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).

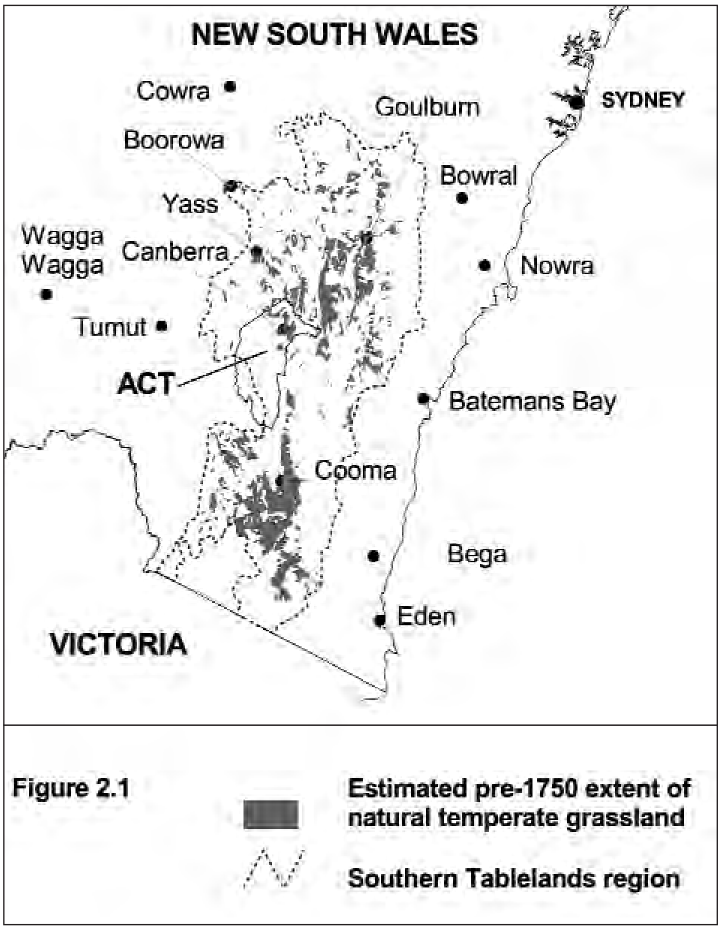

Figure 2.1: Estimated Pre-1750 Extent of Natural Temperate Grassland in the Southern Tablelands Region.

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: *Leptorhynchos 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 (*Nassella 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 umbellata* (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 (*Nassella trichotoma*), Chilean Needle Grass (*Nassella 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 *Phaulacridium 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.