ACT PARKS and CONSERVATION SERVICE

MANAGEMENT DIRECTIONS FOR THE STRIPED LEGLESS LIZARD (*Delma impar*) IN THE AUSTRALIAN CAPITAL TERRITORY

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1. BACKGROUND

The Striped Legless Lizard, *Delma impar*, is listed on Schedule 6 of the Nature Conservation Act 1980 (ACT) as a species vulnerable to, or threatened with, extinction. Since 1990, extensive surveys have been carried out to determine the distribution and abundance of the species in the ACT, and to monitor for any change in status. Several collaborative research projects have also been conducted by the ACT Parks and Conservation Service, Australian National University and the University of Canberra, to provide essential ecological data for the management of the species.

In 1994 a working party was asked to formulate a Conservation Strategy for the Striped Legless Lizard in the ACT. The major conservation objective of the strategy was 'to maintain in the long term, viable, wild populations of *D. impar* as a component of the indigenous biological resources of the ACT and as a contribution to regional and national conservation of the species' (Working Party 1994). The working party reviewed the status of the species and the management issues in the ACT, and made recommendations on open space, habitat links, predation, fire management, salvage protocols, community relations, inter-agency relations and priorities for monitoring and research.

The Striped Legless Lizard is an important component of the fauna that is characteristic of lowland native grasslands. The significance of the remnant areas of native grasslands within the ACT was slow to be appreciated (Falconer 1991), but the conservation of this ecosystem has become a priority in recent years. Principles and strategic options developed by the University of Canberra (Williams *et al.* 1995) for the conservation of the grasslands in the Gungahlin area give strong weighting to the habitat requirements of the Striped Legless Lizard. Williams *et al.* (1995) recommended that grassland conservation should be based on three conservation zones, each sufficiently large to maintain viable populations of the Striped Legless Lizard, and together providing adequate coverage of environmental diversity and adequate replication within the Gungahlin area as a precaution against major disturbance events.

The Nature Conservation Act 1980 (ACT) was amended in 1994 to provide for the establishment of a Flora and Fauna Committee. The newly-established committee is comprised of independent expert scientists, whose role is to recommend the declaration of species and biological communities at risk of extinction, and the threatening processes that place species and communities at risk. The committee

will receive nominations of species, communities and processes, assess each nomination, and recommend to the Minister accordingly. If the recommendation is accepted, a formal declaration follows, and the Conservator of Flora and Fauna is then required to prepare an Action Plan for each declared species, community or process. The Action Plan examines the conservation issues and the measures proposed to enhance the status of threatened species and communities and to ameliorate the effects of threatening processes. A nomination is currently being prepared for the Striped Legless Lizard (Rauhala pers. comm.).

This report on management directions for the Striped Legless Lizard has three purposes:

1. To extend the general directions of the Draft Conservation Strategy for the Striped Legless Lizard in the ACT.
2. To address specific management issues, which relate directly to the Striped Legless Lizard, arising from the principles and strategic options developed for the conservation of grasslands in the Gungahlin area.
3. To provide a platform for the preparation of an Action Plan if this is required under recent amendments to the Nature Conservation Act 1980 (ACT).

This report first reviews all relevant biological information on the species, and identifies the key threatening processes operating in the ACT. The report then proposes a program of management actions designed to meet the conservation objectives of the Draft Conservation Strategy.

The report also represents a change in management emphasis. As Rauhala *et al.* (1995) have pointed out, past actions have been mainly directed towards surveys of populations of the Striped Legless Lizard in the ACT. By contrast, this report proposes an action-research program, which is designed to integrate research into key questions with interventions that are essential for management.

2. CONSERVATION BIOLOGY

This section outlines the current knowledge of conservation biology of the Striped Legless Lizard, with particular emphasis given to data derived from the ACT. Critical aspects of conservation biology that are insufficiently understood at present are highlighted.

2.1 Taxonomy and Status

2.1.1 Identification

The Striped Legless Lizard is a member of the family Pygopodidae. It shows extensive reduction of the limbs that is characteristic of pygopodids, the forelimbs having been lost completely and the vestigial hind limbs persisting only as small flaps (Greer 1989). As its name suggests, the Striped Legless Lizard generally also has a pattern of alternate dark and light parallel stripes running longitudinally down the body and diagonally along the tail, contrasting with the grey-brown background colour of the lateral and dorsal scales (Wilson and Knowles 1988; Cogger 1992). The head scales are darker, ranging to black in young animals, and the throat is usually bright lemon yellow (Coulson 1990). Some individuals also show salmon-pink coloration on the flanks (Burkitt pers. comm.).

The Striped Legless Lizard is technically distinguished from other *Delma* by the partial fusion of two scales surrounding the nostril (Kluge 1974), although Jenkins and Bartell (1980) and Coulson (1990) noted that this character is not always present in specimens from the ACT, and Shea (1991) noted that it sometimes occurs in a second *Delma* species. The Striped Legless Lizard can readily be distinguished from the three other pygopodid species occurring in the ACT. The Striped Legless Lizard differs from its congener, the Olive Legless Lizard, *D. inornata*, in coloration, body size, and head scalation, and from the Pink-tailed Worm Lizard, *Aprasia parapulchella*, and Burton's Legless Lizard, *Lialis burtonis*, in general morphology, coloration and body size (Jenkins and Bartell 1980; Cogger 1992). The first three taxa also differ in their habitat preferences, and show only limited spatial overlap in the ACT (Osborne *et al.* 1993).

2.1.2 Conservation status

The Striped Legless Lizard is considered to be at risk of extinction. It has been listed as a nationally 'vulnerable' species by the Australian and New Zealand Environment and Conservation Council (ANZECC 1991), indicating that it is considered likely to lapse into the 'endangered' category if causal factors continue to operate (Cogger *et al.* 1993).

The status of the species is also recognised by listing under relevant federal, state and territory legislation:

- Endangered Species Protection Act 1992 (Commonwealth) – listed on Schedule 1, denoting species endangered, vulnerable, or threatened with extinction.
- Nature Conservation Act 1980 (ACT) – listed on Schedule 6 (Special Protection Status), denoting species vulnerable to or threatened with extinction.
- Flora and Fauna Guarantee Act 1988 (Victoria) – listed on Schedule 2, denoting threatened taxa.
- National Parks and Wildlife Act 1974 (New South Wales) – listed on Schedule 12, denoting vulnerable and rare species.

Loss of habitat is widely acknowledged as the fundamental process that threatens populations of the Striped Legless Lizard (Coulson 1990; Webster *et al.* 1992; Cogger *et al.* 1993; Osborne *et al.* 1993; Coulson *et al.* 1994). In broad terms, its habitat is much of the lowland grasslands of south-eastern Australia. McDougall and Kirkpatrick (1994) estimated that 99.5% of this diverse group of vegetation communities has been lost or drastically altered since the advent of European settlement. The specific threats to the Striped Legless Lizard have been identified as loss or modification of habitat through urban and industrial development, cultivation, heavy grazing, frequent fire and removal of rock cover (Webster *et al.* 1992; Coulson *et al.* 1994). Measures to conserve the species have been co-ordinated by the Striped Legless Lizard Working Group, convened by Melbourne Zoo (Banks 1992; Kutt *et al.* 1995).

2.2 Distribution and Habitat

2.2.1 Known distribution

The known distribution of the Striped Legless Lizard encompasses three states in south-eastern Australia, and the ACT. The largest portion of the range is in Victoria, mostly on the western plains between Melbourne and the border with South Australia. Other sites are known from central Victoria and the northern plains, as well as one relatively isolated record in the north-east of the state (Atlas of Victorian Wildlife). In South Australia, the species has been recorded from only two localities in the south-east of the state (Shea 1991). The few records from New South Wales are clustered in the south-east, all within 100 km of the ACT (Swan 1990; Shea 1993). The most recent records in New South Wales are from near

Goulburn in 1994 (Husband 1995), representing the northern limit of the species, and from near Cooma in 1995 (Larwill, pers. comm.), which is the first record on the Southern Tablelands this century (Shea 1993).

In the ACT, extensive surveys have been conducted for the Striped Legless Lizard since 1990 (Kukolic 1992, 1993, 1994; Kukolic *et al.* 1994; Rauhala *et al.* 1995). The species is now known to occur in four apparently discrete areas: the Gungahlin area, the lower Majura Valley adjacent to Canberra Airport, the lower Jerrabomberra Valley, and the site of the National Museum of Australia on Yarramundi Reach.

2.2.2 Genetic diversity

A recent study of genetic diversity, using the technique of allozyme electrophoresis, examined 11 polymorphic loci in a sample of 120 individual Striped Legless Lizards from Victoria and the ACT (Osmond 1994). The Victorian specimens were obtained from the outer western suburbs of Melbourne, which lie on an extensive basalt plain with remnants of a once continuous native grassland. Populations from western and northern Victoria were not sampled. The ACT specimens represented the populations from Gungahlin, Majura Valley and the National Museum, which are effectively isolated by topographical and anthropogenic barriers. Measures of genetic similarity revealed two clusters of similar sites, corresponding to their geographic origin. The differences within the Melbourne and ACT genomes were fewer than the differences between them, but the overall high level of similarity confirmed that these populations were conspecific. The genetic profile of the recently-discovered Jerrabomberra population has not been examined, but some divergence from the other sites in the ACT could be expected if the Molonglo River has been a barrier to gene flow.

2.2.3 Habitat preference

The climatic envelope of the Striped Legless Lizard has mean minimum and maximum temperatures of 1.5°C and 30.0°C respectively, and mean annual precipitation is 656 mm (Coulson 1990). Although most field guides (Jenkins and Bartell 1980; Cogger 1992; Swan 1993) list forest and woodlands as habitats of the Striped Legless Lizard, the species occurs almost exclusively in lowland temperate grassland (Coulson 1990; Osborne *et al.* 1993). Typically, this broad habitat type is dominated by native, perennial, tussock-forming grass, particularly *Themeda*

triandra, *Danthonia* spp., *Poa* spp. and *Stipa* spp., but exotic grasses such as *Phalaris aquatica* provide habitat in places (Hadden 1995). The topography is usually level, and the substrate is usually a cracking clay soil, with a scatter of lightly-embedded surface rock (Hadden 1995). The habitats used by the Striped Legless Lizard differ from this general pattern in the ACT, where both cracking clays and surface rock are rare (Osborne *et al.* 1993).

There is evidence that, within these broad habitat requirements, Striped Legless Lizards select components of the habitat at a local scale. In a study of a dense, high quality native grassland in the western suburbs of Melbourne, Kutt (1992) found that captures were patchily distributed over two trapping grids. The microhabitat surrounding traps in which Striped Legless Lizards were caught had slightly lower vegetation density and lower invertebrate diversity than other traps. These successful traps also captured a greater number of other vertebrate species.

In a recent analysis of habitat parameters measured at 119 sampling sites in the ACT, Dorrough (1995) found that most sites were dominated by native grasses, but some had mainly exotics such as *Phalaris aquatica*, *Bromus diandrus*, and *Lolium perenne*. The Striped Legless Lizard occurred in primary grassland, corresponding to the original (pre-European) extent of lowland native grassland, and also occurred in secondary grassland, which has become established following the clearing of the former woodlands on more elevated sites. However, secondary grassland appeared to support the Striped Legless Lizard only if it was within 2 km of an area of primary grassland. Dorrough (1995) also concluded that the history of disturbance influenced both the probability of the species occurring, and its relative abundance, at each site. The most influential site disturbance factor was the time elapsed since a site had last been ploughed, which was negatively correlated with both presence and abundance of the Striped Legless Lizard.

2.3 Foraging Behaviour

2.3.1 Activity and movements

The Striped Legless Lizard experiences a wide range of environmental temperatures due to daily and seasonal variation. Most activity, as reflected by capture rates in pitfall traps, takes place in spring and summer, particularly in the months of November and December (Kukolic 1994; Osmond 1994). During this annual peak, most foraging activity apparently occurs during daylight (Coulson 1990; Kutt 1992). A recent laboratory study by Osmond (1994) found that the preferred body

temperature of the Striped Legless Lizard ranged from 26.0°C for non-gravid animals to 29.3°C for gravid females. In the field, individuals are sometimes seen basking in open patches on sunny days (Martin 1972; Kutt 1992).

There is little information about the mobility of the Striped Legless Lizard. Its small body size precludes the use of radio-tracking techniques because attachment of even the smallest transmitter causes undue stress to individuals (Robertson pers. comm.) and would impede their movement. A test of fluorescent powders as an alternative tracking technique showed that individuals moved vertically and horizontally through grass tussocks, and along the surface of the soil, for up to 19.7 m in less than a day, but also found that the pigment was shed too quickly to yield data over a longer period (Kutt 1993). The species is also not readily trapped, so is not amenable to study by mark-recapture methods (e.g. Kutt 1992; Dorrough 1995). Recaptures in the ACT have revealed minimum movements of 62.5 m in 9 days, and about 60 m in 2 days (Kukolic 1994). However, these measurements are based on the assumption that lizards do not cross the drift fence connecting pitfall traps, and there is evidence that this assumption is not always valid (Rauhala *et al.* 1995).

2.3.2 Diet and feeding style

The diet of the Striped Legless Lizard consists of a range of arthropod prey, particularly wolf spiders and jumping spiders (Arachnida), crickets and grasshoppers (Orthoptera), cockroaches (Blattodea) and the larvae of moths (Lepidoptera) (Coulson 1990; Wainer 1992; Nunan 1995). By comparing prey types consumed with the range of prey available in the ACT, Nunan (1995) concluded that the Striped Legless Lizard is a selective feeder, usually rejecting other common arthropods such as slaters (Isopoda), ants (Hymenoptera) and bugs (Hemiptera).

The Striped Legless Lizard has been described as an ambush predator, hiding in spider burrows and attacking arthropods as they pass (Ehmann 1992). This feeding style is consistent with Osmond's (1994) estimates of preferred temperature and genetic heterozygosity, which are suggestive of fossorial behaviour. However, Nunan (1995) argued that the occurrence of slow-moving prey, such as lepidopteran larvae, in the diet is suggestive of an active, widely-foraging predator. The Striped Legless Lizard may exhibit flexibility in foraging methods.

2.4 Life history

2.4.1 Body size

The Striped Legless Lizard is a small member of the genus *Delma*. Coulson (1989) recorded maximum dimensions from museum specimens of 116 mm for snout-vent length and 306 mm for total length, and a maximum body weight of 7.6 g from live specimens. Slightly heavier specimens, possibly gravid females, have since been recorded (e.g. Hadden and Humphries 1994; Kukolic 1994; Osmond 1994).

2.4.2 Reproduction

Specimens of the Striped Legless Lizard cannot be sexed reliably by external criteria. Kluge (1974) reported sexual dimorphism in the number of enlarged ventral and smaller gular scales. From measurements of a larger sample, Coulson (1990) found that, although there was some overlap between the sexes, the mean ventral scale count was significantly higher in females than in males. However, Kutt (1992) and Handley (1994) found that the ventral scale count was not a reliable sexing technique. Instead, Handley (1994) demonstrated that X-ray examination of lizards immobilised under light anaesthesia could be used to identify the post-cloacal bones, which are present only in male pygopodids (Kluge 1982).

The mating system of the Striped Legless Lizard is unknown, but is assumed to be polygynous. Fecundity is low: only two eggs are laid per clutch, as is characteristic of pygopodids (Patchell and Shine 1986; Greer 1989). Eggs are laid in summer (Banks 1992), but are rarely found. One instance of colonial oviposition, involving three pairs of eggs, was reported by Mills (1992). Hatching time is variable, ranging from 35 to 60 days (Banks pers. comm.; Kukolic pers. comm.). Data on growth and development are accumulating from specimens held in captivity at Melbourne Zoo (Banks 1992), and at Tidbinbilla Nature Reserve and the Wildlife Research Unit in the ACT (Rauhala pers. comm.). The age at sexual maturity has not yet been determined, and no breeding has taken place in the captive groups.

2.4.3 Mortality

The longevity of the Striped Legless Lizard is not known. Specimens captured as adults have been held in captivity for more than four years to date (Banks pers. comm.; Kukolic pers. comm.). Maximum longevity has been assumed to be ten

years for the purpose of population modelling (Webster *et al.* 1991; Dorrough 1995).

Little information is available on the causes of mortality. Individuals have been found dead on the surface of the soil after grasslands have been ploughed or burnt (Coulson 1990). The high frequencies of tail autotomy recorded in many surveys of the Striped Legless Lizard (e.g. Coulson 1990; Kutt 1992; Nunan 1995) attest to attacks by predators. Foxes, *Vulpes vulpes*, and domestic Cats, *Felis domesticus* are assumed to take live Striped Legless Lizards (Kutt 1992; Webster *et al.* 1992). A number of native species that inhabit lowland grasslands are likely to prey on the Striped Legless Lizard. Some, such as the Little Whip Snake, *Suta flagellum*, the Eastern Barred Bandicoot, *Perameles gunnii*, the Fat-tailed Dunnart, *Sminthopsis crassicaudata*, do not occur in the ACT, but avian predators, particularly raptors and corvids, are also likely to be significant.

3. MANAGEMENT

This section examines a series of specific issues concerning the management of the Striped Legless Lizard in the ACT, and recommends specific management actions where appropriate. The implementation of these recommendations will be constrained by the level of resources available, so each of the actions is given a priority rating (high, medium or low) and a time frame (short term, 1–2 years; medium term, 3–5 years; long term, >5 years; ongoing). Some actions offer scope for graduate or post-graduate research, and could be implemented most efficiently by sponsorship of a student project. These are indicated where appropriate.

3.1 Survey

3.1.1 ACT sites

Knowledge of the distribution and abundance of the Striped Legless Lizard is incomplete. Surveys in the ACT have generally been prompted by an urgent need to meet the information requirements of proposed developments, notably the Gungahlin Town Centre (Kukolic 1993; Kukolic *et al.* 1994; Rauhala *et al.* 1995) as well as other sites including the National Museum of Australia (Kukolic 1994), the Yowani Golf Course (Osborne and Nunan 1995) and the Australian Geological Survey Organisation (Rauhala *et al.* 1995). This emphasis has undoubtedly biased the coverage of the ACT, and perhaps also the perception of the characteristics of

suitable habitat. The discovery of the species in the lower Jerrabomberra Valley in 1994 is the first record south of the Molonglo River, and much potentially suitable habitat in the valley remains to be surveyed (Rauhala *et al.* 1995). No other substantial unsurveyed areas of the ACT are considered likely to yield new records (Rauhala pers. comm.), but minor extensions of range are possible on the periphery of known populations, as shown by recent surveys of the Kenny area (Rauhala *et al.* 1995).

ACTION – Continue surveys of distribution and abundance in the ACT with emphasis on sites where development is not imminent, particularly the Jerrabomberra Valley, and on sites peripheral to known concentrations to determine their limit. *High priority, short term.*

Pitfall trapping, as currently used to survey the Striped Legless Lizard, is a time-consuming and relatively expensive technique. Trap installation is labour-intensive and relatively unskilled, although care is required to ensure that quality is maintained. The soil disturbance caused by excavating pits for the traps, and setting the drift fence into the substrate, has the potential to degrade the vegetation of the sampling area (e.g. Craigie and Stuwe 1992). Subsequent monitoring of the traps requires regular (daily) checks by personnel who are skilled in identification and handling of the target species and of others that may be trapped. There is also some concern that predators, particularly foxes, may be attracted to the traps (e.g. Kutt 1992).

The ACT Parks and Conservation Service's Wildlife Research Unit has been investigating methods of installing traps more efficiently and with less soil disturbance. A powered lawn-edger promises to be a better method for installing drift fences in some sites with relatively low ground cover (Fletcher pers. comm.). The addition of raised roofs for traps is also being considered to give protection from predators and to reduce heat stress and dehydration in captive animals (Rauhala pers. comm.). Alternatives to pitfall trapping are considered below (3.3.2 Capture techniques).

ACTION – Continue to refine capture techniques for the Striped Legless Lizard in the ACT, aiming to minimise the time and disturbance involved in installation, and to maximise the survival and welfare of captives. *High priority, ongoing.*

Over 120 sites have been trapped in the ACT since systematic surveys for the Striped Legless Lizard began in 1990. Most surveys have been conducted by the Wildlife Research Unit with assistance from student collaborators and volunteer groups. Many of these sites were dual-purpose, targeting both the Striped Legless Lizard and the endangered Eastern Lined Earless Dragon, *Tympanocryptis lineata pinguicolla* (e.g. Osborne *et al.* 1993). Some additional sites have been surveyed by university staff and students for specific purposes. Together these surveys have generated a considerable amount of data on the occurrence, morphology, movements and reproduction of the Striped Legless Lizard, along with other vertebrate and invertebrate fauna, and the floristics and structure of the vegetation. These data were stored in various forms and in several locations. In 1994 a central database was created, identifying each site with a unique code, giving precise location, and recording all trapping times and results. A second database, linked by site code, has also been established for vegetation surveys conducted in 1994.

ACTION – Maintain and develop the central database of trap sites (successful and unsuccessful) for the Striped Legless Lizard in the ACT, and link or incorporate other data on site characteristics. Ensure, as a condition of any permit issued, that data obtained by organisations other than the ACT Parks and Conservation Service's Wildlife Research Unit are also presented in a form suitable for entry into the database. *High priority, ongoing.*

3.1.2 Regional distribution

The survey effort undertaken for the Striped Legless Lizard in the ACT has not been matched in adjacent areas of New South Wales. There are clear biogeographical affinities between the grasslands within the ACT and the Monaro region as a whole (Benson and Jackson 1994), yet only one general survey for grassland reptiles has been conducted in this region (Osborne *et al.* 1993). In addition, there have been two recent records of the Striped Legless Lizard near Goulburn (Kukolic pers. comm.). In order to place the distribution data from the ACT in a biogeographical context, and to contribute towards the conservation of the Striped Legless Lizard in the region, it is essential to broaden the survey effort for the species.

ACTION – Liaise further with NSW National Parks and Wildlife Service to encourage and, where appropriate, collaborate in surveys for the Striped Legless Lizard in New South Wales. *High priority, medium term.*

3.2 Monitoring

3.2.1 Long-term change

Monitoring is essential to determine the long-term status of the Striped Legless Lizard in the ACT. Some sites in the Gungahlin area and the Majura Valley have been surveyed for up to five years in succession, and there is evidence of a decline in capture success at these sites (Rauhala *et al.* 1995). However, the decline is not uniform across all sites and any trend may be confounded by changes in grazing patterns and variations in weather (Rauhala *et al.* 1995). A similar decline has become evident at the Derrimut Grassland Reserve in Victoria, which has been monitored since 1989 (Coulson 1989; Moro 1990; Kutt 1991, 1992; Webster pers. comm.), although comparisons at this site are further confounded by successive wildfires and by variations in trapping technique. Nonetheless, a possible decline in the populations at these sites is cause for concern.

At present it is not possible to distinguish real decline in these populations from artefacts of the trapping program. The trauma associated with capture, holding, handling and marking may lead directly to higher levels of mortality, although this is generally regarded as unlikely (e.g. Hadden and Humphries 1994). Alternatively, prior experience with traps may lead to trap shyness, resulting in an apparent decline in population size (Coulson 1990; Dorrough 1995). Changes associated with traps may have a similar effect. Some trap sites have been fenced to exclude stock for several years, and have become increasingly less representative of the surrounding vegetation.

ACTION – Establish a limited number of sites in each population of the Striped Legless Lizard in the ACT that are to be used for long-term monitoring. No more than three sites would be required in each population; one would be sufficient for the small National Museum population. The monitoring sites should be representative of a range of grassland communities and, ideally, secure from development. The sites should be trapped over a brief period (perhaps 2 or 3 weeks) at the same time each year (preferably November). Traps and associated fencing should be installed immediately before and removed

immediately after each sampling period. For continuity, the current trap design should be retained for these monitoring sites, unless an evaluation of the design shows it to be highly inefficient (see 3.3.2 Capture techniques). *High priority, ongoing.*

3.2.2 Kaleen population

The population of Striped Legless Lizards at Kaleen is apparently isolated from the remainder of the Gungahlin complex by the Barton Highway, and is bordered on other sides by residential development (Working Party 1994). This population thus offers a natural experiment into the effects of isolation and impacts of possible threatening processes, such as predation by cats and invasion by weeds, although there is no information on the density or extent of the colony prior to its isolation.

ACTION – Include the isolated Kaleen population as a long-term monitoring site for the Striped Legless Lizard (see 3.2.1 Long-term change). The site could be surveyed at a lower frequency than other sites simply to assess its persistence over time. *Low priority, ongoing.*

3.3 Research

3.3.1 Population dynamics

Many aspects of the population biology of the Striped Legless Lizard are poorly understood. The fundamental parameters of longevity, sexual maturity, mobility and absolute population size can only be guessed at, and models of population dynamics are correspondingly weak (Webster *et al.* 1995). Attempts to conduct population research in Victoria have been limited by poor capture success, although 'Dashwood' near Cressy promises to be more successful (Hadden and Humphries 1994). In general, capture success is higher in the ACT, and many more individuals have been captured and recaptured in the ACT than elsewhere in the last four years. However, the trapping program in the ACT has been designed primarily to yield data on distribution and abundance, rather than demography. The demographic data that has been obtained was largely incidental and, in the case of movements of recaptures, required the assumption that they did not cross the drift fence (Rauhala *et al.* 1995).

ACTION – Sponsor a mark-recapture study of the population dynamics of the Striped Legless Lizard in the ACT. The population(s) must be secure

and at a high density so that sufficient data can be obtained. The populations should also cover an area of at least 10 ha to allow the detection of possible long-range movements, several hundred metres in length. The recently-fenced grassland at the 2CY transmitter may be an appropriate site. Innovative, alternative trapping techniques (see 3.3.2 Capture techniques) should be considered to maximise recapture success. This project is ideally suited to a post-graduate student. *High priority, short term.*

3.3.2 Capture techniques

The Striped Legless Lizard is small, cryptic and occupies often dense grassland habitat. It is thus rarely seen and is difficult to capture by hand. Surveys in the ACT have been conducted almost entirely by pitfall trapping, although specimens have been found under debris occasionally (e.g. Kukolic *et al.* 1994). The standard trap design has consisted of an array of 20 pitfall traps in a cross formation, with drift fence along each arm of the cross (Nunan 1995), but single lines of ten traps have been used at times (e.g. Kukolic *et al.* 1994; Osborne and Nunan 1995). However, the efficiency of this design, by comparison with other trap arrangements, is unknown. Previous evaluations of pitfall trapping (Morton *et al.* 1988; Friend *et al.* 1989; Hobbs *et al.* 1994) have measured the efficiency of different trap designs for surveying a range of vertebrate taxa in Australia, but provide little guidance in the choice of a survey technique specifically for the Striped Legless Lizard. The approach used in the ACT has had the advantage of allowing direct comparison of capture rates across all of the trap sites. By comparison, surveys in Victoria have used other designs ranging from lines (e.g. Coulson 1990) to grids of various sizes (e.g. Kutt 1992); their efficiency is unknown, and their capture rates cannot be compared with rates in the ACT. The cross design used in the ACT concentrates the trapping effort in a small area, conservatively estimated at 0.25 ha (Williams *et al.* 1995), which allows precise assessment of a patchy environment but gives poor coverage of large areas, and also limits opportunities for study of movements.

ACTION – Evaluate the current 20-trap, cross-arm design in comparison with a range of alternative trap arrays, including grid-based designs. Ideally, comparisons should be made over a short period of time with replicates in a variety of habitats. The relatively high capture rates in the ACT should yield sufficient data for rigorous statistical analyses. Tests on this scale will involve considerable disturbance to soils and

vegetation, so would be best conducted at sites where irreversible detrimental change is imminent (see 3.5.1 Salvage). This research could be conducted as a student project at honours or post-graduate level. *High priority, medium term.*

Alternatives to standard pitfall traps, such as entanglement traps and 'bee traps' are being investigated by a student at the Australian National University. Other avenues for investigation are suggested by Martin's (1992) observation that the Striped Legless Lizard is attracted to soft fruits, particularly banana, which could be used as a bait. The use of artificial shelters, such as masonry or timber, has also been considered as a means of capturing specimens in the ACT, where alternative hard shelter is rare.

ACTION – Investigate innovative techniques for the capture of Striped Legless Lizards in the ACT. Possible combinations of chemical attractants, artificial shelter and alternative trap designs should be explored. *High priority, short-medium term.*

3.3.3 Habitat preference

Recent ecological studies of the Striped Legless Lizard have generated testable hypotheses about the distribution and abundance of the species in the ACT. Dorrough (1995) found a relationship between the presence of the species at a site and the distance from primary grassland, and between presence and abundance of the species at a site and the time since cultivation. Nunan (1995) found a relationship between the abundance of the species and the relative abundance of lepidopteran larvae. Rigorous tests of these empirical relationships require surveys of sites that show a range of variation in these independent variables. If the relationships prove to be robust, they will offer a valuable predictive tool in future surveys of the Striped Legless Lizard elsewhere in the ACT and in adjacent areas of New South Wales.

ACTION – Where possible, design future surveys for the Striped Legless Lizard in such a way that allows testing of hypotheses about the influence of site history and invertebrate fauna on presence and abundance of the target species. Surveys of the Jerrabomberra Valley in the coming summer provide an opportunity to implement this approach. *Medium priority, short-medium term.*

3.3.4 Population genetics

The relative isolation of the recently-discovered population of the Striped Legless Lizard in the Jerrabomberra Valley suggests that it may be genetically distinct. Genetic data from this population would allow refinement of the model of genetic divergence in the ACT proposed by Osmond (1994), and would be needed if translocations of individuals were to be considered (see 3.5 Translocation).

ACTION – Encourage a study of the genetics of the Jerrabomberra population of the Striped Legless Lizard for comparison with the other three discrete populations in the ACT. This could be conducted as a student project. *Low priority, medium term.*

3.4 Grassland conservation

3.4.1 Reservation

The Striped Legless Lizard is not protected in any present reserve in the ACT, and substantial developments have been proposed for much of its habitat, notably in Gungahlin (Working Group 1994). Rauhala *et al.* (1995) proposed several options for the protection of the Striped Legless Lizard in the ACT, including three conservation zones in the Gungahlin Central area. Eighteen principles for the conservation of native grasslands and their threatened fauna have been developed by the University of Canberra (Williams *et al.* 1995) for the ACT Planning Authority. Williams (*et al.* 1995) applied these principles to the Gungahlin grasslands, and recommended the establishment of three conservation reserves. The proposed reserves are based on Core Conservation Areas of at least 20 ha in size that have high capture rates of Striped Legless Lizards, or evidence of breeding, and must also meet other botanical and zoological criteria. Core Conservation Area and their contiguous areas of grassland are referred to as Conservation Zones. Buffer Zones may be included where necessary to ameliorate the effects o incompatible land use beyond the Conservation Zones.

ACTION – Apply the conservation principles developed by Williams *et al.* (1995) to other areas of grassland that are known to support populations of the Striped Legless Lizard in the ACT in order to identify possible Conservation Zones outside the Gungahlin area. *High priority, ongoing.*

3.4.2 Habitat management

The availability of suitable grassland habitat is critical to the conservation of the Striped Legless Lizard. Evidence from the ACT and Victoria suggests that the origin and floristics of a grassland may be less important than its current structure in determining its suitability as habitat. Grassland that is in poor condition due to heavy grazing, for example, can recover its structure rapidly after grazing has ceased. These recovered areas can provide habitat for individuals that have persisted in refugia (e.g. drainage lines) and have later recolonised the area, or for individuals that are translocated to reinforce or re-establish a population (see 3.5.3 Reintroduction).

The central aim in managing grasslands as habitat for the Striped Legless Lizard should be to provide adequate structure, particularly vertical cover. Numerous options are available for managing grasslands in order to ensure security of habitat for this species while also maintaining or enhancing their botanical integrity (e.g. Barlow *et al.* 1992; Duncan and Mueck 1992; Craigie and Stuwe 1992). The ACT Parks and Conservation Service is undertaking a program of research into lowland native grasslands and their component species, partly funded by the Australian Nature Conservation Agency under its Endangered Species Program. The research program includes consideration of management requirements of native grasslands and measures to rehabilitate degraded areas, including potential habitat for the Striped Legless Lizard.

ACTION – Manage grasslands for the conservation of the Striped Legless Lizard in the ACT in ways that maintain or increase grass cover: minimise mowing, grazing and fire, and cease cultivation and tree planting. Control of weeds such as Serrated Tussock (*Nasella trichotoma*) should be done cautiously, ensuring that cover is not lost on a large scale. Active revegetation programs may be necessary in areas that have become badly degraded. *High priority, ongoing.*

3.5 Translocation

3.5.1 Salvage

In situations where a significant change in land use can be foreseen and an area will clearly be rendered unsuitable for occupation by the Striped Legless Lizard, it is desirable to undertake a salvage operation as a last resort management intervention.

Specimens collected in this way can be used in other aspects of a management program. This approach has been used successfully on several occasions in Victoria and the animals have formed the basis of the captive colony held at Melbourne Zoo (Banks 1992; Webster *et al.* 1995). Appendix 7.1 presents a set of draft protocols to direct the salvage of Striped Legless Lizards from sites in the ACT where irreversible detrimental change is imminent. The protocols have been drafted in consultation with the Striped Legless Lizard Working

Group. They are designed to ensure the safety of personnel involved in salvage operations, to minimise the risk to the target species and to safeguard the welfare of non-target species.

ACTION – Review and modify, where necessary, the draft protocols for salvage of the Striped Legless Lizard in the ACT. *High priority, short term.*

3.5.2 Captive colony

A species management program that is predominantly field-based can be complemented by a captive colony. The Striped Legless Lizards held in captivity in Canberra and Melbourne have already been used for basic studies of morphology, reproduction and growth rates, and for trials of techniques for capture, marking and sexing individuals. Easy access to captive lizards is also valuable for interpretation and publicity purposes. Attempts at captive breeding have so far been unsuccessful, but further changes to the husbandry at Melbourne Zoo are planned to encourage breeding (Burkitt, pers. comm.). It is clearly preferable for the colony to be built up from salvage operations (see 3.5.1 Salvage) rather than withdrawing individuals from otherwise healthy populations. Animals can then be held in captivity pending the availability of habitat that is suitable for a reintroduction program (see 3.5.3 Reintroduction). The small ACT colony is currently housed at Tidbinbilla Nature Reserve, and some individuals are held at the Wildlife Research Unit for educational purposes.

ACTION – Maintain and develop the captive colony of the Striped Legless Lizard in the ACT. Where possible, new captives should be obtained from salvage operations. *Medium priority, medium term.*

3.5.3 Reintroduction

Reintroduction is a widely-used technique in conservation biology, but forms only part of an overall management strategy and is doomed to failure unless the underlying causes of extinction are addressed (Serena and Williams 1995). The technique has not yet been used in the conservation of the Striped Legless Lizard in the ACT. However, there are areas such the proposed Gungaderra-Crace Conservation Zone where experimental reintroduction may be appropriate: the species may have been eliminated from much of the northern part of the zone by heavy grazing in the past, but the native pasture should recover and provide suitable habitat (Williams *et al.* 1995). The technique can also be used to reinforce existing populations, but there is insufficient demographic data from known populations to evaluate this option at present (see 3.3.1 Population dynamics).

Appendix 7.2 proposes draft guidelines for possible future reintroductions of the Striped Legless Lizard in the ACT which have been adapted from those produced by the IUCN Species Survival Group. The guidelines include the source of stock, which will be predominantly from salvage operations, and the necessity to monitor the subsequent progress of a reintroduction, which will be limited by the difficulties in detecting the presence of the species.

ACTION – Review and modify, where necessary, the draft guidelines for reintroduction of the Striped Legless Lizard in the ACT. *Medium priority, medium term.*

4. SUMMARY OF MANAGEMENT DIRECTIONS

This section summarises the proposed management actions, and provides a priority and time framework for their implementation.

Management Action	Priority	Timing
Continue surveys of distribution and abundance in the ACT.	High	Short term
Sponsor research into population dynamics.	High	Short term
Review the draft protocols for salvage.	High	Short-term
Investigate innovative capture techniques.	High	Short-medium term
Continue to refine capture techniques.	High	Ongoing
Maintain and develop the central database of trap sites.	High	Ongoing
Establish a set of sites for long-term monitoring.	High	Ongoing
Apply reservation principles to other populations.	High	Ongoing
Maintain or increase grass cover in grassland habitats.	High	Ongoing
Collaborate in surveys of distribution in NSW.	High	Medium term
Evaluate the current trap design against alternatives.	High	Medium term
Design future surveys to allow testing of hypotheses.	Medium	Short-medium term
Maintain and develop the captive colony.	Medium	Medium term
Review the draft guidelines for reintroductions.	Medium	Medium term
Include the Kaleen population in long-term monitoring.	Low	Ongoing
Encourage genetic research on the Jerrabomberra population.	Low	Medium term

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6. APPENDICES

6.1 Draft Protocols for Salvage Operations

Salvage operations may be warranted in circumstances where detrimental changes to the habitat impose immediate threats to individuals or populations of the Striped Legless Lizard. However, salvage must be undertaken only as a last-resort management intervention. This appendix sets out protocols that should be followed in the choice of areas that are appropriate for salvage, the legislative constraints on salvage activities, and the major considerations in the implementation of a salvage operation.

When should salvage be used?

Salvage of Striped Legless Lizards should be undertaken only in situations where all of the following conditions are met:

1. Changes in land use have been foreshadowed in an area of grassland habitat in the ACT. The grassland may be primary or secondary in origin, and dominated by native or exotic species.

2. The grassland is known to support the Striped Legless Lizard, or could reasonably be expected to support the species from knowledge of the species' habitat requirements and the land use history of the site.

3. The proposed changes will clearly threaten the survival of individuals, and are considered likely to bring about the extinction of the local population.

4. All available management options have been considered and/or attempted, and have been judged as unsuccessful or inappropriate.

5. One or more potential release sites have been identified, and are expected to meet the criteria required for reintroduction (see 7.2 Guidelines for reintroduction).

6. The proposed changes in land use are imminent.

What are the legal requirements?

In the ACT, the Nature Conservation Act 1980 protects native fauna and provides for a range of activities that can be undertaken only under a licence granted by the

Conservator of Flora and Fauna. For species with special protection status, such as the Striped Legless Lizard, a licence will not be granted unless the conservator is satisfied that the action is necessary for 'scientific, educational, propagative or other similar purpose'. An application for a licence to salvage Striped Legless Lizards should meet the following criteria:

1. The applicant has the appropriate knowledge, training and experience to undertake the activity.

2. The applicant is associated with a recognised scientific research institution and the application is supported by the institution's chief executive officer.

3. The proposed activity is genuinely related to the conservation requirements of the species, and salvage and/or keeping objectives are clearly established.

4. The proposed activity will be conducted in such a way that it will minimise unintended mortality of the animals.

5. Appropriate facilities are available for the holding of live animals, and disposal of carcases should address options for preservation.

How should salvage be conducted?

Salvage operations that are poorly planned or poorly implemented pose risks to both the target species and the personnel involved, and may achieve little towards the conservation of the species. Successful salvages operations in Victoria have used heavy earth-moving machinery (back-hoe or equivalent) to remove rocks and adjacent topsoil (to the root line). A team of 3 - 5 people inspects the disturbed areas closely and extracts any animals that are exposed. Cool burning or intense grazing is recommended to reduce grass cover and enhance the visibility of Striped Legless Lizards, and mowing may be equally effective. The salvage operation may be supplemented by hand-searching under rocks or debris, although there are very few rocks in the grasslands of the ACT. Salvage could instead be preceded by intensive trapping and removal of individuals. Standard pitfall traps could be used, but a grid of trenches, lined with plastic sheeting, could be installed more rapidly and achieve good coverage of the site. Techniques that are suitable for the grasslands of the ACT will need to be developed by trial and error to some extent.

The implementation of salvage procedures will vary, depending on such factors as the size and layout of the grassland site, the equipment and personnel available, and

the time allocated to the task. However, there are minimum operational standards that should be adhered to in a salvage operation:

1. Personnel must have appropriate skills in identification and handling of the Striped Legless Lizard. At least one member of the salvage team should have previous direct experience with the target species; other team members should be given appropriate training to undertake the activity.

2. Adequate safety measures for personnel must be adopted. The designated team leader should be identifiable, by wearing a safety vest, and should be the sole person responsible for communication with the machine operator and for co-ordination of the salvage team.

3. Mechanical or hand searching should be preceded by an intensive trapping effort, using pitfall techniques, in the peak period of annual activity (mainly November and December).

4. Salvage with earth-moving machinery and/or by hand searching should be conducted in cool weather and in the early morning so that movement of the target species is minimised.

5. Striped Legless Lizards that are captured must be held individually in calico bags and details recorded of location, habitat, etc., then transported together to Tidbinbilla Nature Reserve as soon as possible.

6. Any injuries to Striped Legless Lizards should be treated by an experienced wildlife veterinarian.

7. Any Striped Legless Lizards that are unintentionally killed during salvage should be:
   (a) fixed in formalin and lodged with the National Wildlife Collection, CSIRO Division of Wildlife & Ecology, with appropriate location details; or
   (b) placed in ice, then stored (as soon as possible) by cryopreservation suitable for genetic studies, with appropriate location details.

8. Members of non-target species that are captured should be held together, if it is safe to do so, in calico bags (for mammals and reptiles) and plastic bags (for frogs), then released as soon as possible in the nearest secure site that provides appropriate habitat.

6.2 Guidelines for reintroduction

Reintroduction is a valuable tool in wildlife conservation, but is not a simple task. Ill-considered and misguided reintroductions have been conducted in the past in Australia and in other countries, and some spectacular failures have occurred (e.g. Short *et al.* 1992). It is essential to establish a clear need for a reintroduction program, to choose secure release sites and to plan releases with care.

The Re-introduction Specialist Group of the IUCN Species Survival Commission defines reintroduction as 'an attempt to establish a species in an area which was once part of its historical range, but from which it has become extinct'. The group has drafted general guidelines for reintroductions. These have been adapted specifically for possible reintroductions of the Striped Legless Lizard in the ACT. The present limitations of the methods for detecting and monitoring individual Striped Legless Lizards pose particular problems in the planning of pre-release and post-release monitoring.

Aims, objectives and multi-disciplinary approach

1. The aim of a reintroduction program for the Striped Legless Lizard in the ACT is to establish a viable, free-ranging population in an area from which the species has become locally extinct.

2. The objectives of a reintroduction program for the Striped Legless Lizard in the ACT are to re-establish a threatened species in native grasslands, to link discontinuous populations of the species in newly-created conservation reserves, and to promote awareness of grassland conservation.

3. A reintroduction program requires a multi-disciplinary approach. Reintroduction of the Striped Legless Lizard in the ACT should involve a team of people with a range of expertise, drawn firstly from the National Striped Legless Lizard Working Group.

Pre-project activities

1. The genetic status of the Striped Legless Lizards to be introduced must be assessed to ensure that they are of the same taxonomic unit as the population that was formerly present. Genetic data for the ACT indicate that there are three

populations that form distinct taxonomic units, and the Jerrabomberra population is likely to comprise a fourth unit.

2. Detailed ecological studies must be conducted on wild populations of the Striped Legless Lizard in the ACT to determine the critical requirements for the species. Substantial progress has been made on some aspects of ecology, particularly thermal physiology, diet and habitat preferences.

3. The growth rate of a newly-released population must be modelled under a range of conditions to determine the optimum numbers and timing of releases. This step requires detailed demographic information that is presently lacking for the Striped Legless Lizard in the ACT.

4. Previous reintroductions of the Striped Legless Lizard, or similar species, must be investigated to aid the development of a reintroduction program.

5. The selected release sites must meet the following criteria:
   (a) They are within the historic range of the species and have few, or no, resident Striped Legless Lizards.
   (b) They have assured, long-term protection.
   (c) They have suitable habitat.
   (d) They are large enough to sustain growth of the new population and to support a viable population in the long term.
   (e) The previous causes of decline of the species have been identified and eliminated, or managed to acceptable levels, at the site.
   (f) A habitat restoration program has been initiated if the site has undergone significant degradation due to human activity.

6. The availability of suitable release stock should be determined according to the following criteria:
   (a) The stock should have a close taxonomic relationship to the original stock.
   (b) Captive stock must be managed according to sound demographic and genetic principles.
   (c) Removal of donors must not endanger captive or free-ranging populations.

7. Socio-economic studies should be conducted to determine the costs and benefits of a reintroduction program to the local human population, and the attitudes of local people to reintroduction of the Striped Legless Lizard.

Planning, preparation and release

1. A multi-disciplinary team must be drawn together to provide expert advice for all stages of the program.

2. Approval of all relevant government agencies and land owners must be obtained.

3. Transport procedures must be devised to minimise stress on the animals to be released.

4. Indicators of short-term and long-term success must be developed to assess progress towards the project's objectives.

5. Adequate funding must be secured for all phases of the program.

6. A pre-release and post-release monitoring program must be devised along sound experimental lines, allowing the methods to be tested scientifically.

7. Appropriate health-screening must be conducted for the release stock and closely-related taxa in the reintroduction area.

8. The release strategy, including the appropriate position and timing of release, must be determined.

9. A package of training, education and public relations must be developed to ensure long-term support for the reintroduction program.

10. A policy for interventions, such as supplementary feeding or veterinary aid, must be developed.

Post-release activities

1. A reliable method of post-release monitoring of all or a sample of individuals must be established.

2. Studies of the demography, ecology and behaviour of the released stock must be conducted.

3. Incidents of mortality should be investigated.

4. Decisions about revising, rescheduling or terminating the program must be taken when necessary.

5. Habitat restoration or protection must be maintained.

6. The success and cost-effectiveness of the program must be evaluated.

7. The progress of the program must be reported in scientific forums and through the popular media.

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