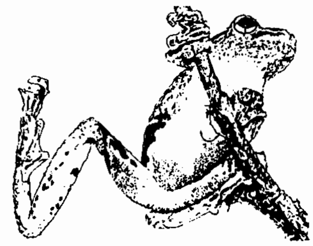

INFORMATION REQUIREMENTS FOR NATIVE GRASSLAND CONSERVATION IN THE A.C.T.

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CONTENTS

ECOLOGICAL TERMS DEFINED

Organism. An individual plant, animal, fungus or microbe.

Population. A group of individuals of one species in an area.

Species. A group of potentially interbreeding populations.

Community. All the species that occur together in a place. Usually defined by its characteristic vegetation.

Remnant. A small area of predominantly native vegetation surrounded by predominantly exotic vegetation or development. Also referred to in this report as a patch.

Patch dynamics. The concept of communities as consisting of a mosaic of interacting patches produced by internal and external disturbances.

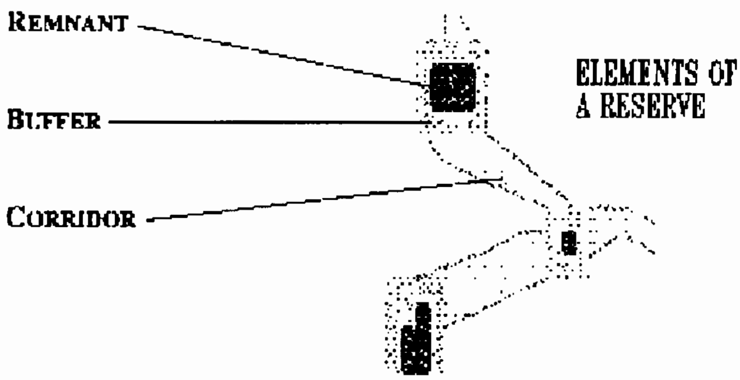
Habitat. The type of place where an organism lives.

Environment. The physical and biological surroundings of an organism.

Buffer. An area of land surrounding a remnant and managed to minimize impacts on the remnant and increase its conservation value.

Corridor. A strip of land connecting two or more remnants or other natural areas and managed in order to facilitate ecological interaction between them.

Reserve. Refers in this report to a system of interconnected land (and water) areas, probably under different tenures and with embedded patches of remnant vegetation, which is managed by various mechanisms towards achieving overall conservation goals.



SCOPE OF REPORT

This report was prepared in response to Planning Brief No. 90/34 from the A.C.T. Planning Authority. No prior familiarity with the fundamental concepts of conservation biology is assumed. The report:

- provides a background to the key **ecological principles** and **current knowledge** on which a conservation plan for native grasslands is based;
- sets out the key **elements of a plan** to conserve the native grassland ecosystems of the A.C.T. and particular endangered species occurring in them;
- details the **information requirements** for the development of the plan;
- details **specific studies** required to remedy deficiencies in current knowledge.

The **objectives** of the report are to assist the A.C.T. Planning Authority in developing a conservation strategy for the tableland grasslands, to recommend where scarce financial resources can be focussed to help achieve this conservation goal, and to present an approach to achieving native grassland conservation.

It **assumes** that the goal of conservation is to maintain biological diversity of the A.C.T. over extended time scales in a way consistent with sustained production and land use demands. It is also accepted that conservation management has to be adaptive in the sense that we don't know everything at the start; all we need is the information to reach the next few steps towards achieving goals.

The **focus** of the report is on the scientific information base required, but this is not to deny the importance of other necessary inputs. Throughout the report, the word "reserve" is used in a broader sense than is usual, to refer to a system of interconnected land (and water) areas, probably under different tenures and with embedded patches of remnant vegetation, which is managed by various mechanisms towards achieving overall conservation goals.

Specific issues and questions addressed include:

- the achievement of conservation goals in a system based mainly on small remnants;
- how we assess the need for protection of a species or community;
- the concept of a viable population and how we define this at any given time for any given species;
- considerations necessary to determine if an area, set aside as a reserve or part of a reserve, will be compatible with the land use around it (e.g. urban development).

The **Recommendations** are directed specifically at information requirements.

The **Summary** covers ecological principles, a planning framework and current knowledge.

Research on *Synemon plana* be directed towards a systematic survey of the A.C.T. for potential and existing habitats; a study to define precisely the moth's life cycle and food plant relationships; determination of the current biogeographic pattern of the moth and estimation of viable population sizes once the species biology is documented.

Conservation management of this species needs to establish techniques for determining population density of the moth, determining suitable means for maintaining and increasing the abundance of the preferred food plants and, in the longer term, methods to disperse the species to new locations and to create suitable habitat.

RECOMMENDATIONS

NATIVE GRASSLAND ECOSYSTEMS

That native grasslands in the A.C.T. be given a high conservation priority on account of the major degree of reduction in area since settlement, continuing threats, general vulnerability, poor knowledge base and a lack of current protection.

That the unique opportunity be taken to conserve the A.C.T.'s native grasslands effectively by linking the remaining grasslands with the hillslope woodlands and forests and the river corridors to form more viable and manageable conservation systems based on a variety of land uses.

A survey be carried out to delineate the past and present distribution and botanical composition of all major occurrences of native grassland in the A.C.T. (and surrounding parts of N.S.W. likely to be influenced by urban and peri-urban development), so as to provide a sound basis for initial planning decisions.

A study be conducted of the soil and litter invertebrates, small vertebrates, and soils in the major grassland sites to relate patterns of flora and fauna to site factors such as size of patches, soil conditions and disturbance history.

Research be commissioned into the population ecology of key species in relation to understanding the influence of external factors on the internal dynamics of remnant patches.

Establishment of permanent monitoring sites to enable likely impacts to grassland patches to be detected earlier and mitigated.

Establishment of management experiments in a range of sites based on their composition and external environment to determine the response of the biota in these remnants to various disturbance regimes including mowing and burning.

Establishment of grassland restoration trials in suitable areas adjacent to existing remnants.

DELMA IMPAR

That the distinctive species *Delma impar* be given a high conservation priority in the A.C.T. based on its restricted distribution, apparent low abundance and specialization on a habitat represented only as remnants. Subsequent research may lead to a strengthening or moderation of this position.

That applied research on *Delma impar* be directed towards establishing its population status and habitat requirements in the A.C.T., assessing the likely impacts of urban development adjacent to protected areas, and monitoring trends in population abundance to enable assessment of the magnitude of any continuing declines in populations.

Further long-term research needs to be initiated on the dispersal of the species between patches. A population viability analysis should be undertaken and incorporate the importance of movement between patches in maintaining populations of *Delma impar* in the A.C.T. This will establish the need for management to intervene by periodically re-establishing the species in the less viable remnant patches. Provision will need to be made for appropriate fire management in relation to this species.

SYNEMON PLANA

That a high conservation priority be given to *Synemon plana*, given its greatly reduced and restricted distribution based on dependence on particular grassland species and its low powers of dispersal. The species to be considered as an indicator species for other invertebrates in grasslands.

The development of **specific objectives** is important when decisions are being made about a regional system of reserves, particularly one based on remnants. This is made difficult when basic information is lacking about the composition, structure and functioning of the remnants under consideration.

A **systematic approach** to conservation planning is required where objectives are agreed upon and assessments are compared for all areas potentially available for conservation. Recent developments in the procedures for systematic selection of remnants for inclusion in conservation reserves emphasize the need for reserve networks to be representative, i.e. to include the range of biological diversity and other natural features within a region.

Assessing representativeness involves using the criteria of size, diversity, rarity and naturalness (both now and in the future). We require assessments of all available remnants on each of these criteria as inputs to a regional, systematic conservation plan. An evaluation scoring system can be devised so as to make comparisons possible between individual patches. Such subjective systems are very dependent on the weightings given to their elements and the way in which these ratings are used to rank sites.

When considering small remnants, the likely extent of physical change imposed must be carefully evaluated. Such impacts on small areas are far more likely to bring about major and rapid community change than apparently more subtle effects such as random local extinction of component populations. Naturalness includes the potential for areas to be restored to a more natural condition and/or to be linked to predominantly natural surrounds.

The structure of a reserve based on remnants requires consideration of the inclusion of the remnants with the highest conservation value, the control of the internal dynamics and external influences on the patches, and the development of linkages between patches and to other relatively natural communities. As well as selecting remnants to represent a region's biological diversity, a conservation plan must consider the **spatial and ecological linkages** between these which will in turn influence the conservation value of patches and the reserve system as a whole.

The areas immediately surrounding remnant patches are likely to have some habitat value, but may be more degraded than the remnant itself. They may be under different land use and tenure but could still be managed to increase the total contribution to conservation values. The development of buffer zones and corridors in order to reduce impacts on high diversity remnants and to reduce barriers for movement between a reserve and other refuges is highly desirable. These could be developed by revegetation management techniques, using existing information on the development and management of native grass swards and woodlots.

In order to make effective planning and management decisions, it is essential to know the **distribution and abundance** of the various species of plants and animals of concern and to develop a clear rationale as to why they are of concern. Such surveys often lead to a dramatic reappraisal of the distribution, abundance and habitat relations of hitherto poorly known species. We also need to understand their **population dynamics** in order to plan for conservation.

Although much research is performed that is of general relevance to such conservation planning and management, there is often a **lack of specific data** for reasons related to the perceptions of researchers and managers. Traditionally, research has been seen as a pre-requisite to management and management planning, but management decisions will always have to be made without adequate knowledge derived from research.

SUMMARY

ASSESSING THE NEED FOR CONSERVATION

Assessing the requirement of species or communities for protection requires knowledge of their distribution and abundance, preferably obtained through systematic evaluation of the distribution of species and communities in a wider regional area. Additional considerations are the extent of **existing reservation protection** and the practical **feasibility of managing** the species or community given any legal, economic, social or biological constraints.

Distinctiveness, distribution, rarity, vulnerability and current threats to species and communities are all important inputs to determining conservation value. **Distinctiveness** of a species is important because it enhances its scientific and aesthetic value, and therefore pressure to ensure its continuance. **Rarity** in the biological sense is a complex concept, and low abundance is not necessarily grounds for concern by the conservation biologist. There are often insufficient data to resolve the taxonomic status and genetic distinctiveness of the populations concerned. Conservation planning for species on endangered species lists must be based on current information on the species in the area of concern and the surrounding region.

In assessing communities we also need to consider their extent of reduction since European settlement and current threats based on up to date information on local and regional distribution and the degree to which they occur in existing conservation areas. The conservation of the diverse range of communities is a highly desirable conservation objective. Conservation assessments need to include rare communities just as much as common ones, for several reasons.

Vulnerable communities are those where the radiation, nutrient or water environment are easily altered. Temperate native grasslands are vulnerable because they respond strongly to changes in fire, nutrient and grazing regimes. **Current threats** to communities arise from the value placed by society on component species or the land itself. Native grasslands in temperate south-eastern Australia are extremely threatened because they occur on sites favourable to agriculture and urban/industrial development.

ASSESSING POPULATION VIABILITY

The presence of a species in a habitat remnant is not in itself a guarantee that the population will be able to persist there for a long period of time. In recent years attention has been focussed on determining the conditions which will allow the long-term persistence of a population in a given place. During the last few decades there has been a significant increase in the estimates of population sizes that will ensure viability because of an increasing realization that factors such as epidemics, catastrophes, fragmentation and genetic drift have important influences on the quality of populations. To assess the **viability of populations** requires extensive and detailed knowledge of population structure and its response to disturbance.

FRAMEWORK FOR CONSERVATION PLANNING

Ecological and genetic theory suggests that the viability of communities and populations on small remnants will be increased if they are able to be linked across the landscape so as to allow increased biotic interchange. Hence a significant trend in conservation management is the **extension of conservation programs outside of formal reserves**.

Remnants pose particular problems for conservation because they are usually a small, non-representative sample of pre-existing communities, they require ongoing management and monitoring because of their small size and they need to be considered as a system or network. **Public perceptions** of grasslands also pose special considerations for their conservation.

CURRENT KNOWLEDGE

Studies here and in Victoria have established aspects of the reproductive biology and ecology of the dominant grass species, with an emphasis on using these natives in landscape plantings. This will prove useful for restoration work in conservation reserve systems. Few studies of the other components of grasslands have been done here but preliminary studies have commenced in the A.C.T. on several rare or endangered faunal species which are found in grassland communities in order to determine their habitat requirements.

Delma impar is one such species. This small legless lizard has the most southerly distribution of all members of its family (Pygopodidae), being restricted to Victoria and adjacent areas of South Australia, and southern N.S.W. west of the Great Divide. *Delma impar* feeds upon soil and litter invertebrates, particularly the larvae of moths of the family (Noctuidae). Despite the close proximity of populations of *Delma impar* to urban centres, very little is known of the fundamental biology of this species.

Almost all known locations for *Delma impar* in the A.C.T. occur in *Themeda* and *Stipa* native grassland remnants in Gungahlin. Apparent specialization on these grasslands makes the species particularly vulnerable to extinction in the A.C.T.

Synemon plana is a brown, orange and black moth, about 3.5 cm across, which is active in daytime in November and December. Its eggs are laid in grass tussocks and the larvae feed preferentially on the roots of the Silver-Top Wallaby Grass, *Danthonia carphoides*.

It survives in the A.C.T. in a few remnant patches of *Danthonia carphoides* and *Danthonia auriculata* grassland. Grasslands where other grass species dominate are unsuitable, even if they contain other *Danthonia* species. This underlines the need for a full documentation of the floristic diversity of the remnant grasslands. Although *Danthonia carphoides* grasslands may occur elsewhere, the moth is apparently not able to colonise them easily as the female does not fly far.

It appears that the species might survive well in small reserved areas as moths are plentiful where they occur, sometimes in very small patches. The moth is considered endangered because its habitat, the *Danthonia* grasslands, is endangered.

Applied research is needed now to establish the past and present distribution and composition of native grasslands and the population status and the habitat requirements of the endangered species in them. Longer term research, combined with management monitoring, is needed to understand key processes in habitat remnant reserves. These include:

- the response of the populations in patches to fragmentation and impacts from the surrounding environments;
- the use of habitat patches, buffer zones and corridors by mobile species.

As knowledge of species biology, population dynamics and habitat use increases, it will be possible to make more accurate estimates of viable population sizes.

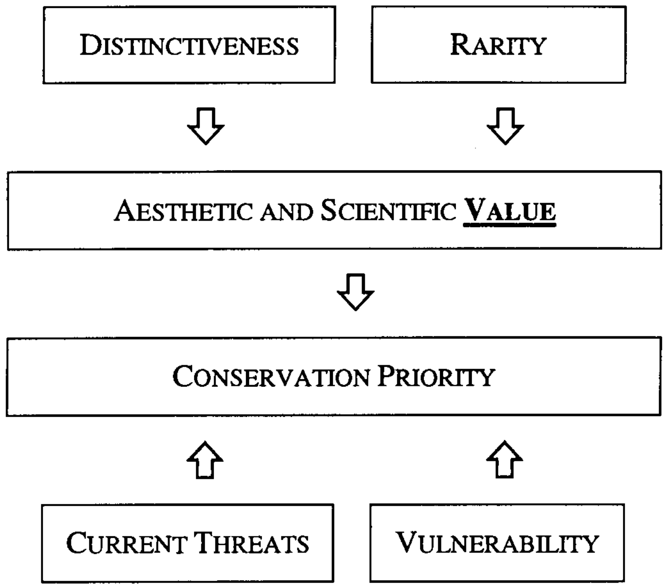


Figure 1. Species attributes contributing to conservation priority

A sound working classification of seven types of rarity, incorporating the notions of abundance, distribution and habitat specificity is shown in Table 1.

When viewed in this framework, natural rarity may arise from several different sets of causes:

- because of specialized adaptation to an environment which itself has only a small geographic range,
- because populations of the species are relicts of former more widespread populations which have contracted with climatic and other environmental change,
- because the species requires conditions which occur only intermittently. Between these times such species may be absolutely rare or simply present in a dormant and often hidden state;
- because the species benefits from being rare, an adaptation to predation or threat of disease.

Human influences can and have operated to produce rarity in addition to these causes of natural rarity by limiting the distribution of suitable environments. The main human activities responsible for rarity are:

- habitat clearance for urban/industrial development;
- modification of ecosystems by management of component species or disturbance regimes e.g. fire, logging, grazing, pest/weed introductions, trampling, mining;
- pollution and change in the insolation, shelter, nutrient or hydrological status of ecosystems;
- direct exploitation of species by harvesting.

1. KEY ECOLOGICAL PRINCIPLES

1.1 ASSESSING NEED FOR CONSERVATION

The assessment of the requirement of individual species or communities for protection requires a knowledge of their distribution and viability, preferably obtained through systematic evaluation of the their distribution in a wider regional area. Once these assessments have been made, several additional considerations must also be taken into account. These are:

- the degree to which species and communities already occur in designated nature conservation areas, i.e. the extent of **existing protection**; and
- the **feasibility of managing** the species or community given any legal, economic, social or biological constraints present.

In the following section we describe the current approaches for species then for communities.

1.1.1 ASSESSING SPECIES

To assess the requirement for conservation of a species we need to consider its distribution, rarity, vulnerability and current threats, and to refine these assessments based on current information and the degree to which it occurs in existing conservation areas.

Many native Australian species are neither a major economic resource nor species whose activities are in conflict with community goals, values or aspirations. Priorities for such species must be based on value that cannot be measured on an economic scale. Their conservation is concerned primarily with the concepts of distinctiveness and rarity, and the related concept of "value", and is also concerned with a species vulnerability to extinction and the degree of current threat to its existence. The relationships of each of these factors to setting conservation priorities is shown in Figure 1.

Distinctiveness of a species is important because it enhances its scientific and aesthetic value, and therefore pressure to ensure its continuance. Whether the species has close relatives is an important consideration because the related species or subspecies may be common and yet share many of its habits and features. A taxonomically distinct species may possess a suite of characters found nowhere else among other living species. In other words, we need to consider how much would be lost to science or the environment if the species were to become extinct. Families with only one species in them attract a higher priority than genera with only one species, which attract a higher priority than does one species among several in a genus, or subspecies, races and populations respectively.

Rarity in the colloquial sense may increase the aesthetic value of the species, and so increase public pressure for adequate measures to be taken to ensure the species' conservation. However, rarity in the biological sense is a complex concept, and low abundances *per se* may not be grounds for concern by the conservation biologist. Rarity is a feature of the biology of many species, and may in fact be a stratagem to enhance survival. A widely distributed species for which low abundances are typical, may well be quite secure. In contrast, forms of rarity defined on the basis of a limited geographical distribution, have a direct bearing on conservation priorities. An abundant species with a geographically restricted distribution can be quite vulnerable to extinction through habitat destruction, climatic change or disease.

In view of this lack of detailed information, conservation planning for species on endangered species lists must be based on improved and current information on the species in the area of concern and the surrounding region. For example, for a plant species to be regarded as adequately reserved on the list of *Rare or Threatened Australian Plants*[2] it must have been assessed as having at least 1000 individuals known to occur in reserves, but this figure will obviously need to be modified depending on the field biology of the plant and the nature of the threats to its existence.

1.1.2 ASSESSING COMMUNITIES

To assess the requirement for conservation of a community we need to consider its distinctiveness, rarity, vulnerability, extent of reduction since European settlement and current threats based on up to date information on its local and regional distribution and the degree to which it occurs in existing conservation areas.

Assessment of the conservation needs of communities is based on a similar set of attributes as those described for species. However communities do not have the same evolutionary potential as species. Many communities are undoubtedly ephemeral in a particular location and in their extent, particularly when considering longer time scales such as inter-glacial cycles. For conservation planning, communities are usually defined in terms of the set of plant species they contain. Since community composition varies continuously from place to place (and over time), the types of communities we recognize are necessarily subjective to some degree, whereas species are much more objectively definable natural units.

However, the conservation of the diverse range of communities is a highly desirable conservation objective since;

- we do not know the **total** species composition of any community,
- species often occur in a number of communities and show genetic differences therein,
- many species **require** different communities in different seasons or in the various stages of their life cycles.

Distinctiveness of a community can derive from unusual growth forms of the dominant species (e.g. *Spinifex* hummock grasslands in arid Australia), from unusual combinations of environmental factors controlling the community structure and composition (e.g. alpine grasslands in frost hollows) and from the basic similarities and differences in species composition it displays compared to other communities.

A practical aspect of distinctiveness is the amount of difference we recognize between communities defined in terms of their plant species. The problem is, how different in composition can two sites be before we call them different communities? The answer is dictated by the available data. If we have only broad scale community descriptions we should err on the side of caution in recognizing community differences. The finer the scale of our data, then the more sure we can be that all major community variations are known and can be allowed for in planning.

Rarity in native communities occurs primarily because the appropriate environmental conditions for their existence do not occur widely in the landscape. These conditions may have been more common in the past (in the case of a relict community) and may be common again in the future. Rare communities often contain species that are rare or distinctive. Conservation assessments need to include rare communities just as much as common ones, for all these reasons.

Table 1. A classification of rare species based on geographic range, habitat specificity, and local population size.[1]

GEOGRAPHIC RANGE	**Large**	
HABITAT SPECIFICITY	**Wide**	**Narrow**
Local Population Size:		
Large, dominant somewhere	Not rare: Locally abundant over a large range in several habitats	Locally abundant over a large range in a specific habitat
Small, non-dominant	Constantly sparse over a large range and several habitats	Constantly sparse in a specific habitat but over a large range

GEOGRAPHIC RANGE	**Small**	
HABITAT SPECIFICITY	**Wide**	**Narrow**
Local Population Size:		
Large, dominant somewhere	Locally abundant in several habitats but restricted geographically	Locally abundant in a specific habitat but restricted geographically
Small, non-dominant	Constantly sparse and geographically restricted in several habitats	Constantly sparse and geographically restricted in a specific habitat

Some species are more **vulnerable** to the vicissitudes of nature and humans than others, and therefore deserve greater attention by conservation biologists. We need to consider the features of a species that render it more vulnerable to extinction, quite irrespective of the existence of current threats to its well being. The species may have specialized requirements with regard to food, breeding sites and conditions, or habitat and therefore be particularly sensitive to habitat modification. Its habits may make it particularly susceptible to predation by introduced predators, and so on.

Finally there is the need to determine if there are any **current threats** to a species' continued existence and to assess the need for intervention to negate or offset the deleterious effects of human activity.

Several caveats apply to the interpretation of published lists of rare and endangered species when used to assess the need for protection of particular species. Due to the limited resources available for this kind of work in Australia, there is often only crude information available to judge the degree of threat and reservation. Such information does not usually encompass basic data on the size, number and spread of populations remaining, factors affecting population size and stability, reproductive strategies and the role of natural succession. Nor does it include the effectiveness of reserve management, if indeed the species does exist in reserves. Moreover there is often a lack of specific data to resolve the taxonomic status and genetic distinctiveness of the populations concerned — the so-called "**taxonomic impediment**". Many species in Australia, particularly invertebrates, are undescribed and our knowledge of genetic variation within most described species is relatively poor.

1.2.2 PROBABILITY AND TIME TO EXTINCTION

It is impossible to guarantee the absolute survival of a population indefinitely on a habitat remnant and it is necessary for conservation programs to establish both the desired time over which one wants the population to persist and the desired probability of success. For example, a particular conservation program might accept a 90% probability that a population will survive for 100 years. Such conditions are value judgements made by conservation managers and are a necessary part of any attempt to calculate MVPs and MARs for target populations.

1.2.3 POPULATION STRUCTURE

The target for conservation efforts at the level of individual species is the population. However, the term population is used in two different ways. It is used to describe both an arbitrary sample of individuals present at one site and also a discrete group of ecologically interacting individuals. It is important, therefore, to determine if the individuals in a habitat remnant represent an isolated group of individuals or part of a larger population extending beyond the boundaries of the remnant. It is essential that detailed information be obtained about the distribution and population structure of species on habitat remnants. Some small populations occupying habitat remnants may not be able to persist, but a network of populations on different adjacent habitat remnants may survive given certain disturbance regimes.

The question of population structure and area in relation to the size and distribution of habitat remnants is particularly relevant in the case of environmental disturbances. Persistence of a species in the face of disturbances such as disease, floods, droughts and fire may depend on recolonization from other populations. Where populations are subject to high extinction rates due to environmental disturbance it is important that either the habitat remnant is large enough to contain undisturbed regions or the remnant is within the dispersal range of individuals from another remnant.

1.2.4 THREATS TO POPULATION PERSISTENCE

The different factors that can affect the probability of a population persisting for a given time period all interact with each other. However, it is convenient to consider them under two general headings, demographic and genetic.

1.2.4.1 Demographic Factors

Knowing the biology of a population including its pattern of reproduction and recruitment, age structure and survivorship, allows one to build models which predict the expected time to extinction for populations of different maximum size. Thus, for a particular persistence time it is possible to calculate the minimum population size that will result in persistence with a particular degree of probability. From the value of this minimum population size and a knowledge of the density of the species it is possible to estimate the minimum area of habitat required to contain this minimum population size.

These demographic models can incorporate the effect of environmental variation on population parameters such as the variance in population growth rate. Simulation models have shown that the incorporation of environmental variation can greatly decrease the persistence times for populations. This means that for a particular persistence time the minimum population size may be very large. This in turn means the habitat size required to contain this minimum population size has to be very large - larger than most existing habitat remnants. These results suggest that a system of interconnecting habitat remnants needs to be incorporated into conservation management.

1.2.4.2 Genetic Factors

The rationale for considering genetic factors in an analysis of minimum population sizes is that long-term persistence requires the capacity of the population to respond to environmental change through the process of natural selection. An evolutionary response requires genetic variation and in

Vulnerable communities are those whose radiation, nutrient or water conditions are easily interfered with, e.g. drainage of peat moss communities. Another cause of vulnerability occurs where communities are dependant on a particular disturbance regime (e.g. fire) and this regime is easily altered (e.g. by fragmentation). Temperate grasslands are vulnerable in both these senses because they respond dramatically to changes in fire, nutrient and grazing regimes.

Current threats to communities arise from the value placed by society on component species (e.g. timber species in forests) or the land itself. Native grasslands in temperate south-eastern Australia are extremely threatened because they occur on sites favourable to agriculture and urban/industrial development. The extent of reduction in their area and modification from the pre-European condition is a clear argument for conservation of all temperate grassland remnants such as occur in the A.C.T.

1.2 ASSESSING POPULATION VIABILITY

During the last few decades there has been a significant increase in the estimates of population sizes that will ensure viability because of an increasing realization that factors such as epidemics, catastrophes, fragmentation and genetic drift have important influences on the quality of populations. More recently, the role of long-term environmental variability has also been seen to necessitate higher estimates of viable population sizes.

To assess the viability of populations requires extensive and detailed knowledge of population structure and its response to disturbance. This includes genetic variation within and between populations, reproductive rates and dispersal patterns in relation to patches. Population viability analysis is unlikely to be a useful management tool in the near future.

1.2.1 THE CONCEPT OF A VIABLE POPULATION

Paralleling the concern of ecologists to determine the minimum size of reserved areas for long-term ecosystem viability is the concern of population biologists to establish estimates of minimal viable population sizes or densities for rare or threatened species. The presence of a species in a habitat remnant is not in itself a guarantee that the population will be able to persist there for a long period of time. In recent years attention has been directed to the problem of determining the conditions which will allow the long-term persistence of a population in a given place.

The problem of population persistence is usually seen in terms of population size since the ability of a population to persist is directly related to the size of the population. The size of a population that is large enough to withstand threats to its persistence is termed the minimum viable population (MVP) size. From a knowledge of the MVP size and the density of the population it is possible, in theory, to estimate how much habitat is required to contain a population large enough to persist for a long period of time. This represents the minimum area requirement (MAR) for the population.

The MARs of populations are clearly of central interest to conservation managers since they enable estimates to be made about either the requirements for the conservation of particular populations or the likelihood that particular reserves or habitat will be able to support the population in the long term.

small populations the amount of genetic variation can be reduced simply by chance processes. In addition to the loss of genetic variation, inbreeding in small populations can lead to a loss of immediate fitness which in turn can make populations more vulnerable. Various attempts have been made to estimate the minimum population size that will avoid the problems of inbreeding or the larger minimum population size that will prevent the loss of genetic variation.

The effects of genetic variation on population persistence were studied before demographic factors were examined and it now appears that in many cases demographic factors will set the lower limit for minimum population size estimates. Nevertheless, the long term persistence of all populations depends on their capacity to evolve and any management effort that removes this capacity will result in the inevitable extinction of the population. If the time frame for conservation for a particular population is longer than a few generations then an assessment of the amount and distribution of genetic variation in the population and a monitoring of this variation over time is essential.

Despite these public perceptions, native grasslands have been identified as communities of conservation priority in recent years and as containing endangered species by, for example, the Australian National Parks and Wildlife Service in the Endangered Species Program, the Save the Bush Scheme and the National Estate Grants Program. On the other hand, there is some concern that programs such as One Billion Trees and Landcare may lead to inadvertent adverse effects on native grasslands.

2.3 CONSERVATION STRATEGY

In developing conservation strategies, a number of overlapping components are recognized:

- development of goals and objectives,
- selecting an appropriate set of remnants,
- planning a reserve structure,
- species, habitat and site assessment and research,
- management, monitoring and recovery planning,
- resource and habitat management,
- public education and involvement,
- development of protection mechanisms including legislation, management agreements etc.

In this section we are concerned with the application and development of the scientific knowledge base which provides direct support to these components.

2.3.1 DEVELOPING CONSERVATION GOALS

It might be assumed that the goals of nature conservation are simple ones. However, while they can be stated simply in general terms, the translation into operational terms leads to the recognition of a variety of possible objectives.

Two broad goals are often espoused in nature conservation. First is the protection of particular species of interest, often rare or endangered ones. Second is the aim of conserving entire functioning communities. Both approaches are necessary and interdependent. An emphasis on species conservation is required because there will always be species whose population size has been reduced to a low level by human activities. The conservation of such species cannot be done in the abstract, in fact the reason for their decline in abundance is most commonly because of changes to the extent or quality of their habitat. Hence one conserves species in nature only by ensuring the maintenance of suitable environments. To reflect this, the term **biological diversity** has come into use to refer to both species and the processes by which they interact; it encompasses the variety and variability of life and its processes in an area. Implicit in this view of biological diversity is the need to maintain ecosystem processes which have been responsible for the production of species over long time scales. This is now seen as an encompassing conservation goal.

The development of more specific objectives is important when decisions are being made about a regional system of reserves, particularly one based on remnants. Ideally one establishes a hierarchy of objectives from national down through regional and local and eventually to those for individual remnants. However major problems exist in defining more specific objectives and priorities when basic information is not available about the composition, structure and functioning of the remnants under consideration.

To assist in developing a set of regional and local objectives for A.C.T. grassland ecosystems, we propose the following objectives as a basis for defensible planning affecting A.C.T. grasslands.

2. FRAMEWORK FOR GRASSLAND CONSERVATION PLANNING

2.1 TRENDS IN NATURE CONSERVATION PLANNING

Nature conservation agencies in Australia now generally agree that a **systematic approach** to conservation planning is required, rather than the *ad hoc* approaches which have predominated in the past. The latter have usually involved land acquisition into reserves using criteria such as availability, aesthetics, lack of demand by other land uses and political pressures generated by community groups. The former are based on an explicit recognition of the scientific and political factors impinging on meeting agreed conservation objectives. With time, the options available for planning an adequate reserve system are diminished as more land is allocated to uses incompatible with nature conservation. This is particularly critical for native grasslands because they are already highly fragmented due to agricultural and urban development.

Another significant trend in conservation management is the **extension of conservation programs outside of formal reserves** to include the broader landscape. Historically, most conservationists have assumed that the key to successful management of endangered species or communities is the prohibition of human exploitation or the inclusion of endangered species within a reserve. Legal protection can be a first step towards conservation but is just the beginning of sound population and community management. Even in well-established national parks, human activities may still threaten species and communities, as disturbance and ecological processes continue across artificial boundaries. Far too often, reserved ecosystems are thought of as static, representing some ideal state. This view, it can be argued, ignores much of what is now known about ecosystem dynamics, disturbance and succession, global climate, natural selection, population genetics and indeed, human cultural history.

2.2 SPECIAL CONSIDERATIONS FOR REMNANTS AND GRASSLANDS

Where nature conservation relies largely on remnants, these patches require planning and management which accounts for the features which distinguish them from larger nature reserves and national parks. These features are that:

- the remnants are usually a small, non-representative sample of pre-existing communities because of selective patterns of land clearance and impacts due to factors such as grazing; but they may contain most of the species of those prior communities;
- they require ongoing management and monitoring because their small size leads to greater external impacts and likelihood of local extinctions; and
- they need to be considered as a system or network because fragmentation produces firstly a new biogeographic pattern of populations and communities, and secondly each remnant has an altered physical environment due to changes in its surrounding.

In addition to these particular considerations for remnants, grasslands themselves pose some uncommon difficulties for conservation, both in the urban and rural environment.

- Grasslands are most commonly thought of as lawn, turf, field or pasture rather than as a distinctive natural ecosystem.
- Grasslands in Australia now usually lack any large native animals, and so have low popular appeal in terms of their conservation.
- In an urban setting there is often an understandable tendency to plant trees on grassland sites or to see them as convenient areas for the spreading of fill or the stripping of topsoil.

Size of individual remnants is often used as a key consideration in deciding conservation value. It directly affects the population sizes able to be reserved therein and also the likely extent of external impact in both the short and long term. Much debate has taken place in conservation biology over the relative merits of remnant patches of differing sizes and shapes.[5] However when considering a system of remnants, the size of individual remnants needs to be balanced against the total area and spatial relation of high diversity remnants able to be incorporated by use of buffer zones, corridors etc. into a reserve. This is discussed in the section on reserve structure.

2.3.2.2 Relative criteria: rarity and naturalness

Rarity in the context of remnants refers to the regional or national rarity of particular vegetation types or habitats. This presupposes a knowledge of the variation in community composition across a region. Often national or state-wide compilations will not be sufficiently detailed when it comes to survey a given region; but the latter surveys must be designed to complement the broad-scale ones in order to give perspective at the various scales. Areas selected to be representative examples of communities need to include both the common and rare communities, even though some species may occur in both.

The criterion of **naturalness** commonly refers to the degree of modification caused directly or indirectly by human influence. For this assessment in Australia, the usual broad baseline adopted has been the immediately pre-European condition of the vegetation communities, even though the role of Aboriginal people in altering some of these communities is recognized. A national map compilation of such natural vegetation is available, but local work using historical records and remnant vegetation is necessary to delineate even approximate boundaries between say woodland and grassland in a local area.

At the site level, characteristics such as the abundance of exotic species, the reduction of dominant plant species through grazing or pasture improvement and the degree of disturbance by development are all appropriate aspects of naturalness which need to be evaluated. In considering small remnants, the likely extent of physical change imposed on the ecosystem must be carefully evaluated. For instance, spray drift leading to toxic accumulations, the diversion of runoff influencing water balance, and urban heat islands changing the microclimate in terms of frost incidence. Such impacts on small areas are far more likely to bring about major and rapid community change than apparently more subtle effects such as random local extinction of component populations.

Another aspect of naturalness is the potential for areas to be restored to a more natural condition and/or to be linked to predominantly natural surrounds. If a patch has been altered in the relative abundances of species by e.g. domestic stock grazing, then the removal of grazing will enable some immediate recovery. In contrast, a site which has had nutrient additions will require a much longer time to recover and will require more specific management treatments, e.g. mowing and removal of biomass.

2.3.3 RESERVE STRUCTURE

As well as selecting remnants to represent a region's biological diversity, a conservation plan must consider the spatial and ecological linkages between these which will to a large extent influence the conservation value of patches and the reserve system as a whole. The structure of a reserve based on remnants can usefully be focussed on three components:

- the inclusion of the remnants with the highest conservation value,
- the control of the internal dynamics and external influences on the patches,
- the development of linkages between patches and of connections to other relatively natural communities.

2.3.1.1 Regional Objectives

- To conserve the A.C.T.'s remnant grassland sites and, where possible, integrate them into broader conservation systems.
- To protect from adverse impacts all sites and habitats where rare, endangered or threatened plant or animal species occur.
- To develop an information base for planning and management of remnant native grasslands.
- To promote public awareness of the conservation value of grasslands.

2.3.1.2 Local Objectives

- To maintain sufficient grassland remnants at a sub-regional level (e.g. Gungahlin) such that all the plant species and known rare/endangered animal species are represented in at least five sites.
- To conserve all grassland remnants in the sub-region which are greater than one hectare and where possible develop buffer zones and corridors adjacent to and linking them so as to form a reserve.
- To involve community groups where possible in identifying and conserving urban grassland sites.

Each of these objectives would place slightly differing emphases on the information requirements for developing conservation and management strategies.

2.3.2 ACHIEVING REGIONAL REPRESENTATIVENESS

Recent developments in the procedures for systematic selection of remnants for inclusion in conservation reserves emphasise the need for reserve networks to be **representative**, i.e. to include the range of biological diversity and of other natural features (e.g. earth surface phenomena) within a region. Systematic procedures for designing a reserve system allow a set of representative areas to be identified explicitly and repeatably, provided a set of goals concerning representation and reserve design are given.[3] Some of these tools are flexible enough to provide a variety of possible schemes to meet the same objectives, thus recognizing that practically all decisions on the allocation of land for nature conservation are finally made on pragmatic rather than scientific grounds alone.

Assessing representativeness involves using the criteria of **size**, **diversity**, **rarity** and **naturalness** (both now and in the future). Ideally we require assessments of all available remnants on each of these criteria as inputs to a regional and systematic conservation plan. Some of these criteria relate to the ecological status of places, e.g. remnant patches, while others relate to their condition relative to other places in the region under comparison. At the planning stage, additional criteria may also be incorporated into a conservation planning exercise, e.g. such features as amenity or aesthetic value and educational usage.

2.3.2.1 Absolute criteria: diversity and size

Diversity here is usually taken to refer to the number of species an area contains. This will often be related to the physical size of an area but can be considered in its own right because the relationship between the two is not a straightforward nor well-understood one. Species diversity should not, however, be an over-riding consideration; other forms of diversity at all levels in the biological hierarchy should be considered.[4] For example, the well accepted concept of spatial diversity at the community level is one that should be incorporated into assessments of conservation significance. This does not deny the importance of species as the carriers of genetic potential, but simply recognizes that species are produced and maintained by ecological processes at all levels.

reproduction and growth patterns of both plant and animal species. Fire regimes will have altered and require reappraisal. Other less direct influences include increased feral animal and weed infestation and changed nutrient status if there is run-on from adjacent sites. All these effects will lead to subtle or not so subtle change in community composition over time.

The following strategies can be used to try to limit the effects of these influences on the patches and the whole reserve.

- wherever possible, include patches which are run-off rather than run-on,
- select patches which have an existing or potential buffer around them (see next section),
- plan to reduce the possibility of pedestrian and vehicle desire lines going across patches,
- plan to minimize the fire ignition risk from adjacent land users,
- be particularly vigilant during any land development phase to protect against vehicular, dumping and nutrient impacts, as well as temporary or permanent diversion of run-on water and suspended material.

2.3.3.3 Buffers and Corridors

It is likely that the area immediately surrounding remnant patches also has some habitat value, but will be more degraded than the remnant itself. Buffer zones around remnants will act to reduce the incidence and impact of weed and feral animal invasion and other disturbances in general. Buffers include for example, water bodies, rocky outcrops and strips of vegetation containing few introduced plants. They may be under different land tenure but still designed and managed to withstand higher levels of grazing pressure, or trampling, for instance, than the remnant.

One feature that is highly desirable to include in the development of a reserve is the provision of corridors, to reduce barriers for movement between a reserve and other refuges. In this context the term corridor is used to denote a strip of land linking areas which otherwise would be isolated, enabling some plant and animal species to move between refuges. Common corridors include road verges, drainage lines, windbreaks or shelterbelts.

The following advantages of corridors are recognised:

- they increase the effective size of plant and animal populations;
- they facilitate recolonization of a remnant which has been affected by some disturbance, such as fire;
- they support communities of plants and animals in their own right;
- they may form refuges in times of stress, such as during or after a fire or a drought.

To achieve these benefits, corridors should be as wide as possible to decrease edge effects, should contain native species as much as possible, and be managed in sympathy with the objectives set for adjacent remnants.

2.3.3.4 Restoration

Buffers and corridors could be developed by restoration management techniques, using existing information on the development and management of native grass swards. While the structure and species composition of such areas will not be identical to that of more natural areas, their general appearance, wildlife habitat values and dynamic character result from similar ecological processes. This creative conservation approach includes planting species on sites which will add to their natural diversity and provide habitat value. Specific management regimes will need to be designed for such areas.

2.3.3.1 Patch Value

The size of a remnant determines the potential size of plant and animal populations that can be maintained over time. Larger populations have a greater ability to withstand perturbations and contain higher levels of genetic diversity. However, different species require different sized areas. The following should be considered when a choice is available between various remnants:

- the smaller and more elongate the remnant the greater the likely influence of external factors on the site;
- larger (and more elongate) remnants potentially contain a greater habitat diversity and therefore a greater diversity of species;
- a collection of smaller remnants may between them contain a greater array of habitats than one larger remnant;
- smaller remnants will not contain viable populations of all species but may be valuable in association with other nearby remnants in a reserve; while
- smaller, isolated remnants will lose species faster from the effects of drought, fire or human related impacts, as no undisturbed areas remain nearby from which recolonization can take place.

An evaluation scoring system can be devised to make comparisons between individual patches. These subjective systems are very dependent on the weightings given to their elements and the way in which these ratings are used to rank sites. The key considerations on which to compare remnant grassland sites would include the following:

- areal extent and topography,
- number of native and exotic species,
- extent of invasion and modification (various categories),
- recent site history,
- number and priority of plant communities present,
- presence of any rare, endangered or threatened species of plant or animal,
- distance to nearest grassland remnant of a larger size,
- distance to a woodland,
- existing or potential to develop a buffer zone around,
- existing or potential to develop a corridor to other remnants,
- adjacent land use and its likely impacts.

Rating scales for each of these considerations could be developed and sites compared in this way, however this approach may lead to interpretation problems when more than a few variables are considered.[6]

2.3.3.2 External Influences on Patches

The ecological character and land use of the area adjacent to a remnant have significant effects, both direct and indirect, on that area's dynamics. These include radiation variations, hydrological influences and wind patterns. Urban development on sites surrounding native grasslands may increase mean temperatures both diurnally and seasonally within the grassland, affecting

There is a clear need to have research and management integrated so that they guide each other. To do this, management actions have to include the establishment of research and monitoring sites. In time, the interpretation of results from these sites provides evaluative feedback to ongoing research, planning and management programs.

It is desirable that surveys are designed so that indicators can be identified and incorporated in ongoing monitoring programs. This allows population trends to be followed in relation to disturbance events and more gradual change such as may be caused by long-term climatic cycles. From such studies we can predict what will happen to a population in specified circumstances.

One most cost-effective means for monitoring some endangered species is to establish and manage a complete database of known occurrence locations, preferably linked into a local geographic information system, so as to be able to examine the species distribution in relation to impacts and to develop models to find possible new occurrences.

2.3.4 INFORMATION BASE

In this section we are concerned with the development of the scientific knowledge base which provides direct support to management. This information derives from one or more of the following activities; surveys, research, management, monitoring and evaluation. Each of these make a particular contribution to conservation strategies.

2.3.4.1 Surveys and Research

In order to make effective planning and management decisions, it is essential to know the distribution and abundance of the various species of plants and animals of concern and to develop a clear rationale as to why they are of concern. Rare species are difficult to survey, but knowing where they occur is a precondition for planning their conservation. A well-designed comprehensive survey will reveal features of the species biology and ecology, reservation status and threats to populations, and also the most suitable sites for potential reserves and questions about the species biology that will need to be answered for ongoing management to be successful. Such surveys often lead to a dramatic reappraisal of the distribution, abundance and habitat relations of hitherto poorly known species.

A beginning study of rare or endangered species soon comes to require more detailed community information so as to be able to determine habitat requirements more precisely. When surveying communities, a vegetation map based on intuitive classification and a composite list of plant species is no longer sufficient for most conservation purposes. Species lists must be collected at well-located sites and the biogeographic patterns in the data elucidated by multivariate and other analytical techniques so as to obtain the maximum information from expenditure on surveys. Species lists must be as complete as possible with voucher collections made wherever there is any doubt as to the species identity.

As well as surveys to document the distribution of species and communities, we also require a knowledge of their dynamics, in order to plan for their conservation. Although much research is performed that is of general relevance to conservation planning and management, there is often a lack of specific data for one or more of the following reasons:

- research workers are seldom interested in filling information gaps found during the development or implementation of management programs and are usually not interested in monitoring the effects of management activities; thus
- research often appears to be oriented to personal areas of interest rather than areas where present information needs for management have been demonstrated;
- research findings are often ignored, hard to find or interpret, when management plans are prepared and implemented, and are unknown to politicians and other decision-makers;
- managers often fail to appreciate that apparently simple management questions may involve scientific uncertainties which are difficult to resolve in the short term.

To maximize the availability of relevant scientific information, conservation plans should address these problems directly. Suggestions for doing so are made later in this report.

2.3.4.2 Management, Monitoring and Evaluation

Traditionally, research has been seen as a pre-requisite to management and management planning, but management decisions will always have to be made without adequate knowledge derived from research. Indeed many decisions could not be postponed to await research results even if resources were available for the necessary investigations.

winter is lethal to the grasshopper *Keyacris scurra* which is active then. As an alternative to burning, grasslands may be mown (at greater heights than is usual in urban grasslands) up to three times a year to retain species diversity, but it is not known to what extent this practise will alter overall community composition.

3.1.2 ESTABLISHING CONSERVATION PRIORITIES

The Limestone and other nearby plains, on which much of Canberra is situated, were a very extensive grassland community prior to settlement by non-Aborigines in the 1820's, and one of the prime reasons for the early settlement of the region, but are now present only as remnants of the pre-European vegetation. Today, partly because of the pattern and timing of urban/industrial development and agricultural practice around and in Canberra, we still have examples of this grassland type, albeit small ones that have undergone varying degrees of alteration since settlement. In most other areas, such as the colder and drier regions of the southern Monaro, pasture development has extensively altered the composition of these communities and areas suitable for reservation are unlikely to be common.

Themeda triandra was the dominant grass species interspersed with numerous herbs and with open woodland on the adjacent lower slopes and dry sclerophyll forest on the hills. It is thought that the distribution of these tableland grasslands was maintained through the combined effects of low rainfall (less than 600 mm per year), cold air drainage causing an inversion layer in the valleys, cracking clay soils, regular burning by Aborigines and the low nutrient content of the soils. Domestic stock, pasture improvement and other disturbances have led to the replacement of native grasses with exotic species.

The reduction of native grassland communities to remnant patches is widespread throughout southern Australia, and very few of these remnants are found in reserves. Instead, they commonly occur as roadside vegetation and in railway sidings and cemeteries, all of which are rather tenuous places for conservation. Grassland communities in the A.C.T. are inadequately conserved.[7]

The survival of the remaining A.C.T. grassland remnants owes much to the removal of grazing from several areas, light grazing regimes and lack of pasture improvement or cultivation in the rural sites. However, these sites have all been subject to some degree of continuing disturbance, including some extreme invasion by exotic species. Since 1970 three grassland patches have been totally removed by development and others have been partially developed. A number of others appear to have become considerably degraded by the invasion of exotic species. Some areas are under threat of further urban development, many others in and near urban areas are at risk from neglect and those occurring in rural areas are under continual invasion pressure by exotic species and subject to pasture development practices.

The high degree of reduction in area, continuing threats, general vulnerability, poor knowledge base and lack of protection of native grasslands in the A.C.T. clearly indicate a high conservation priority for this community.

3.1.3 RESEARCH

Applied research to improve the management of grasslands and aid planning decisions will need to encompass the following projects and considerations. The time frame required for each proposed study is categorized as short (3-9 months), medium (1-2 years), long (3-5 years) or continuing (start now and refine over time).

3. INFORMATION REQUIREMENTS FOR A.C.T. GRASSLANDS

In this section we give a brief overview of current knowledge and then identify the information required for developing conservation and management strategies for each of (i) Grassland Ecosystems, (ii) *Delma impar* and (iii) *Synemon plana*.

3.1 GRASSLAND ECOSYSTEMS

3.1.1 CURRENT KNOWLEDGE OF GRASSLANDS

The floristic composition and distribution of A.C.T. grasslands is not as well known as for other A.C.T. plant communities. Until 1980 there was little mention of native grasslands as a land use issue, other than for their grazing potential. Since then, while the need to incorporate management plans for grasslands has been discussed, none have yet been implemented. Grasslands are now seen as comprising a range of distinctive communities and as habitat for several rare or endangered plant and animal species. Despite this, few documents relating to grassland management in the A.C.T. recognise grassland communities as being a dynamic interaction of both faunal and floral elements. There are likely to be hundreds of faunal species which make a contribution to the stability and diversity of the grasslands, many of which are as yet undocumented.

Several floristic surveys of grasslands in the A.C.T. have been carried out over the last two decades. Forty sites containing predominantly native grasses were mapped from aerial photographs in the late 1970's, and a small number of other sites have been surveyed for plant species at various times.

Studies here and in Victoria have established some aspects of the biology and ecology of the dominant grass species, with an emphasis on using these in landscape plantings. This will prove useful for restoration work. The dominant grass species are strongly influenced by domestic grazing and pasture improvement practises. Grazing causes the demise of *Themeda triandra* (Kangaroo Grass), due partly to its greater palatability than other native grasses; *Danthonia* species (Wallaby Grasses) do not grow well where mechanical disturbance or fertiliser application has occurred; *Stipa bigeniculata* (Spear Grass) is more common in grazed or disturbed pasture partly due to its unpalatability, and the presence of *Bothriochloa macra* (Redleg Grass) often indicates a highly disturbed site.

There is a strong suggestion from studies carried out elsewhere that fauna, especially invertebrates (including soil invertebrates), play an important role in grassland communities. Certain groups, such as ants and termites may be of overriding importance. Disturbance such as grazing and pasture improvement change the dynamics of insect/plant interactions and invertebrate density, with higher numbers occurring in improved pasture than native grassland, but less in grazed native grassland than ungrazed.

Few studies of the other components of grasslands have been done here. Preliminary studies have commenced on several rare or endangered faunal species which are found in grassland communities to determine their habitat requirements. These are the Pink-tailed Legless Lizard (*Aprasia parapulchella*), the Striped Legless Lizard (*Delma impar*), the Wingless Grasshopper (*Keyacris scurra*), and the day-flying moth (*Synemon plana*). However, apart from some regional surveys of birds by the Canberra Ornithologists Group, comprehensive surveys are yet to be carried out of the faunal content of grassland communities in the A.C.T. and no studies appear to have been made of the physical environment of the remaining sites.

It has been recommended to burn grasslands every two to three years to retain native plant species diversity but burning to retain the diversity of a grassland is only going to be successful if the site does not contain a high density of exotic species, or if it has not been grazed or disturbed for a considerable length of time. Additionally, the short and long-term effects of such burning on plant species other than grasses and the fauna have yet to be considered. For instance, control burning in

- Establish permanent management plots in a range of sites based on their composition and external environment.

  (Time frame: medium and continuing)

  For determining effects of mowing and burning on abundances of all species. Encourage all researchers to use these long-term experimental sites for proposed short and long-term studies.

- Establish grassland restoration trials in suitable areas adjacent to existing remnants.

  (Time frame: medium and continuing)

  Needed in order to develop buffer zones and for possible habitat restoration for endangered species. The aim would be to get at least a native grass cover going and then monitor to maintain this while managing to control weeds.

- Publish a list of research topics and maintain a research directory.

  (Time frame: short and continuing)

  To encourage research of a kind suitable for integration into management and monitoring programs.

3.2 THE STRIPED LEGLESS LIZARD, *DELMA IMPAR*

3.2.1 CURRENT KNOWLEDGE

Delma impar (Fischer 1882) is a small legless lizard of the family Pygopodidae. It has the most southerly distribution of all Pygopodids, being restricted to Victoria and adjacent areas of South Australia, and southern NSW west of the Great Divide (Cogger 1986). It is uncommon with recent records from immediately west of Melbourne, Bool Lagoon in South Australia and the Australian Capital Territory. Historical information indicates that it was once more widespread (Coulson 1990).

The species occupies grassland habitats with the highest population densities in dense, relatively undisturbed grassland (Coulson 1990). They are generally collected by turning over rocks, boulders and other surface debris, or when ploughing virgin grasslands. *Delma impar* feeds upon soil and litter invertebrates, particularly the larvae of Noctuid moths.

In general, despite the close proximity of populations of *Delma impar* to centres of human population, very little is known of the fundamental biology of this species.

3.2.2 ESTABLISHING CONSERVATION PRIORITIES

Concern for the status of *Delma impar* by wildlife authorities in the A.C.T. and the Department of Conservation and Environment in Victoria (Ahern et al., 1985; Coulson, 1990) led to it being recommended for listing as a nationally vulnerable species on the CONCOM List of Australian Vertebrate Fauna (March 1991). Concerns about the status of the species were based primarily on its apparent disappearance from areas near Melbourne where it was commonly found one or two decades earlier, and on the low proportion of specimens lodged with museums in recent years. Urbanization has apparently caused local extinctions of the species, while in rural areas its preferred habitat of generally flat grassland has been extensively modified by cropping and introduction of pasture species.

Almost all known locations for *Delma impar* in the A.C.T. occur in *Themeda* and *Stipa* native grassland remnants in Gungahlin. Apparent specialization on these grasslands makes the species particularly vulnerable to extinction in the A.C.T. Following the lead shown in studies of *Delma impar* in Victoria, the restricted distribution, apparent low abundances and specialization on a habitat represented only as remnants clearly indicates that this distinctive species be given a high conservation priority in the A.C.T. Subsequent research may lead to a strengthening or moderation of this position.

3.2.3 RESEARCH

Managers are constrained to make their decisions on the information available here and now, but this does not diminish the need for further research. Further research will provide a firmer foundation for future management decisions and permit more effective evaluation of management intervention in the past. Applied research should be directed preferentially to:

- establishing the population status (abundances, distribution) of *Delma impar* in the A.C.T. so that a more reasoned assessment of its conservation priority can be made;

  (Time frame: short, with seasonal requirement)

- establishing the environmental requirements of *Delma impar* so that suitable habitat can be delineated and protected as reserves or through co-operative management arrangements with the leaseholders;

  (Time frame: medium)

- assessing the likely impacts of urban development adjacent to protected areas;

  (Time frame: medium and continuing)

- monitoring trends in population abundances to enable assessment the magnitude of any continuing declines in populations, the impact of adjacent urbanization and the causes, and the effectiveness of management intervention.

  (Time frame: continuing)

Some of this research has already been started by the A.C.T. Parks and Conservation Service, and much information is available from studies undertaken in Victoria.

3.2.3.1 Population status

Historical records, both published or in formal museum records, and anecdotal reports need to be collated to ascertain the former distribution of *Delma impar* in the A.C.T. Systematic surveys are required to determine the extent of the current distribution of *Delma impar* in the A.C.T. and to compare this distribution with historical records to determine the extent of any recent decline. Study is required to determine habitat specificity, to delineate boundaries of suitable habitat, to survey these areas to estimate population sizes and densities. The research on population status will provide input to the priority placed on management intervention.

3.2.3.2 Habitat specificity

Field studies are required to investigate key elements of the ecology and life history of the species. It is important to determine the specific habitat requirements of *Delma impar*, particularly with regard to the characteristics of native grasslands. How closely tied is *Delma impar* to remnant native vegetation? Does it have specific dietary requirements that are met only in native grassland ecosystems. Is floristic composition important or are structural characteristics of the grassland vegetation the primary determinants of *Delma* distribution? Do any exotic grass species provide the necessary structural elements? What is the role of rocks and boulders in ensuring the persistence of *Delma impar* in an area?

The knowledge of habitat specificity will enable reserve boundaries to be determined and will set the agenda for introducing legislation and management procedures designed to protect the environmental elements of the grassland remnants that are essential to *Delma impar.* This knowledge may enable programs to expand the habitat of *Delma impar* through artificial establishment of suitable habitat in areas where this does not conflict with other land uses (e.g. road easements etc). Success in this may reduce pressure to preserve other areas where there is a strong conflict in use.

3.2.3.3 Impact of urbanization

What impact on *Delma impar* can be expected from factors such as:

- increased proximity of an urban cat population;
- nutrient run-off which will enrich the native grassland remnant with consequential changes in floristic composition and structure;
- invasions by exotic grasses and weeds;
- boulder rolling by local children or rock and boulder collection by older residents;
- destruction of existing linkages between remnant patches.

Assessment of the likely impacts of urban development adjacent to protected areas (feral cats, urban runoff, human interference) will enable action to mitigate against these impacts (public education, modification of drainage plans, regulations).

3.2.3.4 The role of patch dynamics

Destruction of existing linkages between remnant patches may be particularly important in maintaining populations of *Delma impar.* In Gungahlin for example, the remnant grassland is not represented as a single extensive habitat, but rather a series of disjoint small remnants. Viability of small remnant populations may depend on chance extinctions being mitigated by a greater rate of re-invasion from adjacent remnants. Such re-invasions will depend on the lizards' ability to move from one patch to another using corridors of suitable habitat. Drainage channels with their tussock grasses may provide such corridors. Destruction of these dispersal routes by the substantial modification that will accompany urban development may result in the eventual permanent extinction of *Delma impar* from many of the Gungahlin remnant patches of grassland.

A related argument applies to fire. At a time when the native grasslands were at their full extent, the grassland habitat would have comprised a mosaic of patches with each patch differing in important structural and floristic characteristics depending upon such factors such as fire history. Species such as *Delma impar* and *Synemon plana* would have flourished in patches that suited their particular requirements well. The system would have been dynamic, with the species undergoing dramatic population declines in some patches as conditions moved away from the particular requirements of each species, while new suitable patches became available and were invaded.

Grass fires in Victorian grassland reserves have been recorded as killing *Delma impar.* Historically, the species may have persisted in areas of low frequency burn by the mosaic nature of fire. Populations of *Delma* in unburnt patches would disperse to repopulate areas decimated by fire. Such a process cannot operate in a single remnant patch, and interlinking between remnant patches may be very important in maintaining the species in the region. The irony of this situation is that low frequency fire may be important in maintaining the vegetation characteristics of a native grassland, but with the reduction of this habitat to remnant patches, such fire may result in local extinction of *Delma impar*. There will be a clear conflict here for the manager wishing to use fire as a conservation tool.

Research needs to be undertaken on the extent of movement between patches, the routes taken and their floristic and structural characteristics, which may be quite different from the remnant grasslands themselves. A population viability analysis should be undertaken and it should incorporate the importance of movement between patches in maintaining populations of *Delma impar* in the A.C.T.

Knowledge of the dynamics of remnant patches and the corridors between them will enable appropriate planning to preserve both the remnants and the corridors, and so the dynamics of the system. In sites where this is not possible, it will establish the need for managers to intervene by periodically reseeding the less viable remnant patches.

3.2.4 INTERIM MANAGEMENT PRESCRIPTIONS

1. Protect selected native grassland remnants as outlined in section on grassland management prescriptions.

2. Grazing, cultivation, mowing or slashing and rock removal are currently seen as incompatible with the survival of *Delma impar* and must be excluded from the remnants where they occur.

3. Weed invasion, nutrient enrichment through the application of fertilizers, application of herbicides and pesticides, and altered drainage patterns will alter the floristics and consequent vegetation structure in grasslands with consequential impact on *Delma impar*. Many or all of these factors can be expected to accompany urbanization. They should be monitored closely and action taken to minimize their impacts.

4. The impact of fire should be closely monitored and controlled. Burning an entire grassland remnant , whether through wildfire or controlled burning, should be avoided at all costs. If burning is necessary to mimic the natural regime and hence maintain the grassland vegetation, then it should be done in accordance with the guidelines outlined by Coulson (1990).

- The total area burnt in any one year should be less than 10% of the total area of the remnant.
- Adjacent areas should not be burnt in consecutive years.
- Heterogeneity in the vegetation due to soil factors must be considered in the planning of fires.
- Fires should be planned to avoid seasons (or years) when the soil is saturated (and hence unable to provide refuge from fire).

Obviously, separate provision should be made for wildfire and its control. It is also essential that the effectiveness of prescriptions for deliberate burning be regularly monitored, evaluated and modified where necessary (Coulson 1990).

3.2.5 MONITORING

Research is required into effective methods of surveying the distribution and abundance of *Delma impar*, to improve upon the existing method of pitfall trapping. The populations of *Delma impar* should be regularly monitored to ascertain trends in local abundances in order to evaluate the effectiveness of management initiatives and the impact of adjacent urbanization. Declines should result in research to identify causes. Local extinctions should be remedied by introductions from local viable populations.

3.3 THE DAY-FLYING MOTH, *SYNEMON PLANA*

3.3.1 CURRENT KNOWLEDGE

Synemon plana (Family Castniidae) is a brown, orange and black moth, about 3.5 cm across. It is a day-flying moth, active in the late mornings and afternoons on sunny days in November and December. Populations can be very dense in suitable habitat. The males have a rapid energetic flight about one metre above the grasslands in which the females lie and attract the males by flashing their orange hindwings. Eggs are laid in the grass tussocks and the larvae feed on the roots of the Silver-Top Wallaby Grass, *Danthonia carphoides* (Edwards 1991). Because of its abundance the moth larvae are likely to have a major effect on the relative abundance of grass species.

The adults have no functional mouthparts and so are only likely to survive for a few days after emergence. The female has very small wings and rarely flies unless disturbed, which prevents it from colonising areas even adjacent to inhabited sites. Although *Danthonia carphoides* grasslands may occur elsewhere, the moth is apparently not able to colonise them easily (Edwards 1991).

Synemon plana occurred prior to clearing and agriculture in a wide belt of south-eastern Australia, from central west N.S.W. through Victoria to the S.A. border, but today it is known from less than a dozen sites. All except one of these sites are very small and most are in the inner urban areas of the A.C.T., with one in western Victoria. It survives in the A.C.T. in the remnant patches of *Danthonia carphoides* and *D. auriculata* (Wallaby Grass) grassland. Grasslands where other grass species dominate are unsuitable, even if they contain *Danthonia* species (Edwards 1991). This underlines the need for a full documentation of the floristic diversity of the remnant grasslands.

3.3.2 ESTABLISHING CONSERVATION PRIORITIES

Synemon plana may be considered as an indicator species for the variety of invertebrates which occur in grasslands and contribute to their stability and diversity. The species is unique in its family (Castniidae) in having pronounced differences in body form and behaviour between the sexes (Edwards 1991).

It appears that the species might survive well in small reserved areas. The moths were widespread in the past and are plentiful where they do occur. The moth is endangered because its habitat, the *Danthonia* grasslands, is endangered. While *Danthonia* is more resistant to grazing than some other native grassland species, improved pasture plants easily shade and weaken *Danthonia*. This has led to the elimination of many *Danthonia* grassland sites. The known sites for the moth are mostly in areas excluded from agricultural use before the improved pasture revolution based on superphosphate and subterranean clover began.

Principal threats to the moth are urban development of its remaining sites and the invasion of them by weeds or introduced pasture grasses. There are no sites where the grassland or the moth has statutory protection from development. By far the largest remaining population in the A.C.T. occurs at the Belconnen Naval Station; this alone warrants a high conservation priority given present knowledge.

3.3.3 RESEARCH, MANAGEMENT AND MONITORING

To conserve this species research and management needs to be directed towards the following areas.

- A systematic survey of the A.C.T. for potential and existing habitats (grasslands with *Danthonia carphoides*).

  (Time frame: short, but requires appropriate seasons)

Required to evaluate optimal conservation strategy for the species. Measure size of patches and relative abundance of food plant species. Assess threats to sites, particularly processes of weed invasion. Ted Edwards of CSIRO Entomology has documented eight or so urban sites, further ones may be found by using the Canberra community to complement a systematic field survey.

- Limited field study complemented with laboratory culture to establish the moth's life cycle and food plant relationships.

  (Time frame: medium)

  This will provide information essential for development of appropriate management regimes for this species in grasslands, population assessment methods and design of attempts at habitat restoration.

- Determining the current biogeographic pattern of the moth and considering its geographic range, habitat specificity and local population sizes, estimate viable population sizes.

  (Time frame: medium and continuing)

  This is necessary to determine whether current areas under protection are likely to be viable populations in the longer term and hence whether artificial population dispersal will need to be considered.

- Establish techniques for determining population density of moths. Establish permanent population density monitoring stations at key sites, both large and small.

  (Time frame: short and continuing)

  Required to enable population trends to be accurately known and followed on key sites as indicators of changes in the grassland environment impinging on this species.

- Determine suitable means for maintaining and increasing the abundance of the preferred plant food species.

  (Time frame: medium)

  Required if restoration of habitat for this species is to be attempted.

Fire management could be critical for the moth, as it may destroy a local population if a small remnant is completely burnt during a critical phase of the life cycle. However as the moth spends most of its life underground it may well survive a fire in most seasons.

In the long term it may be possible to disperse the species to suitable habitats, if found, and to create habitats, by introducing some of the more obvious elements of the habitat.

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