassland sites in the ACT, including those that may be of low botanical significance rating but important animal habitat is critical to attaining the goals of this *Strategy*.

Sites with remnant native grassland in the ACT occur on land under a variety of tenures, including urban open space (generally Public Land under *The Territory Plan*),

rural leasehold Territory Land, unleased Territory Land, and Commonwealth-owned and managed National Land. Grassland remnants are often small in size, and may be isolated from one another by areas used for urban, agricultural or other purposes. For some sites, the combination of small size, isolation and the impacts of adjacent land uses may preclude or severely limit prospects for their long-term viability, irrespective of protection or other conservation measures. Other sites may have good prospects for long-term viability, but are unavailable for formal inclusion in a reserve system due to land ownership or use.

Protection of sites on Territory land containing native grassland is achieved through the provisions of the *Land (Planning and Environment) Act 1991* and *The Territory Plan*. For National Land, Memoranda of Understanding with Commonwealth Government agencies have been established, however, these do not provide the same level of statutory protection afforded to those areas that are formally recognised by reservation as part of the nature conservation estate. The existing Memoranda of Understanding aim to ensure that sites with high conservation value are managed so as to maintain their conservation values in perpetuity while other compatible land uses, defined in each MOU, continue. There is also an obligation to consult if any change in land ownership or land use is contemplated. The provisions of the *Environment Protection and Biodiversity Conservation Act 1999* (Cwlth) also apply where Commonwealth actions may have a significant impact on nationally listed threatened species or ecological communities (see s. 1.5.2)

Environment ACT will continue to work with the ACT Planning and Land Authority and the National Capital Authority to promote land uses in areas adjacent to grassland areas that are compatible with conservation objectives and to minimise any adverse impacts. In the context of the strategic objectives for protection set out in Table 4.1, the following are specific objectives:

- a core set of Territory Land sites that have the highest priority for conservation are protected in nature reserves (including the grassland reserves already established);
- Memoranda of Understanding (MOU) between Environment ACT, Department of Environment and Heritage, Department of Defence, National Capital Authority, and CSIRO for the protection and management of high conservation value native grassland on National Land, under the control of these Commonwealth agencies, are maintained; and MOUs with the National Transmitting Authority and Canberra International Airport are prepared and maintained;
- management agreements with the lessees of small sites with high conservation value are prepared and/or maintained (e.g. Australian Centre for Christianity and Culture, Barton).

3.4.4 Management

Management activities in grassland sites require a long-term strategic approach based on clear objectives that are developed from scientific principles. These principles are identified from scientific studies of the ecology of the native grassland community and of component species undertaken in the ACT and elsewhere in Australia. The basis for managing an area of grassland is a management plan (Eddy 2002) regardless of whether or not the preparation of such a plan is a statutory requirement e.g. for Public Land in the ACT. For more detail on native grassland management, see s. 3.7.

Development of a management plan is based on the identification of the dominant grassland and weed species at a site or location, information about any species of conservation concern, an understanding of drainage, soil patterns and past management of the site, activities that will be undertaken aimed at biodiversity conservation, and monitoring programs. There is limited knowledge about the long-term effects of management practices on grassland biodiversity, including the most appropriate forms of defoliation management. An adaptive management approach is therefore necessary (see s. 3.7).

Some investigation of the impacts of management practices on the biodiversity and dynamics of grasslands is being undertaken in the ACT. In general, previous management practices are continued at a site until alternative practices are deemed to better fulfil objectives. Options for management of plant biomass include grazing by domestic stock, mowing, slashing or burning. Herbicides are the main control method for weeds.

Native grassland sites may have other values in addition to the natural values associated with the ecological community. Examples of other values include Aboriginal and European cultural values. Management of other values is integrated into statutory management plans, and in some instances, may require separate protection or joint management arrangements. An important aspect of management planning for native grassland is the identification of community interest in both the grassland and the places where it occurs (AHC 2003). This *Strategy* identifies the Conservation Management Network approach as being the means to connect all those with an interest in the conservation management of native grassland (see s. 3.8.3 and Table 4.1).

As noted in s. 1.7, the *Lowland Native Grassland Conservation Strategy* is not a management plan and the forms that management plans take will vary according to land tenure, use and ownership. For nature reserves, grassland conservation is formally incorporated into the statutory management plans (see s. 1.7). For leased land, management advice is provided to landholders where native grassland is present on their land. Under the MOUs with Commonwealth agencies, it is the responsibility of landholders to prepare management plans that incorporate the conservation requirements for threatened species and the ecological community. Canberra Urban Parks and Places have developed management guidelines for all unleased urban sites that contain grasslands or threatened species, with the aim of maintaining their conservation values.

The remaining ACT grassland sites require management arrangements appropriate to their tenure and conservation goals. Management plans for individual sites need to take into consideration factors such as historical and current land uses and management, size, weed infestations, presence of threatened or uncommon species, surrounding land uses and vegetation (see s. 3.7.1). Priority for the development of management plans should be based on the significance of sites and the potential for threats to reduce conservation values. Management plans are being implemented at all grassland Nature Reserves (managed by the ACT Parks and Conservation Service), all sites managed by Canberra Urban Parks and Places, and land managed by the Department of Defence. The Capital Airport Group has prepared a grassland management strategy for the Canberra International Airport. Management actions being undertaken include weed control at sites managed by Commonwealth and Territory agencies. This is based on a priority list of weed species and areas developed by the ACT Weeds Working Group. Environment ACT regularly provides advice on grassland management to managers of grasslands on all tenures.

3.4.5 Ecological Restoration

Restoration means returning existing habitats to a known past state or to an approximation of the natural condition by repairing degradation, by removing introduced species or by reinstatement (AHC 2002). The success of restoration activities is likely to be inversely related to the degree of degradation of particular grasslands. Where grassland is fragmented, restoration may be considered as a means of increasing overall size, buffering and interconnection (Williams *et al.* 1995, p. 15, Principle 14). In particular, it is now possible to establish native grass swards, though establishment of other grassland species is less well understood. Weed control is a key management problem for restoration activities and supply of seed or plants of suitable provenance to maintain genetic integrity is an ongoing issue (Eddy 2002, p. 19).

It is not yet possible to recreate the grassland ecological community in areas where it has been wholly or mostly removed, nor is it possible to move a grassland community from one site to another.

The comments by Ross (1999, p. 8) on grassland restoration are pertinent:

> The uninformed view that native grasslands are relatively simple systems can encourage the notion that they can be easily re-created as a substitute for conservation of existing remnants. While there clearly is a role for restoration of existing remnants as part of overall management strategies, the 're-creation' of native grasslands is impossible (or at least unfeasible) with current funding, knowledge and technology. Accordingly, projects that attempt to 're-create' native grasslands are of low value in pursuing current conservation goals and objectives.

Restoration of the natural integrity of existing grassland areas is a higher priority than widespread replanting; however, replanting may be undertaken on a limited scale, for example:

- at sites where weed removal or other management has caused extensive bare areas;
- in areas designated as buffer zones;
- at selected roadside sites e.g. where adjacent land contains native grassland of conservation value and the road corridor could be a source of weed invasion; and
- at sites where there is an identified need to increase the population size of particular species of plants and/or animals for conservation purposes e.g. increasing the cover of suitable *Austrodanthonia* spp. in areas supporting *Synemon plana*.

This is an area for further research with economic opportunities. In particular there is scope to establish seed orchards in rural areas for species of both natural temperate grassland (grasses and forbs) and lowland woodland species.

Revegetation guidelines that provide information on the development of work programs appropriate to the types of revegetation that occur are currently being drafted (Butler, in prep.).

3.4.6 Key Characteristics of ACT Lowland Native Grassland Sites

In relation to conservation planning, key characteristics of the 47 remaining lowland native grassland sites in the ACT are:

(a) sites range from those that are small and isolated to large areas with high heterogeneity of habitat;

(b) sites are fragmented; and

(c) weeds have invaded all sites and this is a major on-going threat.

SIZE OF GRASSLAND REMNANTS

Native grassland sites range in size from less than one hectare to approximately 200 ha. Although 40% of the native grassland sites are small (19 are less than five hectares and nine of these, or 19% of sites, are less than one hectare), there are eleven sites (23%) over 100 hectares in size (Table 3.2).

Eight sites contain natural temperate grassland in moderate to good condition (mainly BSR 1–3) and are over 50 ha in size (Table 3.2). They are:

- Canberra International Airport (MA06) 204 ha
  BSR 3(1, 2, 5, E)
- Crace Nature Reserve (GU03) 136 ha
  BSR 3(5)
- Majura Training Area (MA01) 127 ha
  BSR 2(1)
- Lawson (Commonwealth) (BE08) 120 ha
  BSR 2(3, 4)
- 'Woden Station'/Jerrabomberra West Reserve (JE03) 117 ha
  BSR 3
- Dunlop Nature Reserve (BE02) 82 ha
  BSR 3(2)
- Mulanggari Nature Reserve (GU01) 69 ha
  BSR 2(3)
- 'Woden Station'/Jerrabomberra East Reserve (JE05) 72 ha
  BSR 4(3)

(Where a site contains small patches of vegetation with a higher or lower BSR than the majority of the site, these ratings are indicated in brackets.)

Remnant size is a critically important factor in conservation planning. Among those attributes positively correlated with size of habitat area are diversity of vegetation types, the likelihood of occurrence of rare or specialised habitats, the richness of plant and animal species, the size of populations and the sustainability of natural disturbance regimes. In particular, the maintenance of natural patch-dynamic processes in fragmented landscapes is critically dependent on the presence of areas of sufficient size to sustain a mosaic of habitats that correspond to different states (Bennett 1999, p. 15).

The integration of smaller remnants into larger conservation systems increases their conservation value (Williams *et al.* 1995, p. 15, Principle 15). Five grassland areas take the form of contiguous patches (Majura Valley East and West, Jerrabomberra East and West, and Lawson). These account for 1484 hectares or 68% of the 2172 hectares of native grassland in the ACT. Five sites connect with extensive areas of other native vegetation (Majura Valley East and West, Jerrabomberra Valley East and West, and Caswell Drive).

FRAGMENTATION OF GRASSLAND REMNANTS

Remaining areas of lowland native grassland in the ACT have survived largely by chance, following the earlier period of pastoral use of ACT lands and the later development of Canberra. Urban Canberra was built over much of the entirely treeless grassland identified by Pryor (1938). The distribution of the remnants is highly fragmented and further fragmentation, especially of the larger areas, still constitutes a major threat to the ecological community.

Some areas exist in an extensive matrix of developed land uses with no possibility of restoring connectivity (e.g. urban sites such Australian Centre for Christianity and Culture, Barton and York Park, Barton). Thirteen of the 47 sites are isolated within a highly modified urbanised landscape. With planned urban development in Gungahlin and Belconnen, another seven sites will become similarly isolated, resulting in almost half of all sites being in this situation.

The setting aside of areas for public institutions and government offices resulted in small grassland areas remaining in the Central National Area of Canberra (Frawley 1995). Examples include the Australian Centre for Christianity and Culture, Barton (1.9 ha) containing very high quality *Themeda* grassland, and York Park, Barton (0.4 ha), an *Austrodanthonia* grassland containing a population of the endangered Golden Sun Moth *Synemon plana*.

Other sites, though isolated to varying degrees from other grassland, are located close to other native vegetation e.g. lowland woodland. Important woodland/grassland interfaces occur at the Caswell Drive and Glenloch Interchange grasslands, Majura East and West and Jerrabomberra West. In some instances, there is potential to connect to other habitat. An example is the actual and potential connectivity from Black Mountain/Aranda Bushland (open forest)—

Aranda Bushland/Glenloch (lowland woodland, native grassland)—Yarramundi Peninsula (native grassland)—Lake Burley Griffin (riparian and aquatic communities).

The locations with large areas of grassland (Lawson, Majura Valley East and West, Jerrabomberra Valley East and West) have some internal fragmentation but still represent critical habitat for both grassland and some threatened plant and animal species. The conservation value of these areas may be enhanced by complementary management of linking areas even if these areas are not high quality natural temperate grassland, or by undertaking restoration activities (see 'Ecological Restoration' in s. 3.4.5). It is important to maintain the natural integrity of these areas by avoiding further fragmentation.

WEED INVASION

The proneness of grassland to weed invasion and ongoing threats are discussed in s. 2.1.7. Weed control is a key element in conservation planning and management of remaining native grasslands (see s. 3.7.5).

The weed species that are of particular threat to the integrity of native grasslands are Serrated Tussock (*Nassella trichoma*), Chilean Needle Grass (*N. neesiana*), both of which are Weeds of National Significance, African Love Grass (*Eragrostis curvula*) and St Johns Wort (*Hypericum perforatum*). While there are many more species that are far more common in the grasslands, these species are highly invasive and can become extremely dense, sometimes forming monocultures, in even the least disturbed sites. Woody weeds, particularly Briar Rose (*Rosa rubiginosa*), are common in grasslands but these are relatively easy to control.

3.5

Assessing the Conservation Value of Native Grasslands

In order to be able to determine the conservation significance of each grassland site and, where appropriate, to compare sites with different characteristics, it is necessary to develop criteria that enable the available data to be evaluated. Criteria used to assess the conservation significance of sites have been developed from principles defined in Williams *et al.* (1995) (see s. 3.4.1).

The primary criteria used in this *Strategy* for native grassland sites are:

- botanical significance rating (s. 3.2, Appendix 1);
- size and shape (which affects viability, ability to withstand disturbance and species diversity); and
- significance as threatened species habitat (see below).

Secondary criteria that assist in assessing conservation value are:

- the presence of more than one grassland association or threatened species;
- integration of smaller areas into larger units;
- distribution throughout the ACT;
- connectivity with other native vegetation (e.g. lowland woodland).

Data and other relevant information for each grassland site against these criteria is summarised for each district in Tables 3.4–3.8. For the purposes of this *Strategy*, the size of an area is considered to be:

- large if it is greater than 100 ha;
- medium if between 100 ha and 10 ha;
- small if between 10 ha and 1 ha; and
- very small if less than 1 ha.

Grassland sites in the ACT (Table 3.2) have been grouped into three categories based on the above criteria. These are discussed in s. 3.5.1 to s. 3.5.3 (below).

ASSESSMENT OF THREATENED SPECIES HABITAT

Native grasslands provide important habitat for threatened species. Threatened species habitat is identified from known occurrences of species, relative population sizes/distributions and from knowledge of the biology and habitat requirements of species. In addition to native grassland habitat, other areas (including exotic pasture or degraded native pasture) may be important in providing connections between habitats or acting as buffers to adjacent incompatible land uses.

In this *Strategy*, habitat supporting a threatened species population that is considered viable in the medium to long-term (at least 50 years) is considered key habitat. As discussed by Williams et al. (1995), to assess the viability of populations requires extensive and detailed knowledge of population structure (e.g. sex ratio, age structure, age at first breeding, mortality rates) and the response of populations to disturbance. Response to disturbance or fragmentation is affected by genetic variation within and between populations, reproductive rates and dispersal patterns in relation to patches. Population viability also depends on the frequency of stochastic catastrophic events, such as bushfire, drought or disease outbreak.

Much of this information is not available for threatened species in the ACT, and consequently it is not possible to rigorously and quantitatively assess the long-term viability of their populations. Instead, a qualitative approach has been taken to assess key habitat, based on the following ecological principles relating to the viability of small populations:

- Larger populations are more likely to be viable in the long-term (more robust to demographic and environmental stochasticity and loss of genetic diversity).
- Larger areas of habitat with high 'area to perimeter' ratio (less 'edge' effect) are more likely to maintain their ecological condition in the long term (particularly if buffered from incompatible landuse) and are more likely to support a higher number of species.
- Higher quality habitat is more likely to support reproducing populations, and to buffer populations against poor seasonal conditions. For the threatened ACT grassland species, higher quality habitat is more likely to be grassland that is relatively less modified (i.e. higher BSR).

There is a clear connection between the principles relating to habitat (last two above) and principles relating to the conservation of vegetation communities. In addition to supporting viable populations, an area is considered to be key habitat if it supports a population that is important in terms of genetic diversity for a species.

3.5.1 Category 1: Core Conservation Sites

Sites in this category meet the following criteria:

- high botanical significance rating (BSR of 1 or 2, but may contain or adjoin areas of lower rating); or
- key threatened species habitat; or
- large sites (more than 100 ha) with a BSR of 3.

Nineteen sites in the ACT have been assessed as meeting these criteria. The total area of these sites is 1663 ha (comprising 808 ha of natural temperate grassland, 714 ha of native pasture, 141 ha of exotic pasture. The sites represent the core group of areas needed to ensure conservation of the best quality natural temperate grassland and the major habitats for grassland threatened species. They warrant the highest level of protection. The sites are (see also Figures 2.3–2.7):

- Majura Valley East (Training Area (MA01), Airport Services Beacon (MA02) and Canberra International Airport (MA03));
- Majura Valley West (Campbell Park (MA05) and Majura West (MA06))
- Jerrabomberra Valley East ('Woden Station' East (JE05), Harman Bonshaw South (JE06), Harman Bonshaw North (JE07));
- Jerrabomberra Valley West ('Callum Brae' (JE02) and 'Woden Station' (JE03);
- Lawson (Commonwealth) (BE08));
- Dunlop Nature Reserve (BE02); and
- Gungahlin grassland reserves (Mulanggari (GU01), Gungaderra (GU02), Crace (GU03)).

Four sites (totalling 11 ha) with a high BSR are each relatively small in size:

- Caswell Drive (BE10) and Glenloch Interchange (BE11):
  —These sites have a BSR of 2 and are contiguous with woodland, including Snow Gum Lowland Grassy Woodland.
- Australian Centre for Christianity and Culture, Barton (CC04):
  —This is the only site with a BSR of 1. Because of its low degree of disturbance and rarity, the site is considered to be of high conservation value even though it is a small site.
- Isabella Pond, Monash (TU01):
  —This small site has a BSR of 2.

For areas that are Territory Land, the appropriate level of protection is reservation under the *Land (Planning and Environment) Act 1991* (four sites totalling 474 ha are already protected in reserves). The ACT Government has identified a further two sites (totalling 177 ha) in the Jerrabomberra Valley as nature reserves. Sites managed by Canberra Urban Parks and Places are protected as Urban Open Space and are managed to maintain their conservation values. Where grasslands are located on National Land, Memoranda of Understanding with Commonwealth Government agencies have been established, though statutory reservation is desirable to ensure protection in the long term. MOUs cover 479 ha in five sites. For privately leased land (Australian Centre for Christianity and Culture, Barton; Canberra International Airport) protection provisions may be incorporated in lease conditions or other arrangements such as a Memorandum of Understanding.

3.5.2 Category 2: Complementary Conservation Sites

Sites in this category meet the following criteria:

—moderate botanical significance rating (BSR of 3, but may contain or adjoin areas of higher or lower rating); or

- threatened species habitat; or
- medium area sites (10–100 ha) and BSR of 4.

Grassland sites meeting these criteria are those with a history of greater modification than Category 1 sites (e.g. they exhibit reduced plant species diversity, loss of disturbance sensitive species and increase in disturbance tolerant species, and greater weediness) or those that do not contain key threatened species habitat. They are assessed as having a BSR of not higher than 3 as their long-term viability as conservation areas may be limited by virtue of their size, low area to perimeter ratio and/or impacts from surrounding land uses. Category 2 sites may contain threatened species habitat that is not key habitat, however, they may complement core conservation grassland, providing habitat and/or a buffer. Although populations of some threatened species occurring in these areas are small they are considered to be viable in the medium term.

Twenty-two sites in the ACT are assessed as being complementary conservation sites. The total area of these sites is 421 ha (comprising 175 ha of natural temperate grassland, 239 ha of native pasture, 7 ha of exotic pasture). The sites are (see also Figures 2.3–2.7):

- Rural sites:
  —Ginninderra Experimental Station (BE01) and 'Jarramlee' (BE03).
- Near-urban sites:
  —'Mugga Mugga' (Special Purpose Reserve) (JE01) and North Mitchell (GU04).
- Sites with threatened species, but not containing key habitat for those species:
  —York Park (CC05), St Johns Church, Reid (CC03), Lake Ginninderra (BE06), Constitution Ave, Reid (CC02), Woods Lane (JE04), Cookanalla (JE08), Amtech (JE09), Tennant St, Fyshwick (JE10), Malcolm Vale (MA04), and Yarramundi Reach (CC06).
- Isolated urban sites with BSR 3:
  —Umbagong (BE04), Evatt Powerlines (BE05), CSIRO Headquarters (CC01), Lady Denman Drive (CC07), Dudley St, Yarralumla (CC08), Kintore St, Yarralumla (CC09), Black St, Yarralumla (CC11) and Mitchell (GU05).

In addition to the above sites, important habitat for the Grassland Earless Dragon is located in degraded native pasture or exotic pasture surrounding Category 1 sites in the Jerrabomberra Valley (JE05, JE06, and JE07) (Figure 2.4). These areas do not contain natural temperate grassland, but are likely to provide a buffer for key habitat where the species is known to breed. In the case of Amtech where the Grassland Earless Dragon has been recorded, further work is required to determine whether the area should be retained or allowed to be developed.

Recognition and protection of these areas on Territory Land may be achieved through Public Land categories of the *Territory Plan* including Nature Reserve, Urban Open Space and Special Purpose Reserve. Thirteen, mainly small, grassland sites are located in Urban Open Space and one ('Mugga Mugga') in Special Purpose Reserve.

Activities permitted in these land use categories may be compatible with conservation of native grassland values, provided that appropriate conservation management is in place. In these cases maintenance of the conservation values of the site is the responsibility of the relevant ACT Government agency. Other similar land uses include road reserves and power-line easements.

For National Land, Memoranda of Understanding with Commonwealth Government agencies are appropriate. MOUs can embrace all native grasslands managed by these agencies, not only those that are core conservation sites. Land Management Agreements provide the primary means to achieve conservation management of these grasslands on rural leases.

3.5.3 Category 3: Landscape and Urban Sites

Category 3 sites have a lower conservation value than those in categories 1 or 2, but may still contribute to conservation of grassland biodiversity. They meet the following criteria:

- low to very low botanical significance rating (BSR of 4 or 5); and small to very small area (less than 10 ha); 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.

These sites tend to be very fragmented and have reduced viability as a grassland community. However, some have value as buffers or connections between higher conservation value sites, as landscape features within the urban fabric, or in providing opportunities for education or rehabilitation research.

Six sites in the ACT are categorised as landscape and urban sites. The total area of these sites is 88 ha (comprising 8 ha of natural temperate grassland, 71 ha of native pasture, 9 ha of exotic pasture). The sites are (see also Figures 2.4–2.7):

- Urban sites with BSR 4 or 5:
  —Lawson (Territory) (BE07), Novar St, Yarralumla (CC10).
- Isolated near-urban sites:
  —Kaleen East paddocks (BE09), Belconnen Pony Club (GU06), Wells Station Road (GU07), Nicholls (GU08).

OTHER AREAS INCLUDED IN CATEGORY 3

In addition to the above sites, there are areas of degraded native pasture or exotic pasture of insufficient quality to be included in the grassland inventory (Table 3.2), that contain records of threatened species. These areas are generally associated with higher quality native pasture or natural temperate grassland. Figures 2.3, 2.4, 2.5 and 2.7 show the distributions of threatened species habitat and their relationship to the various grassland types.

Where possible, sites with these characteristics should be retained and appropriately managed until their long-term future is determined. Each one needs to be assessed as part of the outline planning, environmental assessment and development approval process. Planning and management arrangements to protect and manage their natural values may include agreements with non-government landholders, property management agreements with rural lessees and protection of sites within the urban fabric.

These areas are:

- East Jerrabomberra (Block 2060 Jerrabomberra and adjoining Block 6 Section 53 Hume):
  —This area is situated between the Monaro Highway and JE06 (Figure 2.4). The area has records of the Striped Legless Lizard and forms a logical connection between habitat in east and west Jerrabomberra;
- East Jerrabomberra (Part of Block 49 Jerrabomberra):
  —This area is situated between JE06 and the ACT/NSW border (Figure 2.4) and is habitat for the Grassland Earless Dragon and to a lesser extent Striped Legless Lizard. It provides an opportunity to maintain a habitat connection across the ACT/ NSW border.
- West Majura (parts of Block 3 Section 9 and adjoining Block 2 Section 12 Pialligo):
  —Both sites are adjacent to Majura Road west of the airport (Figure 2.3). This area is also most likely to be habitat for the Striped Legless Lizard and provides an opportunity for a connection between grassland in east and west Majura.
- Gungahlin (Kenny):
  —An area of Striped Legless Lizard habitat in degraded native pasture east of Mitchell.
- Baptist Church (Parkes):
  —This area contains a small population of Button Wrinklewort.

3.5.4 Summary of Grassland Sites and Categories

The following table summarises the data on grassland type and area according to the three categories above (s. 3.5.1 to s. 3.5.3). Eighty-one per cent (808 ha) of the remaining natural temperate grassland meets the criteria for Category 1 sites (Core Conservation Sites) where there is a high level of protection in reserves and through Memoranda of Understanding.

Table 3.3: Grassland Types and Areas in Each Category of Grassland Sites in the ACT

	Hectares				
	No. of Sites	TOTAL	NTG	NP	EX
Category 1 (Core)	19	1663	808	714	141
Category 2 (Complementary)	22	421	175	239	7
Category 3 (Landscape and Urban)	6	88	8	71	9
Total	**47**	**2172**	**991**	**1024**	**157**

NTG: Natural Temperate Grassland; **NP**: Native Pasture; **Ex**: Exotic

3.6

Planning and Conservation Issues for Lowland Native Grasslands and Threatened Species Habitats in the ACT

The areas of land in the ACT that contain remnants of the original natural temperate grassland and grassland habitat for species of conservation interest are located in five geographic areas: Gungahlin, Majura Valley, Jerrabomberra Valley, Belconnen, and Central Canberra. The only remaining site in Tuggeranong is included in the Central Canberra group. These areas are the remnants of the original valley floor distribution in the ACT of natural temperate grassland. Each geographic area, sub-units and the key species found in them are described in detail in sections 3.6.1 to 3.6.5.

Planning and conservation issues relevant to the remaining grassland are common across all or most locations and need to be considered regardless of the exact location. The issues are:

- ensuring the core conservation sites (Category 1) (see s. 3.5.1 and Table 3.2) are protected in perpetuity and other sites are afforded appropriate protection and conservation management consistent with their size, condition, location and tenure;
- avoiding, where possible, any further fragmentation of remaining sites through clearing for urban, industrial and infrastructure development and for agricultural purposes;
- providing for ecological connectivity where possible between separated sites, across common boundaries, and with other adjacent natural ecological communities (usually lowland woodland);
- ensuring that selection of protected areas takes into account any information about the genetic variability of remaining species populations;
- restoring (through revegetation or regeneration) patches of vegetation with a low botanical significance rating in natural temperate grassland sites;
- exploring opportunities for restoring substantially modified grasslands and habitats for threatened species;
- increasing the area of occupancy of threatened flora and fauna, particularly where these have small populations or restricted distributions; and
- taking into account the regional context of any grassland and habitat for threatened plants and animals.

3.6.1 Majura Valley

DESCRIPTION

The Majura Valley contains some of the most diverse and valuable areas of natural temperate grassland and habitat for threatened species left in the ACT (Figure 2.3, Table 3.4). The dominant floristic association is *Austrodanthonia* (191 ha), with a small area (17.5 ha) of Wet *Themeda*. Approximately 430 hectares of grassland habitat has been confirmed as supporting threatened species. The biodiversity significance of the area is recognised in *The Canberra Spatial Plan* (ACT Government 2004b). The existing Majura Road that will be upgraded in the future to parkway standard divides the valley into eastern and western sections. There has also been a proposal for a future railway connection from Sydney to the Canberra International Airport. This may be revived given the significant benefits for businesses in the ACT and surrounding NSW. Protection of remaining grasslands and their threatened species will be an important issue as these transport links are planned and constructed, and when subsequent development and employment opportunities are realised.

On both the eastern and western sides of the valley, natural grassland merges with Yellow Box–Red Gum grassy woodland. Woodland–grassland ecotones such as these were identified in the *ACT Lowland Woodland Conservation Strategy* (ACT Government 2004a) as being a priority for protection. The western example is more disturbed than the eastern one due to the intrusion of the Campbell Park offices, Northcott Drive and previous land management practices that have significantly reduced the area of natural temperate grassland. However, habitat for the Grassland Earless Dragon and other threatened species still exists along the woodland–grassland edge of Mt Ainslie Nature Reserve. Only about 12 ha of this area are assessed as being natural temperate grassland, but the extended area of native pasture contains habitat for the Grassland Earless Dragon and the Striped Legless Lizard.

Grassland habitat east of the Majura Road, including that at the Majura Training Area, the Canberra International Airport and Blocks 102 and 146 Majura (approximately 500 ha in total) is one of only a few large contiguous areas containing extensive samples of natural temperate grassland. The area contains *Austrodanthonia* and Wet *Themeda* floristic associations. These grasslands are highly diverse floristically and are habitat for five threatened species typical of natural grasslands (Button Wrinklewort, Striped Legless Lizard, Grassland Earless Dragon, Perunga Grasshopper and Golden Sun Moth).

Table 3.4: Majura Valley: Grassland Types and Conservation Significance

Majura Valley		Area (ha) and Grassland Type NTG, NP, E	Botanical Significance Rating	Wet *Themeda*	Dry *Themeda*	*Austrodanthonia*	*Austrostipa*	*Poa*	Grassland Earless Dragon	Striped Legless Lizard	Golden Sun Moth	Perunga Grasshopper	Button Wrinklewort	Comments	Conservation Category*
Majura Valley East (Majura Training Area)	MA01	113.7 NTG 5.8 NP 7.1 E	2(1)	6.8		106.9			K	K	K	✔	K	Links with extensive woodland	1
Majura Valley East (Air Services Beacon)	MA02	10.7 NTG	2(4)	10.7					K	K	K	✔		Surrounded on three sides by MA01	1
Majura Valley East (Airport)	MA03	73.6 NTG 62.9 NP 67.1 E	3 (1,2,5)			73.6			K		✔	✔		Contiguous with MA01	1
'Malcolm Vale'	MA04	155.4 NP							✔		✔			Contiguous with MA01	2
Campbell Park	MA05	10.9 NTG 0.8 E	3(2)			10.9			K	✔	✔	✔	✔	Links with woodland on Mt Ainslie and contiguous with MA06	1
Majura West	MA06	133.3 NP							K	✔	✔	✔		Links with woodland on Mt Ainslie and contiguous with MA05	1
Total Natural Temperate Grassland		**208.9**		**17.5**		**191.4**									
Total other threatened species habitat		**432.4**													

NTG: Natural Temperate Grassland; **NP**: Native Pasture; **E**: Exotic; **K**: Key habitat; ✔: Species present. * Refer ss. 3.5.1–3.5.3.

Grasslands in the mid-valley floor, west Majura Road, and north of the Majura Training Area are now highly disturbed as a result of soil cultivation and cropping. One record of the Striped Legless Lizard near Majura Road might indicate that in former times the populations of this species (and probably others) were once joined. Maintaining or re-establishing such a link should be a long-term goal for conservation in the Majura Valley.

No natural temperate grassland areas of the Majura Valley have been destroyed or significantly degraded since publication of Action Plan 1 (ACT Government 1997a) although development at the Canberra International Airport has reduced the area of grassland. Surveys undertaken since then have revealed a population of the Striped Legless Lizard at Campbell Park, an extension of the known population of Button Wrinklewort at Campbell Park, and the presence of the Grassland Earless Dragon on Blocks 102 and 146 Majura, between the Training Area and Canberra International Airport. Development of runway infrastructure at the airport in 2001 reduced the area of grassland habitat and required the salvage of five specimens of Grassland Earless Dragon. Future planned works at the airport will have similar impacts.

PLANNING AND CONSERVATION ISSUES

In addition to the issues summarised above (s. 3.6), the following are specific to the Majura Valley:

- Resolving planning proposals, transport and other infrastructure development for the airport and its surrounds, including identifying boundaries of areas to be protected for nature conservation or managed with nature conservation as a primary objective.

  The ACT Planning and Land Authority is undertaking a detailed planning study of the north-south employment corridor along Majura Road (Majura Valley) and the Monaro Highway to the Hume industrial area (Jerrabomberra Valley). The study will identify areas that are significant for biodiversity conservation as well as identifying other environmental issues.
- Maintaining the integrity of the remaining areas and improving the condition of grassland habitats by selective revegetation and weed control, avoiding fragmentation, degradation and impacts from adjacent developments.
- Maintaining ecological connectivity between grasslands and adjacent woodlands at both the eastern and western valley fringes, and if feasible across the Majura Valley.
- Restoring habitat for threatened species on land adjacent to areas with high conservation value. This is particularly relevant to Blocks 53, 102 and 146 Majura adjacent to the Majura Training Area (MA01), to Blocks 687 and 655 near Campbell Park offices and to the Canberra International Airport (MA03).
- Implementing Environment Management Plans for those areas owned or occupied by private organisations or Commonwealth government agencies (Canberra International Airport (Capital Airport Group), Majura Training Area (Department of Defence)).

3.6.2 Jerrabomberra Valley

DESCRIPTION

The Jerrabomberra Valley is similar in many ways to the Majura Valley, with large and significantly diverse areas of natural temperate grassland, a range of threatened flora and fauna, and examples of the grassland–woodland interface. The dominant floristic association is *Austrodanthonia* (172 ha) with *Austrostipa* (84 ha) and Wet *Themeda* (11 ha). Another 430 ha are grassland habitat containing threatened species. The valley is also divided north-south by a major transport corridor, the Monaro Highway. When considering planning and conservation issues in this valley, it is important to recognise similar natural areas in adjacent land in NSW, namely the Letchworth Nature Reserve and rural land known as 'The Poplars', separated from the ACT by the railway and railway easement.

West of the Monaro Highway is a large area (280 ha) of natural temperate grassland and other grassland habitat, with one of the largest remaining populations of Grassland Earless Dragon. Other threatened species found here are the Perunga Grasshopper, Golden Sun Moth and the Pink-tailed Worm Lizard (*Aprasia parapulchella*) (listed as Vulnerable under the EPBC Act (Cwlth)). This grassland was identified in Action Plan 1 (ACT Government 1997a) as being a core area for natural temperate grassland protection. In the south-western and north-western parts of the area, grassland merges with lowland woodland.

East of the Monaro highway, remnant patches of natural temperate grassland (119 ha) are surrounded by native pasture (the two categories totalling 374 ha). This area provides habitat for the Striped Legless Lizard and Grassland Earless Dragon and there are several populations of the Button Wrinklewort (in Woods Lane and Harman Bonshaw North, as well as in Letchworth and 'The Poplars'). Previous land use associated with the Defence communication facility is likely to have resulted in a management regime conducive to the survival of these species, particularly in those areas where there are communication aerials.

Table 3.5: Jerrabomberra Valley: Grassland Types and Conservation Significance

Jerrabomberra Valley		Area (ha) and Grassland Type NTG, NP, E	Botanical Significance Rating	Wet Themeda	Dry Themeda	Austrodanthonia	Austrostipa	Poa	Grassland Earless Dragon	Striped Legless Lizard	Golden Sun Moth	Perunga Grasshopper	Button Wrinklewort	Comments	Conservation Category*
'Mugga Mugga'	JE01	15.0 NTG	4(3)			1.4	13.7								2
'Callum Brae'	JE02	162.7 NTG	5						K					Contiguous with JE03 Links to woodland	1
'Woden Station'	JE03	115.2 NTG 1.7 NP	3			62.8	52.4		K		K	K		Links to woodland	1
Woods Lane	JE04	10.3 NTG	3		10.3								✔	Contiguous with JE05 and Links to Letchworth NR (NSW)	2
'Woden Station' east	JE05	62.2 NTG 7.8 NP 2.0 E	4(3)			44.2			K	K	K	✔		Links to Letchworth NR (NSW)	1
Harman-Bonshaw South	JE06	105.7 NP	5						K	K	✔	✔		Contiguous with JE05	1
Harman-Bonshaw North	JE07	46.3 NTG 68.3 NP	5(4)			46.3			K	K		✔	✔	Contiguous with JE06	1
'Cookanalla'	JE08	81.5 NP	5						✔						2
AMTECH, Fyshwick	JE09	18.0 NTG	4			18.0			✔	✔		✔		Isolated by major roads	2
Tennant St, Fyshwick	JE10	0.3 NTG	3		0.3								✔	Isolated	2
Total Natural Temperate Grassland		**267.4**			**10.6**	**172.7**	**84.1**								
Total other threatened species habitat		**429.7**													

NTG: Natural Temperate Grassland; **NP**: Native Pasture; **E**: Exotic; **K**: Key habitat; ✔: Species present. * Refer ss. 3.5.1–3.5.3.

Providing for ecological connectivity between the high value areas east and west of the highway, across the ACT–NSW border and between grasslands and woodlands is a particular issue for the Jerrabomberra valley. The *ACT Lowland Woodland Conservation Strategy* (ACT Government 2004a) has also identified the importance of these areas for animal movements and maintaining ecological connectivity between and beyond the Majura and Jerrabomberra valleys. The ACT Government has identified Blocks 6 and 12 of Section 18 Jerrabomberra in the southern part of the valley as the location for the ACT prison, subject to environmental and other assessments. This is expected to provide an opportunity to maintain some habitat suitable for east-west connectivity between 'Woden Station' east and the prison. Protection of land known as Mikes Hill adjacent to the Letchworth Nature Reserve and 'The Poplars' provides another opportunity to maintain connectivity and achieve an enlarged area of occupancy for the Grassland Earless Dragon. There are several locations elsewhere in the valley where connectivity between grassland areas should be a consideration as planning and development proposals are progressed into specific developments.

In 2000 the ACT Government ruled out intensive development of the Jerrabomberra Valley to ensure the protection of its environmental values. The ACT Planning and Land Authority has undertaken a planning study of the valley that will inform government decisions about detailed development and conservation opportunities. The study identifies key areas where protection of nature conservation values will be the major objective. In order to ensure that habitat for threatened species is maintained on land leased for rural purposes, the Conservator of Flora and Fauna has issued Conservator's Directions, pursuant to s. 47 of the Nature Conservation Act 1980. These directions require landholders to obtain the prior agreement of the Conservator before carrying out activities (e.g. cultivating, fertilising, cropping) that may damage the conservation values of the land. During 2005, new grassland reserves will be established east and west of the Monaro Highway. They will be the first to ensure protection of Grassland Earless Dragon habitat in the ACT.

PLANNING AND CONSERVATION ISSUES

- Establishing the new nature reserves announced in July 2004 within the context of overall planning for the Jerrabomberra Valley.
- Maintaining the integrity of remaining areas and improving the condition of grassland habitats by selective revegetation and weed control, avoiding fragmentation, degradation and impacts from adjacent developments.
- Maintaining ecological connectivity between grasslands east and west of the Monaro Highway, between grasslands and adjacent woodlands west of the Monaro Highway and between adjacent grasslands on the ACT–NSW border near Queanbeyan.
- Enlarging the area of occupancy of threatened species by restoring suitable habitat on land adjacent to existing or future nature reserves.
- Preparing and implementing Environment Management Plans for those areas owned or occupied by private organisations or government agencies (Harman-Bonshaw (Department of Defence), Southcare Helicopter base, ACT Prison).

3.6.3 Gungahlin

DESCRIPTION

The natural vegetation of the Gungahlin valley was originally a mosaic of natural temperate grassland and lowland grassy woodland, primarily Yellow Box–Red Gum grassy woodland. The *ACT Lowland Woodland Conservation Strategy* (ACT Government 2004a) sets out the priorities for woodland conservation in the area, focussing mostly on the extensive band of woodland from the Federal Highway, through Gooroo and Mulligans Flat and westward to Kinlyside and Hall. Existing and future proposed reserves would protect a significant part (1500 ha) of this area.

In the valley floors natural grassland predominated prior to more recent rural use and urban development, which left three relatively large areas of native grassland and several very small and isolated fragments, to the south and south-east of the Gungahlin town centre. The dominant floristic association is *Austrodanthonia* (93 ha) with Wet *Themeda* (46 ha), *Austrostipa* (36 ha) and Dry *Themeda* (5 ha) (Table 3.6). As a result of a major planning study in 1995, three nature reserves were established (Crace, Gungaderra, Mulanggari) known collectively as the Gungahlin Grassland Reserves.

The location of the three nature reserves was determined on the basis of both the remaining fragments of natural temperate grassland and the known distribution of the Striped Legless Lizard. The reserves include about 160 ha of natural temperate grassland and another 230 ha of habitat occupied by the Striped Legless Lizard. Parts of each reserve are adjacent to one of the others, but are separated by Gungahlin Drive. In the Gungaderra Nature Reserve nearly 16 ha of Wet *Themeda* grassland is contained

Table 3.6: Gungahlin Valley: Grassland Types and Conservation Significance

Gungahlin		Area (ha) and Grassland Type NTG, NP, E	Botanical Significance Rating	Wet *Themeda*	Dry *Themeda*	*Austrodanthonia*	*Austrostipa*	*Poa*	Grassland Earless Dragon	Striped Legless Lizard	Golden Sun Moth	Perunga Grasshopper	Button Wrinklewort	Comments	Conservation Category*
Mulanggari Nature Reserve	GU01	58.6 NTG 9.4 NP 0.5 E	2(3)	7.5		51.1				K	K	✔		Linked to GU02; separated by major road	1
Gungaderra Nature Reserve	GU02	41.9 NTG 115.2 NP 30.2 E	5(2,4)	15.7		4.3	21.9	#		K	✔	✔		Linked to GU01, GU03; separated by major road Linked to woodland to the west; small patch of remnant Snow Gum woodland on one slope	1
Grace Hill Nature Reserve	GU03	61.6 NTG 41.1 NP 33.3 E	3(5)	22.5	3.1	35.9				K	K	✔	K	Linked to GU02; separated by major road	1
North Mitchell	GU04	14.8 NTG 1.2 E	3(4)			1.4	13.4				✔				2
Mitchell	GU05	1.6 NTG	3		1.6					✔					2
Belconnen Pony Club	GU06	0.3 NTG	4			0.3									3
Wells Station Road	GU07	0.2 NTG	4				0.2			✔					3
Nicholls	GU08	0.3 NP	4				0.3			✔					3
Total Natural Temperate Grassland		**179.2**		**45.7**	**4.7**	**93.0**	**35.8**								
Total other threatened species habitat		**230.9**													

NTG: Natural Temperate Grassland; **NP**: Native Pasture; **E**: Exotic; **K**: Key habitat; ✔: Species present. * Refer ss. 3.5.1–3.5.3.

An area (6 ha) of degraded native pasture dominated by Poa remains in Gungaderra Nature Reserve.

within a fenced area occupied by the NTL Transmitting Station. A trunk sewer laid across the Gungaderra Nature Reserve in 2004 avoided any natural temperate grassland and minimised impact on the Striped Legless Lizard. The Commonwealth Government assessed the project for its environmental impact under the *Environment Protection and Biodiversity Conservation Act 1999* (Cwlth).

Since these reserves have been established and the grazing management altered to promote conservation values, populations of Button Wrinklewort, Perunga Grasshopper, and Golden Sun Moth have been recorded during monitoring by Environment ACT ecologists. Vegetation surveys undertaken in 2003–4 indicate that in Crace Nature Reserve, the area dominated by native species has increased since 1995. The Gungaderra Nature Reserve protects a small example of the interface between grassland and woodland on the southern slopes of Gungahlin Hill, near the Barton Highway. The Grassland Earless Dragon has never been recorded in the Gungahlin Valley.

Small areas of natural temperate grassland are also located in Mitchell and north of Mitchell (west of the junction between Flemington Road and the future Wells Station Drive), at the foot of Percival Hill and on Wells Station Road. The Striped Legless Lizard is found in several locations across Kenny in habitat that no longer represents natural temperate grassland. Small populations have been recorded at Percival Hill, CSIRO (Sustainable Ecosystems), the Gungahlin Cemetery and at Palmerston, but never above 620 m asl.

PLANNING AND CONSERVATION ISSUES

The distribution of natural temperate grassland and related habitat for threatened species (particularly the Striped Legless Lizard) was the subject of a significant planning study by Williams *et al.* (1995) that resulted in a major change to *The Territory Plan* (ACTPLA 2003). As a result of this, the location for the Gungahlin Town Centre and other planned developments were moved to permit establishment of the Gungahlin Grassland Reserves. Consequently, the planning and conservation issues in Gungahlin are not as great as in other areas, although some remain. These are:

- Resolving the future status of natural temperate grassland at Flemington Road.
- Improving the condition of grassland habitats protected in reserves, particularly addressing impacts from adjacent residential developments as these are built.
- Providing ecological connectivity between the Gungahlin Grassland Reserves.
- Investigating the potential for small areas of habitat in Kenny occupied by Striped Legless Lizard to be retained as part of the urban fabric (road reserves, public parks, large area developments).
- Preparing and implementing Environment Management Plans for those areas owned or occupied by private organisations or government agencies (Gungahlin Cemetery, CSIRO (Sustainable Ecosystems)).

3.6.4 Belconnen

DESCRIPTION

The pattern of urban development in the area now occupied by Belconnen is similar to that seen elsewhere in Canberra, with large areas of former natural temperate grassland changed initially through rural land uses and subsequently cleared for residential development. Nevertheless, 175 ha of *Austrodanthonia*, 57 ha of *Austrostipa*, 53 ha of Dry *Themeda* and 15 ha of Wet *Themeda* remain in the area (Table 3.7). A much higher proportion of the remaining native grassland in Belconnen is assessed as natural temperate grassland compared with Gungahlin, and the Majura and Jerrabomberra valleys.

As a result of security fencing of land at Lawson for the Belconnen Naval Station (Department of Defence communications facility) and minimal disturbance, about 120 ha of natural temperate grassland (*Austrodanthonia*) remains in very good condition, supporting the largest population of the Golden Sun Moth in the region. In 1994, a previously undescribed species of herb was found on the site, and is the only known population of the species. It was named the Ginninderra Peppercress (*Lepidium ginninderrense*) and is now listed as an endangered species in the ACT and nationally. The Perunga Grasshopper has also been found there, but repeated searches for the Grassland Earless Dragon have failed to record any. In 2001 a small area of *Themeda* grassland containing the Striped Legless Lizard was found near Baldwin Drive during ecological studies associated with planning for the future suburb of Lawson.

It is anticipated that as a result of the planning studies for Lawson carried out by ACT and Commonwealth Government agencies, Category 1 grassland will be identified for declaration as a new nature reserve that protects a core ACT grassland site and the significant population of the Golden Sun Moth.

If a grassland nature reserve is established at Lawson, it is likely to retain an existing population of Eastern Grey Kangaroos. Whether this will remain a viable option in the long-term will depend upon development

Table 3.7: Belconnen: Grassland Types and Conservation Significance

Belconnen		Area (ha) and Grassland Type NTG, NP, E	Botanical Significance Rating	Wet *Themeda*	Dry *Themeda*	*Austrodanthonia*	*Austrostipa*	*Poa*	Grassland Earless Dragon	Striped Legless Lizard	Golden Sun Moth	Perunga Grasshopper	Button Wrinklewort	Comments	Conservation Category*
Ginninderra Experimental Station	BE01	18.9 NTG 0.5 E	4		18.9										2
Dunlop Nature Reserve	BE02	81.9 NTG	3(2)	4.9		77.0					✔			Important habitat for uncommon plant species in Wet *Themeda* area	1
'Jarramlee'	BE03	52.0 NTG	4(3)	4.7			47.3								2
Umbagong Park	BE04	9.0 NTG 1.8 NP 4.7 E	4(3,5)		8.0	0.8	0.2								2
Evatt powerlines	BE05	1.1 NTG	3		1.1										2
Lake Ginninderra	BE06	1.9 NTG	3		1.7	0.1					✔				2
Lawson (Territory)	BE07	3.3 NTG 46.9 NP 9.1 E	5(3)		1.1	2.2									3
Lawson (Commonwealth)	BE08	120.3 NP	2(3,4)	2.9	16.5	91.2	9.8			✔	K	✔	K		1
Kaleen east paddocks	BE09	4.0 NTG 24.2 NP	5(3)			4.0				✔					3
Caswell Drive	BE10	5.8 NTG	2	2.3	3.5									Links to Snow Gum Woodland and other woodland	1
Glenloch Interchange	BE11	2.2 NTG	2	2.2										Links to Snow Gum Woodland and other woodland	1
Total Natural Temperate Grassland		**300.4**		**14.8**	**53.0**	**175.3**	**57.3**								
Total other threatened species habitat		**87.2**													

NTG: Natural Temperate Grassland; **NP**: Native Pasture; **E**: Exotic; **K**: Key habitat; ✔: Species present. * Refer ss. 3.5.1–3.5.3.

of a humane method for fertility control of the kangaroo population, an ability to protect kangaroos from domestic dogs, and successful management of visitors to the reserve. The existing buildings that are used to manage the communications facility may lend themselves to subsequent uses that complement the nature conservation objectives of the area.

At Glenloch interchange, small fragments of the former grassland now remain within the existing road network. Designs for development of this road system as part of the Gungahlin Drive extension project retain all of the grassland. Across Caswell Drive there is another area of natural temperate grassland that adjoins the Aranda Bushland, including areas of Yellow Box–Red Gum grassy woodland and Snow Gum woodland. This ecological interface was identified in the *ACT Lowland Woodland Conservation Strategy* (ACT Government 2004a) as being of significance and warranting protection. A small area of the natural temperate grassland on the roadside of Caswell Drive is to be removed as a part of the Gungahlin Drive Extension.

Elsewhere in Belconnen, land containing natural temperate grassland is found along the ACT–NSW border at 'Jarramlee', the Ginninderra Experimental Station and at Dunlop. An area of natural temperate grassland (containing Wet *Themeda* and *Austrodanthonia* floristic associations) and Yellow Box–Red Gum grassy woodland was excised from land proposed for residential development at Dunlop and included in the Dunlop Nature Reserve. Other small areas of natural temperate grassland are found in open space at Evatt and Florey e.g. Umbagong Park contains nine hectares of natural temperate grassland.

The Striped Legless Lizard has been recorded at several locations at Kaleen, in land between the existing suburb, the Barton Highway and the future Gungahlin Drive Extension. These animals are likely to have been connected to populations at Crace, and their ability to maintain a viable population is unknown.

PLANNING AND CONSERVATION ISSUES

- Resolving planning issues for the new suburb of Lawson, and protecting those areas that have natural values as future nature reserve or other open space.
- Preventing any future development or inappropriate activities on Umbagong Park (south) (requiring variation to the *Territory Plan*).
- Ensuring protection and conservation management of grassland remnants in close proximity to developments such as the Gungahlin Drive Extension.
- Improving the condition of grassland and threatened species habitats by appropriate management, including weed control.
- Establishing an appropriate management regime for any areas of grassland protected at Lawson, including management of the kangaroo population.
- Preparation of Environment Management Plans for those areas owned or occupied by private organisations or government agencies.
- Maintaining habitat for Striped Legless Lizard within the small fragmented areas in Kaleen.

3.6.5 Central Canberra and Tuggeranong

DESCRIPTION

Grasslands in the Central Canberra area now comprise only twelve, small remnants (totalling 37 ha), each well separated from the others. Restoring ecological connectivity between these remnants is impossible. However, some of the remaining areas are of high quality and retain sufficient suitable habitat to support small populations of some threatened species. These remnants are reminders, in the central part of the city, of the previous natural landscape.

The largest remaining native grassland remnant in Central Canberra is at Yarramundi Reach. A population of the Striped Legless Lizard (*Delma impar*) has been recorded and monitored for a number of years. It appears that there may be some inter-specific interaction with a related species *Delma inornata* that is displacing *Delma impar* from this habitat. It will be of interest to monitor this over time.

Both the Yarramundi and Glenloch interchange grasslands (Table 3.8) are included in a National Capital Authority study of land uses and land use policies in the western foreshores area of Lake Burley Griffin following the bushfires of December 2001 and January 2003 (Capital Planners Pty Ltd 2004).

Other small fragments of grassland are located in Yarralumla (Dudley St, Kintore St, Novar St, Black St and Lady Denman Drive adjacent to the Royal Canberra Golf Course), in Campbell (CSIRO corporate headquarters on Limestone Avenue) and in Reid (Constitution Avenue).

A small but significant area (BSR 1) of natural temperate grassland (Dry *Themeda*) in very good condition remains in Barton on land occupied by the Australian Centre for Christianity and Culture and the Anglican Church (St Marks Theological College). The site is unusual in that it is little disturbed by exotic weeds or human activities, and populations of Button

Table 3.8: Central Canberra and Tuggeranong: Grassland Types and Conservation Significance

Central Canberra/Tuggeranong		Area (ha) and Grassland Type NTG, NP, E	Botanical Significance Rating	Wet *Themeda*	Dry *Themeda*	*Austrodanthonia*	*Austrostipa*	*Poa*	Grassland Earless Dragon	Striped Legless Lizard	Golden Sun Moth	Perunga Grasshopper	Button Wrinklewort	Comments	Conservation Category*
CSIRO Headquarters, Campbell	CC01	3.0 NTG 0.5 E	3		3.0						✔				2
Constitution Avenue, Reid	CC02	0.7 NTG	3		0.7						✔				2
St John's Church Reid	CC03	0.9 NTG	4			0.9					✔				2
ACCC, Barton	CC04	1.9 NTG	1		1.9						✔		✔		1
York Park, Barton	CC05	0.4 NTG	4			0.4					✔				2
Yarramundi Reach	CC06	21.2 NTG	3(5)		4.8		16.4	#		✔ ?		✔			2
Lady Denman Drive, Yarralumla	CC07	0.4 NTG	3			0.4									2
Dudley Street, Yarralumla	CC08	1.5 NTG	3	0.9		0.6					✔				2
Kintore Street, Yarralumla	CC09	0.8 NTG	3		0.8								✔	Only one Button Wrinklewort present	2
Novar Street, Yarralumla	CC10	0.2 NTG	4				0.2								3
Black Street, Yarralumla	CC11	3.6 NTG	3		3.6						✔				2
Isabella Pond, Monash	TU01	1.2 NTG	2		1.2										1
Total Natural Temperate Grassland		**35.8**		**0.9**	**16.0**	**2.4**	**16.6**								
Total other threatened species habitat		**0.7**													

NTG: Natural Temperate Grassland; **NP**: Native Pasture; **E**: Exotic; **K**: Key habitat; ✔: Species present. * Refer ss. 3.5.1–3.5.3.

A very small remnant (less than 0.2 ha) of degraded native pasture dominated by *Poa* remains in the Yarramundi Reach site.
? Striped Legless Lizard was last recorded on the site in 1991. Surveys to determine presence are continuing.

Wrinklewort (approximately 100 plants) and Golden Sun Moth are located there. Considerable cooperative effort over several years by a range of government agencies and other organisations has endeavoured to retain the conservation values of the grassland while at the same time allowing for a major development in the immediate area. The lease for the area identifies the grassland as requiring conservation management according to an Environment Management Plan agreed to by the Conservator of Flora and Fauna. The Button Wrinklewort is also found in substantially modified native grassland in the grounds of the Baptist Church in Barton.

At York Park, Barton another very small fragment of natural temperate grassland (*Austrodanthonia*) that is highly modified is being maintained by the National Capital Authority. The half-hectare site contains a small population of Golden Sun Moth. The Authority carries out weed control and other management activities under an MOU with Environment ACT.

The original vegetation of what is now the Tuggeranong Valley was largely natural temperate grassland. Now, only one small area (about 1 hectare) of natural grassland remains next to Isabella Pond.

PLANNING AND CONSERVATION ISSUES

- Improving the condition of small grassland remnants and threatened species habitats by appropriate management, including weed control.
- Establishing an appropriate management regime for areas of grassland that are retained around Lake Burley Griffin, particularly at Yarramundi Reach.
- Preventing any future development or inappropriate activities on Isabella Pond, Monash (requiring a variation to *The Territory Plan*).
- Preparing and implementing Environment Management Plans for those areas owned or occupied by private organisations or government agencies (Yarramundi Reach (National Capital Authority), Australian Centre for Christianity and Culture, Barton (Anglican Church)).

3.7

Management of Native Grassland for Conservation

3.7.1 Best Practice Management and Adaptive Management

A central management objective for the remaining areas of native grassland in the ACT is to maintain or improve their ecological condition and habitat quality (see s. 4.2). Management that is regarded by experts in a particular field to be of the highest standards at the time is termed ‘best practice management’. In the context of biodiversity conservation, best practice management is that which promotes biodiversity and healthy ecosystem function. Details of a best practice approach to conservation of native grasslands are outlined in Ross (1999, pp. 25–42) who suggests five main elements for a systematic and comprehensive conservation program:

- knowledge gathering and processing;
- priority setting;
- strategic planning;
- developing the means to achieve conservation objectives; and
- stewardship and management.

The approach outlined by Ross is based on experience from grassland extension programs in Victoria and includes advice based on the ‘lessons’ learned from that program.

Guidance on protecting natural heritage through conservation planning, based on the principles, processes and practices outlined in the *Australian Natural Heritage Charter* (AHC 2002) is provided by the Australian Heritage Commission (AHC 2003). The following is based on this approach, adapted for native grassland:

- Obtaining and studying evidence about native grassland.
  (This includes evidence for: (i) the characteristics of the ecological community that existed prior to European settlement and the effects of Aboriginal people on the grassland environment; (ii) how the ecological community has changed since European settlement and what disturbance factors have been involved.)
- Identifying/involving ‘stakeholders’
  (Those people or groups with an interest in native grassland and those who have native grassland on lands they own or manage.)

- Assessing the physical condition of a native grassland area and identification of management issues.
  (This involves an assessment of the condition and natural integrity of the place and the threats to that natural integrity. A clear understanding of management issues is necessary to determine an appropriate conservation policy and required management actions in a management plan.)
- Determining the natural significance of a native grassland area.
  (This is derived primarily from an assessment of botanical significance and the presence of threatened/uncommon flora and fauna. Grassland areas may also have other values e.g. aesthetic, cultural heritage.)
- Developing conservation policy or objectives.
- Developing and implementing the conservation (or management) plan.
- Monitoring the results and reviewing the plan.

ADAPTIVE MANAGEMENT

Though there have been significant advances in knowledge of native grassland in south-eastern Australia over the last two decades, many aspects remain uncertain. Within an overall objective of maintaining and improving grassland biodiversity, an appropriate response to this uncertainty is to apply 'adaptive management' to remaining grassland areas. Adaptive management allows for the testing of management practices *in situ* to determine if they are achieving the desired outcomes, and adapting them as required. Adaptive management 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 both the management goals and on-ground management be subject to ongoing review (Bruce and Lunt 2003). The results of the management regime that is established must be monitored, so that its effectiveness can be assessed and management practices modified as required. Monitoring assists in distinguishing between seasonal fluctuations in the abundance of particular species and long-term changes to species and site characteristics (Sharp 1998).

An important part of this adaptive management approach is the recognition that flexibility is required in the management techniques applied to particular grasslands. Grassland structure and composition differ dramatically between sites in different regions, and between sites with different soils and management histories in the same region. Consequently, no single management regime will be suitable for all species and all sites in all regions (Lunt 1995). Where sites contain threatened species, management must take account of the requirements for their survival (Rowell 1994; Sharp 1995). There is now widespread acceptance by grassland ecologists of the need to adopt site-specific management approaches within the more general theoretical and empirical framework of native grassland management.

Environment ACT has adopted a step-by-step guide to the preparation and implementation of site-based management plans outlined in Sharp *et al.* (2005).

3.7.2 Key Aspects of Best Practice Management of Native Grassland

Increased attention given to the conservation of native grassland over the last two decades has resulted in a better knowledge of management requirements for long-term conservation though much still remains to be understood. A number of management guidelines have been published (Barlow 1998 (Victoria); Department of Conservation and Environment 1992 (Melbourne area); Diez and Foreman 1996 (Riverine Plains); Dorrough 1996 (Monaro); Eddy 2002 (based on NSW Southern Tablelands but written in general terms). A grassy ecosystem management kit (Sharp *et al.* 2005) provides a guide to developing management plans for native grassland based on current best practice and adaptive management. The kit highlights the importance of managing grass biomass in a way that is most suitable to individual remnants, rather than adopting the more prescriptive approaches that were sometimes advocated in the 1990s.

MANAGEMENT OBJECTIVES

It is essential to define specific management objectives for grassland remnants (Robertson *et al.* 2000; Sharp 2000). These objectives may vary from one remnant to another, within the broad goals and objectives for native grassland conservation. Specific management objectives may include: maintaining the structure and integrity of the community; managing biodiversity and/or particular flora and/or fauna species; removing or controlling threats; and maintaining a certain amount of biomass. Sharp (1995) and Sharp and Rehwinkel (1998) recommended a site-specific management approach. Where sites contain threatened species, management must take account of their requirements for survival (Sharp 1995; Rowell 1994).

The broad management goal for natural temperate grassland in the ACT is to maintain it in perpetuity as a viable and well-represented ecological community (Table 4.1). Achieving this goal and supporting objectives requires maintaining ecosystem processes

(Williams *et al.* 1991; Williams *et al.* 1995), maintaining dominant species, and maximising or enhancing species diversity and structural complexity (ACT Government 1997a; Rowell 1994; Sharp 1995; Sharp and Rehwinkel 1998). It also requires maintaining soil and existing drainage conditions, controlling plant introductions and weediness, removing biomass through appropriate defoliation regimes to enable native plants to flower, set seed and allow their seedlings to establish, and if possible maintaining connectivity between natural temperate grassland remnants and between them and other native grassland, woodland or naturally vegetated areas (ACT Government 1997a; Environment ACT 2005). Where native tree species are a natural component of the grassland, these should be managed as an integral part of the community (Eddy 2002; Sharp and Rehwinkel 1998).

Ideally, management actions should be tailored to the specific habit, habitat and life cycle requirements of individual species in the grassland (Wildlife Research Unit 1994; Williams *et al.* 1995). Such information is generally available for threatened plants and animals in various action plans and recovery plans (see ACT Government 1997a-c, 1998 a-b, 1999, 2004a; NSW NPWS 2000; Osborne and Jones 1995; Robertson and Cooper 2000; Smith and Robertson 1999; Zich *et al.* 1995). However it is rarely available for all the component species in a grassland remnant. In these situations categorising species into broad ecological types (for example dominant tussock grasses, inter-tussock perennial forbs, and inter-tussock annuals) may assist in the development of particular management regimes (Lunt 1995).

Where growth-form data allow the effect of different forms of management to be predicted; Lunt (1995), McIntyre (1995) and Tremont and McIntyre (1994) noted that such knowledge might also be useful in developing specific management regimes. For example, Lunt (1995) noted that mowing or grazing generally select for small rather than tall species, while low rosette plants or creeping species will survive best where there is little competition for light from dominant grasses. Small annuals will generally increase in abundance in open grazed areas, while tall upright species have a greater ability to survive thick grass. Barrer (1993) noted that mowing can discriminate against taller and slower-maturing species, and considered that herbs such as the endangered Button Wrinklewort (*Rutidosis leptorrhynchoides*) were unlikely to survive annual mowing.

In the absence of detailed knowledge about the requirements of individual species in grasslands and the effects of management activities on them, a 'default' management approach has been widely espoused (e.g. ACT Government 1997a). This involves continuing the previous management at particular sites, if it has resulted in the maintenance of high quality grassland and/or the continued presence of threatened species. However, given the threatened status of the natural temperate grassland ecological community and species within it, the continuing spread of weeds, and the possibility that the past disturbance regime has been causing a slow loss of biological diversity, this approach needs to be kept under review for each site. As noted in s. 3.2.1, a literature review on the use of grazing for management of biomass in native grasslands has been prepared (Lunt 2005).

DISTURBANCE

Natural temperate grassland remnants require active management and monitoring, in part because their small size leads to greater external impacts and likelihood of species becoming locally extinct (Williams *et al.* 1991;Williams *et al.* 1995). It is widely accepted that natural temperate grasslands need appropriate disturbance as part of a specific management regime, both on- and off-reserve to maintain their conservation values (ACT Government 1997a; Eddy 2002; Environment ACT 2005; Lunt and Morgan 2002; McIntyre 1995).

The main type of disturbance needed for management is highlighted in a 'model' of *Themeda triandra* dominated natural temperate grassland, developed by Lunt and Morgan (2002). These authors note that grasslands are characterised by the following features:

- A dominant, vigorous perennial grass that rapidly out-competes associated species (mostly forbs) through the accumulation of biomass which reduces the amount of light available for inter-tussock species.
- Inter-tussock spaces that provide the habitat for many smaller forb species. These are predominantly perennials; growing, flowering and setting seed in spring and early summer and dying back to buds or tubers at or below ground level over summer. This vegetative 'bud and tuber bank' is critical for the persistence of the species.
- Many perennial native inter-tussock species that possess small, transient soil seed banks, and whose seedling recruitment appears to occur infrequently;
- With appropriate climatic conditions, plants that flower and set seed abundantly when biomass levels are low.
- Many plants that will die beneath the dense grass sward if the biomass is not removed. In the absence of a persistent soil seed bank, the species

may become locally extinct, especially in small isolated remnants.

Under this model, the key disturbance required is managing the biomass of the dominant grass (e.g. by burning, mowing/slashing and/or grazing) to maintain its health and retain a high diversity of forb species (Lunt and Morgan 2002). These authors comment that perennial grasses such as *Austrodanthonia* and *Austrostipa* typically have less biomass and shorter life spans than *Themeda triandra* or *Poa* species, and thus removal of their biomass through management actions is not necessarily required in order to retain the floristic diversity of the communities they dominate.

Although the above model was based predominantly on detailed studies of natural temperate grassland in southern Victoria, it appears to be generally applicable to the natural temperate grassland in the Southern Tablelands (R. Purdie pers. comm.). For example, grasslands on the Monaro also contain a high proportion of forbs that are perennials with protected reproductive buds (Costin 1954), and biomass control is a critical aspect of the proposed management of natural temperate grassland remnants (e.g. Environment ACT 2005; see also Benson 1997; Rowell 1994). Sharp (pers. comm.) considers that biomass management should be based on removing biomass 'as often as is necessary' (i.e. without causing adverse effects) to maintain inter-tussock species, noting that the frequency of biomass removal will vary with different dominant grasses and seasonal variation.

Activities that should generally be avoided in conservation based disturbance of grassland include ploughing, earthworks that alter drainage patterns, clearing, rock removal, cultivation, pasture improvement, adding fertiliser, excessive livestock grazing, topsoil removal, and stockpiling, dumping or spreading of soil (Eddy 2002; Wildlife Research Unit 1994; Sharp and Rehwinkel 1998). Prolonged intensive uses that may reduce plant cover and cause soil compaction, disturbance or erosion should also be avoided (ACT Government 1997a). Exotic or non-local tree or shrub species should not be planted, and self-sown exotic or non-local trees and shrubs removed (Eddy 2002). Introduced pest animals such as rabbits, cats, pigs and foxes should also be controlled (Eddy 2002). It is important to avoid grassland areas becoming shaded from tree planting or the construction of buildings (Dorrough 1996; Environment ACT 2005).

MOSAIC MANAGEMENT

When using destructive management practices to remove biomass, a mosaic management approach should be adopted. This is preferable to applying such practices uniformly across entire remnant areas (Dorrough 1996; Sharp and Dunford 1994; Sharp and Rehwinkel 1998). Williams *et al.* (1991) and Williams *et al.* (1995) also stressed the importance of maintaining a diversity of patch types (e.g. burnt and unburnt) between remnants as well as within high conservation value areas. Such mosaics or patchiness are needed to ensure that features reported to be important for grassland conservation, such as structural diversity and optimum habitat for animal and plant species are always present (Rowell 1994; Sharp 2000; Williams *et al.* 1991).

In natural temperate grassland in southern Victoria, Lunt (1995) noted that the regular use of any particular management regime (e.g. frequent mowing or grazing) would strongly select for some species and lead to a reduction in species diversity and structural complexity. He advocated the use of a combination of management techniques, such as integrated burning or mowing with seasonal grazing or selective applications of herbicides.

Sites adjacent to high quality grassland remnants need to be managed sympathetically to avoid adverse effects such as run-on of water containing fertilisers, herbicides or pollutants, weed invasion, unplanned fires and trampling (Sharp and Dunford 1994; Sharp and Rehwinkel 1998; Williams *et al.* 1995). Williams *et al.* (1995, p. 66) noted that each adjacent land use had a characteristic set of possible impacts on conservation areas. They provided a table showing the level of compatibility of a range of adjacent uses with conserving the threatened Striped Legless Lizard (*Delma impar*). This approach can be applied more widely to other threatened species.

MONITORING

The importance of monitoring in a best practice management regime for grassland areas has been discussed in s. 3.4.2.

3.7.3 Rehabilitation, Regeneration and Restoration of Native Grassland

As noted in s. 2.1.7, some form of degrading disturbance threatens all grassland remnants even those in permanent reserves, and it is difficult to find sites not invaded by weeds. In this context, the rehabilitation of grassland remnants will take an increasingly important role in grassland management. The small size, fragmentation and proneness to weed invasion of remaining grassland areas pose particular difficulties for management (see s. 3.4.6).

Native grasslands are highly dynamic by comparison with other vegetation communities in which a higher proportion of the biomass is relatively 'fixed' in woody

tissue that can stand for many years. Perennial grasses form the structural backbone to the ecological community, yet this structure can fluctuate dramatically with the seasons and in response to soil moisture, temperate, frost, grazing, fire and human activities. Though most of the plants in the grassland community are perennials, many of them can reach productive maturity in their first growing season, and produce seed and recruit new plants under favourable conditions. Because native grasslands can show such a high rate of turnover, of both biomass and individual plants, disturbance to either the biomass or plant population can change substantially the structure or composition of the grassland in a short period (Eddy 2002). The dynamics of grassland, including the rapid response to changed management or climatic conditions, and the difficulty in distinguishing between short-term fluctuations and long-term detrimental change, highlight the need for regular monitoring (Sharp 1999).

Rehabilitation of native grasslands may involve regeneration, restoration or reinstatement that represent progressively greater degrees of human intervention. Definitions adopted for this *Strategy* are from the *Australian Natural Heritage Charter*, 2nd Edit. (AHC 2002).

- *Regeneration* means the natural recovery of natural integrity following disturbance or degradation.

Regeneration is essentially dependent on natural processes. It does not include physical intervention, but should be accompanied by monitoring and protection measures that do not create degradation. However, intervention is now required in native grasslands, particularly with regard to defoliation management. Native grasslands have evolved under a defoliation and disturbance regime (burning, defoliation by large and small animals, and ground disturbance by animals and in some grassland areas by Aboriginal people harvesting edible tubers). Defoliation is a requirement for natural regeneration and the appropriate type for individual grassland sites is a major management issue. While current management of native grasslands is directed mainly towards a self-sustaining condition based on natural regeneration, increased intervention to deal with threats such as weed invasion will be necessary for many significant grassland areas.

- *Restoration* means returning existing habitats to a known past state or to an approximation of the natural condition by repairing degradation, by removing introduced species or by reinstatement.

Native grassland restoration is discussed also in s. 3.4.5. A restoration process implies sufficient evidence of an earlier state to guide the conservation process. While historical and other records, and the existence of sites that appear relatively undisturbed provide some guidance, the actual species composition of the pre-European grasslands is unknown. Restoration activities, consistent with the natural significance of the place, should therefore be focussed on maintaining and improving the biological diversity of the site and improving the overall condition of the remnant (Kirkpatrick *et al.* 1995, p. 87). Restoration activities mostly involve grass and litter removal to promote growth and survival of inter-tussock herbs, weed control, and specific actions to provide suitable conditions for the survival of threatened plant and animal species (Kirkpatrick *et al.* 1995; Lunt 1995; Ross 1999).

- *Reinstatement* means to introduce to a place one or more species or elements of habitat or geodiversity that are known to have existed there naturally at a previous time, but that can no longer be found at that place.

For the foreseeable future, reinstatement is unlikely to be part of native grassland management except on a very small scale or for particular purposes. While there is clearly a role for restoration of existing remnants that might include some specific reinstatement, large-scale expansion or 're-creation' of native grasslands is not feasible with current knowledge, technology and funding (Ross 1999). However, establishment of native grass swards, using seed stock of known provenance, is becoming a practical and economic proposition in buffer areas to native grassland. This approach has been used in parts of the ACT e.g. Barton Highway road verges near Crace Grassland Reserve.

PURPOSES OF REHABILITATION

Generalised purposes of rehabilitation of native grasslands include:

- maintaining and restoring native grassland as a unique Australian ecosystem;
- providing for, or increasing connectivity for animal movement (this may include connectivity through areas of lower quality native grassland and to other ecological communities e.g. lowland woodland);
- increasing the size of remnants to improve resilience to external threats, increase animal habitat, increase landscape heterogeneity and minimize the impact of edge effects from adjacent land uses;
- restoring specific habitat elements for reptiles, birds, small mammals and invertebrates especially for threatened species;
- mitigating against erosion and to control salinity;

- rehabilitating weed infested areas in otherwise good sites; and
- replacing inappropriate introduced species.

PRINCIPLES FOR RESTORATION

Principles for undertaking regeneration and plant restoration activities (after Eddy 2002 and McIntyre *et al.* 2002) are:

- ensure that the reasons for undertaking the activities are clear, that the project is viable, and that the activities will achieve the desired outcomes;
- consider managing to increase natural regeneration before undertaking planting to recreate habitat;
- encourage natural regeneration by controlling grazing and weeds, using fire, and preventing erosion or soil compaction;
- where possible, collect seed for restoration activities from local populations to maintain local genetic provenances;
- avoid soil disturbance when undertaking rehabilitation activities;
- avoid tree planting in native grassland areas. Remove self-sown exotic trees and native trees where these have not been previously part of the grassland;
- use restoration to provide buffer areas to core conservation areas, to increase size of remnants and to enhance connectivity; and
- minimise opportunities for re-invasion by introduced species after rehabilitation.

RESTORATION OF HABITAT FOR FAUNA

To restore habitat for fauna, an essential management objective for native grassland is to maintain or improve the diversity of its structure and species composition (see s. 3.4 and Fauna Habitat Management in s. 3.7.5). Williams *et al.* (1995) suggest that rehabilitation of fragmented habitats be considered as a means of increasing overall size, buffering and interconnection. There are few examples of projects in native grassland aimed specifically at restoration of habitat. This reflects limited knowledge of species requirements, uncertainty surrounding outcomes, and the high initial and ongoing cost of such activities. There is a need for ongoing research into, and experimentation with methods of rehabilitating grassland habitats.

An attempt to re-establish *Austrodanthonia* grassland and re-introduce the Golden Sun Moth at the Victorian Open Range Zoo (Werribee, Victoria) indicates some of the challenges involved in such an activity including site preparation, sourcing of seed, and obtaining female moths (O'Dwyer 2003).

3.7.4 Defoliation Management

As noted previously, some form of defoliation is essential to maintaining the structure and botanical composition of most native grasslands (Eddy 2002). Without regular removal of some herbage, excess grass will accumulate and die, and can inhibit the growth of many plant species in the sward. Inter-tussock forbs are particularly affected; however there may be also loss of vigour of dominant grasses e.g. Kangaroo Grass. The amount of defoliation required is related to the productivity of the site and the dominant grass species found there. Productive areas carrying Kangaroo Grass or *Poa* tussock will need more intensive treatment than areas of poorer soils carrying spear and wallaby grasses which have much less biomass and shorter life spans (Eddy 2002; Lunt and Morgan 2002).

The three main forms of grassland defoliation are grazing, mowing and slashing, and burning. Eddy (2002) has outlined recent thinking on best practices for grassland management and much of the following and s. 3.7.5 has been drawn from his management guide. This guide and the references cited in s. 3.7.2 should be consulted for more detail.

GRAZING

Natural temperate grassland evolved under the influence of grazing herbivores. Since European settlement, grazing by domestic livestock has been, and is likely to continue to be, the primary use and main method of defoliation in native grasslands. Grazing by domestic stock has had an incalculable effect on the composition and structure of lowland grasslands and grassy woodlands (Lunt 1991) and to the ecosystems as a whole (Freudenberger 2000). Grazing by domestic stock, kangaroos and rabbits is not indiscriminate in its effects on plants (Sharp and Rehwinkel 1998). Grazing by sheep is considered to be more destructive than by cattle (Moore and Biddiscombe 1964 in Lunt 1991). All native grasslands are affected by grazing but this depends on its timing, selectivity, intensity and duration.

The effects of stock grazing in native grasslands have been:

- soil compaction and erosion;
- selection pressures that eliminate more palatable species and allow the less palatable to survive;
- loss of taller and more succulent species (e.g. lilies and orchids) and palatable forbs (e.g. Yam Daisy *Microseris lanceolata*);
- increases in nutrients, especially stock camps that become dominated by exotic weeds; and

- change in community dominants e.g. tall perennial grasses such as Kangaroo Grass are replaced by spear and wallaby grasses and then by introduced, annual grasses and herbs.

(Eddy 2002; Lunt 1991, 1995; Sharp and Rehwinkel 1998)

Where native grassland sites have been maintained under light grazing, continuation of grazing may be the best form of management (Scarlett *et al.* 1992). In some situations, this may be the best way known to control specific weeds or to retain control over biomass production, where alternatives such as burning and mowing may not be possible. In some instances, it may be appropriate to re-orient the management activity e.g. by changing the purpose of grazing from just animal production to also achieving conservation objectives (Sharp and Rehwinkel 1998). Good management of grazing pressure in grasslands requires sound stock proof fencing (Eddy 2002). The use of grazing as a management tool should be carefully monitored and literature on the effects of grazing kept under review. Total grazing pressure needs to be considered (domestic stock, native and feral animals) to ensure a holistic approach to grazing management.

In designing a suitable grazing management regime, the timing, selectivity, intensity and duration of grazing need consideration (Eddy 2002):

- *Timing:* Native grassland must be allowed to grow freely enough to replenish root reserves, flower and set seed or it will inevitably deteriorate. During flowering and seed production (mainly late spring to early summer), grazing should be light or completely removed.
- *Selectivity:* All grazing animals have preferences for certain species and parts of plants over others. Grazing animals are most selective under continuous light set-stocking. Higher stocking for a shorter period can reduce this effect, however stock management of this type is more intensive and must be undertaken carefully.
- *Intensity and duration:* Maximising the harvest of herbage by livestock in order to maximise production tends to result in loss of the tall and diverse structure of grasslands and a shorter and more even grassland structure. The consequences are loss of species, habitat and ecosystem resilience. When herbage quality or quantity becomes too low to maintain livestock condition, stock should be moved rather than supplementary fed, to protect the grassland from over-grazing and excessive trampling.

MOWING AND SLASHING

Mowing and slashing are used in small grassland remnants such as urban areas and cemeteries and on roadsides where there may be small grassland patches. Biomass removal is often based on landscape aesthetics, pedestrian access, and fire hazard reduction. Mowing has the effect of maintaining open structured grassland conducive to the germination of a wide range of wildflowers associated with native grasslands. Any mowing/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. Grassland should not be mowed when significant plant species are flowering or setting seed, or when animals likely to be harmed by mowing are active, and depend on the vegetation for shelter or food (Sharp and Rehwinkel 1998).

Important considerations for a mowing/slashing regime include disposal of clippings, impacts of machinery, season/height prescriptions, and seed collection:

- *Clippings:* The creation of 'windrows' or clumps of grass clippings should be avoided by using flail mowers that spread out mulched litter, by catching the clippings, or raking and removing them.
- *Machinery:* Machinery should not be used when the ground is wet to avoid soil compaction, creation of ruts and damage to 'soil crust' lichens and bryophytes (cryptogams). In particular, machinery should be cleaned prior to use to avoid the spread of weed seeds.
- *Season/height prescriptions:* Various prescriptions on height (with a minimum of 10 cm above the ground) and mowing seasons have been advocated previously (Dorrough 1996; Sharp and Rehwinkel 1998). Current best practice is to manage biomass on a site-specific basis in the appropriate season, however, generally applicable guidelines have been developed for *Austrostipa*, *Austrodanthonia*, *Poa* and *Themeda* dominated grasslands respectively (S. Sharp pers. comm.). Groves and Lodder (1991) noted that the vigour and persistence of native grasses is reduced if mowing is performed more than once or twice in any 12-month period.
- *Seed collection:* Where mowing is used as part of a management strategy for collecting seed for grassland restoration, the removal of seed must be monitored to avoid over-collection (Wildlife Research Unit 1994).

BURNING

Changed and inappropriate fire regimes in natural temperate grassland are discussed in s. 2.1.7.

Fire has been an integral part of the evolution of native grasslands and is used as a management tool to maintain plant diversity in *Themeda triandra* grasslands, especially in southern Victoria (Lunt and Morgan 2002). It is less commonly used elsewhere. For the ACT region, Sharp and Dunford (1994) suggested that fire should be used as a management tool only in grassland remnants that have been burnt regularly in the past or where it is recommended for specific purposes. In general, long unburnt patches should not be burnt (Sharp and Rehwinkel 1998) or burnt in patches to allow the fire impacts to be monitored (Rowell 1994).

Considerable uncertainty exists with regard to use of fire as a management tool and with the extrapolation of the results of burning from one site to another. In their review of fire regimes in temperate lowland grasslands, Lunt and Morgan (2002) note that there is only one study that compares the effects of frequent burning against the exclusion of fire and other disturbances (e.g. grazing). This study, over a 17-year period (1978–1995) was of productive *Themeda* grassland in western Melbourne (Lunt and Morgan 1999). The frequently burnt area retained a much higher native cover and low exotic cover compared with the unburnt area. The exotic daisy *Hypochaeris radicata* (Catsear or Flatweed), which attained 33% mean cover of the unburnt zone, had only minimally invaded the burnt area.

If burning is to be used as a management tool, similar considerations apply as for the other means of defoliation, viz. timing, intensity, frequency, fauna impacts, fire breaks, weeds:

- *Timing:* Fires should be timed to allow grassland species to flower and set seed. Some species (e.g. Small Purple Pea *Swainsona recta*) may require fire for germination and establishment (Sharp and Rehwinkel 1998). Eddy (2002) suggests burning between the end of seed set (mid to late summer) and when the plants begin to produce flowers in spring. This is often the only time the grassland will carry a fire. Groves and Lodder (1991) noted that fires could be used between June and August to rejuvenate the grass sward in communities dominated by *Austrodanthonia*, *Poa* and *Themeda*. The season of burn may need to take account of the requirements of individual plant and animal species in particular grassland remnants (Dorrough 1996; Rowell 1994; Sharp 1994).
- *Intensity:* Hot, dry summer conditions and a large dry grass biomass can result in fires that are too hot. These can destroy seeds and burn down into the soil. Fires should only be lit when the soil is reasonably moist and temperature and wind conditions will enable the fire to be kept under control (Eddy 2002).
- *Frequency:* Burning should be carried out only as often as is needed to reduce excessive biomass. In the ACT and Southern Tablelands, a burn frequency of once every two or three years has been recommended, but on low productivity sites may never or only occasionally be necessary (Eddy 2002; Groves and Lodder 1991; Wildlife Research Unit 1994). Current best practice is not to adhere to a prescriptive fire regime, but be guided by the level of biomass present and factors such as the history of the site and presence of particular flora and fauna that may be either advantaged or adversely affected by a certain fire frequency.
- *Fauna impacts:* Fire can threaten small native fauna within grassland remnants. For this reason, patch burning is recommended to ensure unburnt patches are left as faunal refuges (Eddy 2002; Dorrough 1996, Sharp and Rehwinkel 1998). This should be followed by monitoring of potentially affected species.
- *Fire breaks:* If the accidental spread of fire into or from a native grassland is considered a risk, then a firebreak should be mown or slashed around the perimeter. It should not be ploughed or sprayed, which will create an entry point for weed species.
- *Weeds:* When fire is proposed as a management tool, the risk of promoting weed species needs to be assessed, as the benefits of fire to native plant diversity may be overwhelmed by post-fire weed invasion (Morgan and Lunt 1999; Rowell 1994). The soil seed store in some grasslands may be dominated by exotic species which are likely to become dominant after fire. Particularly in degraded remnants, burning promotes many exotic species (Lunt 1990). Sharp and Rehwinkel (1998) noted that burning may enhance invasion by the perennial grass weed African Lovegrass (*Eragrostis curvula*). Fire also promotes the spread of Chilean Needlegrass (*Nassella neesiana*), which is one of the most threatening invasive plants of grassy ecosystems in south-eastern Australia (Muyt 2001).

3.7.5 Other Management Activities

WEED MANAGEMENT

All remaining natural temperate grassland is invaded to varying degrees by weeds (see s. 2.1.7), the control of which is a critical component of management. It is impractical to remove all exotic species, so the aim of management should be to reduce populations of the most invasive weeds present (Sharp and Rehwinkel

1998). The majority of weeds are annual or biennial grasses or forbs that are not particularly troublesome if their populations are kept low. These types of weeds are nearly impossible to completely remove as they germinate, develop and set seed quickly and there is already a large seed store in the soil. The best way to keep their populations low is to maintain a dense groundcover of native plants, particularly in late autumn and winter when most weed species are germinating and establishing (Eddy 2002). However, apparently bare areas containing a cryptogamic crust should not be planted, or disturbed by machinery or vehicles.

Perennial weeds are of greater concern and there are a number that have made significant impacts on native grasslands and remain a threat (see s. 2.1.7). Woody weeds can also make an impact over a long period, but can easily be controlled in small areas and by early action before populations increase. Mechanisms for weed control include hand weeding, strategic grazing, mowing or burning and spot spraying (Dorrough 1996; Sharp and Dunford 1994; Sharp and Rehwinkel 1998; Wildlife Research and Monitoring 1994). A particular problem for weed control is that activities targeting a particular species may create disturbance that facilitates further weed invasion (Rowell 1994).

A key aspect of weed control is to avoid management activities that facilitate weed introduction or expansion including too-frequent burning, burning sites with a soil bank of weed seeds, additions of fertilisers or excess water, heavy grazing for too long a period, importing soil or organic material (e.g. straw), cultivation of fire breaks, excessive vehicle use, and using machinery that has not been cleaned (Dorrough 1996; Eddy 2002; Rowell 1994; Sharp and Rehwinkel 1998).

SOIL MANAGEMENT

To maintain native grassland areas, soil disturbance should be minimised as disturbance is followed by significant colonisation by exotic species (Lunt 1991). Disturbance includes physical disturbance (e.g. dam construction and maintenance, laying pipelines), changes in soil structure (e.g. compaction or changed drainage patterns), chemical disturbance (e.g. addition of fertilisers), and stockpiling, dumping and spreading materials such as soil or gravel. If disturbance is necessary in a native grassland remnant, follow up rehabilitation should be undertaken including levelling, weed removal and encouragement of native plant species from the adjacent vegetation (Eddy 2002).

FAUNA HABITAT MANAGEMENT

Natural temperate grassland has a rich diversity of invertebrates, reptiles, amphibians, birds and mammals (see s. 2.3). As a general principle, to maximise the habitat value of native grassland for all faunal groups, the grassland should be managed to maintain or improve the diversity of its structure and species composition. The backbone of the food chain is the plants, and the greater the diversity of plant species, the greater the variety of food types available to support fauna (Eddy 2002). For example, herbivores include folivores such as kangaroos and grasshoppers, granivores such as ants and birds (including Quail, Superb Parrot and Diamond Firetail) and there are numerous insect pollenators. Habitat elements include the grass tussocks and inter-tussock spaces, soil cracks and holes, rocks, wet areas and watercourses, specific micro-habitats (e.g. basking sites for reptiles), plant litter, trees and shrubs. The habitat value of native grassland will be greater where it adjoins or forms a mosaic with other ecosystems such as woodland, forest or wetland (Eddy 2002).

Where grassland contains a diverse flora and threatened fauna, the major management challenge is to maintain an open vegetation structure to maintain plant diversity, while maintaining viable animal populations (Lunt and Morgan 2002). Remaining grassland areas tend to be small in area and highly fragmented. Populations of animals (especially less mobile species) in such areas are at greater risk of extinction through too-frequent burning or a very hot fire, as areas of protective habitat may be reduced and re-colonisation from adjacent areas is not possible.

Management of fauna habitat should be site specific, based on animals (particularly threatened species) known to be present and their habitat and life cycle requirements. Examples of specific management adaptations to maintain habitat include:

- A grassland defoliation regime modified to maintain habitat e.g. for the Striped Legless Lizard (*Delma impar*), not mowing when the lizards are active, mowing on a rotational basis so that in any one season mown and un-mown areas adjoin, and not burning the whole of a site at one time (Rowell 1996).
- For the Grassland Earless Dragon (*Tympanocryptis pinguicolla*) and Golden Sun Moth (*Synemon plana*), maintaining the short, more open grasslands dominated by *Austrodanthonia* spp. (Osborne *at al.* 1995; Sharp 1995). Management actions would include not allowing such sites to become wetter or nutrient enriched so that the *Austrodanthonia* was out-competed by other native species or weeds.

For reptiles generally, maintaining night and day shelter sites, basking sites, foraging areas, food, micro-habitats for reproduction and avoidance of predators,

and over-wintering habitats (Osborne *at al.* 1995). Threats to these habitat requirements include grassland defoliation, use of machinery, vehicle traffic, collection of bushrock and ground disturbance (e.g. ploughing).

Trees and shrubs, where naturally present as part of the community, provide important habitat for many animal, notably birds and mammals. The interface between grassland and woodland is particularly important to a range of species that require both habitat components e.g. Hooded Robin (*Melanodryas cucullata*) and Flame Robin (*Petroica phoenicea*). Particular attention should be given to managing the ecotones where native grassland adjoins forest, woodland or wetland.

TREE MANAGEMENT

Natural temperate grassland is naturally treeless or has a low tree cover (less than one mature tree per hectare) (see s. 2.1.4). Trees can have a strong influence on grassland structure and species composition through competition for light, moisture and nutrition. Trees also provide nutrition to plants under their canopy through litter fall and by attracting birds and other animals that leave droppings under the tree. Natural populations of native trees should be retained and managed as an integral part of the grassland ecological community (Eddy 2002).

Tree planting in grasslands can have an effect on grassland species composition especially due to shading. In general, tree planting should not be undertaken in natural grasslands, but may be part of reinstatement in secondary grasslands (ACT Government 2004a). Self-sown exotic trees (e.g. pine wildings) should be removed while they are still young. Consideration should also be given to removing older exotic trees, possibly replacing them with local native species (Eddy 2002).

FERAL ANIMAL MANAGEMENT

Feral animals can have deleterious impacts on native grasslands. Rabbits have a strong dietary preference for smaller and more succulent plants and plant parts. These are often the more vulnerable native forb, lily and orchid species. Cats and foxes prey on smaller native animals potentially contributing to local extinctions or affecting the composition of local fauna populations. Feral pigs can have a severe impact on grassland areas. Especially favoured are low elevation areas that contain the more sensitive and less well-conserved types of native grassland. Grasslands adjacent to the shelter of tree cover are more prone to damage (Eddy 2002). These animals should be the subject of control programs in conjunction with adjacent land holders. Rehabilitation of grassland will be necessary after some activities e.g. ripping of rabbit burrows.

3.8

Management Agreements and Networks

3.8.1 Land Management Agreements

Land Management Agreements (LMAs) are required under the *Land (Planning and Environment) Act 1991* for all non-urban leases in the ACT. Linked to the granting of long-term leases (20 and 99 years), the purpose of LMAs is to establish a co-operative management regime for non-urban land in the ACT. Over seventy agreements between lessees and Environment ACT were in place in 2003. Except for the Jerrabomberra Valley (Table 3.2), there are few areas of natural temperate grassland on rural leases in the ACT, though patches of native pasture and particular native grassland species occur on many leases.

The principal objective of LMAs is to establish management practices on leases that support the land management aims of both the lessee and the ACT Government. This involves agreement on general management goals and responsibilities; documentation of the current state of the property (including nature conservation, cultural heritage or other significant values); and identification of land management issues and the means for their resolution. Environment ACT provides environmental information to lessees, drawing attention to conservation issues, in particular, presence of, or habitat for, threatened species and ecological communities.

Lessees are required to address the following objectives in the LMA within a framework of sustainable agricultural and pastoral land use practices:

- retain or improve the ecological functioning and integrity of the natural and modified resources of the leased area;
- preserve the extent and character of any threatened ecological community or population of a threatened species;
- pursue all development and management of the land in a way that is consistent with any Action Plan for a threatened species or ecological community;
- manage vegetation identified in the LMA as being of significant conservation value, with the aim of maintaining its structure, floristics and habitat value; and

- ensure that any activities do not adversely impact on riparian or other wetland areas.

The LMA also provides for Land Action Plans to be prepared for a range of issues, including drought risk management, pest plants and animals, sites of significant natural or cultural heritage value, maintenance of water quality, and protection of riparian zones and other native vegetation. Lessees are required to ensure that a flexible grazing strategy is in place designed to achieve conservation objectives.

In 2005, the ACT Government established the Land Keepers program, which will target practical biodiversity conservation outcomes through on-ground works, an education program or demonstration project, or the gathering of information about conservation assets and their management requirements. Funded projects are typically on-ground works e.g. fencing to protect native vegetation remnants or better managing grazing pressure, off-stream watering facilities to protect streamlines, and revegetation to provide habitat links. Where the project involves a continuing commitment by a lessee to a particular management strategy, relevant details of the commitment are entered in the Land Management Agreement for the land in question. The intention is to protect the investment that has been made and to ensure longer-term conservation outcomes.

3.8.2 Voluntary Agreements

Voluntary agreements enable landholders to acknowledge the conservation values of their land through mechanisms designed to provide a level of protection but allow for current land uses to continue. Some involve arrangements that are binding on future landholders, some are binding for current landholders while others can be revoked by landholders at any time. Examples of some of the arrangements that exist in NSW are Voluntary Conservation Agreements, Joint Management Agreements and Wildlife Refuges. Similar arrangements do not exist in the ACT, although Memoranda of Understanding with major Commonwealth landholders in the ACT (Department of Defence, CSIRO and National Capital Authority) are in place, and these provide protection for areas of land that contain natural temperate grassland. Some of these areas are the largest remaining examples of natural temperate grassland in the ACT.

Landholders with such agreements contribute land, their skills, labour, time and materials towards the conservation of native ecosystems, which in turn provide of a range of ecosystem services such as clean water and air and healthy soils (Stephens 2002). For such voluntary agreements to work well, it has been shown that landholders require sufficient support, particularly on-ground labour, advice on non-financial as well as funding sources, technical advice, evaluation of remnant vegetation and habitat values, and links with other landholders (Stephens 2002).

The Conservation Management Network described below can provide such support, and is therefore seen as a way of maintaining management agreements and assisting in their implementation.

3.8.3 Conservation Management Networks

A Conservation Management Network (CMN) is a network of remnants of an ecological community, their owners and managers as well as other people with an interest in that community (Rehwinkel 2002). There is a particular focus on sites, including encouragement of protection measures and the adoption of conservation management. The CMN provides opportunities for information dissemination (including regular newsletters) and participation in knowledge sharing and decision-making. A CMN can assist land managers to access technical and funding assistance, develop site management plans, establish formal protection measures such as voluntary agreements, and link up with people with similar interests. Membership can provide a sense of being part of a larger system, and facilitate access to a range of quality sites (Oliver 2003).

One of the most important goals of CMNs is to help integrate conservation principles and practices into land use management. CMNs are a potential way of developing an integrated conservation estate that is more than the existing nature conservation estate on public land, where the existing landholders continue to manage their own sites, with support and advice from the CMN (Oliver 2003).

In the ACT region, CMNs have been developed for White Box Woodlands in NSW, Monaro Grasslands and Southern Tablelands (NSW) Grasslands. There is potential for Environment ACT to link with this initiative of the NSW Department of Environment and Conservation and become part of an enlarged ACT and Southern Tablelands CMN for grassy ecosystems. Formation of a Conservation Management Network for natural temperate grassland sites in the ACT and New South Wales is an objective of this *Strategy* (see Table 4.1).

4 The Lowland Native Grassland Conservation Strategy

4.1

Introduction

The *Lowland Native Grassland Conservation Strategy* is intended to fulfill a number of roles. These are:

- action plans for species and ecological communities listed as threatened under the *Nature Conservation Act 1980*;
- a multi-species/ecological community strategy for native grassland conservation;
- a source document on native grassland for ACT and Commonwealth Government agencies with responsibilities for nature conservation, planning and land management; and
- a source document for community and other stakeholders with an interest in native grassland conservation.

As an Action Plan prepared under the *Nature Conservation Act 1980*, the *Strategy* addresses the requirement in section 23 of the Act, that it *'shall include proposals to ensure, as far as is practicable, the identification, protection and survival of the species, or the ecological community; or proposals to minimise the effect of any process which threatens any species or ecological community'*.

The *Strategy* provides information, strategic direction and performance criteria for a variety of government planning exercises, including:

- Proposals in *The Canberra Plan* (ACT Government 2004c) (Theme 'Living with the Environment—Our Bush Capital), which state that areas of high conservation value will be enhanced and protected.
- Proposals in *The Canberra Spatial Plan* (ACT Government 2004b). An objective of the *Spatial Plan* (p. 72) is to:

  Protect and enhance biodiversity through nature reserves and maintaining connectivity between them.

  In particular the *Spatial Plan* notes that development in the new employment corridor in Majura, Symonston and Jerrabomberra, including around the airport, will take into account the areas of native grassland and habitat for threatened species that are of significant nature conservation value.
- Proposals in *The Social Plan* (ACT Government 2004d): **(Priority 7 Respect and protect the environment)** '7.4 *Ecological protection and urban development*: The Government will help protect our threatened species and ecological communities as part of best practice planning for urban development'; and

  '7.5 *Conservation strategies*: The Government will continue to ensure that key biodiversity assets are identified, protected and managed through preparation of conservation strategies for lowland woodlands (2003), native grasslands (2004) and aquatic and riverine communities (2005)'.
- Preparation of the Outline Plan for the Jerrabomberra Valley.
- Preparation of any future land use proposals including those involving variations to *The Territory Plan* and amendments to the *National Capital Plan*, the shape and location of urban development and the use to be made of land surrounding metropolitan Canberra.

As part of these planning processes, decisions will be made by the ACT Government as to whether grasslands will be protected as Public Land (Nature Reserve), will remain without formal protection in other tenures under *The Territory Plan*, but subject to management requirements, or be modified or destroyed as pressures for urban expansion are addressed. This *Strategy* will be used by all agencies and others involved in land use planning decisions as one source of information on the values and significance of remaining grassland areas. The

Strategy also identifies and places in context, grassland areas on National Land in the ACT which are managed by Commonwealth agencies. These areas remain outside of the management arrangements provided for under the *Land (Planning and Environment) Act 1991* (see s. 1.5.2). Memoranda of Understanding are in place regarding conservation planning and management of most of these areas (see s. 3.4.3 and 3.4.4).

Other natural and cultural values of particular areas of native grassland, such as evidence of Aboriginal occupation, recreational use, aesthetic amenity, educational and special scientific features are normally taken into consideration during the planning phase before specific proposals are developed by government agencies. Management of these values is set out in management plans for particular areas or groups of areas, such as the *Canberra Nature Park Management Plan* (ACT Parks and Conservation Service 1999) (see s.1.7).

Presenting information on these values is beyond the scope of the *Strategy*. It is recognised that other values placed on native grassland areas by interested expert bodies, community groups and individuals may be important in their own right and complement the nature conservation values, thus adding to the overall significance of particular areas of grassland. The ACT Government takes these values into account through a variety of mechanisms, including environment impact assessment, and public consultation on proposals to amend *The Territory Plan*, Action Plans such as this *Strategy*, and Management Plans for Public Land prepared under the *Land (Planning and Environment) Act 1991*.

4.2

Vision, Goals, Objectives and Actions for the *Lowland Native Grassland Conservation Strategy*

As outlined in chapters 2 and 3, detailed surveys, research work and annual monitoring over a ten-year period have enabled the development of a good understanding of the location, extent, floristics and conservation significance of the ACT's native grasslands and their regional context in the Southern Tablelands. Based on this information, a vision statement, conservation goals and objectives, actions necessary to achieve the objectives, and performance criteria were prepared in draft form for consideration at a public forum in March 2004 (s. 1.6). These have been refined, based on comment received at the forum and on the draft *Strategy* (Table 4.1). The statements in Table 4.1 are grouped into: Information, Protection, Threats, Planning, Management and Community/ Landholder Involvement and are set out in a format similar to that adopted by some Australian jurisdictions for recovery plans for threatened species. Actions related to particular threatened or uncommon plant and animal species are included at the end of Table 4.1.

Performance Criteria have been developed as an aid to future reviews of progress in implementing the *Strategy*. Achievement of targets depends on a number of factors including budget funding by the ACT Government, commitment by landholders, the involvement of community groups and other factors beyond the control of Environment ACT, which will take a leading role in coordinating the implementation of the *Strategy*.

Table 4.1: Vision, Goals, Objectives, Actions and Performance Criteria for the *ACT Lowland Native Grassland Conservation Strategy*

VISION

The Australian Capital Territory makes an outstanding contribution, regionally and nationally, to conservation of natural temperate grassland and grassland flora and fauna.

PROTECTION GOALS

Goal (Grassland)

Conserve in perpetuity all remaining core conservation sites and other viable areas of the natural temperate grassland ecological community in the ACT.

Goal (Fauna and Flora)

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.

MANAGEMENT GOAL

Manage and rehabilitate natural temperate grassland and related habitat with appropriate regeneration, restoration, and reinstatement practices across all land.

(Continued) ▶

Table 4.1: *(Continued)*

Natural Temperate Grasslands

Before European settlement, the temperate grasslands of the ACT and region, and their associated flora and fauna, were part of an extensive band of grasslands in south-eastern Australia. Occurring across broad plains and in low elevation areas subject to cold air drainage, they formed a mosaic with lowland woodland and riparian and wetland communities. These grasslands and associated grassy woodlands were the natural resource base for the development of the Australian pastoral industry from the early 1800s. Their accessibility and productivity resulted in their almost complete transformation by the new pastoral economy. In the ACT, the development of Canberra in the valleys and on the plains during the 20th century destroyed most of the grassland that remained.

Natural temperate grassland is one of Australia's most threatened ecosystems. In south-eastern Australia, 99.5% of the estimated pre-European natural temperate grassland has been destroyed or grossly altered. Some form of degrading disturbance threatens all grassland remnants, even those in permanent reserves. Loss of grassland habitat and the fragmentation and degradation of the remaining areas has had a severe impact on plants and animals that are dependent on grasslands. Characteristic species of grasslands such as the Grassland Earless Dragon and the Striped Legless Lizard now survive only in small and disconnected populations. The once extensive 'wildflower' displays provided by species of inter-tussock forbs are restricted to remnants of relatively undisturbed grassland.

The *ACT Lowland Native Grassland Conservation Strategy* builds on more than ten years of survey, monitoring, research, conservation planning and management in relation to lowland native grasslands in the ACT and region. From a slim knowledge base in 1990, a good understanding has been developed of the remaining grasslands in the ACT and some of their component species. Some grasslands have been placed in reserves and there are good prospects for conserving other areas. The *Strategy* provides the strategic context for the ongoing protection, management and restoration of this unique Australian ecosystem.

NOTE: (i) See end of table for abbreviations and footnotes

(ii) Bracketed items at end of each Action indicate primary responsibility for, or significant participation in the Action

1. Information

Objective	Actions	Performance Criteria
(a) The location, type and ecological condition of all natural temperate grassland and habitat for threatened species in the ACT are described and the information kept current. (b) A comprehensive database of natural temperate grassland and component species in the ACT is maintained. (c) ACT data is included in national, state and community databases. (d) Ecological information is used to underpin adaptive management.	(a) Undertake monitoring to maintain up to date information on the ecological condition of all remaining natural temperate grassland in the ACT (EACT). (b) Maintain the ACT database for vegetation and grassland species to support planning, management and research (EACT). (c) Assess priorities and address gaps in information on native grassland and grassland species. (d) Link data collection to national, state (especially NSW) and community databases and to *National Recovery Plans for Natural Temperate Grassland of the Southern Tablelands, Striped Legless Lizard, Grassland Earless Dragon, Button Wrinklewort, Ginninderra Peppercress* (NSW and ACT) (EACT, NSW, Cwlth, community). (e) Assess the implications of research results for management.	**2005–2007** ■ Location, type and condition assessments of native grassland remnants completed and are kept up to date. ■ Survey and other relevant data entered into ACT vegetation database within 6 months of collection. ■ Priorities reviewed and data deficiencies addressed. ■ *Integrated Nature Conservation Plan** includes up-to-date ecological data on native grassland and grassland species. ■ Data exchange protocols established with other priority database managers and regular exchange takes place. ■ Extent to which management recommendations arising from research outcomes are adopted. * The *Integrated Nature Conservation Plan* is the central repository for information related to nature conservation in the ACT. Based on a Geographical Information System it shows, for example, all ACT reserves, distribution of threatened species and cological communities, important fauna habitat and locations where major works are planned or being undertaken.

(Continued) ▶

Table 4.1: *(Continued)*

2. Protection

Objective	Actions	Performance Criteria
(a) A comprehensive, adequate and representative (CAR) system of natural temperate grassland areas in the ACT is protected by reservation, or other measures where reservation is not practical or desirable. (b) All Category 1 native grasslands (Core Conservation Sites) are afforded the highest available level of protection, relevant to their tenure. (c) All Category 2 native grasslands (Complementary Conservation Sites) are afforded appropriate protection, and conservation management is undertaken where compatible uses are permitted on these sites. (d) Category 3 native grasslands (Landscape and Urban Sites) are maintained and managed according to their values (e.g. as buffers, landscape features and habitat). (e) Key habitat for threatened grassland flora and fauna species is protected including where this may involve lower conservation value grassland areas. (f) Land development proposals affecting natural temperate grassland and component species are assessed for their ecological impact and if proceeded with adverse impacts are minimised to an acceptable level. (g) The ACT Heritage Places Register includes natural temperate grassland and key habitats for threatened grassland species.	(a) Evaluate the extent to which protected and other areas managed for conservation contribute to a CAR system. (b) Develop and support appropriate proposals that will protect areas identified for reservation representing: (i) the geographic and ecological extent of natural temperate grassland including representation of all floristic associations; (ii) key habitat for threatened, uncommon and declining grassland species; (iii) important areas for improving connectivity or acting as buffers for high conservation value grasslands; and (iv) elements that will achieve a CAR protected area system (EACT, community). (c) Determine the most appropriate form of protection (e.g. through LMAs, MOUs, voluntary agreements) for ecologically important off-reserve areas. Include protection requirements in agreements and monitor the effectiveness of the agreements (EACT, ACTPLA, Cwlth). (d) Ensure land development proposals are assessed under relevant environmental impact and nature conservation legislation. (e) Work with the ACT Heritage Council to identify natural temperate grassland and threatened species habitat suitable for nomination to the ACT Heritage Places Register. Prepare nominations (EACT, ACTPLA, ACT Heritage Council).	**2005–2007** ■ CAR principles are satisfied across the nature conservation estate. ■ Area of natural temperate grassland cleared or significantly modified by land development proposals. ■ Extent to which ecological connectivity is maintained or enhanced. ■ Natural temperate grassland and threatened species habitat identified as being essential for the ACT's reserve and off-reserve nature conservation system is appropriately protected. ■ Natural temperate grassland and threatened species habitat that qualify for the ACT Heritage Places Register are listed. ■ Extent to which protection agreements are in place for important off-reserve natural temperate grasslands and the effectiveness of the agreements in protecting the values of these grasslands.

3. Threats

Objective	Actions	Performance Criteria
(a) Substantially reduce or eliminate threats to natural temperate grassland through appropriate planning and management actions. (b) Reduce the impact and occurrence in grasslands of weeds of concern.	(a) Identify and monitor threats (including urban expansion, fragmentation, overgrazing, weed invasion, unplanned fire, other damaging disturbance) to natural temperate grassland and component species (EACT, ACTPLA, Cwlth, community). (b) Prepare and implement threat abatement responses (EACT, ACTPLA, Cwlth, community). (c) Monitor effect of threat abatement measures (EACT, ACTPLA, Cwlth, community). (d) Prepare and implement control programs for weeds of concern (all landholders)	**2005–2007** ■ Actions to address priority threats to natural temperate grassland are in place and being implemented. ■ Area of grassland occupied by weeds of concern is reduced. **2008–2010** ■ Priority threats to natural temperate grassland and component species are substantially reduced or decreasing.

(Continued) ▶

Table 4.1: *(Continued)*

4. Planning

Objective	Actions	Performance Criteria
(a) The *Lowland Native Grassland Conservation Strategy* and up-to-date ecological information is the major basis for assessing planning decisions impacting on conservation of native grassland and component species. (b) Government and non-government organisations recognise the biodiversity conservation values of natural temperate grassland and component species and incorporate their conservation requirements in planning, development and land management activities. (c) Native grassland remnants are assessed for their potential to contribute to the ACT's protected area system, conserving threatened species and maintaining ecological connectivity across the ACT. (d) Natural temperate grassland conservation contributes to targets established in the *Murrumbidgee Catchment Blueprint* through meeting targets in the *ACT Natural Resource Management Plan* (ACT NRM Board 2003). (e) Co-ordinated arrangements for the protection of native grassland are established across the region.	(a) Consult with all government and non-government parties participating in ACT and regional planning processes to ensure that information on the conservation significance of natural temperate grassland and component species is incorporated: (i) into strategic planning for the ACT and region; (ii) at an early stage into planning for urban and other development in the ACT; and (iii) into development control and management plans (EACT, ACTPLA, NSW, Cwlth, community). (b) Proposals assessed under the *Land (Planning and Environment) Act 1991* include appropriate information on natural temperate grassland and their component species. (c) Work with other agencies (development and infrastructure) and landholders (especially rural lessees and Commonwealth agencies) to: (i) prevent or minimise further fragmentation; (ii) maximise connectivity of natural temperate grassland; and (iii) encourage activities aimed at improving viability of natural temperate grassland remnants (EACT, Cwlth, landholders, community). (d) Work with NSW agencies to develop, implement and promote measures for protection of native grassland communities in the region (EACT, NSW).	**2005–2007** ■ All ACT planning and urban development decisions involving natural temperate grassland and habitat for component species are based on the *Lowland Native Grassland Conservation Strategy* and up to date ecological information. ■ Extent to which protection of natural temperate grassland communities contribute to regional targets for protection and connectivity. ■ Planning and development proposals in NSW affecting natural temperate grassland and grassland species have regard to ACT information and the regional context. **2008–2010** ■ The majority of ACT native grasslands under a range of tenures are part of a regional Conservation Management Network (CMN).

5. Management

Objective	Actions	Performance Criteria
(a) 'Best practice' management is applied to natural temperate grassland in the ACT across all land tenures with particular attention to grassland habitat of threatened, uncommon and declining species. (b) The ecological condition and habitat quality of the remaining natural temperate grassland communities in the ACT is maintained or improved. (c) Rural and other private landowners manage natural temperate grassland and habitat for threatened species in a way that preserves its natural values.	(a) Have in place management plans (Public Land) or similar arrangements (for other tenures) that reflect commitment to active and effective conservation of natural temperate grassland remnants. (b) Continue to develop and promote 'best practice' management of natural temperate grassland and its component species (with particular attention to declining and threatened species in the ACT) by: (i) Promoting research into conservation management of natural temperate grassland including the functional role and dynamics of the grassland and key component species and research focused on best management practice (EACT);	**2005–2007** ■ Area of natural temperate grassland with management plans or similar arrangements for 'active' conservation management. ■ 'Best practice' guidelines for natural temperate grassland restoration are prepared and regularly updated to take into account restoration experience and relevant research. ■ Effectiveness of management actions in protecting the conservation values of the grassland areas. ■ A register of suitable sites supports regeneration/restoration* activities and guides priority setting.

(Continued) ▶

Table 4.1: *(Continued)*

5. Management *(continued)*

Objective	Actions	Performance Criteria
* *Regeneration* means the natural recovery of natural integrity following disturbance or degradation. *Restoration* means returning existing habitats to a known past state or to an approximation of the natural condition by repairing degradation, by removing introduced species or by reinstatement. *Reinstatement* means to introduce to a place one or more species or elements of habitat or geodiversity that are known to have existed there naturally at a previous time, but that can no longer be found at that place (*Australian Heritage Commission* 2002).	(ii) Identifying and prioritising activities and sites for regeneration and restoration* of natural temperate grassland (EACT); (iii) Developing and applying an 'adaptive management' approach linking research and monitoring to management (EACT); (iv) Monitoring the effectiveness of management actions applied as part of 'best practice'; (v) Providing up to date 'best practice' management guidelines for managers of all land tenures and community groups to apply when undertaking natural temperate grassland restoration* activities (EACT, Cwlth, landholders, community); (vi) Taking into account the known conservation requirements of component flora and fauna species (in particular, declining and threatened species) in management of natural temperate grassland (EACT, Cwlth, landholders, community). (c) Liaise with Commonwealth agencies responsible for managing National Land containing natural temperate grassland and habitat for threatened species, and keep the MOUs with those agencies under review (EACT, Cwlth).	■ Area of natural temperate grassland subject to restoration/regeneration management. ■ Extent and nature of liaison with Commonwealth agencies, and effectiveness of MOUs in protecting natural temperate grassland and associated species on National Land. **2008–2010** ■ Research and monitoring are continuing and the results used to inform managers of measures to improve ecological condition and habitat qualities.

6. Community/landholder involvement

Objective	Actions	Performance Criteria
(a) Landholders, community groups and others are actively involved in native grassland conservation. (b) Native grassland sites, their managers and the community are linked together in a Conservation Management Network.	(a) Encourage the involvement of landholders, community groups and others in the protection and management of native grasslands (EACT). (b) Facilitate information and skills exchange between stakeholders aimed at achieving best practice management of native grasslands (EACT, NSW, Cwlth, landholders, community). (c) Encourage the formation of an ACT and NSW regional Conservation Management Network (CMN) for natural temperate grassland, building upon the existing NSW CMNs (EACT, NSW, landholders, community).	**2005–2007** ■ A Conservation Management Network (CMN) of sites with links to NSW CMNs is established. ■ Number and type of opportunities for managers of natural temperate grassland sites to exchange information about 'best practice' management. ■ Availability and take-up of agreements and incentives to conserve natural temperate grassland and undertake 'best practice' management. ■ Number and type of opportunities for community groups to participate in grassland conservation and restoration activities.

(Continued) ▶

Table 4.1: *(Continued)*

6. Community/landholder involvement *(continued)*

Objective	Actions	Performance Criteria
	(d) Investigate opportunities for voluntary agreements, and incentives for land managers to conserve natural temperate grassland and component species (EACT, landholders). (e) Raise community awareness through community liaison and public education, with the aim of fostering protection of native grasslands.	

7. Threatened or Uncommon Plants

(see s. 2.2.2 and Parts 1–6 of this table for more detail)

(Button Wrinklewort, Ginninderra Peppercress and any other threatened or uncommon grassland plant)

Actions	Performance Criteria
INFORMATION (Survey, Monitoring, Research) ■ Maintain alertness to the possible presence of threatened or uncommon grassland species when undertaking surveys in appropriate habitat (EACT). ■ Maintain a database of known occurrences and abundance of threatened and uncommon grassland species to enable analysis of changes in distribution and abundance (EACT). ■ Maintain a watching brief on ACT populations of threatened and uncommon grassland species and evaluate their conservation status in a regional context (EACT). ■ Review research by the CSIRO directed towards understanding how genetic variations influence the viability of small populations, for its potential to be applied to the conservation management of threatened and uncommon species in the ACT (EACT). **PROTECTION AND MANAGEMENT** ■ Protect threatened and uncommon grassland species through the provisions of the *Land (Planning and Environment) Act 1991*, *The Territory Plan,* Memoranda of Understanding and other management agreements (EACT, Commonwealth and other land managers). ■ Seek to ensure known populations of threatened and uncommon grassland species are protected from inadvertent damaging actions (e.g. by advising landowners and managers of their presence) (EACT, LMA). ■ Prepare management guidelines for threatened and uncommon grassland species if required (EACT). ■ Manage sites, and provide advice to other landowners and managers, to maintain optimum habitat (where known) for threatened and uncommon grassland species (EACT). ■ Consider nomination for ACT listing if uncommon grassland species show evidence of local decline in extent and abundance (EACT). **REGIONAL AND NATIONAL COOPERATION** ■ Maintain links with, and participate in, regional and national recovery efforts for threatened grassland species to ensure that conservation actions are coordinated with regional and national programs (EACT). ■ Liaise with interstate agencies involved in protection and management of threatened and uncommon grassland species with the aim of increasing knowledge of their biology, and habitat and conservation requirements (EACT). **COMMUNITY INVOLVEMENT AND EDUCATION** ■ Encourage the community to assist in the conservation of native grasslands and their component species, and provide community education materials (EACT).	**2005–2007** ■ Grassland flora is a key component of grassland monitoring programs. ■ Conservation status of grassland flora is kept under review. ■ Environmental impact assessment of native grassland sites includes threatened and uncommon species. ■ Relevant genetic research is applied to the management of threatened and uncommon grassland plants. ■ The extent and type of protection for habitat supporting threatened and uncommon grassland plants. ■ Management guidelines have been prepared for threatened and uncommon grassland plants (as required). ■ The extent of community involvement in the protection and management of threatened and uncommon grassland plants

(Continued) ▶

Table 4.1: *(Continued)*

8. Threatened and Uncommon Animals

(see s. 2.3.6 and 2.3.7 and Parts 1–6 of this table for more detail)

(Striped Legless Lizard, Grassland Earless Dragon, Golden Sun Moth, Perunga Grasshopper and any other threatened or uncommon grassland animal)

Actions	Performance Criteria
INFORMATION (Survey, Monitoring, Research) ■ Maintain alertness to the possible presence of threatened or uncommon grassland species when undertaking surveys in appropriate habitat (EACT). ■ Maintain a database of known occurrences and abundance of threatened and uncommon grassland species to assist in detecting changes in distribution and abundance (EACT). ■ Maintain a watching brief on ACT populations of threatened and uncommon grassland species and evaluate their conservation status in a regional context (EACT). ■ Facilitate and encourage research that will provide information on status of threatened and uncommon grassland species and management requirements (EACT). **PROTECTION AND MANAGEMENT** ■ Seek to ensure known populations of threatened and uncommon grassland species are protected from inadvertent damaging actions (e.g. by advising landowners and managers of their presence) (EACT, LMA). ■ Prepare management guidelines for threatened and uncommon grassland species where necessary (EACT). ■ Manage sites, and provide advice to other landowners and managers, to maintain optimum habitat (where known) for threatened and uncommon grassland species (EACT). ■ Consider nomination for ACT listing if uncommon grassland species show evidence of local decline in extent and abundance (EACT). **REGIONAL AND NATIONAL COOPERATION** ■ Maintain links with, and participate in, regional and national recovery efforts for threatened grassland species to ensure that conservation actions are coordinated with regional and national programs (EACT). ■ Liaise with interstate agencies involved in protection and management of threatened and uncommon grassland species with the aim of increasing knowledge of their biology, and habitat and conservation requirements (EACT). **COMMUNITY INVOLVEMENT AND EDUCATION** ■ Encourage the community to assist in the conservation of native grasslands and their component species, and provide community education materials (EACT).	**2005–2007** ■ Grassland fauna are a key component of grassland monitoring programs. ■ Conservation status of grassland fauna is kept under review. ■ Environmental impact assessment of native grassland sites includes threatened species. ■ Best Practice Guidelines include information relevant to management of grassland animals.

ABBREVIATIONS:

EACT	Environment ACT
NSW	Relevant NSW government agencies primarily the Department of Environment and Conservation
Cwlth	Commonwealth agencies responsible for managing National Land in the ACT (Department of Defence, National Capital Authority, CSIRO)
ACTPLA	ACT Planning and Land Authority
LMA	Land Management Agreement (for rural leases in the ACT)
MOU	Memorandum of Understanding
CMN	Conservation Management Network

4.3

Policy Guidelines for Lowland Native Grassland Conservation in the ACT

4.3.1 A Comprehensive, Adequate and Representative Reserve System

ACT Government policies for conservation of the diversity of ecological communities in the Territory are set out in documents such as *The Territory Plan*, *The Canberra Spatial Plan*, *The ACT Nature Conservation Strategy* (ACT Government 1998c), and specifically for natural temperate grassland, Action Plan No. 1 (ACT Government 1997a). Statements in these documents point towards a system of protection for the ACT that places its natural environments within a regional context and reflects national priorities. The latter are contained in several inter-governmental agreements: *Australian Guidelines for Establishing the National Reserve System* (Commonwealth of Australia, 1999), a *National Strategy for the Conservation of Australia's Biological Diversity* (Commonwealth of Australia 1996) and related documentation.

A key objective of this *Strategy* is the establishment of a comprehensive, adequate and representative system of protection of grassland in reserves or by other measures where reservation is not practicable or desirable (Table 4.1). This recognises that in the ACT, high conservation value grasslands and areas forming a core of critical habitat occur on National Land and unless the status of the land changes, these areas are unavailable for incorporation into the ACT reserve system.

The origin of the comprehensive, adequate and representative (CAR) principles for reservations for biodiversity conservation was in the *Nationally Agreed Criteria for the Establishment of a Comprehensive, Adequate and Representative Reserve System for Forests in Australia* (JANIS 1997) produced to meet a commitment in the *National Forest Policy Statement* (NFPS) (Commonwealth of Australia 1992) for the establishment of a national forest reserve system. While the CAR criteria were initially developed in the context of conserving forest ecosystems, the principles are generic in nature and can be applied generally to establishment of a CAR reserve system, together with other protection measures, for conservation of biodiversity (ACT Government 2004a).

Socio-economic considerations may preclude protection of all currently unprotected occurrences in the ACT of natural temperate grassland and grassland habitat for threatened species. However, advantage can be taken of some urban planning opportunities and primary land uses compatible with conservation to modify land use proposals that would otherwise result in loss of small areas of grassland. The fragmented nature of much of the remaining unprotected natural temperate grassland points to off-reserve conservation measures as a supplementary option to pursue. The guidelines for the National Reserve System program (Commonwealth of Australia 1999) call for decision making processes to integrate long-term and short-term environmental, economic, social and equity considerations; and endorse the principle of 'least cost', where an optimal reserve configuration can be established with the minimum economic and social cost to the community.

The following definitions apply to the comprehensive, adequate and representative reserve system principles:

Comprehensiveness—sampling the full range of communities/ecosystems. In the ACT this would include the full range of the five floristic associations identified for ACT natural temperate grassland (see s. 2.1.4).

- Comprehensiveness should be addressed in a biogeographical context (i.e. using IBRA regions (Thackway and Cresswell, 1995; Environment Australia 2000)) and at an appropriate scale. For natural temperate grassland, the appropriate regional scale is the 'Southern Tablelands' as defined in Environment ACT (2003).
- All remaining occurrences of endangered ecosystems should be reserved or protected by other means as far as is practicable.

  An endangered ecosystem is one where its distribution has contracted to less that 10% of its former range, or the total area has contracted to less than 10% of its former area, or where 90% of its area is in small patches which are subject to threatening processes and unlikely to persist.

Flexibility in the application of reserve criteria is needed to ensure that the reserve system delivers optimal nature conservation outcomes as well as acceptable social and economic outcomes. Reserve design criteria should, therefore, be considered as guidelines rather than mandatory targets. For example, the effort to achieve reservation of all occurrences of an endangered community may reach a point of diminishing return and nature conservation objectives may be more efficiently and effectively achieved through other strategies. If socio-economic impacts are such that trade-offs are required to meet all criteria for reserve design, optimisation of biodiversity protection should take precedence.

Adequacy—the maintenance of ecological viability and integrity of populations, species and communities. An adequate protected area system will replicate ecologically viable natural temperate grassland communities, species and populations.

- Extent and replication of samples of populations, species and communities in the reserve system across their range such that their viability is ensured, particularly as a safeguard against catastrophic events (e.g. the 2003 ACT bushfires). Two key principles are: (a) the greater the extent reserved, the more likely that the ecological functioning and species composition of an ecosystem will be maintained; (b) ecosystems are represented within the protected area network at more than one site.

Decline in range and area of the community (reserved or otherwise) and fragmentation of the remnants are important reasons why natural temperate grassland and associated species are threatened with extinction. It follows that adequacy is a limiting factor in the ACT's contribution to a bio-regionally adequate reserve system. A systematic approach is called for to compensate, involving reservation where possible and an increased emphasis on off-reserve conservation measures such as protection of habitat links, special protection measures for occurrences on private land and sympathetic management of adjacent land.

Representativeness—sample areas included in the reserve system or other protected areas should reasonably reflect the biological diversity of the communities.

- Consider the range of species that comprise the community, especially those that depend on reservation for protection. The objective is to maximise their viability in a region through adequate reservation, not reserve every ecosystem in which they have been recorded. Consider the range of floristic and structural mixes that are found in the community.

In the ACT there is scope for greater representation of natural temperate grassland and habitat for threatened grassland species in the reserve system, with strong complementary measures for off-reserve occurrences. The ACT reserve system should sample natural temperate grassland as a component of the regional ecosystem. Representative coverage of regional ecosystems can only be satisfied at a bioregional scale.

In the context of this *Strategy*, the terms 'comprehensive', 'adequate' and 'representative' need to be described in ways relevant to the level and scale of decision-making by government and other stakeholders in the ACT. Planning and conservation issues outlined in Chapter 3 have been reviewed and reference made to the scope of explanations for the terms included in the National Reserve System guidelines to derive the following elements for an assessment of the ACT's contribution to a CAR reserve system:

A 'comprehensive' protected area system will contain the full range of natural temperate grassland types in the ACT including:

- natural temperate grassland across the full range of altitude, soil types, and aspect;
- all five floristic associations; and
- areas where natural temperate grassland intergrades with Yellow Box–Red Gum Grassy Woodland.

An 'adequate' reserve system will include areas of natural temperate grassland that retain viable ecological communities and populations of their component species including:

- large areas of natural temperate grassland preferably with small perimeter/area ratios;
- replicated samples of each of the natural temperate grassland floristic associations; and
- natural temperate grassland areas that are well connected to other native grassland or other native ecological communities to ensure ecological processes are maintained to the greatest possible extent.

A 'representative' protected area system that encompasses the diversity of species and habitats including:

- threatened and uncommon grassland plants and animals;
- the geographic range of species.

These elements have been assessed in terms of the degree to which they are demonstrated or included in the five grassland complexes (s. 3.6). These assessments, together with a summary of the priority tasks necessary to achieve an improved CAR reserve system for the ACT are outlined in Table 4.2.

The extent to which the priority tasks are addressed will be a measure of the contribution made by the ACT nature reserve system and off-reserve measures in achieving the Vision and Goals identified for this *Strategy*. A strong, representative reserve system will be complemented by off-reserve conservation measures. The latter should be aimed at improving ecological connectivity, providing opportunities for restoration and regeneration of grasslands, and

conserving habitat for those species that range widely across the landscape either in migratory movements, in response to climatic conditions or because home ranges are larger than the protected areas system. For this to be successful managers of land that provides connectivity must first recognise that maintaining and/or enhancing connectivity should be a part of their management practices.

4.3.2 Other Policy Guidelines for Lowland Native Grassland Conservation in the ACT

In addition to guidelines for a comprehensive, adequate and representative protected area system, policy frameworks for the upper Murrumbidgee River catchment as part of the Murray–Darling Basin are relevant to nature conservation in the ACT region.

Targets of the Integrated Catchment Management Policy for terrestrial biodiversity in the Murray–Darling Basin are: maintaining key ecological processes; maintaining or re-establishing viable populations of native species and the integrity of ecological communities (especially vegetation); and controlling threats to biodiversity (MDBC, 2001). The ACT is a participant in the Murray Darling Basin initiative, and is involved in a number of programs of relevance to the ACT, such as the sustainable rivers audit.

At the sub-regional level, the *Murrumbidgee Catchment Blueprint* (Murrumbidgee Catchment Management Board 2003) has been prepared to satisfy legislative requirements in the NSW *Catchment Management Act 1989* and in response to arrangements under the *National Action Plan for Salinity and Water Quality* (COAG 2000). Although the *Murrumbidgee Catchment Blueprint* is inclusive of the ACT at the broader catchment level, the ACT has a separately identified component that reflects the ACT's different governmental arrangements, land tenure system, and urban focus. ACT aspects are dealt with in the *ACT Natural Resource Management Plan* (ACT NRM Board 2003)

The ACT targets, actions and activities have been prepared through a process of community and government consultation. They provide direction for future natural resource management investment and will enable the ACT to assign funding to address issues of concern to the Territory as well as to participate in projects spanning more than one catchment. However, each jurisdiction needs to deal with natural resource management within its own policy and planning framework.

For the Murrumbidgee Catchment as a whole, a target of the *Blueprint* (p. 32) is to manage for biodiversity conservation a minimum of 30% of the area of each of the *remaining* native vegetation communities of the Murrumbidgee Catchment by 2012. The proposed ACT contribution to the catchment target is to manage for biodiversity conservation a minimum of 30% of the *pre-European* extent of each vegetation community in the ACT (ACT NRM Board 2003, p. 15). The *Natural Resource Management Plan* notes that this may not always be feasible, as is the case with natural temperate grassland where only about 5% of the estimated original area of 20 000 ha remains in a moderate to good condition (see s. 3.3).

ACT management targets in the *ACT Natural Resource Management Plan* relevant to the natural temperate grassland conservation are:

- by 2006, have in place biodiversity targets that enable on-going assessment and protection of biodiversity values;
- all protected areas of the ACT managed for the conservation of ecosystems and ecological processes 100% of the time;
- by 2005, all significant remnant vegetation on rural land in the ACT is managed to maintain and enhance its biodiversity values;
- by 2005, have in place targets for urban biodiversity; and
- by 2006 incorporate urban biodiversity targets into integrated urban ecological function targets.

4.4

The State of Protection of Natural Temperate Grassland and Other Grassy Habitats in the ACT

As outlined previously (see ss. 2.1.3, 2.1.7, 3.3), most of the original extent of natural temperate grassland in the ACT and region has been cleared since European settlement for pastoral and agricultural use and for the development of Canberra as the National Capital. In this context, all remaining areas of the ecological community in the ACT warrant serious consideration for their conservation potential, either in the case of core conservation areas (s. 3.5.1) as part of the ACT's nature conservation estate or as a secondary land use in areas where statutory protection is not practicable.

In addition to protection of habitat as nature reserves, opportunities also need to be sought to improve the ecological condition of the more degraded areas, to supplement core sites with buffers (particularly where the core area is small) and to ensure that their potential role as habitat for threatened flora and fauna is

considered. Such restoration work can make an important contribution to conservation, even in places where the habitat no longer qualifies as natural temperate grassland endangered ecological community

Recognition of natural temperate grassland and the need to conserve it has only developed recently (over the last 15 years) as public policy. The fragments remaining of this once extensive ecological community and the few areas protected for nature conservation reflect this lack of recognition. However, the ACT is now in a good position to conserve the last remaining viable examples of grassland and threatened species habitat (some of which are relatively large in area) as part of the ACT's nature conservation estate. The challenge will be to manage these areas 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 certain.

The remaining 991 ha of natural temperate grassland in the ACT is about 5% of the estimated pre-European extent in the ACT of 20 000 ha. If the more highly modified areas containing areas of native pasture and exotic grasslands and associated threatened species are included (Tables 2.1, 3.2–3.8), the remaining area totals about 2172 ha or about 10% of the pre-European extent.

In the region defined by Fallding (2002), which includes the ACT (see s. 1.1), about 9% of the pre-1750 area of grassland in various conditions remains, only a portion of which would now qualify as the natural temperate grassland endangered ecological community. For the Southern Tablelands as a whole, less than 3% remains. Virtually all these grasslands are threatened in some way, even in reserves, especially by weed invasion.

An important precursor to sound conservation planning (including protection) is knowledge of the resource. The need for grassland surveys in the ACT was recognized in the early 1990s, and with support initially from Commonwealth funding, comprehensive surveys were carried out between 1991 and 1996. These formed the basis for the Action Plan for natural temperate grassland (ACT Government 1997a) (see s. 3.1). Survey of ACT grasslands is now largely complete, in terms of the flora and vertebrate fauna.

As elsewhere, there is limited knowledge of grassland invertebrates (see s. 2.3.3), although quite extensive invertebrate studies have been undertaken in the ACT, which is far better surveyed for invertebrates than most of the southern tablelands grassland ecosystems. Lack of knowledge of invertebrates is related to complexity of sampling, enormous diversity and large, short-term fluctuations due to climate, management and other disturbance factors. Recent surveys have shown improvements in the condition of some of the grasslands (e.g. Crace Nature Reserve), as well as new or extended populations of some threatened species (e.g. in the Majura Valley, see s. 3.6.1).

Sites where natural temperate grassland and other grassy habitat for threatened species now remains are shown in Figures 2.3–2.7 as at 1 March 2004, and a summary for each geographic area is in Table 4.2. The summary information allows an assessment to be made of the state of grassland conservation across the ACT and to identify priorities for conservation action.

Significant conclusions for the ACT include:

(a) About 991 ha of natural temperate grassland (partially or moderately modified) are now left in a condition that meets the definition of this endangered ecological community. This represents about 5% of the estimated original area in the ACT.

(b) An additional 542 ha of highly modified and exotic grassy vegetation is closely associated with the sites containing the endangered ecological community. Another 639 ha of grasslands are known habitat for threatened species.

(c) By deduction about 19 000ha of former natural temperate grassland have been destroyed or substantially changed during the development of Canberra or as a result of other land uses. This represents about 95% of the original area.

(d) In the regional context, the remaining area of natural temperate grassland endangered ecological community in the ACT (991 ha) represents approximately 1% of the original area (estimate 83 000 ha) and about 6% of what is left in 2000 (estimate 15 500 ha) (regional data from Fallding 2002 and Environment ACT 2003). By any measure this is a very small amount of a once extensive native grassland community.

(e) About 799 ha (37%) of the remaining natural temperate grassland and other grassland habitat (2172 ha) are protected within Public Land (Nature Reserve) areas. Another 531 ha (24%) are managed under MOUs with Commonwealth or other agencies.

(f) Significant areas of natural temperate grassland and other grassy habitat are not protected (Category 1: 258 ha and Category 2: 447 ha). Almost all this land is in the Majura and Jerrabomberra valleys.

(g) Another 136 ha are in small fragments that have been assessed as Category 3 or Landscape and Urban fragments. Almost all of this land is located in the Belconnen area.

Table 4.2: Summary of Lowland Native Grassland Data Showing Areas Remaining Under Various Categories of Land Use, Presence of Threatened Species and Conservation Planning Issues

All areas in hectares	Area of Natural Temperature Grassland	Area of other grassy habitat	Total area grassland and grassy habitat	Area protected in Public Land (Nature Reserve)	Area managed under MOU	Area not formally protected in each Conservation Category (s 3.5)—includes area managed by CUPP*			Threatened Species present in native grassland and other suitable habitat	Issues for identifying priority tasks for conservation of grasslands and threatened grassland species
	(a)	*(b)*	*(c)*	*(% of (c))*	*(% of (c))*	*1*	*2*	*3*		
Total for ACT	**991 (542)**	**639**	**2172**	**799 (37%)**	**531 (24%)**	**258**	**447**	**136**		
Gungahlin	179 (231)	0	410	392 (96%)	0 (0%)	0	17.5	0.8 (*0.3)	Golden Sun Moth Perunga Grasshopper Striped Legless Lizard Button Wrinklewort	Key habitats identified and protected. Resolve planning around Mitchell. Priority to manage to improve condition.
Majura	209 (144)	289	641	0 (0%)	138 (22%)	348	155	0	Grassland Earless Dragon Striped Legless Lizard Golden Sun Moth Perunga Grasshopper	No threatened species or natural temperate grassland formally protected. Priority to protect and manage to improve condition. Road and airport developments a threat.
Jerrabomberra	267 (80)	350	697	325 (47%)	220 (32%)	42	110	0.3	Grassland Earless Dragon Striped Legless Lizard Golden Sun Moth Perunga Grasshopper	Priority to manage to improve condition.
Belconnen	300 (88)	0	388	82 (27%)	139 (36%)	8	71 (*18.6)	87	Golden Sun Moth Perunga Grasshopper Ginninderra Peppercress Striped Legless Lizard	Largest Golden Sun Moth habitat in the region a priority for protection.
Canberra City and Tuggeranong	36 (1)	0	37	0 (0%)	26 (70%)	1.2 (*1.2)	8.6 (*6.2)	0.2 (*0.2)	Golden Sun Moth Button Wrinklewort	Most sites are vulnerable to neglect and lack recognition as assets. Further fragmentation and weed invasion threaten survival in the long term.

Notes:

(a) Includes Natural Temperate Grassland and, in brackets, area of closely associated native pasture (BSR 5) and exotic grassland

(b) Other grassland habitat (BSR 5) containing threatened species

(c) Total, all grassland and grassy habitat types ((a) + (b))

CUPP: Canberra Urban Parks and Places

(h) The largest area of unprotected native grassland and threatened species habitat is in the Majura Valley. There has been significant recent improvement in protection in the Jerrabomberra Valley. About 150 ha remain unprotected in both the Jerrabomberra Valley and Belconnen areas respectively. The remaining native grassland and threatened species habitat in these three areas are the planning and/or management responsibility of either the ACT or Commonwealth Governments, or of a private landholder (Canberra International Airport and rural lessees).

(i) Almost all natural temperate grassland and other grassland habitats in the Gungahlin area (96%), a high proportion in Jerrabomberra (79%) (following the recent establishment of reserves), and much of this habitat in the Belconnen (58%) and Canberra City (66%) areas have protection by virtue of either their status as nature reserves or as land subject to MOUs with Commonwealth agencies.

4.4.1 Actions to Improve Conservation of Lowland Native Grassland in the ACT

Significant early actions to improve grassland conservation in the ACT were:

- developing and implementing (from 1993) the *Recovery plan for lowland native grasslands in the ACT* (Wildlife Research Unit 1991) (see s. 3.1); and
- protecting about 400 ha of natural temperate grassland and other grassland habitat in the Gungahlin grassland reserves (Mulangarri, Crace, Gungaderra) (1995).

Since the first Action Plans for natural temperate grassland and component threatened species were adopted, beginning in 1997, there have been several Government decisions implementing some of the priority actions identified in these plans. These are:

- Removing about 82 ha of natural temperate grassland, including some Wet *Themeda* grassland from the Dunlop residential estate and adding it to Dunlop Nature Reserve (1997).
- Establishing Memoranda of Understanding with Commonwealth managers of National Land (see s. 3.4.3).
- Announcing (22 July 2004) protection in nature reserves of over 300 hectares of natural temperate grassland and other grassy habitat for threatened species (Grassland Earless Dragon) in the Jerrabomberra Valley.

In 2003–04 the ACT Planning and Land Authority, Land Development Authority and Environment ACT initiated work on an Outline Plan for the Jerrabomberra Valley. This 'Southern Broadacre Planning Study' is a comprehensive land use study of the Jerrabomberra Valley that will provide the framework and land use policies for this part of the ACT. The study has identified the need to establish new nature reserves to protect native grassland and habitat for the Grassland Earless Dragon. The study is expected to form the basis of a draft Variation to the Territory Plan (DVP) that will formally set out proposed land uses, including nature conservation.

Funding to establish the new reserves was included in the ACT Government's 2004–05 Budget. It will ensure protection of two core grassland sites and other key habitat for the endangered Grassland Earless Dragon. Parts of the foreshadowed reserves will join Yellow Box–Red Gum Grassy Woodland that are to be protected following an announcement in May 2003, as well as other grassland habitat at the Queanbeyan Nature Reserve (Letchworth) in NSW.

Notwithstanding the progress made to date, and until announced new reserves are formalised through a Variation to the Territory Plan, there is no part of the ACT that provides certain, long-term protection for three of the ACT's threatened species. These are the Grassland Earless Dragon, the Golden Sun Moth, and the Ginninderra Peppercress. Although work is in progress to rectify this situation for both the Jerrabomberra valley and at Lawson, long-term security for these species will not be assured until detailed planning is completed and management of their habitat is directed towards their conservation rather than being an adjunct to the primary land use. Implementation of protection and conservation management is the top priority.

4.4.2 Priority Tasks to Improve Conservation of Lowland Native Grassland and Component Threatened Species in the ACT

Priority tasks to improve the protection status of lowland native grassland (including the natural temperate grassland endangered ecological community), and the several plant and animal species that are regarded as grassland species are set out in Table 4.2. Making the decisions to implement any of these tasks is the responsibility of the ACT Government through its land planning and management actions. In summary the priority tasks are:

- Completing planning studies of those parts of the ACT where the long-term land use has yet to be defined, including identifying those areas that are best used as nature reserves.

The key areas for these studies are the Jerrabomberra and Majura Valleys and at Symonston. The 'Southern Broadacre Planning Study' has identified indicative boundaries for protection of grassland habitat for threatened species in the Jerrabomberra valley. This is in the context of competing demands for land capable of supporting alternative uses for an expanding city.

The Canberra Spatial Plan provides the strategic directions for the development of Canberra, which include protection in nature reserves of key nature conservation assets and threatened species. It also identifies the need for further investigations to be undertaken (to identify potential land for industrial and related employment purposes) in the corridor along the Monaro Highway in Jerrabomberra, Symonston and Majura.

- Protecting all grasslands assessed as being the core conservation areas (Category 1 sites), either as part of the ACT's nature conservation estate or through equivalent, secure management.
- Including in the protected area system, grassland habitat for threatened species not yet adequately protected:
  - — Grassland Earless Dragon in the Jerrabomberra and Majura valleys;
  - — Golden Sun Moth at Lawson; and
  - — Ginninderra Peppercress at Lawson.
- Providing for improved habitat connectivity for wildlife movement between grasslands and woodlands or other adjacent habitats. This complements the same connectivity consideration included in the *ACT Lowland Woodland Conservation Strategy* (ACT Government 2004a). Important examples for grassland are between:
  - — Mount Ainslie Nature Reserve and Campbell Park paddocks (MA04);
  - — woodland and grassland at the Training Area in the Majura valley (MA01);
  - — woodland and grassland in the Jerrabomberra valley (JE02);
  - — Aranda Bushland and natural temperate grassland at Caswell Drive (BE10); and
  - — adjacent native grassland areas on either side of the ACT and NSW border at Queanbeyan (Mikes Hill (JE04), Woods Lane (JE06) (ACT)) and Queanbeyan Nature Reserve (Letchworth) (NSW).
- Reviewing management of native grassland areas in ACT nature reserves to ensure ecological condition is improved. A priority is managing invasive weeds such as Chilean Needlegrass and African Lovegrass.
- Assessing grasslands and threatened species habitats for their potential for listing on the ACT Heritage Places Register.
- Establishing mechanisms to assist in the application of best practice management (Conservation Management Networks, voluntary management agreements, guidelines) to facilitate conservation outcomes on reserve and off-reserve land.

Implementation of these priority actions depends upon a variety of government administrative processes. Briefly these are:

- Preparing recommendations from the Conservator of Flora and Fauna to the ACT Planning and Land Authority (ACTPLA) for those areas that should be protected, by including them in the ACT nature conservation estate.
- Including grassland conservation priorities in the principles and policies applied by ACTPLA when undertaking detailed planning for urban development (e.g. for Jerrabomberra valley, Lawson and East Gungahlin).
- Concluding agreements between the Conservator of Flora and Fauna and landholders, such as Memoranda of Understanding and Land Management Agreements (for rural leases).
- Implementing best practice management in grasslands managed by Environment ACT, including nature reserves, as well as in areas that are agisted and areas managed by other Territory agencies (Canberra Urban Parks and Places) and Commonwealth agencies (Department of Defence, National Capital Authority).
- Applying this *Strategy* and the information that it provides to future planning proposals for the ACT.
- Establishing Conservation Management Networks and investigating voluntary management agreements.
- Promoting cross border cooperation between ACT and NSW government agencies and other stakeholders so that coordinated conservation planning and management activities maximise the opportunities to achieve regional targets for biodiversity conservation.

APPENDIX

1 Botanical Significance Ratings used for Natural Temperate Grassland Sites

The botanical significance ratings are based on a qualitative assessment of the naturalness of the vegetation community in grassland sites. They have been modified by Environment ACT (Wildlife Research and Monitoring) from Stuwe (1986) to assist with the identification of conservation values of sites. A further modification of the ratings as applied in Action Plan 1 (ACT Government 1997a) has been undertaken using a more thorough knowledge of the response of species of plants to disturbance. The ratings reflect the diversity of native and exotic plant species and the occurrence of species that are indicative of disturbance levels. Diversity is a measure of species richness measured over a specified area, such as species per hectare.

Botanical significance rating has been applied to polygons, which are the smallest units surveyed in 2003–04 and are identified as homogeneous areas in terms of vegetation structure and composition. The species identified in the polygons were used to enable interpretation of the extent to which sites are likely to have been modified. This was based on the diversity and abundance of species that have been identified as sensitive to disturbance. Studies undertaken by Prober and Thiele (1995) and Dorrough (Dorrough *et al.* 2004) have described which species occur more frequently in grazed and ungrazed areas. Plant ecologists from Environment ACT and the NSW National Parks and Wildlife Service have been analysing the frequency with which native species have been encountered during grassland and woodland surveys in over 700 sites in the ACT and NSW Southern Tablelands since 1991. These studies have provided information on those species that are less common, and those that appear to have declined as a result of site disturbance. The following table lists examples of these species.

Because annual exotic species fluctuate in their cover and diversity between seasons and years, they are not used in the evaluation of botanical significance rating, although generally there is a greater cover of annual exotic species in the more disturbed sites. However, grasslands almost invariably now contain perennial and annual plant species.

Within a site there may be multiple polygons, which may differ in terms of their botanical significance. This may be due to differing disturbance levels or differences in natural site conditions such as drainage, soil depth or nutrient levels. Where the BSR varies in a site, the botanical significance of the minor areas is indicated in brackets.

Botanical significance rating does not include other assessments of conservation value, including the occurrence of threatened species, the occurrence of particular floristic associations, site size, threats from surrounding land uses and assessments of viability. These assessments, together with the botanical significance, are used to determine appropriate protection and management requirements (see s. 3.4).

The attributes of each botanical significance rating are expressed in tabular form in Table 3.1 (Chapter 3).

Botanical Significance Rating 1 (Very High)

Sites with this rating contain a very high diversity and cover of native plant species, especially native forbs and including uncommon species and several to many disturbance sensitive species, and a low cover of exotic species. These sites contain species indicative of minimal disturbance and generally include the most natural examples of the ecological community. They are amongst the best available sites of their type, and are often one of only a small number of sites with similar conservation values remaining in Australia. These sites are categorised as **partially modified natural temperate grassland**.

Botanical Significance Rating 2 (High)

Sites with this rating have a high to very high diversity of native plants. They generally have fewer species indicative of minimal disturbance than areas classed as BSR 1, but contain uncommon species and several disturbance sensitive species. They have a low cover of perennial exotic species. These sites are categorised as **partially modified natural temperate grassland**.

Botanical Significance Rating 3 (Moderate)

Sites with this rating have usually been moderately altered by disturbance or land uses. They have moderate to high native species diversity, but only those species that are tolerant of disturbance. There is low to moderate exotic species cover. These sites are categorised as **moderately modified natural temperate grassland**.

Botanical Significance Rating 4 (Low)

Sites with this rating contain a very low diversity of native species, particularly native forbs, but contain a high cover of native grasses. They contain a low to moderate cover, but may have a high diversity of perennial exotic plants. They include no species that are indicative of low levels of disturbance. They are unlikely to have a diverse native seed bank, and therefore may not be able to naturally regenerate to increase diversity. The maintenance of these sites as natural temperate grassland generally requires considerable management input. However, they may be valuable for fauna habitat, for wildlife corridors or buffers to areas of higher conservation value, and as potential sites for rehabilitation. These sites are categorised as **highly modified natural temperate grassland**.

Botanical Significance Rating 5 (Very Low)

Sites with this rating have a high cover of native grasses, but native forb cover and diversity is very low to zero. They contain only native species tolerant of high levels of disturbance (such as previous cropping, regular fertiliser input or continuous intensive grazing). Exotic species cover is moderate to low but diversity may be high. However, they may be valuable for fauna habitat, for wildlife corridors or buffers to areas of higher conservation value, and as potential sites for rehabilitation. These sites are categorised as **substantially modified native grassland (native pasture)** and are not regarded as the natural temperate grassland endangered ecological community.

Botanical Significance Rating E (Exotic)

These sites are dominated by perennial exotic species. They may contain low to very low cover of disturbance tolerant native species, mainly grasses or may be entirely exotic (such as sown pasture).

SPECIES TYPICAL OF DIFFERENT LEVELS OF DISTURBANCE

Species typical of different levels of disturbance in lowland grassy ecosystems are shown in the following table.

Degree of Disturbance	Ground Layer Species	Examples of Characteristic Species	Typical Flora of the Ground Layer	BSR Rating
Very low	Disturbance sensitive species	*Diuris* spp., *Caladenia* spp., *Thelymitra* spp.	Native species include orchids, lilies and other highly sensitive species, as well as more tolerant species.	**1**
Low	Moderately disturbance tolerant species	*Dichopogon* spp., *Bulbine bulbosa*, *Craspedia variabilis*, *Cryptandra amara*, *Themeda triandra*, *Pimelia* spp., *Wurmbea dioica*	Species present include those moderately tolerant of disturbance, as well as disturbance tolerant species.	**2**
Moderate	Disturbance tolerant species	*Chrysocephalum apiculatum*, *Convolvulus erubescens*, *Plantago varia*, *Asperula conferta*, *Glycine* spp., *Hibbertia obtusifolia*	Native species include those commonly found in a range of sites that have been subject to moderate disturbance; sensitive species are rarely present.	**3,4**
High	Disturbance tolerant native grasses	*Poa* spp., *Austrodanthonia* spp., *Austrostipa* spp., *Bothriochloa macra*, *Microlaena stipoides*	Site may contain a variety of native grass species but few or no native forbs are present.	**5**
Very high	Exotic species	Perennial and annual* weeds, introduced or adventitious species.	Either dominated by perennial exotic species species or a low cover and diversity of native species, of which most are native grasses.	**E**

* Because annual exotic species fluctuate in cover and diversity between seasons and years, they are not used in the evaluation of the degree of disturbance although generally there is a greater cover of annual exotic species in the more disturbed sites.

APPENDIX

2 Changes in Areas of Lowland Native Grassland and Threatened Species Habitat in the ACT Since 1997

1. Increase in Area of Natural Temperate Grassland since 1997

(a) New Sites Identified as Containing Natural Temperate Grassland

Area/Site Name	Floristic Association—2005	BSR—2005	Area (ha)
Canberra Central			
St Johns Church, Reid, CC03	*Austrodanthonia* grassland	BSR 4	0.9
Kintore St, Yarralumla, CC09	Dry *Themeda* grassland	BSR 3	0.8
Jerrabomberra Valley			
Tennant St, Fyshwick, JE10	Dry *Themeda* grassland	BSR 3	0.3
Gungahlin			
Nicholls, GU08	*Austrostipa* grassland	BSR 4	0.3
Wells Station Road, GU07	*Austrostipa* grassland	BSR 4	0.2
TOTAL (additional area of Natural Temperate Grassland)			**2.5**

(b) Sites Described as Being Natural Temperate Grassland Due to Improvements in Survey and Condition Assessment Techniques

Area/Site Name	Floristic Association—1997	BSR—2005	Area (ha)
Belconnen			
Dunlop Nature Reserve, BE02	*Austrostipa grassland*, native pasture	BSR 3, 4	51.1
Umbagong Park, BE04	*Austrodanthonia*, dry *Themeda* grassland, native pasture, exotic vegetation	BSR 4, 5	4.0
Glenloch Interchange, BE11	Dry *Themeda* grassland, native pasture	BSR 2	0.7
Gungahlin			
Gungaderra Grassland Reserve, GU02	*Austrostipa* grassland, native pasture	BSR 4	12.3
Crace Grassland Reserve, GU03	*Themeda* grassland, native pasture	BSR 3	8.2
Jerrabomberra Valley			
Mugga Mugga, JE01	*Austrostipa* grassland, native pasture	BSR 4	12.0
Woods Lane (Tharwa Road), JE04	Dry *Themeda* grassland, exotic, native pasture	BSR 3	8.3
Canberra Central			
Dudley St, Yarralumla, CC08	*Austrodanthonia* grassland, exotic vegetation	BSR 3	0.6
TOTAL (area reassessed as Natural Temperate Grassland)			**97.2**

2. Reduction in Area of Natural Temperate Grassland Since 1997

(a) Sites Developed in Whole or Part Since 1997

Area/Site Name	Floristic Association—1997	Status 2005	Decrease in Area (ha)
Gungahlin			
'Stray Leaf' Property, GAP 4	*Austrostipa* grassland, BSR 4	Loss of all of site	4.8
Majura Valley			
Canberra International Airport, MA03	*Austrodanthonia* grassland, BSR 3, 4	Loss of part of site	2.0
Canberra Central			
ACCC, Barton, CC04	Dry *Themeda* grassland, BSR 1	Loss of part of site	1.2
TOTAL (decrease in area of Natural Temperate Grassland)			**8.0**

(b) Sites that Have Deteriorated Since 1997

Area/Site Name	Floristic Association, Change in BSR	Cause of Reduction in Area	Decrease in Area (ha)
Canberra Central			
Yarramundi Reach, CC06	Dry *Themeda*, Wet *Themeda*, *Poa* grasslands, BSR 3 to 4	Weed invasion	10.8
Lady Denman Drive, CC07	*Austrodanthonia* grassland, BSR 3 to exotic	Weed invasion	2.1
Belconnen			
Evatt Powerlines, BE05	*Austrodanthonia* grassland, BSR 4 to exotic	Weed invasion	1.1
Gungahlin			
Mitchell, GU05	Dry *Themeda* grassland, BSR 3 to 5 (native pasture)	Site disturbance	0.3
Total area (decreased BSR)			**14.3**

(c) Sites Described in 2005 as Native Pasture or Exotic Grassland and not Natural Temperate Grassland, Based on Improvements in Survey and Condition Assessment Techniques

Area/Site Name	Floristic Association—1997	2005 Classification	Decrease in Area (ha)
Belconnen			
Lawson Territory, BE07	*Austrostipa* grassland, BSR 3	Native pasture, BSR 5	46.9
Kaleen East, BE09	*Austrodanthonia* grassland, BSR 3	Native pasture, BSR 5	24.6
Lake Ginninderra, BE06	*Austrodanthonia* grassland, BSR 4	Exotic	0.4
Majura Valley			
Canberra International Airport, MA03	*Austrodanthonia* grassland, BSR 2, 3	Native pasture, BSR 5	44.2
Jerrabomberra Valley			
Amtech, JE09	*Austrodanthonia* grassland, BSR 4	Exotic	6.2
Canberra Central			
Constitution Avenue, Reid, CC02	Dry *Themeda* grassland, BSR 3	Exotic	2.3
Lady Denman Drive, CC07	*Austrodanthonia* grassland, BSR 3	Exotic	2.1

(Continued) ▶

2. (c) *(Continued)*

Area/Site Name	Floristic Association—1997	2005 Classification	Decrease in Area (ha)
Gungahlin			
Belconnen Pony Club, GU06	*Austrodanthonia* grassland, BSR 3	Exotic	1.2
Kenny North, GAP 11	*Austrostipa* grassland, BSR 4	Exotic	11.4
Gundaroo Road South, GAP 8	*Austrostipa* grassland, BSR 4	Exotic	4.2
Kenny, GAP 12	*Austrostipa* grassland, BSR 4	Exotic	1.7
TOTAL (reduction in area of Natural Temperate Grassland)			**145.2**

Note that all these sites retain some native grassland.

3. Sites Formerly Described as Natural Temperate Grassland, but Re-assessed as Secondary Grassland or Woodland and Now Included in the *ACT Lowland Woodland Conservation Strategy* (ACT Government 2004a)

Area/Site Name	Floristic Association—1997	Area (ha)
Gungahlin		
Horse Park Entrance, GAP 1	Wet *Themeda*, *Austrodanthonia* grassland, BSR 3, 4	32.1
Mulanggari Grassland Reserve, GU01	*Austrodanthonia* grassland, BSR 3	23.5
Kosciusko Ave., Palmerston, GAP 7	Dry *Themeda* and *Austrostipa* grassland, BSR 3, 4 (developed)	14.2
Harrison, GAP 5	*Austrostipa* grassland, BSR 4	4.7
Majura Valley		
Majura Training Area, MA01	*Austrodanthonia* grassland, BSR 2	15.6
Jerrabomberra Valley		
'Woden Station', JE03	*Austrodanthonia* grassland, BSR 2	10.9
Belconnen		
Caswell Drive, BE10	Dry *Themeda* grassland, BSR 3	1.0
TOTAL (included in Lowland Woodland Conservation Strategy)		**102.0**

Note:

1. **GAP** (Grassland Action Plan) location numbers are from Action Plan 1 (ACT Government 1997a).
2. **BSR**: Botanical Significance Rating (see Appendix 1).
3. **Site numbers (e.g. MA01)**: A complete list is contained in Table 3.2

APPENDIX

3 Specific and Common Names of Species in this Strategy

NATIVE GRASSES

Bothriochloa macra	Red Grass
Chloris truncata	Windmill Grass
Danthonia spp.	Wallaby Grasses
D. caespitosa	Ringed Wallaby Grass
D. carphoides	Short Wallaby Grass
D. laevis	Wallaby Grass
Elymus scaber	Common Wheat Grass
Enneapogon nigricans	Niggerheads
Poa spp.	Tussock Grasses
Poa labillardieri	Tussock Grass
P. sieberiana ssp. *sieberiana*	Tussock Grass
Panicum effusum	Hairy Panic
Stipa spp.	Spear grasses
S. scabra ssp. *falcata*	Spear grass
S. bigeniculata	Spear grass
Themeda triandra	Kangaroo Grass

NATIVE FORBS

Asperula conferta	Common Woodruff
Bulbine bulbosa	Golden Lily
Carex appressa	Sedge
C. inversa	Common Sedge
Chrysocephalum apiculatum	Common Everlasting
Goodenia pinnatifida	Scrambled Eggs
Haloragis heterophylla	Perennial Raspweed
Hydrocotyle laxiflora	Stinking Pennywort
Juncus spp.	Rushes
Leptorhynchos squamatus	Scaly Buttons
Microseris lanceolata	Yam Daisy
Oxalis perennans	Wood Sorrel
Plantago varia sens. lat.	Variable Plantain
Psoralea tenax	Emu Foot
Rutidosis leptorrhynchoides	Button Wrinklewort
Solenogyne dominii	Solenogyne
Stackhousia monogyna	Creamy Candles
Swainsona monticola	Purple Pea
S. sericea	Purple Pea
S. recta	Purple Pea
Thesium australe	Toadflax
Triptilodiscus pygmaeus	Common Sunray
Vittadinia muelleri	Narrow-leaf New Holland Daisy
Wahlenbergia spp.	Native bluebells
Wurmbia dioica	Early Nancy

EXOTIC GRASSES

Aira caryophyllea	Silvery Hairgrass
Aira elegantissima	Delicate Hairgrass
Avena spp.	Wild Oats
Bromus hordaceous	Brome
Dactylis glomerata	Cocksfoot
Holcus lanatus	Yorkshire Fog
Phalaris aquatica	Phalaris
Poa pratensis	Kentucky Bluegrass
Vulpia myuros	Rat's Tail Fescue

EXOTIC FORBS

Arctotheca calendula	Cape Weed
Carthamus lanatus	Saffron Thistle
Centaurium erythraea	Common Centaury
Cerastium glomeratum	Chick weed
Cirsium vulgare	Spear Thistle
Hypochaeris glabra	Smooth Catsear
Hypochaeris radicata	Flatweed
Paronchyia brasiliana	Chilean Whitlow
Rumex crispus	Curled Dock
Tolpis umbellata	Tolpis
Tragopogon porrifolius	Salsify
Tragopogon dubius	Salsify
Trifolium spp.	Clovers
T. arvense	Haresfoot Clover
T. campestre	Hop Clover
T. dubium	Yellow Suckling Clover
T. glomeratum	Clover
T. repens	White Clover

INVERTEBRATES

Cooraboorama canberrae	Canberra Raspy Cricket
Keyacris scurra	Key's Matchstick
Perunga ochracea	Perunga Grasshopper
Synemon plana	Golden Sun Moth

REPTILES

Aprasia parapulchella	Pink-tailed Worm Lizard
Delma impar	Striped Legless Lizard
Lampropholis delicata	Delicate Skink
Tympanocryptis pinguicolla	Grassland Earless Dragon

AMPHIBIANS

Lymnodynastes dumerilii	Eastern Banjo Frog
Neobatrachus sudelli	Spotted Burrowing Frog
Uperoleia laevigata	Orange-groined Toadlet

BIRDS

Ardeotis australis	Australian Bustard
Coturnix australis	Brown Quail
Coturnix novaezeelandiae	Stubble Quail
Ephthianura albifrons	White-fronted Chat
Gallinago hardwickii	Latham's Snipe
Gymnorhina tibicen	Australian Magpie
Pedionomus torquatus	Plains Wanderer
Rhipidura leucophrys	Willy Wagtail

APPENDIX

4 Threatened Plant Species in Natural Temperate Grassland in the ACT (declared under the *Nature Conservation Act 1980* (ACT))

Appendix 4.1

Button Wrinklewort (*Rutidosis leptorrhynchoides*)

(Illustration: John Pratt)

In accordance with section 21 of the *Nature Conservation Act 1980*, the **Button Wrinklewort (*Rutidosis leptorrhynchoides*)** was declared an **endangere**d species on 15 April 1996 (formerly Determination No. 29 of 1996 and currently Determination No. 7 of 1998). Section 23 of the Act requires the Conservator of Flora and Fauna to prepare an Action Plan in response to each declaration. The Action Plan requirements are incorporated into this *Lowland Native Grassland Conservation Strategy*.

Conservation Status (ACT) Endangered

Criteria satisfied (ACT Flora and Fauna Committee 1995)

The species is known or suspected to occur in the ACT region and is already recognised as endangered in an authoritative international or national listing.

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 the following:

- Current severe decline in population or distribution, from evidence based on:
  - —direct observation, including comparison of historical and current records; and
  - —severe decline in quality or quantity of habitat.
- Imminent risk of severe decline in population or distribution from evidence based on severe decline in quality or quantity of habitat.
- Severely fragmented distribution for a species currently occurring over a small range or having a small area of occupancy within its range.

DESCRIPTION

The Button Wrinklewort (*Rutidosis leptorrhynchoides*) is a slender perennial forb, 25–35 cm tall with up to 30 leafy stems, branching mainly at the base. The leaves are narrow, dark green, ageing to yellow–green and up to 3.5 cm long and 1.5 mm wide, with rolled edges concealing the undersides. The stems usually die back in late summer or autumn, and the new basal leaves appear by early winter. The species has bright yellow button flowers (2 cm wide) from December to April.

DISTRIBUTION AND ABUNDANCE

R. leptorrhynchoides appears to have been formerly widespread in south-eastern New South Wales and across the western plains of Victoria. The species has a disjunct distribution and is known from 17 populations in the ACT region (ten within the ACT, six near

Queanbeyan and one near Goulburn (NSW)) and nine in Victoria. Current populations range in size from five to approximately 95,000 plants. These are often restricted to small, scattered refugia that have escaped grazing, ploughing and the application of fertilisers, for example, road margins, railway easements and cemeteries (Young 1997).

Of the nine sites occurring within the ACT, two have large populations. The larger is within Stirling Park, Yarralumla, where up to 70 000 plants have been recorded (A. Young and F. Zich unpublished data). The other, comprising about 30 000 plants, occurs on the Majura Training Area, although this is confined to a small area and is therefore vulnerable to damage (Crawford and Rowell 1996). Smaller populations occur on Red Hill, at Barton, on the edge of Capital Hill, near West Block, the Campbell Park Offices and near HMAS Harman, in the Jerrabomberra Valley.

In NSW, the species is known to occur naturally at six sites within the Queanbeyan area, with the largest population (10 000 plants in February 1995) being found within the Queanbeyan Nature Reserve (A. Young and F. Zich unpubl. data). Other sites occur at 'The Poplars' near Jerrabomberra, Letchworth, along the slopes of Mt. Jerrabomberra, and along a roadside by the Queanbeyan–Captains Flat Road.

The largest known NSW population is at Gundary Reserve, a Travelling Stock Reserve and Arboretum, 5 km SSE of Goulburn, NSW and contains 95 000 plants (A. Young unpubl. data).

HABITAT

In the ACT, *R. leptorrhynchoides* occurs on the margins of open stands of Yellow Box–Red Gum Grassy Woodland with a ground layer of various native grasses and other forbs, and extends into Natural Temperate Grassland. Soils are usually shallow stony red–brown clay loams. Occasionally, Apple Box (*Eucalyptus bridgesiana*) is also present.

Rutidosis leptorrhynchoides prefers an open habitat and is a poor competitor amongst tall, dense sward-forming grasses. It is found where the soil is too shallow to support the growth of plants that may rapidly overtop it, or on deeper soils where the vegetation is kept short by regular disturbance (Scarlett and Parsons 1990). It may also be adapted to the sparser *Themeda* growth found under trees in woodlands (Morgan 1995a).

BIOLOGY

The population density of the species affects seed production, with sparsely distributed individuals producing fewer seeds per inflorescence than plants from denser colonies. This suggests that the species is dependent on the maintenance of the standing population for recruitment (Morgan 1995a).

In Victoria, recruitment may be limited by high summer mortality of seedlings in open microsites and by deep shading in dense, unburnt grasslands (Morgan 1995b).

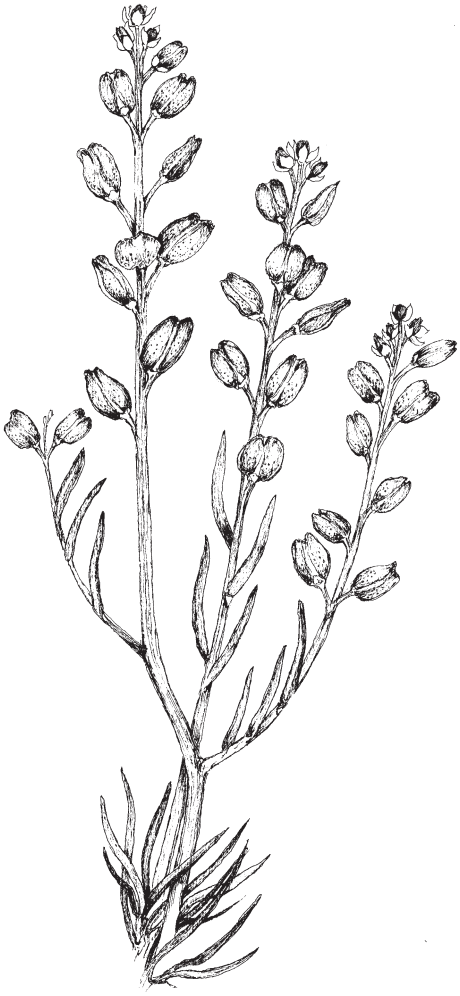
The reproductive potential and viability of small remnant populations may also be limited by inbreeding and related reductions in fitness (inbreeding depression). Research using genetic markers to characterise the mating patterns of *R. leptorrhynchoides* shows evidence of increased potential for mating among relatives in populations of less than 200 plants, especially when these are isolated by more than 5 km from other populations. The demographic consequences of this are as yet unknown, but could be significant.

Reproductive capability of populations also depends on their chromosome number. Chromosome counts of *R. leptorrhynchoides* show the species to be cytologically complex. Northern populations in the ACT and NSW are diploid (2n=26), while in the south of the range, Victorian populations are either wholly diploid, or primarily tetraploid (2n=44), with a mix of anueploids and even some hexaploids. Diploids produce more seed per head than tetraploids and any mating between the two ploidy levels produces few seed, all of which are triploids with low pollen fertility (Young 1997).

R. leptorrhynchoides has been the subject of considerable ecological and genetic research aimed at understanding the factors that limit population viability. Most of this is reviewed in Young *et al.* (2000). Issues and options for the genetic conservation of the species are contained in Young (2001).

Appendix 4.2

Ginninderra Peppercress (*Lepidium ginninderrense*)



(Illustration: Kim Neubauer)

In accordance with section 21 of the *Nature Conservation Act 1980*, the **Ginninderra Peppercress (*Lepidium ginninderrense*)** was declared an **endangered** species on 4 September 2001 (Instrument No. 192 of 2001). Section 23 of the Act requires the Conservator of Flora and Fauna to prepare an Action Plan in response to each declaration. The Action Plan requirements are incorporated into this *Lowland Native Grassland Conservation Strategy*.

Conservation Status (ACT) Endangered

Criteria satisfied (ACT Flora and Fauna Committee 1995)

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:

- Severely fragmented distribution for a species currently occurring over a small range or having a small area of occupancy within its range.

DESCRIPTION

The Ginninderra Peppercress *Lepidium ginninderrense* N. H. Scarlett is a perennial herb to a maximum height of about 20 cm, with one to six branched stems arising from a rootstock. Stems are striate and moderately papillose. Leaves are thick and fleshy, glabrous and shiny on the upper surface. Rosette leaves are widely spaced and very narrow (1.5 to 2.0 mm wide) and 15–55 mm long. The inflorescence is an elongating raceme with a maximum length of 15 cm. Flowers are small, 2 mm wide and 1.5 mm long. Sepals are less than 1 mm long and about 0.5 mm wide, green and with scarious margins. Petals are absent (Scarlett 2001). *Lepidium ginninderrense* flowers in late spring. It sets seed mainly in December and the majority of seed is dispersed before August (Avis 2000).

DISTRIBUTION AND ABUNDANCE

The only known population of *Lepidium ginninderrense* occurs in the north-west corner of Belconnen Naval Transmission Station in the suburb of Lawson in the Australian Capital Territory (which is the type locality). The population is currently about 2000 plants, occupying an area of 90 x 30 metres (Avis 2000).

A second record of *L. ginninderrense* is from 1952 in the ACT suburb of Reid, however, a recent search failed to locate the species in this area (M. Gray pers. comm. cited in Scarlett 2001).

L. ginninderrense has been recorded only from these two cited localities in the ACT and is not known from outside the ACT. The species is remarkably disjunct from all other members of the allied *Lepidium* section *Papillosa* in south-eastern Australia, which are mainly confined to the inland plains west and north of the Eastern Highlands (Scarlett 2001).

HABITAT

At the type locality *Lepidium ginninderrense* grows on the flood plain of Ginninderra Creek, in Natural Temperate Grassland dominated by *Austrodanthonia* spp. and *Bothriochloa macra*. Associated herbaceous species include *Plantago gaudichaudii*, *Juncus filicaulis*, *Triptilodiscus pygmaeus*, *Parentucellia latifolia* and *Calocephalus citreus* (Scarlett 2001).

Avis (2000) has shown that *L. ginninderrense* grows in areas with relatively low perennial grass cover, often with indications of past soil disturbance.

The soil type over most of the site is a shallow red earth, with patches of colluvium on the footslopes (Crawford and Rowell 1995a cited in Lowe 1996, p. 41). The population occurs at an altitude of approximately 580 metres.

BIOLOGY

Almost nothing is known about the general biology of the species but fecundity (seed set) appears to be good. The species may still contain significant genetic variation that could form the basis for a conservation strategy (Young 2001).

APPENDIX

5 Threatened Animal Species in Natural Temperate Grassland in the ACT (declared under the *Nature Conservation Act 1980* (ACT))

Appendix 5.1

Striped Legless Lizard (*Delma impar*)

In accordance with section 21 of the *Nature Conservation Act 1980*, the **Striped Legless Lizard (*Delma impar*)** was declared a **vulnerable** species on 15 April 1996 (formerly Determination No. 29 of 1996 and currently Determination No. 89 of 1997). Section 23 of the Act requires the Conservator of Flora and Fauna to prepare an Action Plan in response to each declaration. The Action Plan requirements are incorporated into this *Lowland Native Grassland Conservation Strategy*.

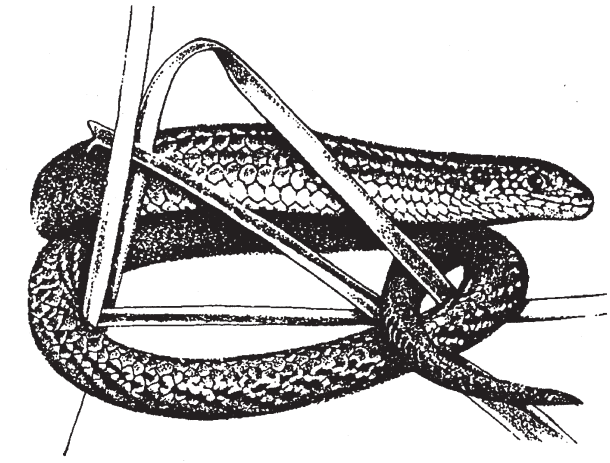


Figure 1: Striped Legless Lizard (*Delma impar*)

(Illustration: Marjorie Crosby-Fairall)

Conservation Status (ACT) Vulnerable

Criteria satisfied (ACT Flora and Fauna Committee 1995)

The species is known to occur in the ACT region and is already recognised as vulnerable in an authoritative international or national listing.

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 the following:

- Current serious decline in population or distribution from evidence based on:
  - —serious decline in quality and quantity of habitat;
  - —high actual or potential levels of exploitation or persecution; and
  - —serious threats from herbivores, predators, parasites, pathogens or competitors.
- Imminent risk of serious decline in population or distribution from evidence based on the above.
- Seriously fragmented distribution for a species currently occurring over a moderately small range or having a moderately small area of occupancy within its range.

DESCRIPTION

The Striped Legless Lizard *Delma impar* (Fischer 1882) (Figure 1) is a reptile of the family Pygopodidae. The average snout-vent length of adults is 90 mm (Cogger 2000), with a maximum total length of about 300 mm and an average body weight of 4.1 grams (Coulson 1990). Sexes are externally similar.

The species is variable in colour but is most commonly pale grey-brown above, with a series of dark brown or blackish longitudinal stripes along the length of the body and tail, commencing at the neck (Cogger 2000). A large amount of variation exists between individuals in colour and intensity of the striping, and in some animals (particularly in the young), striping is indistinct or absent. The colour of the head is darker than that of

the body, being dark brown to dark slate grey in adults and black in young individuals. The ventral surface has been described as whitish (Cogger 2000), however some individuals have salmon-pink coloration on the flanks that may extend to the undersurface. Most individuals have yellow coloration on the infralabial and adjacent gular scales, extending back to the tympanum (Coulson 1990). The Striped Legless Lizard can usually be distinguished from the Inornate Legless Lizard *Delma inornata*, a closely related species that also occurs in the ACT region, by the presence of stripes.

Legless lizards superficially resemble small snakes, however, they can be readily distinguished from snakes by having a visible ear opening, fleshy broad tongue, the presence of remnant hindlimbs (which are reduced to two scaly flaps near the vent) and a tail that is longer than the body, which can be voluntarily shed.

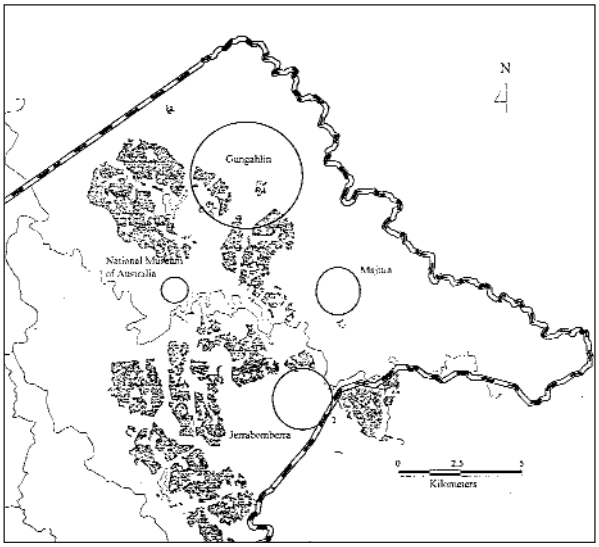


Figure 2: Four Areas Known to Support *Delma impar* in the ACT

DISTRIBUTION AND ABUNDANCE

ACT Distribution

In the ACT, the potential range of the species prior to European settlement is likely to have been within the more or less continuous area of treeless plains covering over 20 000 hectares. However, most of this area has been developed for urban and related purposes and the current distribution of the Striped Legless Lizard in the ACT is a fragmented one, with four disjunct populations recognised (Figure 2): Gungahlin, Yarramundi Reach, Majura Valley and the Jerrabomberra Valley (Rauhala *et al.* 1995). Unsuitable habitat, roads and urban development separate these sites.

Gungahlin

Three grassland reserves (Mulanggari, Gungaderra and Crace) have been established in the Gungahlin area to protect the species. It has also been found in the Kenny area and in some relatively small and isolated patches of habitat (ACT Government 1997b).

Yarramundi Reach

This small area of grassland was surveyed in 1993 and low numbers recorded (Kukolic 1994). The Delma impar population on the site appears to be in decline and may have become extinct.

Majura Valley

This is a large area of habitat with surveys showing the species to be present in moderate densities. To the east of the Majura Road, the habitat comprises part of the Majura Training Area and the Airservices Australia navigational beacon enclosure. To the west of Majura Road, the species has been found in the Campbell Park area but has not been fully surveyed.

Jerrabomberra Valley

The species is currently known only in the grassland to the east of Jerrabomberra Avenue on the Woden, Bonshaw and Wendover properties, as well as on HMAS Harman. In the Jerrabomberra Valley, *Delma impar* has been found in relatively low densities and is more scattered in distribution compared with the Gungahlin area.

Distribution in South-eastern Australia

The geographic range of *Delma impar* is confined to south-eastern Australia. Throughout its range, the species is considered to have suffered a substantial contraction in its distribution since European settlement.

It has been recorded from south-eastern South Australia but the area now appears unlikely to support a population (Coulson 1990; Hadden 1995). It is currently known from scattered locations in Victoria, mainly on the basalt plains to the north and west of Melbourne and in the western district of the state (Department of Conservation and Environment 1992). Surveys by the NSW National Parks and Wildlife Service in 1998–9 identified populations near Yass and Goulburn. Other records are for Cooma (1995) (Biosis Research Pty Ltd 1995) and Batlow (1977) (Cogger *et al.* 1993

HABITAT

The Striped Legless Lizard is found primarily in lowland native grasslands (Coulson 1990; Osborne, Kukolic and Williams 1993). This habitat type occurs on flat or gently undulating plains (Coulson 1990; Hadden 1995),

and is dominated by perennial, tussock-forming grasses such as Kangaroo Grass *Themeda triandra*, spear grasses *Austrostipa* spp. and wallaby grasses *Austrodanthonia* spp. (Coulson 1990; Hadden 1995). The species is also found in some areas dominated by exotic grasses (Coulson 1990; Williams and Kukolic 1991; Kukolic *et. al.* 1994; Rauhala *et. al.* 1995; Hadden 1995). A tussock structure in grassland appears to be an important habitat characteristic (Wildlife Research Unit 1994; Hadden 1995), although little is known about the way in which the vegetation is utilised. There is evidence that lizards over-winter at the base of grass tussocks or just below the soil surface (Wildlife Research Unit 1994). Soils that have a moderate to high clay content and often produce cracks in summer are another habitat feature. In Victoria, most sites supporting the species have a cover of lightly embedded rocks, although this is not a feature of its habitat in the ACT (Hadden 1995).

Although the Striped Legless Lizard is found in both primary and secondary grasslands, Dorrough (1995) found that it inhabited secondary grasslands only within two kilometres of primary grasslands.

Most areas where the species persists, are thought to have had low to moderate levels of agricultural disturbance in the past (Coulson 1990; Hadden 1995; Dorrough 1995). It has been suggested (Coulson 1990; Dorrough 1995) that ploughing in particular may be incompatible with the survival of the species.

BEHAVIOUR AND BIOLOGY

The Striped Legless Lizard is known to feed on a variety of insects and arthropods including spiders, crickets, cockroaches and caterpillars (Coulson 1990; Wainer 1992; Nunan 1995). The species may display some selectivity in its diet, with *Lepidoptera* larvae (caterpillars) being implicated as a particularly important food resource (Nunan 1995).

The species is diurnal and active on the ground surface from late spring to early autumn, with a peak in activity in November and December (Kukolic 1994). Gravid individuals are commonly caught in these months, with two eggs being laid in December. There is some evidence for communal oviposition and that sometimes; eggs may be laid under rocks or other substrate (Mills 1992; Rauhala 1996). Incubation periods of between 35 and 60 days have been observed in captivity under ideal conditions; however, the incubation period is likely to be longer in the field.

The longevity of the species is not known but a maximum of ten years has been estimated (Webster *et al.* 1991; Dorrough 1995).

Appendix 5.2

Grassland Earless Dragon (*Tympanocryptis pinguicolla*)

In accordance with section 21 of the *Nature Conservation Act 1980*, the Grassland Earless Dragon (Tympanocryptis pinguicolla) was declared an endangered species on 15 April 1996 (formerly Determination No. 29 of 1996 and currently Determination No. 89 of 1997). Section 23 of the Act requires the Conservator of Flora and Fauna to prepare an Action Plan in response to each declaration. The Action Plan requirements are incorporated into this *Lowland Native Grassland Conservation Strategy*.

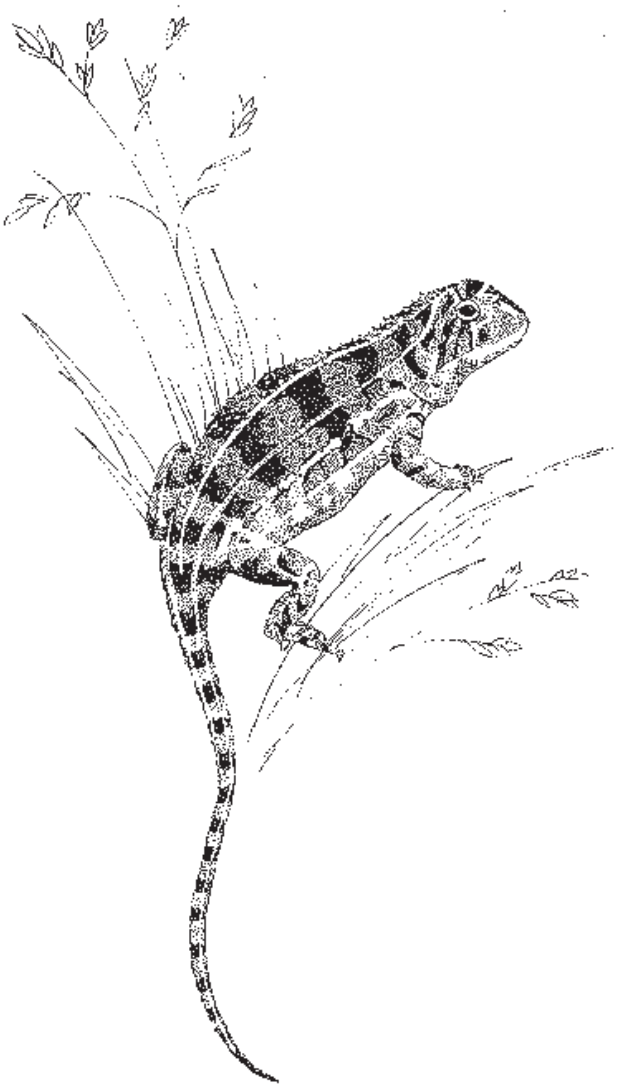


Figure 1: Grassland Earless Dragon (*Tympanocryptis pinguicolla*)

(Illustration: Liz Faull)

Conservation Status (ACT) Endangered

Criteria satisfied (ACT Flora and Fauna Committee 1995)

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:

- Current severe decline in population or distribution from evidence based on:
  - —severe decline in quality or quantity of habitat; and
  - —severe threats from herbivores, predators, parasites, pathogens or competitors.
- Severely fragmented distribution for a species currently occurring over a small range or having a small area of occupancy within its range.
- Extremely small population.

DESCRIPTION

This species was originally considered to be a sub-species of *Tympanocryptis lineata* and named *Tympanocryptis lineata pinguicolla* (Mitchell 1948). Smith et al. (1999) reviewed the systematic status of *Tympanocryptis* in south-eastern Australia and determined that *T. l. pinguicolla* should be raised to specific status and thus be renamed *Tympanocryptis pinguicolla*. The common name has been changed from Eastern Lined Earless Dragon to Grassland Earless Dragon.

The Grassland Earless Dragon (*Tympanocryptis pinguicolla*) is a member of the family Agamidae, the dragon lizards. Most members of the genus *Tympanocryptis*, including *T. pinguicolla*, lack an external ear opening (Greer 1989) and a functional tympanum (ear drum) (Witten 1993).

T. pinguicolla is a small lizard with a stout body and short robust limbs (Figure 1). Total adult body length is between 180 and 210 mm (Smith 1994). These lizards have three longitudinal light stripes on the dorsal surface and the ventral surface is either intricately patterned with dark brown or grey markings or immaculate white or cream. They are diurnal and are cryptic in their grassland habitat. When captured, individuals can be identified from distinct grey and dark brown dorsal surface markings (Nelson *et al.* 1996) that usually form thick irregular transverse bars across the body and down the tail. Many individuals exhibit yellow or orange flushing of the throat that sometimes extends to the sides of the head and down the dorsal stripes and flanks (Smith 1994). Differentiation of these markings occurs between sexes and age classes (Langston 1996). Specimens usually have a narrow

pale bar on their head between the anterior corners of the eyes (Cogger 2000).

T. pinguicolla is distinguished from other *Tympanocryptis* in south-eastern Australia by its greater number of mid-body dorsal scales and greater number of scattered dorsal spinous scales which are also higher than their basal width (Mitchell 1948; Smith 1994; Smith *et al.* 1999).

DISTRIBUTION AND ABUNDANCE

Former Distribution

In 1938 Pryor described the species as more common than the Brown Snake (*Pseudonaja textilis*) in the ACT, and animals were captured adjacent to Northbourne Avenue in the 1950s (Pryor 1938; Young 1992).

NSW records show that the species occurred near Cooma in the Southern Tablelands (Mitchell 1948) and at Bathurst (Osborne, Kukolic *et al.* 1993).

Most former records of *T. pinguicolla* in Victoria are from the basalt plains in the south of the state (Brereton and Backhouse 1993). There are also records from Maryborough and Rutherglen in central Victoria (Lucas and Frost 1894).

Present Distribution

T. pinguicolla has shown a dramatic decrease in its geographical range. The species is found in small and seasonally variable numbers in seven sites with suitable native grassland habitat in the Majura and Jerrabomberra valleys in the ACT and at 'Letchworth' near Queanbeyan in NSW (Figure 2). The lizards have also been recorded at several sites near Cooma (Osborne, Kukolic and Williams 1993; Biosis Research Pty Ltd 1995).

From the early 1990s considerable survey and research effort has been directed towards the species. The Action Plan for the species (ACT Government 1997c) identified survey and monitoring as important components of the conservation management of the species. Surveys have been undertaken of areas of potential habitat and a monitoring program of known populations is in place (e.g. Dunford et al. 2001; Evans and Ormay 2002).

Surveys of potentially suitable habitat at the Belconnen Naval Station, in areas outside of Public Land Nature Reserve, and in the Crace and Mulanggari grassland reserves at Gungahlin have failed to locate the species (Kukolic 1992; Nelson et al. 1996; Dunford et al. 2001; Evans and Ormay 2002). Similarly, Langston (1996) surveyed for the species in the Gundaroo, Bungendore and Hoskingtown areas without success. In 2000, the NSW National Parks and Wildlife Service conducted surveys for the species in the Bungendore and Goulburn areas but none were found.

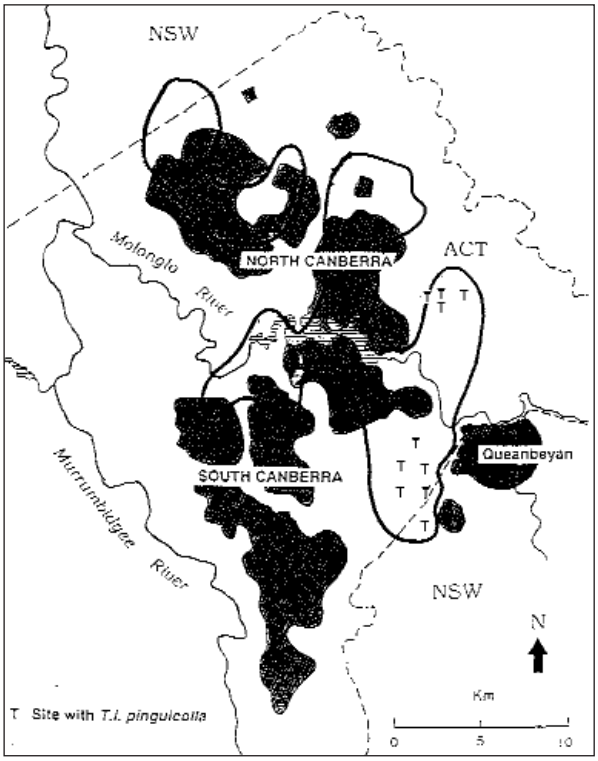


Figure 2: Distribution (T) of *Tympanocryptis pinguicolla* in the ACT and adjacent region. Former extent of natural temperate grassland outlined.

HABITAT

Observations in the ACT and region indicate that *T. pinguicolla* is found in Natural Temperate Grassland dominated by wallaby grasses (*Austrodanthonia* spp.), spear grasses (*Austrostipa* spp.), Kangaroo Grass (*Themeda triandra*) and tussock grasses (*Poa* spp) (ACT Government 1997c; Robertson and Cooper 2000). Capture locations in the ACT suggest that the animals prefer well-drained Natural Temperate Grasslands that are relatively undisturbed and minimally pasture-improved. Nelson *et al.* (1998) also recorded the species in *Austrostipa* dominated grassland with low diversity, which had been modified by pasture improvement and weed invasion. There appears to be a preference for shorter grassland with an open structure or with open areas, however, the patchy occurrence of *T. pinguicolla* within such areas may indicate a more subtle relationship of the species to its grassland habitat (Robertson and Cooper 2000).

T. pinguicolla makes use of arthropod burrows and may retreat into these when alarmed. It also shelters beneath rocks (Victoria, Monaro region NSW) and within *Austrostipa* tussocks (ACT) (Robertson and Cooper 2000).

BEHAVIOUR AND BIOLOGY

Most of what is known about the biology and ecology of *T. pinguicolla* is derived from university research and project work in the last decade (Smith 1994; Langston 1996; Nelson 2004) and survey and monitoring by Environment ACT. Field observation is difficult because *T. pinguicolla* avoids detection by remaining still and uses its cryptic coloration to blend in with its grassland environment (Smith 1994).

Capture data is characterised by a dominance of young animals and low recaptures of previous-year adults (Smith 1994; Langston 1996; Nelson *et al.* 1996) indicating a predominantly annual turnover of adults. This turnover suggests that females breed once and gravid females have been recorded in the field from September to January (Langston 1996). However, some females survive to their second year and may produce a second clutch (Langston 1996).

T. pinguicolla is oviparous (Witten 1993). The only two known records of egg laying are for late November and early December (Langston 1996). Both records comprised a clutch of five eggs, one in a shallow scrape that was covered with soil and small stones to disguise its presence, and the other was unintentionally disturbed with the eggs successfully incubated in the laboratory. Field incubation time has been recorded at 11 weeks and two days (Langston 1996).

Hatching occurs from January to March and hatchlings show rapid growth (mean 0.3 mm/day) approaching adult size by the end of March (Smith 1994). Adult growth rates are much slower with a mean of 0.08 mm/day (Langston 1996). The young may disperse soon after hatching as small lizards have been caught in pitfall traps.

Fat storage in the neck, body and tail is thought to be an adaptation to a cooler climate (Mitchell 1948). Animals in the *T. lineata* group have been found during winter in a torpid state under rocks (Jenkins and Bartell 1980) and in arthropod burrows (Langston 1996). However, active individuals have been observed above-ground in June and trapped in August, suggesting that individuals can be active anytime weather conditions are suitable (Robertson and Cooper 2000).

Although the sizes of home ranges of *T. pinguicolla* are unknown, individuals are highly mobile. Individual adult animals have been shown to move 40 m in a day (Langston 1996) with some movements of more than 230 m between yearly trapping seasons.

Population density may be influenced by social interactions, as aggressive encounters between individuals, involving vocalisation (using a soft hiss) and displays, have been observed in captive animals and in the field (Robertson and Cooper 2000). There appears to be a dominance hierarchy based on the size of individuals (Smith 1994).

T. pinguicolla feeds on a variety of insects, banana and apple in captivity (Robson 1968; Smith 1994). In the field, animals have been observed consuming spiders and insects, however precise field dietary requirements are yet to be determined.

Appendix 5.3

Golden Sun Moth (*Synemon plana*)

In accordance with section 21 of the *Nature Conservation Act 1980*, the **Golden Sun Moth (*Synemon plana*)** was declared an **endangered** species on 15 April 1996 (formerly Determination No. 29 of 1996 and currently Determination No. 7 of 1998). Section 23 of the Act requires the Conservator of Flora and Fauna to prepare an Action Plan in response to each declaration. The Action Plan requirements are incorporated into this *Lowland Native Grassland Conservation Strategy*.

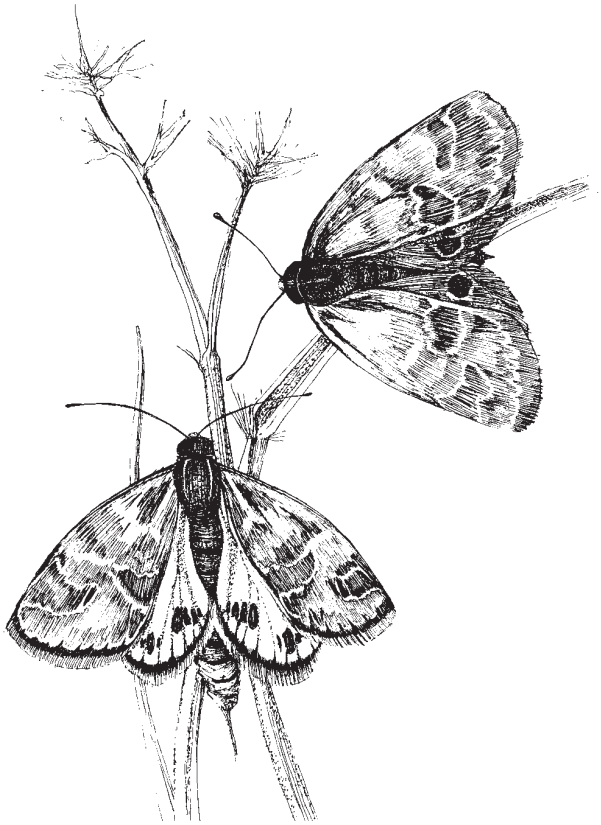


Figure 1: Golden Sun Moth (*Synemon plana*) (female—bottom left; male—top right)

(Illustration: Sarah Reglar)

Conservation Status (ACT) Endangered

Criteria satisfied (ACT Flora and Fauna Committee 1995)

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:

- Current severe decline in population or distribution, from evidence based on:
  - —direct observation, including comparison of historical and current records; and
  - —severe decline in quality or quantity of habitat.
- Continuing decline or severe fragmentation in population, for species with a small current population.

DESCRIPTION

The Golden Sun Moth (*Synemon plana*) is a medium sized moth belonging to the family Castniidae, which is thought to be of Gondwanan origin (Edwards, 1990). The male has a wingspan of about 34 mm, the female about 31 mm. This larger male wingspan is unique in the Australian Castniidae. The upperside of the forewing of the male is dark brown with patterns of pale grey scales and the hind wing is dark bronzy brown with dark brown patches. The underside of both wings of the male is mostly pale grey with dark brown spots. The upperside forewing of the female is very dark grey with patterns of pale grey scales and the hind wing is bright orange with black submarginal spots. The underside of both wings of the female is silky white with small black submarginal spots. The adults have no functional mouthparts. They have strongly clubbed antennae and the female has a long extensible ovipositor. Coloured illustrations may be found in Common (1990) and Fraser and McJannett (1996).

DISTRIBUTION AND ABUNDANCE

At the time of European settlement, *S. plana* was widespread in south-eastern Australia and relatively continuous throughout its range, showing a close correlation with the distribution of native grasslands dominated by *Austrodanthonia* spp. (O'Dwyer and Attiwill 1999a). Museum records show that *S. plana* was still common and widespread prior to 1950, before the advent of extensive pasture improvement and other land use changes that have reduced native grasslands to scattered fragments.

The known distribution of the species from museum specimens extended from Bathurst, NSW, through the

Southern Tablelands of NSW and central Victoria to the South Australian border (Edwards 1993). There are about 30 localities in Victoria represented by museum specimens.

Currently, the species is known from 27 sites in the ACT of various sizes, 42 sites in NSW, and nine sites in Victoria. In the ACT, the species occurs in lowland areas adjacent to the city of Canberra and within the city. There are extensive populations within the Majura Training Area, 'Malcolm Vale', Canberra International Airport and the Belconnen Naval Station. Less extensive populations occur within large grassland sites at 'Woden' property in the Jerrabomberra Valley and in the Mulanggari and Crace Grassland Reserves in Gungahlin. Together, these make up the eight sites of high conservation value. Smaller sites at Campbell Park, York Park in Barton, Mulligans Flat (North and South), North Mitchell, Black Street and Stirling Ridge in Yarralumla and the Dunlop Hills Grassland Reserve in Belconnen contain populations of high to moderate density (Edwards 1994). A further eleven sites contain very small populations, which may not be viable in the short to medium term.

The 42 NSW sites are found within grassland and grassy woodlands near Yass, Boorowa, Binalong, Rye Park, Sutton, Gundaroo, areas immediately north of the ACT, and at Queanbeyan and Tumut (Clarke and Dear 1998). All sites are below 700 m (with the exception of one site south of Queanbeyan recorded at 790 m), suggesting that *S. plana* is a western species at the limit of its range. The survey by Clarke and Dear (1998) did not locate any populations in the Goulburn, Tarago and Bungendore areas, or on the Monaro (Bredbo, Cooma, Adaminaby and Dalgety).

Population estimates for *S. plana* at ACT and NSW sites vary from a few hundred to more than 100 000 individuals (Ginninderra Road and Letchworth, NSW)(Clarke and Dear 1998; ACT Government 1998a). One population estimate based on monitoring is from the small (0.4 ha) site at York Park, Barton, ACT. Population size estimates of males at York Park were 520 (1992–3), 456 (1993–4) and 736 (1994–5) or a mean for the three years of 571 (Harwood *et al.* 1995). This gives a crude population of 1700 males per hectare. There is no information about the sex ratio in adult S. plana, and the females are much more inconspicuous than the males, therefore no female population estimates were attempted at York Park. A 1:1 sex ratio would give a population density of 3500 per hectare. A two-year life cycle would mean that double the number of adults observed is potentially present, but the genetic interchange between the odd and even cohorts may be low.

Population estimates are crude and refer to the number of adults in the population (census size) not the actual number of individuals contributing to the next generation (effective size). Based on census data from a single ACT site, it is estimated that up to 99% of female fecundity is unrealised, through either adult or immature immortality (Clarke and O'Dwyer 2000). Small sites may be less viable than the observed population size would indicate. It is the effective population size that is critical in assessing the extinction risk of a population.

HABITAT

The habitat of *S. plana* is native grassland dominated by wallaby grasses *Austrodanthonia* spp., in particular, *A. carphoides*, *A. auriculata*, *A. setacea* and *A. eriantha*. In a study of eight ACT sites and six Victorian sites (four current, two historical), O'Dwyer and Attiwill (1999a) found that the percentage cover of *Austrodanthonia* at currently inhabited sites was 40% and soils were low in available phosphorus. Weed invasion is a major threat to Austrodanthonia on these sites (O'Dwyer and Attiwill 1999b).

In the ACT, *S. plana* usually occurs in Natural Temperate Grassland dominated by *Austrodanthonia carphoides*. Some populations of the moth at Mulligans Flat occur in grassy areas within open woodland, but all other sites are believed to have been treeless grassland prior to European settlement. In the ACT, these grasslands are not found at an altitude above 630 m. Areas dominated by *A. carphoides* occur in grasslands containing *Austrodanthonia* or *Austrostipa* associations, and may occur in patches in Dry *Themeda* grasslands. Wallaby grass is very low growing with tussocks usually separated by bare ground. These grasslands normally contain several species of *Austrodanthonia* and the species actually fed on by the moth larvae are uncertain.

In NSW, *S. plana* is also found in grasslands dominated by *Austrodanthonia setacea* and *A. auriculata* as well as *D. carphoides* (Clarke and Dear 1998)

In Victoria, *S. plana* may be found in grassland dominated by *Austrodanthonia setacea* (Douglas 1993), *A. pilosa* (Britten *et al.* 1995) and *A. eriantha* (O'Dwyer and Attiwill 1999a, 1999b). Field studies at Mt Piper, where a large *S. plana* population remains, indicate that the habitat of *S. plana* is native grassland dominated by *Austrodanthonia eriantha*, with a smaller cover of *A. auriculata*, *A. carphoides* and *A. racemosa* (O'Dwyer and Attiwill 1999b). A 40% cover of

Austrodanthonia has been shown to be the minimum density required to sustain a *S. plana* in Victoria (Dear 1997; O'Dwyer and Attiwill 1999a).

BEHAVIOUR AND BIOLOGY

The life history of *S. plana* is not fully understood. Common and Edwards (1981) described the life history of *S. magnifica* and the life history of *S. plana* is probably similar (E.D. Edwards, pers. comm. 1996 in O'Dwyer and Attiwill 1999a). The following summary of the life history of the species is drawn mainly from ACT Government (1998a) and Clarke and O'Dwyer (2000).

Most of the life cycle of *S. plana* is in the pre-adult stage. Adults are short lived (1–4 days) and do not feed, having no functional mouthparts. Five days is the longest recorded life span for the male but 1–2 days is normal (Cook and Edwards 1993). Males spend their entire adult life patrolling grassland for females, and females, once mated, spend their time laying eggs within clumps of *Austrodanthonia*. Females are reluctant to fly, even when disturbed, and walk between grass tussocks. Males are capable of active and prolonged flight, usually about one metre above the ground, but will not fly long distances (more than 100 m) from areas of suitable habitat. Thus populations separated by more than 200 m can be considered effectively isolated, and sites from which the moth has gone extinct, or vacant patches of suitable habitat are highly unlikely to be (re)colonised.

S. plana is a day flying moth, active in the warmest part of the day (1000–1400 h) and only under sunny conditions. The flying season is relatively short (6–8 weeks) mainly in November and December, but to early January in the ACT. Warm dry spring weather may result in earlier emergence while cool moist conditions may delay emergence until late November (Cook and Edwards 1993). Adult emergence continues throughout the flying season.

Females are estimated to lay 100–150 eggs (Edwards 1994). It is not known if they are laid singly or in clusters on grass clumps. Eggs are laid between the tillers of an *Austrodanthonia* tussock or between the tillers and the soil. They are inserted into the crevices by the long ovipositor of the female. The larvae feed on the underground parts of the *Austrodanthonia*. Whether the larva needs a single tussock for development or must move between tussocks to complete its development is unknown. The length of the life cycle is unknown, but may vary between one and three years. As noted above, up to 99% of total potential fecundity is unrealised, through either adult or immature mortality but levels of these are not known. Predation of adults has been observed at York Park, Barton, by several species of birds including the Willie Wagtail (*Rhipidura leucophrys*), the Magpie Lark (*Grallina cyanoleuca*), the Starling (*Sturnus vulgaris*) as well as robber flies (*Colepia abludo* and *Brachypogon* sp.) (Cook and Edwards 1993, 1994). Some reptiles may also be predators. No parasites or predators of the early stages have been recorded.

Clarke and O'Dwyer (1998, 2000) assessed the levels of genetic variation and diversity, and investigated patterns of population structure, in a sample of 20 populations of *S. plana* throughout its geographic range (Victoria, ACT, NSW). Genetically, the populations clustered into five distinct groupings corresponding to geographic locations of the populations. The Victorian group (two populations) is significantly different genetically from the other four groupings, and the two Victorian populations, 220 km apart, are significantly different from one another. These results conform to an isolation by distance model, in which genetic distance is correlated with geographical distance.

The level of genetic differentiation among groups may be sufficient for each group to be subject to separate conservation management in an effort to conserve as much genetic diversity as possible for the species. The average genetic differences between the Victorian group and the other four groups can be considered quite high and typical of values that distinguish sub-species or races. Given the limited mobility of the species, the lack of differentiation between closely located populations may indicate that these were all historically connected and have only recently undergone fragmentation.

Appendix 5.4

Perguna Grasshopper (*Perunga ochracea*)

In accordance with section 21 of the *Nature Conservation Act 1980*, the **Perunga Grasshopper (*Perunga ochracea*)** was declared a **vulnerable** species on 19 May 1997 (formerly Instrument No. 89 of 1997 and currently Instrument No. 192 of 1998). Section 23 of the Act requires the Conservator of Flora and Fauna to prepare an Action Plan in response to each declaration. The Action Plan requirements are incorporated into this *Lowland Native Grassland Conservation Strategy*.

Figure 1: Perunga Grasshopper (*Perunga ochracea*) (Female (above) and male (below))

(Illustration: Fiona Sivyer)

Conservation Status (ACT) Vulnerable

Criteria satisfied (ACT Flora and Fauna Committee 1995)

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:

- Current serious decline in population or distribution, from evidence based on:
  - —direct observation, including comparison of historical and current records; and
  - —serious decline in quality or quantity of habitat.
- Seriously fragmented distribution for a species currently occurring over a moderately small area of occupancy within its range.

DESCRIPTION

The Perunga Grasshopper, *Perunga ochracea* is the only described species in the genus (Orthoptera: Acrididae: Catantopinae). The Australian National Insect Collection (ANIC), Canberra, has specimens also of an undescribed species (designated as *Perunga* sp. 1), known only from South Australia. *Perunga* belongs to the sub-tribe Apotropina of the tribe Catantopini (Rentz 1996). Members of the sub-tribe are characterised principally by the stout femur of the hind leg and the presence of an auditory tympanum on the anterior abdomen under the wings. In males, there is a furcula (a forked structure) near the tip of the abdomen. Both sexes of *P. ochracea* are short-winged and flightless (Figure 1).

The species is distinctive in having the pronotum (the dorsal surface of the first thoracic segment) wrinkled and slightly extended caudally. In the Canberra region, the species is distinguished further by the appearance on the pronotum of a pale 'X' (D. Rentz pers. comm.), which is the most useful field identification characteristic. The wings are shorter than the length of the pronotum and possess many raised longitudinal veins. Adult females range in length from 26–35 mm and adult males from 15–20 mm. Males possess short, rounded furculae and simple, elongate cerci (the pair of appendages at the apex of the abdomen), each with a blunt, rounded tip which is slightly deflexed. Females bear very short, stout cerci and the dorsal ovipositor valves are strongly recurved. Adults are variable in colour, ranging from brown to grey and often with green. Colour can vary from year to year with a tendency toward grey-brown in dry years and greenish in wet years (R.C. Lewis pers. comm.). A colour photograph is found in Rentz (1996).

DISTRIBUTION AND ABUNDANCE

Perunga ochracea has been collected mainly as individuals or in low numbers, though population

densities may vary among years and sites (ACT Government 1999).

The species was first described from Wagga Wagga in NSW. Until the collection of individuals in surveys in 1997–1998, and one individual taken at Mt Majura in 1992, all specimens in the ANIC were collected prior to 1970. They came from near Wagga Wagga (at Uranquinty), Boorowa or nearby Galong, or from the ACT and adjacent areas of NSW, including Jeir, Murrumbateman and Queanbeyan. Localities in the ACT where ANIC specimens of *P. ochracea* had been collected include Black Mountain, Gungahlin, 1.6 km SW of Hall, 3.2 km NE of Kambah Pool, at the foot of Mt Stromlo, at Reid and near Weetangera.

In 1975–76 *P. ochracea* was recorded from specific localities in Tuggeranong (now the suburbs of Calwell and Gordon) and the lower slopes of Mt Jerrabomberra (in areas that are now housing estates). There are also records from sites on the edge of Naas Road north of the junction of the Gudgenby and Naas rivers and near the cork oak plantation adjacent to William Hovell Drive (R.C. Lewis pers. comm.).

In 1997–8 *P. ochracea* was found in Natural Temperate Grassland in the Mulanggari, Gungaderra and Crace Nature Reserves at Gungahlin, in the Majura Valley (Majura Training Area, Air Services Australia Beacon site and the Campbell Park paddocks), in the Jerrabomberra Valley ('Woden' property) and in Belconnen Naval Station (Stephens 1998, Dunford pers. comm.). In addition, a female specimen was collected in the grassland at Letchworth Housing Estate near Queanbeyan in December 1997 (Stephens 1998). More recently, new sites have been found in Natural Temperate Grassland in the Jerrabomberra Valley (2001–2) and a single specimen at East O'Malley (2002). A new population has also been located in NSW.

On the basis of ANIC and other records, it is suggested that the species has a small range stretching 180 km east-west and 150 km north-south. However, the area of occupancy within this range is likely to be low because of the reduction in size or extinction of populations through habitat alteration and fragmentation. The ANIC records and recent collections suggest that the species was once quite widespread across the ACT.

No population studies have been undertaken, therefore it is impossible to estimate population sizes.

HABITAT

In the ACT, *P. ochracea* has been found in both Natural Temperate Grassland dominated by *Danthonia* spp., *Stipa* spp. or *Themeda triandra*, and in native pasture (Stephens 1998, M. Dunford pers. comm.). The species may also occur in open woodland areas with a grassy understorey, including the endangered Yellow Box–Red Gum Grassy Woodland community, as suggested by earlier collections from the Black Mountain and Mt Majura areas. Field observations suggest that the species uses grass tussocks as shelter spaces. Stephens (1998) recorded several individuals in heavily grazed habitats, where the availability of dense grass tussocks was low. Despite this, these individuals were found in or near grass tussocks, suggesting they are an essential habitat requirement.

BEHAVIOUR AND BIOLOGY

P. ochracea is a cryptic grasshopper which is difficult to see unless first disturbed. When disturbed, the species appears to actively seek shelter, jumping once or twice before burying itself into a grass tussock. It is a powerful jumper, covering distances of a metre or more.

Nymphs hatch in late summer and autumn, and develop over the winter and early spring (Rentz 1996). This is unusual compared with most other ACT grasshopper species that overwinter as eggs rather than nymphs. Adults of *P. ochracea* have been collected from late October to mid February (ANIC specimens). The life cycle is a single year.

It has been suggested that *P. ochracea* has a dietary relationship with *Chrysocephalum* spp. (Rentz 1996), largely due to collection of the species at sites containing these forb species, particularly Common Everlasting (*Chrysocephalum apiculatum*). Dietary analysis undertaken by Stephens (1998) found that all six individuals of *P. ochracea* examined had consumed forb species. *Perunga* sp. 1, from South Australia, has been recorded eating several species of forbs, both flowerheads and leaves. In feeding trials, *Perunga* sp. 1 readily fed on the petals and flowers of Capeweed (*Arctotheca calendula*) and less so on wild geranium (*Erodium* spp.) and *C. apiculatum* (P. Birks pers. comm.). Although Stephens (1998) ultimately made no attempt to determine the exact forb species that *P. ochracea* was eating, there was no evidence from crop contents that the individuals collected had consumed *C. apiculatum*, despite this forb species being present where the individuals were collected.

Although no work has been done to identify predators of *P. ochracea*, parasitic wasps (*Scelio* spp.) in south-eastern Australia have been shown to regulate some populations of other acridid grasshoppers (Baker *et al.* 1996). Vertebrate predators such as birds may reduce population numbers, as shown in other studies of grasshopper assemblages (e.g. Belovsky and Slade 1993).

REFERENCES

ACT Flora and Fauna Committee 1995 *Threatened Species and Communities in the ACT: Criteria for Assessment* (ACT Government, Canberra).

ACT Government 1997a *Natural Temperate Grassland: An endangered ecological community*. Action Plan No. 1 (Environment ACT, Canberra).

ACT Government 1997b *Striped Legless Lizard* (Delma impar): *A vulnerable species*. Action Plan No. 2 (Environment ACT, Canberra).

ACT Government 1997c *Grassland Earless Dragon* (Tympanocryptis pinguicolla): *An endangered species*. Action Plan No. 3 (Environment ACT, Canberra).

ACT Government 1998a *Golden Sun Moth* (Synemon plana): *An endangered species*. Action Plan No. 7 (Environment ACT, Canberra).

ACT Government 1998b *Button Wrinklewort* (Rutidosis leptorrhynchoides): *An endangered species*. Action Plan No. 8 (Environment ACT, Canberra).

ACT Government 1998c *The ACT Nature Conservation Strategy* (ACT Dept of Urban Services, Canberra).

ACT Government 1999 *Perunga Grasshopper* (Perunga ochracea): *A vulnerable species*. Action Plan No. 21 (Environment ACT, Canberra).

ACT Government 2003 *Ginninderra Peppercress* (Lepidium ginninderrense): *An endangered species*. Action Plan No. 25 (Environment ACT, Canberra).

ACT Government 2004a *Woodlands for Wildlife: ACT Lowland Woodland Conservation Strategy*. Action Plan No. 27 (Environment ACT, Canberra).

ACT Government 2004b *The Canberra Spatial Plan* (ACT Planning and Land Authority, Canberra).

ACT Government 2004c *The Canberra Plan* (Chief Minister's Department, Canberra).

ACT Government 2004d *The Canberra Social Plan* (Chief Minister's Department, Canberra).

ACT NRM (Natural Resource Management) Board 2003 *ACT Natural Resource Management Plan. Draft for Public Comment September 2003* (ACT NRM Board, Environment ACT, Canberra).

ACT Parks and Conservation Service 1999 *Canberra Nature Park Management Plan* (ACT Government, Dept of Urban Services, Canberra).

ACTPLA (ACT Planning and Land Authority) 2003 *The Territory Plan* (ACT Government, Canberra). www.actpla.act.gov.au/tplan/web.default.htm

AHC (Australian Heritage Commission) 2002 *Australian Natural Heritage Charter for the conservation of places of natural heritage significance*. 2nd edit. (Australian Heritage Commission/Australian Committee for IUCN, Canberra).

AHC (Australian Heritage Commission) 2003 *Protecting Natural Heritage: using the Australian Natural Heritage Charter*. 2nd edit. (Australian Heritage Commission/Australian Committee for IUCN, Canberra).

Andren, H. 1994 Effects of habitat fragmentation on birds and mammals in landscapes with different proportions of suitable habitat: a review, *Oikos* 71: 355–366.

ANPC 1997a *Guidelines for the Translocation of Threatened Plants in Australia*, Australian Network for Plant Conservation Translocation Working Group. ANPC, Canberra.

ANPC 1997b *Germplasm Conservation Guidelines for Australia—An Introduction to the Principles and Practices for Seed and Germplasm Banking of Australian Species*. Australian Network for Plant Conservation Germplasm Working Group. ANPC, Canberra.

Australian State of the Environment Committee 2001 *Australia State of the Environment 2001* (CSIRO Publishing on behalf of the Dept of Environment and Heritage, Canberra).

Avis, K. 2000 *Monitoring of* Lepidium ginninderrense *at the Belconnen Naval Transmission Station Lawson ACT* (Canberra Institute of Technology, Bruce Campus).

Baker, G.L., Dysart, R.J. and Pigott, R.G. 1996 Parasitism of grasshopper and locust eggs (Orthoptera: Acrididae) by *Scelio* species (Hymenoptera: Scelionidae) in southern Australia, *Australian Journal of Zoology* 44: 427–43.

Barlow, T. 1998 *Grassy Guidelines: How to manage native grasslands and grassy woodlands on your property* (Trust for Nature (Victoria), Melbourne).

Barrer, P. 1993 *Bushlands, grasslands and the ecological resources of the City of Queanbeyan, N.S.W. A report to the Trees for Queanbeyan Committee, the Queanbeyan Branch of the Monaro Conservation Society, the Queanbeyan City Council and the Save the Bush Grants Scheme* (Holt, ACT).

Bauer, J. and Goldney, D. 2000 Extinction processes in a transitional agricultural landscape, in *Temperate Eucalypt Woodlands in Australia: Biology, Conservation, Management and Restoration*, Eds R.J. Hobbs and C.J. Yates (Surrey Beatty and Sons, Chipping Norton), pp. 107–126.

Begon, M., Harper, J.L. and Townsend, C.R. 1990 *Ecology: individuals, populations and communities*. 2nd Edit. (Blackwell Scientific Publications, Boston).

Beier, P. and Noss, R.F. 1998 Do habitat corridors provide connectivity, *Conservation Biology* 12(6): 1241–1252.

Belovsky, G.E. and Slade, J.B. 1993 The role of vertebrate and invertebrate predators in a grasshopper community, *Oikos* 68: 193–201.

Bennett, A.F. 1999 *Linkages in the Landscape: the role of corridors and connectivity in wildlife conservation* (The IUCN Forest Conservation Program: Gland, Switzerland).

Bennett, R. 1997 *Reptiles and Frogs of the Australian Capital Territory* (National Parks Assoc. of the ACT Inc., Canberra).

Benson, J. 1994 The native grasslands of the Monaro region: Southern Tablelands of NSW, *Cunninghamia* 3 (3): 609–650.

Benson, J. 1996 *What is a native grassland?* Unpublished paper, 1996 Grasslands Society of NSW Conference, Wagga Wagga, NSW.

Benson, J. 1997 Conservation of native lowland grassland remnants in south-eastern Australia, in *Conservation outside nature reserves*, Eds P. Hale and D. Lamb (Centre for Conservation Biology, The University of Queensland, Brisbane), pp. 424–28.

Benson, J. and Wyse Jackson, M. 1994 The Monaro region, in *Conservation of lowland native grasslands in south-eastern Australia*, Eds K. McDougall and J.B. Kirkpatrick (Report to the World Wide Fund for Nature Australia), pp. 13–43.

Benson, K.A. 1999 *Resource Use and Selection by the Grassland Earless Dragon, Tympanocryptis lineata pinguicolla: microhabitat and diet*, BAppSc (Hons) (Applied Ecology Research Group, University of Canberra).

Biosis Research Pty Ltd 1995 *Eastern gas pipeline project: Flora, fauna and ecology studies*. Background Paper No. 5 (Consultant report for BHP Petroleum and Westcoast Energy).

Bossenbroek, P., Kessler, A., Liem, A.S.N. and Vlijm, L. 1977 The significance of plant growth-forms as 'shelter' for terrestrial animals, *Australian Journal of Zoology* 182: 1–6.

Bowman, D.J.M.S. 1998 The impact of Aboriginal landscape burning on the Australian biota, *New Phytologist* 140: 385–410.

Brereton, R. and Backhouse, G. 1993 *Flora and Fauna Guarantee Action Statement No. 35*. Southern Lined Earless Dragon Tympanocryptis pinguicolla (Department of Conservation and Natural Resources, Victoria).

Britten, D.R., New, T.R. and Jelinek, A. 1995 Rare Lepidoptera at Mt Piper, Victoria: The role of a threatened butterfly community in advancing understanding of insect conservation, *Journal of the Lepidopterists' Society* 49: 97–113.

Bruce, N. and Lunt, I. 2003 Grazing Management for Biodiversity Conservation: An Adaptive Approach from Terrick Terrick National Park Victoria, in *Sustainability and Beyond. Proceedings of the 3rd Stipa Conference on management of Native Grasses and Pastures, 27–28 November 2003, Cooma, NSW*, Eds C. O'Dwyer and S. Hamilton (ILFR University of Melbourne, Dookie Campus), pp. 203–210.

Burbidge, N.T. and Gray, M. 1970 *Flora of the Australian Capital Territory* (Australian National University Press, Canberra).

Butler, G. and associates (in preparation) *ACT Vegetation Restoration Guidelines*. Report to Environment ACT, Canberra.

Capital Planners Pty Ltd 2004 *Central National Area Western Foreshores and Environs: Planning Framework Study* (Unpublished, Report to National Capital Authority and ACT Planning and Land Authority, Canberra).

Carter, O., Murphy, A.M. and Cheal, D. 2003 *Natural Temperate Grassland*. Report to Environment Australia (Arthur Rylah Institute for Environmental Research, Dept of Natural Resources and Environment, Victoria).

Chan, C. 1980 *Natural grasslands in Canberra: Their distribution, phenology and effects of mowing*. MSc Thesis (Australian National University, Canberra).

Clark, D.P. 1967 A population study of *Phaulacridium vittatum* Sjostedt (Acrididae), *Australian Journal of Ecology* 15: 799–872.

Clarke, G.M. 1999 *Genetic analysis of ACT populations of the endangered golden sun moth*, Synemon plana. A report prepared for Wildlife Research and Monitoring, Environment ACT (CSIRO Entomology, Canberra).

Clarke, G.M. and Dear, C. 1998 *A survey of Native Grassland Sites in Southeastern New South Wales for the Endangered Golden Sun Moth*, Synemon plana. A report prepared for the Threatened Species Unit, NSW National Parks and Wildlife Service, Southern Zone (CSIRO Entomology, Canberra).

Clarke, G.M. and O'Dwyer, C. 1998 Genetic Analysis of Populations of the Endangered Golden Sun Moth *Synemon plana*. A report prepared for the Threatened Species Unit, NSW National Parks and Wildlife Service, Southern Zone and the Wildlife Research and Monitoring Unit, Environment ACT (CSIRO Entomology, Canberra).

Clarke, G.M. and O'Dwyer, C. 2000 Genetic variability and population structure of the endangered Golden Sun Moth, *Synemon plana, Biological Conservation* 92: 371–381.

Cogger H.G., Cameron, E.E., Sadlier, R.A. and Eggler, P. 1993 *The action plan for Australian reptiles* (Australian Nature Conservation Agency, Canberra).

Cogger, H.G. 2000 *Reptiles and amphibians of Australia*. 6th edit. (Reed Books, Chatswood).

Coman, B. 1995 Fox, in *The Mammals of Australia*, Ed. R. Strahan (Reed Books, Chatswood, NSW), pp. 698–699.

Common, I.F.B. 1990 *Moths of Australia* (Melbourne University Press, Carlton).

Common, I.F.B. and Edwards, E.D. 1981 The life history and early stages of *Synemon magnifica* Strand (Lepidoptera; Castniidae), *Journal of the Australian Entomological Society* 20: 295–302.

Commonwealth of Australia 1992 *National Forest Policy Statement: A New Focus for Australia's Forests* (Department of the Environment, Sport and Territories, Canberra).

Commonwealth of Australia 1996 *National Strategy for the Conservation of Australia's Biological Diversity* (Department of the Environment, Sport and Territories, Canberra).

Commonwealth of Australia 1999 *Australian Guidelines for Establishing the National Reserve System* (Environment Australia, Canberra).

COAG (Council of Australian Governments) 2000 *National Action Plan for Salinity and Water Quality* (Commonwealth of Australia, Canberra). http://www.napswq.gov.au/publications/vital-resources.html

Cook, L. and Edwards, E.D. 1993 *Population monitoring of endangered moth* Synemon plana *1992–93, York Park, Barton*. Report to the National Capital Planning Authority, Canberra (CSIRO Division of Entomology, Canberra).

Cook, L. and Edwards, E.D. 1994 *Population monitoring of endangered moth* Synemon plana *1993–94, York Park, Barton*. Report to the National Capital Planning Authority, Canberra (CSIRO Division of Entomology, Canberra).

Corbett, L.K. 1995 *The Dingo in Australia and Asia* (New South Wales University Press, Sydney).

Costin, A.B. 1954 *A study of the ecosystems of the Monaro region of New South Wales* (Government Printer, Sydney).

Costin, A.B. 1981 Alpine and sub-alpine vegetation, in *Australian Vegetation*, Ed. R.H. Groves (Cambridge University Press, Melbourne), pp. 361–376.

Coulson, G. 1990 *Conservation biology of the Striped Legless Lizard* (Delma impar): *An initial investigation*. Arthur Rylah Institute for Environmental Research Technical Report Series No. 106 (Department of Conservation and Environment, Melbourne).

Crawford, I.L. and Rowell, A.M. 1996 *Uncommon or declining plants of lowland native grasslands of the ACT* (Unpublished report to the ACT Parks and Conservation Service, Canberra).

CSIRO Plant Industry 2001 *Issues and Options for Genetic Conservation of Small Populations of Threatened Plants in the ACT*. Report to Environment ACT (Wildlife Research and Monitoring, June 2001) (CSIRO Plant Industry, Canberra).

Dear, C. 1997 *Restoration of a native grassland inhabited by Synemon plana* (Lepidoptera). MSc Thesis (University of Melbourne, Melbourne).

Delbridge, A., Bernard, J.R.L., Blair, D., Peters, P. and Butler, S. 1996 *The Macquarie Dictionary* (The Macquarie Library, Macquarie University, NSW).

Department of Conservation and Environment 1992 *Native grassland management in the Melbourne area* (Department of Conservation and Environment and the Victorian National Parks Association, Melbourne).

Dickman, C.R. 1994 Native mammals of western New South Wales: past neglect, future rehabilitation? In *Future of the Fauna of Western New South Wales*, Eds D. Lunney, S. Hand, P. Reed and D. Butcher (Royal Zoological Society of New South Wales, Mosman), pp. 81–91.

Dickman, C.R. 1996 *Overview of the Impacts of Feral Cats on Australian Native Fauna*, Report to the Australian Nature Conservation Agency, Canberra.

Diez, S. and Foreman, P. 1996 *Draft: Practical Guidelines for the management of native grasslands on the Riverine Plain of south-eastern Australia* (Department of Natural Resources, Bendigo).

Dorrough, J. 1995 *Past and present habitat of the Striped Legless Lizard (*Delma impar, *Pygopodidae) in the Australian Capital Territory*. BSc (Hons) Thesis (Department of Botany and Zoology, Australian National University).

Dorrough, J. 1996 *Monaro Remnant Grasslands Management Guide* (World Wide Fund for Nature Australia, Sydney).

Dorrough, J., Ash, J. and McIntyre, S. 2004 Plant responses to livestock grazing frequency in an Australian temperate grassland, *Ecography* 27: 798–810.

Douglas, F. 1993 *The conservation status, distribution and habitat requirements of diurnal Lepidoptera in central and western Victoria. Part 1: Family Castniidae*. Report to the Department of Conservation and Natural Resources, Victoria.

Driscoll, D.A. 1994 *Invertebrates of Lowland Native Grasslands in the Australian Capital Territory: Conservation and Research Strategies for a Recovery Plan*. Technical Report No. 9 (ACT Parks and Conservation Service, Tuggeranong, ACT).

Dunford, M.A., Nelson, L.S., Jekabsons, M.J., Ormay, P. and Webb, N. 2001 *2000–2001 Survey and Monitoring Program for the Striped Legless Lizard* (Delma impar) *and the Grassland Earless Dragon* (Tympanocryptis pinguicolla) *in the ACT*. Internal Report 2001/03 (Wildlife Research and Monitoring, Environment ACT).

Eddy, D., Mallinson, D., Rehwinkel, R. and Sharp, S. 1998 *Grassland Flora: a field guide for the Southern Tablelands (NSW and ACT)* (WWF Australia, Australian National Botanic Gardens, NSW National Parks and Wildlife Service, and Environment ACT, Canberra).

Eddy, D.A. 2002 *Managing Native Grassland. A guide to management for conservation, production and landscape protection* (WWF Australia, Sydney).

Edwards, E.D. 1990 Belconnen Naval Station harbours endangered moth, *Bulletin of the National Parks Association of the ACT*, June 1990: 16–17.

Edwards, E.D. 1993 The Golden Sun Moth, *Synemon plana*—an endangered species, *ANIC News* No. 2: 7–8.

Edwards, E.D. 1994 *Survey of lowland grassland in A.C.T. for the Golden Sun Moth* (Synemon plana). Report to the Wildlife Research Unit, ACT Parks and Conservation Service (CSIRO Division of Entomology, Canberra).

Environment ACT 2005 *National Recovery Plan for Natural Temperate Grassland of the Southern Tablelands (NSW and ACT): an endangered ecological community* (Environment ACT, Canberra).

Environment Australia 2000 *Revision of the Interim Biogeographic Regionalisation for Australia (IBRA) and Development of Version 5.1—Summary Report* (Department of Environment and Heritage, Canberra).

Evans, M. and Ormay, P. 2002 *2001–2002 Survey and Monitoring Program for the Grassland Earless Dragon* (Tympanocryptis pinguicolla) *in the ACT*. Internal Report 2002/01 (Wildlife Research and Monitoring, Environment ACT).

Fallding, M. 2002 *Planning Framework for Natural Ecosystems of the ACT and NSW Southern Tablelands* (Natural Heritage Trust, NSW National Parks and Wildlife Service and Land and Environment Planning).

Farrow, R.A. 1999 *Diversity and abundance of canopy-living insects in natural grassland remnants of high conservation value in the ACT: Effects of site characteristics and management*. Unpublished report to Environment ACT (Tilembeya Consulting, Queanbeyan).

Flood, J. 1980 *The Moth Hunters: Aboriginal Prehistory of the Australian Alps* (Australian Institute of Aboriginal Studies, Canberra).

Flood, J.M., David, B., Magee, J. and English, B. 1987. Birrigai: A Pleistocene site in the south-eastern highlands, *Archaeology in Oceania*: 9–26.

Fraser, I. and McJannett, M. 1996 *Neighbours in trouble! Endangered plants and animals in the ACT* (Conservation Council of the South-East Region and Canberra, Canberra).

Frawley, K.J. 1991 *The conservation of remnant woodland and native grassland in the ACT* (National Parks Association of the ACT, Canberra).

Frawley, K.J. 1995 Planning for urban native grassland conservation: York Park, Barton, ACT, in *Management of relict lowland grasslands. Proceedings of a workshop and public seminar, September 24 and 25, 1993*, Eds S. Sharp and R. Rehwinkel (Conservation series No. 8, ACT Parks and Conservation Service, Canberra), pp. 55–62.

Freudenberger, D. 2000 Conservation of biodiversity in grazed landscapes: some patchy principles, in *Balancing Conservation and Production in Grassy Landscapes. Proceedings of the Bushcare Grassy Landscapes Conference, Clare, South Australia, 19–21 August 1999*, Eds T. Barlow and R. Thorburn (Environment Australia, Canberra), pp. 154–161.

Freudenberger, D. 2001 *Bush for the Birds: Biodiversity enhancement guidelines for the Saltshaker Project, Boorowa, NSW* (CSIRO Sustainable Ecosystems, Canberra).

Greenslade, P. 1994 *A study of the use of indicator groups in assessing the conservation value of native grassland sites in the ACT and NSW*. Project report to Australian Capital Territory Parks and Conservation Service (CSIRO Division of Entomology, Canberra ACT).

Greenslade, P. and Rentz, D. C. n.d. *Disappearing Insects of Native Grasslands.* Information poster (CSIRO Entomology, Canberra).

Greer, A.E. 1989 *The biology and evolution of Australian lizards* (Surrey Beatty & Sons, Chipping Norton).

Groves, R.H. and Lodder, M. 1991 Flora of the ACT's natural grasslands, in *The ACT's Native Grasslands. Proceedings of a Workshop, February 1991*, Ed. R. Falconer (Conservation Council of the South-east Region and Canberra, Canberra), pp. 7–10.

Groves, R.H. and Williams, O.B. 1981 Natural grasslands, in *Australian Vegetation*, Ed. R.H. Groves (Cambridge University Press, Melbourne), pp. 293–316.

Hadden, S. 1995 *Distribution, population habitat estimates and habitat requirements of the Striped Legless Lizard* (Delma impar) (Fischer). Unpublished final report to the Australian Nature Conservation Agency (Department of Conservation and Natural Resources, Heidelberg).

Hancock, W.K. 1972 *Discovering Monaro: A Study of Man's Impact on his Environment* (Cambridge University Press, Cambridge).

Harwood, T., Narain, S. and Edwards, E.D. 1995 *Population monitoring of endangered moth* Synemon plana *1994–95, York Park, Barton*. Report to the National Capital Planning Authority, Canberra (CSIRO Division of Entomology, Canberra).

HLA—Envirosciences 2004 Rutidosis leptorrhynchoides *Survey HMAS Harman, Canberra Avenue, ACT*. Report prepared for Resolve FM (HLA—Envirosciences, PO Box 73, HRMC, NSW 2310).

Hutchinson, K.J. and King, K.L. 1980 The effects of sheep stocking level on invertebrate abundance, biomass and energy utilisation in a temperate sown grassland, *Journal of Applied Ecology* 17: 369–387.

JANIS 1997 *Nationally Agreed Criteria for the Establishment of a Comprehensive, Adequate and Representative Reserve System for Forests in Australia* (A Report by the Joint ANZECC / MCFFA National Forest Policy Statement Implementation Sub-committee, Canberra).

Jenkins, R. and Bartell, R. 1980 *A Field Guide to the Reptiles of the Australian High Country* (Inkata Press, Melbourne).

Jones, S. 1995 *Nature at the grave's edge: remnant native flora and fauna in the cemeteries of the Southern Tablelands of New South Wales*. Draft Report to the Conservation Council of the South East Region and Canberra.

King, K.L. 1991 The role of microarthropods in decomposition and nutrient cycling in temperate pastures. Thesis abstract, *Australian Journal of Ecology* 16: 131–132.

Kirkpatrick, J.B. 1993 Methods, in *Conservation of lowland native grasslands in south-eastern Australia*, Eds McDougall, K. and Kirkpatrick, J.B. (Report to the World Wide Fund for Nature, Australia), p. 3.

Kirkpatrick, J., McDougall, K. and Hyde, M. 1995 *Australia's Most Threatened Ecosystems: the southeastern lowland native grasslands* (Surrey Beatty/World Wide Fund for Nature Australia, Chipping Norton, NSW).

Kukolic, K. 1994 *Survey for the Striped Legless Lizard* (Delma impar) *during 1993 at the National Museum of Australia site, Yarramundi Reach, ACT*. Unpublished report to the National Capital Planning Authority (ACT Parks and Conservation Service, Canberra).

Kukolic, K., McElhinney, N. and Osborne, W.S. 1994 *Survey for the Striped Legless Lizard* (Delma impar) *during 1993 in the proposed development area E1 comprising sites for the Gungahlin Town Centre and the suburb of Franklin*. Internal Report 94/3 (ACT Parks and Conservation Service, Canberra).

Langston, A.C. 1996 *The ecology and distribution of* Tympanocryptis lineata pinguicolla *(Southern Lined Earless Dragon) in the Australian Capital Territory and adjacent sub-region*. BAppSc (Hons) Thesis (Faculty of Applied Science, University of Canberra).

Lee, K.E. 1985 *Earthworms: their ecology and relationships with soils and land use* (Academic Press, North Ryde, NSW).

Litchfield, C. 2000 Monaro, NSW—A question of need, in *Balancing Conservation and Production in Grassy Landscapes. Proceedings of the Bushcare Grassy Landscapes Conference, Clare, South Australia*, 19–21 August 1999, Eds T. Barlow and R. Thorburn (Environment Australia, Canberra), pp. 28–33.

Lovett, S. and Price, P. 1999 *Riparian land management technical guidelines, Volume 1: Principles of sound management* (Land and Water Resources Research and Development Corporation, Canberra).

Lowe, C.R. 1996 *HMAS Conservation Management Plan for HMAS Harman Bonshaw and the Belconnen Naval Transmitting Station*.

Lucas, A.H.S. and Frost, C. 1894 The lizards indigenous to Victoria, *Proc. Roy. Soc. Vic.* 6: 24–92.

Lunt, I.D. 1990 Impact of an autumn fire on a long-grazed *Themeda triandra* (Kangaroo Grass) grassland: implications for management of invaded, remnant vegetation, *Victorian Naturalist* 107: 45–51.

Lunt, I.D. 1991 Management of remnant lowland grasslands and grassy woodlands for nature conservation: a review, *Victorian Naturalist* 108 (3): 56–66.

Lunt, I.D. 1995 A flexible approach to grassland management based on plant life-forms and growth-forms, in *Management of relict lowland grasslands. Proceedings of a workshop and public seminar, September 24 and 25, 1993*, Eds S. Sharp and R. Rehwinkel (Conservation series No. 8, ACT Parks and Conservation Service, Canberra), pp. 112–121.

Lunt, I.D. 2005 *Effects of stock grazing on biodiversity values in temperate native grasslands and grassy woodlands in SE Australia: A literature review for Environment ACT.* Technical Report 18 (Environment ACT, Canberra).

Lunt, I.D. and Morgan, J.W. 1999 Effect of fire frequency on plant composition at the Laverton North Grassland Reserve, Victoria, *Victorian Naturalist* 116: 84–90.

Lunt, I.D. and Morgan, J.W. 2002 The role of fire regimes in temperate lowland grasslands of southeastern Australia, in *Flammable Australia: the Fire Regimes and Biodiversity of a Continent*, Eds R.A. Bradstock, J.E. Williams and M.A. Gill (Cambridge University Press, Cambridge), pp. 177–196.

Lunt, I., Barlow, T. and Ross, J. 1998 *Plains Wandering: Exploring the Grassy Plains of South-Eastern Australia* (Victorian National Parks Association Inc. and Trust for Nature (Victoria), Melbourne).

MacLeod, N.D. 2002 Principles for property planing, in *Managing and Conserving Grassy Woodlands*, Eds S. McIntyre, J.G. McIvor and K.M. Heard (CSIRO Publishing, Collingwood), pp. 25–40.

Martin, T.G. and Green, J.L. 2002 Wildlife and core conservation areas, in *Managing and Conserving Grassy Woodlands*, Eds S. McIntyre, J.G. McIvor and K.M. Heard (CSIRO Publishing, Collingwood), pp. 111–142.

McIntyre, S. 1994 Integrating agricultural land-use and management for conservation of a native grassland flora in a variegated landscape, *Pacific Conservation Biology* 1: 236–244.

McIntyre, S. 1995 Disturbance: does it have a role in the maintenance of rare grassland plants? in *Management of relict lowland grasslands. Proceedings of a workshop and public seminar, September 24 and 25, 1993*, Eds S. Sharp and R. Rehwinkel (Conservation series No. 8, ACT Parks and Conservation Service, Canberra), pp. 39–41.

McIntyre, S. and Hobbs, R. 1999 A Framework for Conceptualizing Human Effects on Landscapes and Its Relevance to Management and Research Models, *Conservation Biology* 13(6): 1282–1292.

McIntyre, S., McIvor J.G. and Heard, K.M. 2002 *Managing and Conserving Grassy Woodlands* (CSIRO Publishing, Collingwood).

McIvor, J.G. and McIntyre, S. 2002 Understanding grassy woodland ecosystems, in *Managing and Conserving Grassy Woodlands*, Eds S. McIntyre, J.G. McIvor and K.M. Heard (CSIRO Publishing, Collingwood), pp. 1–23.

MDBC (Murray–Darling Basin Commission) 2001 'Integrated Catchment Management in the Murray–Darling Basin 2001–2010', in *Murray–Darling Basin 2051: Setting the Vision*, WWF Australia 2001 (WWF, Australia), p. 7.

Mills, D. 1992 *Report of* Delma impar *trapping survey conducted at Werribee, Jan–Feb 1992*. Report to the Striped Legless Lizard Working Group (Deakin University, Geelong).

Mitchell, F.J. 1948 A revision of the lacertilian genus Tympanocryptis, *Records South Australian Museum* 9: 57–86.

Mitchell, T.L. 1838 *Three expeditions into the interior of eastern Australia: with descriptions of the recently explored region of Australia Felix, and of the present colony of New South Wales* (T. & W. Boone, London).

Moore, C.W.E. 1964 Distribution of grasslands, in *Grasses and grasslands*, Ed. C. Barnard (Macmillan, London) pp. 182–205.

Moore, R.M. and Biddiscombe, E.F. 1964 The effects of grazing on grasslands, in *Grasses and Grasslands*, Ed. C. Barnard (Macmillan, London) pp. 221–235.

Moore, R.M. and Perry, R.A. 1970 Vegetation, in *Australian Grasslands*, Ed. R.M. Moore (Australian National University Press, Canberra), pp. 59–73.

Morgan, J.W. 1995a Ecological studies of the endangered *Rutidosis leptorrhynchoides*. 1. Seed production, soil seed bank dynamics, population density and their effects on recruitment, *Australian Journal of Botany* 43: 1–11.

Morgan, J.W. 1995b Ecological studies of the endangered *Rutidosis leptorrhynchoides*. 2. Patterns of seedling emergence and survival in a native grassland, *Australian Journal of Botany* 43: 13–24.

Morgan, J.W. and Lunt, I.D. 1999 Effects of time-since-fire on the tussock dynamics of a dominant grass (*Themeda triandra*) in a temperate Australian grassland, *Biological Conservation* 88: 379–386.

Murrumbidgee Catchment Management Board 2003 *Murrumbidgee Catchment Blueprint* (NSW Dept of Land and Water Conservation, Sydney).

Muyt, A. 2001 *Bush Invaders of South-East Australia* (R.G. and F.J. Richardson, Meredith, Victoria).

NCA (National Capital Authority) 2003 *Consolidated National Capital Plan* (Commonwealth Government, Canberra). www.nationalcapital.gov.au/plan/index.htm

Nelson, L. 2004 *Thermal ecology and implications for life history variation in* Tympanocryptis pinguicolla *(Grassland Earless Dragon)*. Unpubl. PhD Thesis (Division of Botany and Zoology, Australian National University, Canberra).

Nelson, L.S., Bensley, N., Edwards, S., Pinner, L. and West, P. 1998 *1998 Survey and Monitoring Program for the Eastern Lined Earless Dragon* (Tympanocryptis lineata pinguicolla) *in the Majura and Jerrabomberra valleys, ACT*. Internal Report 98/2 (Wildlife Research and Monitoring, Environment ACT).

Nelson, L.S., Smith, W.J.S. and Goldie, R. 1996 *1996 survey program for the Eastern Lined Earless Dragon*, (Tympanocryptis lineata pinguicolla). Internal Report 96/2 (ACT Parks and Conservation Service, Canberra).

Newsome, A. 1995 Cat, in *The Mammals of Australia*, Ed. R. Strahan (Reed Books, Chatswood, NSW), pp. 700–702.

NSW NPWS (National Parks and Wildlife Service) 2000 *Draft NSW and national recovery plan for the Tarengo Leek Orchid* (Prasophyllum petilum) (NSW National Parks and Wildlife Service, Hurstville, NSW). Accessed July 2003, www.nationalparks.nsw.gov.au /PDFs/recoveryplan_draft_prasophyllum_petilum.pdf.

Nunan, D. 1995 *Diet and feeding ecology of the Striped Legless Lizard* (Delma impar) *(Fischer, 1882) within the Australian Capital Territory*. BAppSc (Hons) Thesis (Faculty of Applied Science, University of Canberra).

O'Dwyer, C. 2003 Re-establishment of grasslands for Golden Sun Moths, in *Sustainability and Beyond. Proceedings of 3rd Stipa Conference on management of native grasses and pastures, 27–28 November 2003. Cooma NSW*, Eds C. O'Dwyer and S. Hamilton (ILFR University of Melbourne, Dookie Campus), pp. 214–215.

O'Dwyer, C. and Attiwill, P.M. 1999a A comparative study of habitats of the Golden Sun Moth *Synemon plana* Walker (Lepidoptera: Castniidae): implications for restoration, *Biological Conservation* 89: 131–141.

O'Dwyer, C. and Attiwill, P.M. 1999b Restoration of a Native Grassland as Habitat for the Golden Sun Moth *Synemon plana* Walker (Lepidoptera; Castniidae) at Mount Piper, Australia, *Restoration Ecology* 8 (2): 170–174.

Oliver, L. 2003 *Conservation Management Networks: Managing Ecosystems (and associated habitat) across the landscape*. Paper given at the Woodland Birds Seminar, Canberra Ornithologists Group and the Bird Interest Group Network, Canberra 22 March 2003.

Osborne, W.S and Jones, S.R. 1995 *Recovery Plan for the Pink-tailed Worm Lizard* (Aprasia parapulchella). ACT Parks and Conservation Service Technical Report 10 (Department of Environment, Land and Planning, Tuggeranong, ACT).

Osborne, W.S., Kukolic, K., Davis, M.S. and Blackburn, R. 1993 Recent records of the Earless Dragon *(Tympanocryptis lineata pinguicolla)* in the Canberra region and a description of its habitat, *Herpetofauna* 23(1): 16–25.

Osborne, W., Kukolic, K. and Jones, S. 1995 Management of vertebrates in native grasslands: a case of clutching straws? in *Management of relict lowland grasslands. Proceedings of a workshop and public seminar, September 24 and 25, 1993*, Eds S. Sharp and R. Rehwinkel (Conservation Series No. 8, ACT Parks and Conservation Service, Canberra), pp. 89–96.

Osborne, W.S., Kukolic, K. and Williams, K.D. 1993 Conservation of reptiles in lowland native grasslands in the Southern Tablelands of New South Wales and the Australian Capital Territory, in *Herpetology in Australia: A diverse discipline*, Eds D. Lunney and D. Ayers (Transactions of the Royal Zoological Society of New South Wales), pp. 151–8.

Osborne, W.S., Lintermans, M. and Williams, K.D. 1991 *Distribution and Conservation Status of the Endangered Pink-tailed Legless Lizard* Aprasia parapulchella *(Kluge)*. Research Report 5 (ACT Parks and Conservation Service, Canberra).

Osmond, H. 1994 *Habitat specialisation and the isolation of remnant populations of the Striped Legless Lizard,* Delma impar *(Pygopodidae). Temperature preference, metabolic and allozyme correlates of activity in lizards, with particular reference to fossorial habit*. Unpublished Report to ACT Parks and Conservation Service.

Parsons, W.T. and Cuthbertson, E.G. 1992 *Noxious Weeds of Australia* (Inkata Press, Melbourne).

Prober, S. and Thiele, K. 1995 Conservation of the grassy white box woodlands: relative contributions of size and disturbance to floristic composition and diversity of remnants, *Australian Journal of Botany* 43: 349–366.

Pryor, L.D. 1938 The botany, forestry and zoology of the Australian Capital Territory on an ecological basis, in *Handbook for Canberra, ANZAAS Meeting, Canberra January 1939*, Ed. K. Burns (Commonwealth Government Printer, Canberra), pp. 1–31.

Pryor, L.D. 1938 *Vegetation Map of the ACT* (Cwlth Dept of the Interior, Canberra).

Rauhala, M.A. 1996 *1995 Survey and Monitoring Program for the Striped Legless Lizard* (Delma impar). Internal Report 96/1 (ACT Parks and Conservation Service, Canberra).

Rauhala, M.A., Shorthouse, D.J. and Ingwersen, F. 1995 *The Striped Legless Lizard* (Delma impar) *in the Gungahlin, Majura and Jerrabomberra Valleys*. Internal Report 95/2 (ACT Parks and Conservation Service, Canberra).

Recher, H. and Lim, L. 1990 A review of current ideas of the extinction, conservation and management of Australia's terrestrial vertebrate fauna, *Proceedings of the Ecological Society of Australia* 16: 287–301.

Rehwinkel, R. 1996a *Draft report of the significant native grasslands of the Snowy River Shire*. Unpublished report (NSW National Parks and Wildlife Service, Queanbeyan).

Rehwinkel, R. 1996b *Draft report of the significant native lowland grasslands on Travelling Stock Reserves in the Cooma Rural Lands Protection Board District*. Unpublished report (NSW National Parks and Wildlife Service, Queanbeyan).

Rehwinkel, R. 1996c *The Monaro and Southern Tablelands native grasslands conservation project* (NSW National Parks and Wildlife Service, Queanbeyan).

Rehwinkel, R. 1997 *Grassy ecosystems of the South Eastern Highlands: Technical Report.* Stage 1, Joint regional biodiversity survey of grassy ecosystems of the South Eastern Highlands Project (Unpublished report to ACT Parks and Conservation service, ACT Planning and Land Management, Housing Industry Association, National Capital Authority, NSW National Parks and Wildlife Service).

Rehwinkel, R. 2002 What is a Conservation Management Network? *Austral Bugle* 1(1), Winter 2002.

Reid, N. and Landsberg, J. 2000 Tree decline in agricultural landscapes: what we stand to lose, in *Temperate Eucalypt Woodlands in Australia: Biology, Conservation, Management and Restoration*, Eds R.J. Hobbs and C.J. Yates (Surrey Beatty and Sons, Chipping Norton), pp. 127–166.

Rentz, D.C.F. 1996 *Grasshopper country: the abundant orthopteroid insects of Australia* (University of NSW Press, Sydney).

Robertson, G., Treanor, M. and Eddy, D. 2000 Identifying and conserving quality grassy vegetation, in *Grassland beyond the reserve: off-reserve conservation of native grassy ecosystems. Proceedings of Friends of Grasslands Workshop, 1–2 December 2000 at Cooma, NSW*, Eds Friends of Grasslands (Friends of Grasslands Inc., Canberra), pp. 43–50.

Robertson, P. and Cooper, P. 2000 *Recovery Plan for the Grassland Earless Dragon* (Tympanocryptis pinguicolla). Unpublished report to Environment Australia, Canberra.

Robson, P. 1968 A rare Agamid, *Wildlife in Australia* 5(3): 84.

Ross, J. 1999 *Guide to Best Practice Conservation of Temperate Native Grasslands* (World Wide Fund for Nature, Australia).

Rowell, A. 1994 *A study of the native grasslands of the Monaro District*. A report for the New South Wales National Parks and Wildlife Service and the Department of Planning (Heritage Assistance Program, Dickson, ACT).

Rowell, A. 1996 *Yarramundi Grassland Vegetation Mapping and Management Recommendations*. Report to the National Capital Planning Authority. (Report prepared by Alison Rowell for ANUTECH Pty Ltd, Canberra).

Rowell, A. and Crawford, I. 1995 *Survey of the Morabine Grasshopper* Keyacris scurra *(REHN) in the ACT.* Report to the Wildlife Research Unit, ACT Parks and Conservation Service (CSIRO).

Rowell, A. and Crawford, I. 1999 Keyacris scurra: *Grasshopper density and vegetation composition at selected sites in the ACT region*. Unpublished report to Environment ACT (Alison Rowell, Biologist and Environmental Consultant, Dickson, ACT and Isobel Crawford, Australian Botanical Surveys, O'Connor, ACT).

Saunders, D.A. and Hobbs, R.J. 1991. The role of corridors in conservation: what do we know and where do we go? in *Nature Conservation 2: the role of corridors*, Eds D.A. Saunders and R. J. Hobbs (Surrey Beatty and Sons, Chipping Norton, NSW), pp. 421–427.

Saunders, D.A., Hobbs, R.J. and Margules, C.R. 1991 Biological consequences of ecosystem fragmentation: a review, *Conservation Biology* 5(1): 18–32.

Scarlett, N.H. 2001 *Lepidium ginninderrense* (Brassicaceae), a new species from the Australian Capital Territory, *Muelleria* 15: 69–73.

Scarlett, N.H. and Parsons, R.F. 1990 Conservation biology of the Southern Australian Daisy *Rutidosis leptorrhynchoides*, in *Management and conservation of small populations: Proceedings of a conference, Melbourne, Australia, September 26 and 27, 1989*, Eds T. Clark and J. Seebeck (Chicago Zoological Society, Brookfield, Illinois), pp. 195–205.

Scarlett, N.H., Wallbrink, S.J. and McDougall, K. 1992 *Field Guide to Victoria's Native Grasslands* (Victoria Press, South Melbourne).

Scott, I.A.W. and Keogh, J.S. 2000 Conservation genetics of the endangered grassland earless dragon *Tympanocryptis pinguicolla* (Reptilia: Agamidae) in Southeastern Australia, *Conservation Genetics* 1(4): 357–363.

Sharp, S. 1994 *Lowland native grasslands in the ACT and surrounding region: a review and research strategy for a recovery plan*. ACT Parks and Conservation Service Technical Report 8 (Department of Environment Land and Planning, Tuggeranong, ACT).

Sharp, S. 1995 Floral diversity in lowland native grassland in the ACT, in *Management of relict lowland grasslands. Proceedings of a workshop and public seminar, September 24 and 25, 1993*, Eds S. Sharp and R. Rehwinkel (Conservation series No. 8, ACT Parks and Conservation Service, Canberra), pp. 80–88.

Sharp, S. 1997 *Diversity, patterns and processes of vegetation and invertebrate orders in natural temperate grasslands in the Australian Capital Territory*. MAppSc Thesis. University of Canberra.

Sharp, S. 1998 The role of Environment ACT in the conservation of Natural Temperate Grassland sites, in *Development and Native Grasslands: Resolving Conflicts*. Abstracts and Proceedings of a Workshop held on 26 May 1998—Canberra, Eds A. Langston, N. Hirsch and K. Pullen (Friends of Grasslands, Civic Square, ACT), pp. 65–70.

Sharp, S. 1999 The role of monitoring in the adaptive management of grasslands in the ACT, in *Down to Grass Roots. Proceedings of a conference on management of grassy ecosystems, 9 and 10 July 1998, Victoria University St Albans*, Eds V. Craigie and C. Hocking (School of Life Sciences, Victoria University, St Albans), pp. 92–94.

Sharp, S. 2000 A 'State' agency's case study in off-reserve conservation: grassy ecosystem protection and management in the ACT, in *Grassland beyond the reserve: off-reserve conservation of native grassy ecosystems. Proceedings of Friends of Grasslands Workshop, 1–2 December 2000 at Cooma, NSW*, Eds Friends of Grasslands (Friends of Grasslands Inc., Canberra), pp. 18–25.

Sharp, S. and Dunford, M. 1994 *Ecological Diversity and Dynamics of Native Grassland Communities in the ACT Sub-region and implications for their Conservation Planning*. Final Report to the ACT Heritage Council (ACT Parks and Conservation Service, Tuggeranong, ACT).

Sharp, S. and Rehwinkel, R. 1998 Draft guidelines for the conservation management of remnant natural temperate grassland sites in the Southern Tablelands, in *Conservation assessment of grasslands and grassy woodlands in the Goulburn City Council area*, Ed. R. Rehwinkel (NSW National Parks and Wildlife Service, Queanbeyan), App. 3.

Sharp, S.B. and Shorthouse, D.J. 1996 Native grasslands and threatened species in the Australian Capital Territory: Steps towards protection and recovery. In *Back from the brink: Refining the threatened species recovery process*, Eds S. Stephens and S. Maxwell (Surrey Beatty & Sons, Chipping Norton), pp. 138–149.

Sharp, S., Dorrough, J., Rehwinkel, R., Eddy, D. and Breckwoldt, A. 2005 *The Grassy Ecosystems Management Kit: A Guide to Developing Conservation Management Plans* (Environment ACT, Canberra).

Smith, J.N.M. and Hellmann, J.J. Population persistence in fragmented landscapes, *Trends in Ecology and Evolution* 17(9): 397–399.

Smith, W.J.S. and Robertson, P. 1999 *National Recovery Plan for the Striped Legless Lizard* (Delma impar): *1999–2003*. Unpublished Report to Environment Australia. Canberra.

Smith, W.J.S., Osborne, W.S., Donnellan, S.C. and Cooper, P.D. 1999 The systematic status of earless dragon lizards, Tympanocryptis (Reptilia: Agamidae), in south-eastern Australia, *Australian Journal of Zoology* 47: 551–64.

Smith, W.J.S. 1994 *The ecology and taxonomy of the Southern Lined Earless Dragon* (Tympanocryptis lineata pinguicolla). BSc (Hons) thesis (Department of Botany and Zoology, Australian National University).

Stephens, C.J. 1998 *Grasshopper (Orthoptera: Acrididae) assemblages in natural temperate grasslands of differing native plant diversities*. BSc (Hons) thesis (Department of Botany and Zoology, Australian National University).

Stephens, S. 2002 Landholders' views on conservation covenants, *Australian Landcare* June 2002: 6–7.

Story, R. 1969 Vegetation of the Queanbeyan–Shoalhaven area, *CSIRO Aust. Land Res. Er*. No. 24: 113–133 (CSIRO, Australia).

Strahan, R. (Ed.) 1995 *The Mammals of Australia* (Reed Books, Chatswood, NSW).

Stuwe, J. 1986 *An assessment of the conservation status of native grasslands on the Western Plains, Victoria and sites of botanical significance*, Arthur Rylah Institute for Environmental Research Technical Report Series No. 48 (Department of Conservation, Forests and Lands, Melbourne).

Thackway, R. and Cresswell, I. D. (Eds) 1995 *An interim biogeographic regionalisation for Australia* (Australian Nature Conservation Agency, Canberra).

Thiele, K.R., Prober, S.M., Rehwinkel, R., Eddy, D. and Edwards, R. 2003 Sustaining and enhancing native grassy ecosystems through conservation management networks, in *Sustainability and Beyond. Proceedings of 3rd Stipa Conference on management of native grasses and pastures, 27–28 November 2003. Cooma NSW*, Eds C. O'Dwyer and S. Hamilton (ILFR University of Melbourne, Dookie Campus), pp. 11–18.

Thomas, V., Gellie, N. and Harrison, T. 2000 *Forest Ecosystem Classification and Mapping for the Southern CRA Region*, 2 Vols. A report undertaken for the NSW CRA/RFA Steering Committee. Project No. NS 08EH (NSW National Parks and Wildlife Service Southern Directorate, Queanbeyan).

Titlyanova, A.A., Zlotin, R.I. and French, N.R. 1990 Changes in structure and function of temperate grasslands under the influence of man, in *Managed Grasslands: Regional Studies. Ecosystems of the World* 17A, Ed. A.I. Breymeyer (Elsevier, Amsterdam).

Traill, B. 2000 Declines in woodland birds in New South Wales, *News of Friends of Grasslands* Nov–Dec 2000: 5–6.

Tremont, R.M. and McIntyre, S. 1994 Natural Grassy Vegetation and Native Forbs in Temperate Australia: Structure, Dynamics and Life Histories, *Australian Journal of Botany* 42: 641–658.

Wainer, J.W. 1992 *Diet of the Striped Legless Lizard* (Delma impar) *at the Derrimut Grassland Reserve, to the west of Melbourne*. Unpublished report to the Striped Legless Lizard Working Group (Department of Conservation and Environment, Melbourne).

Walker, J. and Hopkins, M.S. 1984 Vegetation, in *Australian soil and land survey field handbook*. 1st Edition, Eds R.C. McDonald, R.F. Isbell, J.G. Speight, J. Walker and M.S. Hopkins (Inkata Press, Melbourne), pp. 44–67.

Webster, A., Smith, S., Robertson, P. and Banks, C. 1991 *Striped Legless Lizard* (Delma impar) *population viability assessment: A preliminary examination*. Unpublished report prepared for Department of Conservation and Environment, Victoria.

Whalley, R.D.B. 2003 Grassland Management for Production or Conservation—Are they the two sides of the one coin?, in *Sustainability and Beyond. Proceedings of 3rd Stipa Conference on management of native grasses and pastures, 27–28 November 2003. Cooma NSW*, Eds C. O'Dwyer and S. Hamilton (ILFR University of Melbourne, Dookie Campus), pp. 182–192.

Whalley, R.D.B., Chivers, I.H. and Waters, C.M. 2003 The assumptions behind the recommended use of local provenances of Australian native grasses for revegetation, in *Sustainability and Beyond. Proceedings of 3rd Stipa Conference on management of native grasses and pastures, 27–28 November 2003. Cooma NSW*, Eds C. O'Dwyer and S. Hamilton (ILFR University of Melbourne, Dookie Campus), pp. 96–106.

Wildlife Research Unit, 1991 *Recovery plan for lowland native grasslands in the Australian Capital Territory*. Unpublished report to the Australian National Parks and Wildlife Service (ACT Parks and Conservation Service, Canberra).

Wildlife Research Unit, 1992 *Lowland native grassland ecosystems in the Australian Capital Territory*. Unpublished report to the Australian National Parks and Wildlife Service (ACT Parks and Conservation Service, Canberra).

Wildlife Research Unit 1994 *Management plan for ACT lowland native grasslands*. Unpublished report to the Australian Nature Conservation Agency (ACT Parks and Conservation Service, Canberra).

Williams, D.G., Georges, A., Dearn, J. and Sharp, S. 1991 *Information requirements for native grassland conservation in the A.C.T. Prepared for the A.C.T. Planning Authority under Planning Brief No. 90/34* (Applied Ecology Research Group, University of Canberra).

Williams, D., Osborne, W., Georges, A., and Holloway, S. 1995 *Principles and Strategic Options for the Conservation of Native Grasslands and their Threatened Fauna in Gungahlin, ACT*. Report to the ACT Planning Authority (Applied Ecology Research Group, University of Canberra).

Williams, K.D. and Kukolic, K. 1991 Fauna of the ACT's native grasslands, in *The ACT's native grasslands: Proceedings of a workshop*, Ed. R. Falconer (Conservation Council of the South-east Region and Canberra, Canberra), pp.11–19.

Witten, G.J. 1993 Family Agamidae, in *Fauna of Australia: Vol. 2A Amphibia and Reptilia*, Eds C.J. Glasby, G.J.B. Ross and P.L. Beesley (AGPS, Canberra), pp. 240–52.

Yen, A. 1995 Some issues involved in the conservation of lowland native grassland invertebrates, in *Management of relict lowland grasslands. Proceedings of a workshop and public seminar, September 24 and 25, 1993*, Eds S. Sharp and R. Rehwinkel (Conservation series No. 8, ACT Parks and Conservation Service, Canberra), pp. 97–111.

Yen, A.L. and Butcher, R.J. 1997 *An overview of the conservation of non-marine invertebrates in Australia* (Environment Australia, Canberra).

Young, A. 1997 Viable or Vulnerable—Genetic and demographic studies on *Rutidosis leptorrhynchoides, Danthonia* 5(4): 8–9.

Young, A. 2001 *Issues and Options for Genetic Conservation of Small Populations of Threatened Plants in the ACT* (Consultancy Report by CSIRO Plant Industry for Environment ACT, Wildlife Research and Monitoring, June 2001).

Young, A.G., Brown, A.H.D., Murray, B.G., Thrall, P.H. and Miller. C.H. 2000 Genetic erosion, restricted mating and reduced viability in fragmented populations of the endangered grassland herb: *Rutidosis leptorrhynchoides*, in *Genetics, Demography and Viability of Fragmented Populations*, Eds A.G. Young and G.M. Clarke (Cambridge University Press, Cambridge), pp. 335–59.

Young, G. 1992 Herpy days of youth, *ACT Herpetological Association Newsletter*, June–July 1992: 4–6.

Zich, F.A., Briggs J.D. and Corrigan V.T. 1995 Rutidosis leptorrhynchoides *(Button wrinklewort) Recovery Plan (1995)* (NSW National Parks and Wildlife Service).

GLOSSARY

Abbreviations

asl = above sea level

km = kilometre

ha = hectare

m = metre

cm = centimetre

mm = millimetre

yr = year

Biodiversity

The variability among living organisms from all sources (including terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part) and includes diversity within and between species and the diversity of ecosystems (AHC 2002).

Buffer

A buffer is a form of vegetation or land use (e.g. road or other infrastructure) that acts as a barrier or absorbs the effects of an activity or another land use. It is undesirable to have high intensity land uses located next to areas of high conservation value, and low or medium intensity land uses may be used as buffers (MacLeod 2002).

Connectivity

Habitat connectivity is the degree to which an organism can move around the landscape due to the presence of suitable habitat. For fauna, connectivity has been defined as the 'degree to which the landscape facilitates or impedes movement among patches' (Bennett 1999).

Conservation Value

With regard to the natural environment, conservation value is an expression of the importance of a place in terms of its *natural significance*. *Natural significance* means the importance of ecosystems, biodiversity and geodiversity for their existence value or for present or future generations, in terms of their scientific, social, aesthetic and life-support value (AHC 2002).

Crown Cover Density

The percentage of the sample site within the vertical projection of the periphery of the crown i.e. the whole crown is treated as opaque.

Declining Species

Species that have a reduced extent of occurrence and/or decline in abundance, significant enough to raise conservation concern.

Disturbance

An event that removes organisms and opens up space that can be colonized by individuals of the same or different species (Begon *et al*. 1990). Examples include soil cultivation, herbicide use, tree removal, fire and grazing.

Dominant Species

Species that make up a large proportion of biomass, or numbers of organisms in a community (Begon *et al.* 1990).

Ecological Community

An assemblage of plant and animal species that occur together in space and time.

Ecological Processes

All the processes that occur between organisms, and within and between communities, including interactions with the non-living environment, that result in existing ecosystems and bring about changes in ecosystems over time (AHC 2002).

Ecosystem

A dynamic complex of organisms and their environment, interacting as a functional unit (AHC 2002).

Ecosystem Function

In a functioning (or healthy) ecosystem, processes such as nutrient, energy and water flows, and the organisms and their populations, are maintained at levels appropriate to that system. A degraded or dysfunctional ecosystem has one or more of these processes disrupted (McIntyre *et al.* 2002).

Ecotone

Transition zone between two vegetation communities (e.g. between woodland and grassland).

Endangered

Means:

(a) in relation to a community—an ecological community that is in immediate danger of extinction unless the circumstances and factors threatening its distribution, composition and viability as an ecological unit cease.

(b) in relation to a species:

  (i) its likely extinction unless the circumstances and factors threatening its abundance, survival or evolution cease, or

  (ii) the reduction of its numbers or habitats to such a level that the species is in immediate danger of extinction. (*Nature Conservation Act 1980*).

Evolutionary Processes

Genetically-based processes by which life forms change and develop over generations (AHC 2002).

Exotic Species

A species of foreign origin; not native; introduced from abroad (Delbridge *et al.* 1996).

Forb

An herbaceous (non-woody) plant that is not a grass (Scarlett *et al*. 1992).

Fragmentation

The separation into parts, of an assumed previously continuous vegetation community.

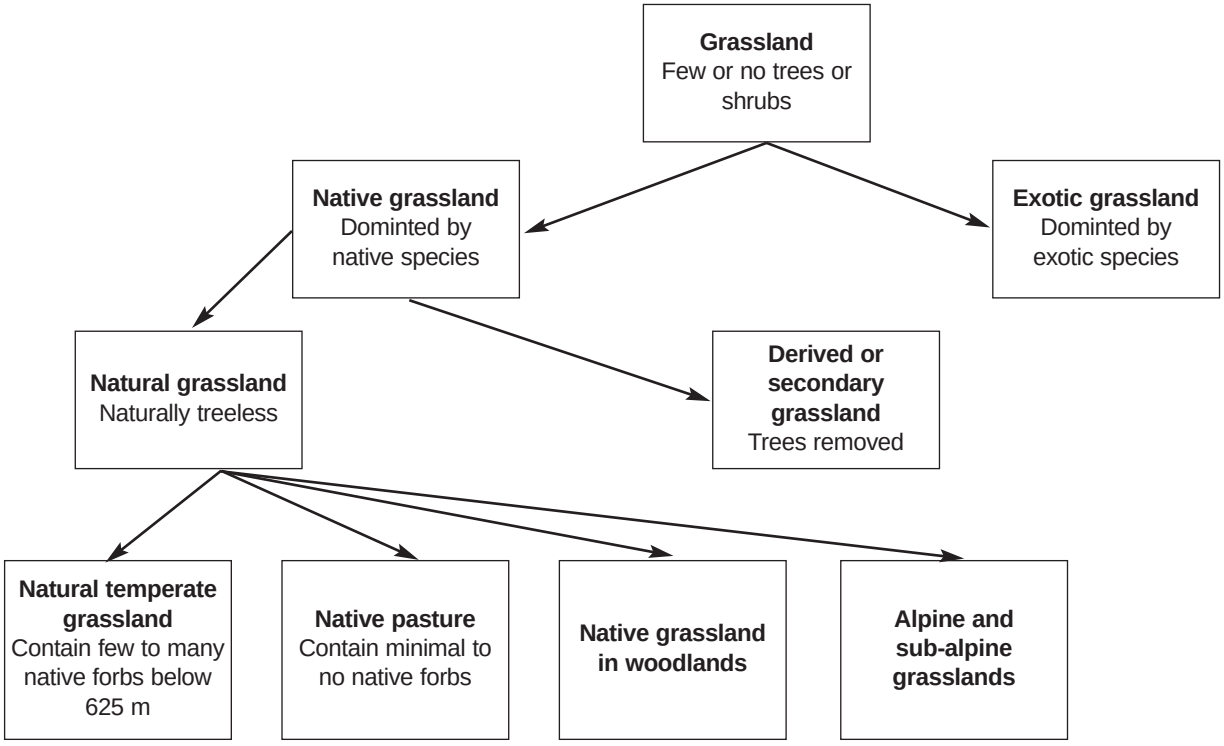
Geodiversity

The natural range (diversity) of geological (bedrock), geomorphological (landform) and soil features, assemblages, systems and processes (AHC 2002).

Grassland

Benson (1996 in Rehwinkel 1997) compiled a set of grassland definitions that would be universally accepted by grassland ecologists and those involved with grassland management, as follows:

- **Grassland**—vegetation dominated by grasses and forbs, <10% tree and shrub cover;
- **Native grassland**—grassland with >50% of vegetation cover composed of indigenous species, >50% of species are native, and minimum vegetation cover, alive or dead is >10%;
- **Natural grassland**—native grasslands occurring in regions considered to have had <10% tree and shrub cover at the time of European settlement (cf. secondary grassland below);
- **Secondary grassland**—a native grassland remaining after the removal or dieback of previously occurring trees and shrubs, where these occupy >10% cover;
- **Native pasture**—contains native and introduced species, where introduced species occupy >50%, but <75% of both cover and species present, where pasture species have been mechanically sown;
- **Exotic grassland**—where >75% of species and cover are introduced.



Native pasture and natural temperate grassland are considered in this Strategy.

A detailed definition for **natural temperate grassland** is contained in s. 2.1.4. This definition was developed as part of the nomination process that lead to natural temperate grassland being declared an endangered ecological community under the *Nature Conservation Act 1980* (ACT).

Habitat

The structural environments where an organism lives for all or part of its life, including environments once occupied (continuously, periodically or occasionally) by an organism or group of organisms, and into which organisms of that kind have the potential to be reinstated (AHC 2002).

Herbs

Plants without woody stems.

Land Management Agreement

An agreement between a lessee and the Territory establishing a co-operative management regime for non-urban land in the ACT.

Natural Integrity

The degree to which a place or ecosystem retains its natural biodiversity and geodiversity and other natural processes and characteristics (AHC 2002).

Organism

Any living being.

Projective Foliage Cover

The percentage of the sample site occupied by the vertical projection of foliage only i.e. gaps in the crown are excluded.

Protection

Taking care of a place by managing impacts to ensure that natural significance is retained (AHC 2002).

Regeneration

The natural recovery of natural integrity following disturbance or degradation (AHC 2002).

Relictual

Where a plant or animal species is now living in an environment that has changed from that which is typical for it.

Restoration

Returning existing habitats to a known past state or to an approximation of the natural condition by repairing degradation, by removing introduced species or by reinstatement (AHC 2002).

Riparian

Any land that adjoins, directly influences, or is influenced by a body of water (Lovett and Price 1999).

Secondary Grassland

An ecological community that develops when the tree canopy cover of grassy woodland or forest is removed or suffers dieback and natural regeneration is prevented (Benson 1996).

Species Diversity

The variety of species in a place (AHC 2002).

Taxa

Another term for species.

Threatened

An umbrella term for various categories of risk of premature extinction.

Vulnerable

In relation to a species, means a species that within the next 25 years is likely to become endangered unless the circumstances and factors threatening its abundance, survival or evolution cease (*Nature Conservation Act 1980*).

Weed

A plant that threatens human welfare by competing with other plants that have food, timber or amenity value (Begon *et al.* 1990). Environmental weeds are plants that threaten diversity and functioning in native ecosystems.