

THE ACTION PLAN FOR



AUSTRALIAN
REPTILES

BY H.G. COGGER E.E. CAMERON
R.A. SADLIER AND P. EGLER

Australian Nature Conservation Agency
Endangered Species Program
Project Number 124



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by

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The views and opinions expressed in this report are those of the authors and do not necessarily reflect those of the Commonwealth Government, the Minister for the Environment, Sport and Territories, or the Director of National Parks and Wildlife.

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FOREWORD

Australia is noted for the enormous diversity and abundance of its reptile fauna, from the most arid deserts to the tropical waters of the northern coasts. An increasing fascination with these animals is reflected in the recent proliferation of texts, both professional and amateur, on reptile identification, distribution, biology, evolution and conservation. *The Action Plan for Australian Reptiles* is a landmark document for those interested in the conservation of our reptiles as it summarises for the first time the conservation status and requirements of those species at risk.

As a group, the reptiles seem to have survived the perturbations of the last 200 years rather better than the mammals and birds. As this action plan reveals however, there is no room for complacency. Some species such as the Western Swamp Tortoise would probably be extinct by now without the action being taken to conserve the last remaining wild population and to establish another free-living population. Even with all the effort being undertaken, its continued existence is not guaranteed.

One species has recently re-emerged from presumed extinction. Not sighted since 1959, the Pygmy Bluetongue was rediscovered in October 1992 to the excitement of more than a few herpetologists. As with many species the major threat has been the loss of habitat. Found only in small patches of remnant native grassland in a sea of introduced pastures, the Pygmy Bluetongue highlights the urgent need for habitat as well as species conservation.

Many of the arid and semi-arid zone species seem to be relatively secure, but in many cases little is known about their former distributions and abundances. Without further investigation and long-term monitoring there is no way of knowing if species are declining. For many species the collection of further scientific information is essential before an accurate assessment can be made of their conservation status and needs.

The marine reptiles, particularly the migratory turtles, have conservation requirements beyond Australia's control and legislative powers. Our assent to the international Convention on the Conservation of Migratory Animals (Bonn Convention) does, however, give us some capability in helping to secure these species. Meanwhile we should be leading the world in ensuring the security of their feeding and

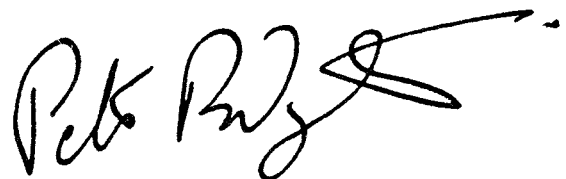
breeding grounds here and reducing the incidental take by fisheries.

Island species have suffered more than species in any other habitat. Having evolved in isolation, often in response to specialised conditions, and lacking reservoirs for recolonisation, these species display the characteristics of small populations including their sensitivity to changes in their environment. This vulnerability of island species to extinction should alert us to the effects of habitat fragmentation on mainland species.

One factor that emerges from this document is the paucity of information on many reptile species. Reptiles have been often neglected by scientists (apart from an eager cohort), planners and decision-makers, and their public profile has been poor. As a fascinating and integral part of Australia's environment, it is time that their status and requirements were taken seriously.

The Action Plan for Australian Reptiles is the third in the series of Action Plans commissioned by the Australian Nature Conservation Agency. Preceding this were the action plans for birds and freshwater fishes, as well as that for marsupials and monotremes produced by WWF/IUCN. Currently in preparation are action plans for amphibians, rodents, bats, cetaceans, and seals and dugongs, as well as conservation overviews for non-vascular plants and non-marine invertebrates.

The Action Plan for Australian Reptiles will play a key role in determining priorities for both research and conservation management needed to prevent extinctions of Australia's unique reptilian fauna.



Peter Bridgewater
Chief Executive Officer
Australian Nature Conservation Agency
December 1993

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EXECUTIVE SUMMARY

Of Australia's diverse reptile fauna comprising some 765 species, 204 species or subspecies or geographically-discrete populations (henceforth collectively called "species") have been nominated by conservation agencies and individuals as warranting threatened status and requiring management actions to slow or halt the processes which are threatening their survival. This represents about 25% of Australia's reptile fauna.

The authors have reviewed the knowledge available on these species in consultation with a panel of representative herpetologists, and recommend 11 species for Endangered status and 41 species for Vulnerable status. A further 152 species are recommended for Rare or Insufficiently Known status.

Ranking of threatened taxa was achieved by use of a modified version of a system developed by Millsap *et al.* (1990) for the vertebrate fauna of Florida. Initially trialed in a national workshop of representative herpetologists, this system was adopted when found to reliably rank threatened species on the limited data available for Australian reptiles.

It is recommended that all the species assigned Endangered or Vulnerable status in this Action Plan be included on the ANZECC List of Endangered Vertebrate Fauna and on the gazetted schedules of relevant Federal, State and Territory conservation agencies.

Recovery outlines have been prepared for all Endangered and Vulnerable species except marine turtles. The outlines summarise current knowledge of the conservation status, distribution, habitats and threats to each species. They also review current research and management actions and identify gaps in the knowledge needed to effectively manage and conserve these species, and list the actions (together with their costs) needed to reduce or eliminate the current threats and ensure secure status for the species on and off reserves.

Families with the highest proportion of Endangered and Vulnerable species are the marine turtles (Cheloniidae and Dermochelyidae), the freshwater tortoises or turtles (Chelidae) and the legless lizards (Pygopodidae).

Western Australia, followed by Queensland and New South Wales, has the highest number of species in the Endangered and Vulnerable categories.

The WORLDMAP software package, using a variety of biodiversity measures to analyse the distribution of Endangered and Vulnerable terrestrial reptiles, identifies 13 areas (at a resolution of 2° of latitude and longitude) that collectively contain the highest biodiversity of this subset of species. It is recommended that priority be given to these areas in the allocation of national conservation resources and in the establishment and management of reserves by State and Territory conservation agencies.

The class of habitat with the greatest number of reptiles at risk is "isolated rocky outcrops" which includes small offshore islands. Other habitats with high numbers of Endangered or Vulnerable species are open woodland, woodland, tussock grassland and heathland.

The threatening processes identified in this review as affecting the greatest number of species, are habitat clearance or modification, overgrazing by stock, cropping, urban development, and predation by introduced mammals (principally foxes, cats and rats).

This review has highlighted the dearth of knowledge on the distribution, biology and ecology of Australia's reptiles, with the result that 85% of the \$4,848,900 required to implement the recommended actions is assigned to these basic areas of research.

INTRODUCTION

This Action Plan was commissioned by the Australian Nature Conservation Agency (formerly the Australian National Parks and Wildlife Service), through the Endangered Species Program. The assigned task was to "...prepare an overview of the conservation status of Australian reptiles, develop a list of endangered and vulnerable reptile taxa, and develop conservation profiles for these taxa."

This task faced some difficulties which were probably not encountered in the Action Plans for birds and mammals. Australian reptiles are exceptionally diverse (765 species in 136 genera spanning 17 families). Within this fauna, some 270 species (36% of the total reptilian fauna) have been described only during the past two decades - a figure indicative of the continuing need for herpetofaunal surveys and taxonomic research.

Unlike birds, few reptiles can be confidently identified by observation from a distance; in most cases, a reptile must be taken in hand and a suite of morphological and meristic characters examined before an accurate identification is possible. Recognition of sibling (cryptic) species is becoming increasingly common as the application of molecular and biochemical techniques permits them to be identified; once such species are characterised, it is often possible to find correlated morphological features, but even so, identification of wild specimens almost invariably requires capture of the individual. Capturing most live reptiles for examination and identification requires knowledge, skill and, in most States and Territories, a permit from the appropriate conservation and wildlife agency.

Unlike the Australian birds and mammals, few reptiles have been subjected to intensive bio-ecological study. The life histories of fewer than 10 species have been studied with any degree of completeness and the distributions of individual species are typically extrapolated from a handful of specimen-based museum records.

For all of the foregoing reasons, the knowledge base available to identify and assess the status of threatened species of reptiles in Australia is inadequate, uneven and usually fragmentary. (In this document, the term 'threatened' is used in a

broad sense to describe all or any species whose conservation status is considered insecure; it includes reptiles in Endangered, Vulnerable, and Rare or Insufficiently Known categories).

In an effort to overcome these shortcomings, the preparation of this Action Plan involved extensive consultation with individual Australian herpetologists and with Commonwealth, State and Territory agencies responsible for aspects of reptile conservation in Australia and its Territories.

No Australian reptile is known to have become extinct since 1788. However, the importance of a quantified, objective ranking system was emphasised during the course of the Plan's preparation when the only Australian reptile believed to be "probably extinct" - the Pygmy Bluetongue, *Tiliqua adelaidensis* - was rediscovered in extraordinary circumstances near Burra, South Australia (Armstrong and Reid, 1993). More than 50 of these lizards have since been discovered, albeit in a very small area, and population studies are currently under way. Successful reproduction was recorded during the 1992-93 summer.

Recognition of taxa and use of common names

We have recognised some undescribed species, subspecies and geographically-discrete populations in the Reptile Action Plan. The taxonomic integrity of most of the undescribed chelids is supported by an allozyme electrophoresis study (Georges and Adams, 1992) but some of the other taxa widely recognised as distinct, lack published data to define them. We strongly urge herpetologists concerned about the conservation status of undescribed reptiles, to formally describe such taxa.

With the intention of making this Plan more readable for non-specialists, we have given common names to all the reptiles listed as Endangered or Vulnerable. Some names are already in common usage and others have been applied in the recent literature on threatened species; for the remainder we depended on recommendations from the people most familiar with the species, or coined names ourselves. All members of the family Chelidae have been

called "Tortoise" to conform with the preferred common name of "Western Swamp Tortoise" for *Pseudemydura umbrina*.

Definitions of threatened categories

All nominated taxa were classified into one of three categories: 'Endangered', 'Vulnerable', and 'Rare or Insufficiently Known'. The definitions of 'Endangered', 'Vulnerable' and 'Insufficiently Known' used in this publication are those used officially by the World Conservation Union (IUCN), with minor additions to the endangered and vulnerable categories. These modifications are used by the Endangered Species Program (ESP) and the Australian and New Zealand Environment and Conservation Council (ANZECC). The categories 'Extinct' and 'Rare' are also used in this publication and are defined below:

'Extinct': Taxa not definitely located in the wild during the past 50 years, or species that have not been found in recent years despite thorough searching.

'Endangered': Taxa in danger of extinction and whose survival is unlikely if the causal factors continue to operate.

Included are taxa whose numbers have been reduced to a critical level or whose habitats have been so drastically reduced that they are deemed to be in immediate danger of extinction. Also included are taxa that may now be extinct but have definitely been seen in the wild during the past 50 years and have not been subject to thorough searching.

'Vulnerable': Taxa believed likely to move into the 'Endangered' category in the near future if the causal factors continue to operate.

Included are species of which most or all of the populations are decreasing because of over-exploitation, extensive destruction of habitat or other environmental disturbance; species with populations that have been seriously depleted and whose ultimate security has not yet been assured; and taxa with populations that are still abundant but are under threat from severe adverse factors throughout their range. Also included are taxa with low or localised populations or dependent on limited habitat that would be vulnerable to new threatening processes. In practice, both 'Endangered' and

'Vulnerable' categories may include, temporarily, species whose populations are beginning to recover as a result of remedial action, but whose recovery is at present insufficient to justify their transfer to another category.

'Rare': Taxa with small populations that are not at present 'Endangered' or 'Vulnerable', but are threatened. These taxa are usually localised within restricted geographical areas or habitats or are thinly scattered over a more extensive range.

'Insufficiently Known': Species that are *suspected* of being 'Endangered', 'Vulnerable' or 'Rare' but whose true status cannot be determined without more information.

While these categories may appear relatively unambiguous to the layman, they are highly subjective, with the boundaries between one category and another being difficult to define in any objective way: boundaries between the categories vary widely in different countries and regions, and in different taxonomic groups.

More recently the shortcomings of these categories have been recognised and a new classification (Mace and Lande, 1991) using more objective criteria, has been proposed to replace them. The proposed classification is:

'Critical': 50% probability of extinction within 5 years or 2 generations, whichever is the longer.

'Endangered': 20% probability of extinction within 20 years or 10 generations, whichever is the longer.

'Vulnerable': 10% probability of extinction within 100 years.

The criteria used to assign species to the above categories are summarised in Appendix 10, Table 4, where full details of the approach and methods adopted in preparing this Action Plan appear.

Summary of methods and results

Initially a list was compiled of Australian reptiles which had been included by conservation and wildlife agencies on schedules of threatened species. Further nominations of threatened species were sought from the

community through a questionnaire mailed to herpetological, natural history and conservation societies. The collection databases of all major natural history museums in Australia were then consulted to obtain information on distribution and the history and chronology of geographic records held on these species.

Government conservation and wildlife agencies in all States and Territories were approached for assistance. They were asked to supply non-specimen-based distribution data and information on reserves and research and management programs relevant to reptiles on the ANZECC List of Endangered Vertebrate Fauna (April, 1991) or on their own schedules of threatened fauna. (The reptiles listed on the ANZECC List are the same as those on Schedule 1 of the Commonwealth's *Endangered Species Protection Act 1992*).

A working list of 204 taxa (about 25% of all species known from Australia and its Territories) was prepared from the above sources. The conservation status of each of these species was discussed and ranked by specialist herpetologists at a workshop held in December 1991.

As indicated above, knowledge of Australian reptiles is generally poor, so even small amounts of new information can require dramatic revision of prior perceptions of distribution, habitat preferences and conservation status. For these reasons the authors considered that a system of objective ranking of threatened taxa was essential if new information about individual taxa was to be rapidly processed and incorporated into relevant legislation and regulations. Several such systems are in use (eg Ahern *et al.*, 1985; Molloy and Davis, 1992), but after preliminary trials, the wildlife ranking system developed by Millsap *et al.* (1990) for the Florida Game and Freshwater Fish Commission was modified, trialed and adopted.

As a result of the workshop (and subsequent consideration of recent research which resulted in the re-scoring of biological variables for some species), 11 species, subspecies or geographically-discrete populations of Australian reptiles are considered to warrant Endangered status and a further 41 reptiles are considered to warrant Vulnerable status. The remaining 152 reptile taxa are classified as Rare or Insufficiently Known and warrant further

study to assess whether they are likely to become Vulnerable or Endangered in the near future. The scores for all 204 taxa, based on Millsap *et al.*, appear in Appendix 11.

Some of the species which have been identified as Endangered or Vulnerable in this Plan are not currently gazetted in State, Commonwealth or ANZECC schedules of threatened reptiles. We strongly recommend that they be added to the relevant schedules as soon as possible.

Four species on the 1991 ANZECC List did not score enough points in our analysis to qualify for Endangered or Vulnerable status in this Action Plan (see Appendix 3 and Appendix 11). They are *Aprasia parapulchella*, *Delma mitella*, *Ctenotus angusticeps* and *Morelia carinata*; a review of recent information on the distribution of these species and the processes threatening them was the reason for their changed status.

An extensive survey of *A. parapulchella* by the ACTP&CS has located it at many sites within two conservation reserves in the ACT; recent records from Bathurst and Tarcutta in NSW suggest its total range may not have declined since it was described. The area occupied by *Delma mitella* is estimated to have declined by less than 25% and the trend in its population size is unknown. Although it is known from only a few specimens, it occurs in a region which has not been adequately surveyed and which is not subject to drastic habitat modification at this time. It was the opinion of the Workshop participants (including its describer) that *Delma mitella* was Rare or Insufficiently Known rather than Vulnerable.

The known range of *Ctenotus angusticeps* was recently extended by the discovery of five individuals on the mainland near Roebuck Bay, 700 km north-east of the type locality, Airlie Island (Sadler, 1993). Although *Morelia carinata* is known from only a few individuals, it occurs in sandstone gorges in a remote region which has not been fully surveyed. No major threatening processes have been identified and both population size and area occupied are considered to be stable or increasing.

All six marine turtles were nominated for threatened status but none scored as high as the lowest ranked Vulnerable terrestrial reptile. This was in part due to the low endemism of the marine turtles compared with the high

endemism of terrestrial reptiles, in part to the large geographic distribution of most marine turtles compared with the usually limited range of threatened terrestrial species, and in part to the great pressures being placed on many terrestrial habitats.

Some species, such as the Luth (*Dermochelys coriacea*), have no significant nesting sites in Australia. However, given the intense hunting pressure put on this and other species in many neighbouring countries, it is critical that the species be afforded protection in Australian waters so as not to contribute to the depletion of regional breeding stocks. Conversely Limpus (pers. comm.) has indicated that Australian nesting populations of the Green Turtle (*Chelonia mydas*) are genetically distinguishable from those of adjacent areas such as Indonesia, maintaining discrete breeding sites while sharing feeding areas. Hence hunting activities in such regions can impact on Australian breeding stocks. Limpus and Reimer (in prep.) have also shown that eastern Australian stocks of the Loggerhead Turtle (*Caretta caretta*) have fallen sharply in the past two decades.

Consequently, with all species of sea turtles (except *Natator*) declining globally, and the Australian populations of several species in serious decline at least regionally, we believe that a special case can be made for all species except *Natator depressus* to be listed as Vulnerable. This view reflects the conservation status previously accorded marine turtles by ANZECC. It is also supported by most Australian marine turtle experts, who have prepared a series of draft recommendations for marine turtle conservation (Australian Nature Conservation Agency and Queensland Dept of Environment and Heritage, in press).

The Australian Nature Conservation Agency has retained the Queensland Department of Environment and Heritage (Dr Col Limpus) as a consultant to prepare a Strategy for Regional Cooperation on Marine Turtle Conservation in the Indo-Pacific Region. Because of that ongoing consultancy and the draft recommendations in press, and because they constitute a special case in the conservation of Australian reptiles, marine turtles have been treated differently from terrestrial reptiles in this Action Plan. Brief Species Profiles and distribution maps for the Vulnerable species appear in Appendix 6.1.

Only three species of sea snakes were nominated for threatened status and all were eventually classified as Rare or Insufficiently Known. The same classification could well be applied to many other species in this group.

Sea snakes are a significant by-catch of commercial prawn trawling in northern Australian waters - more than 200,000 were taken during 1989 and 1990 (Ward, 1993) - and many of their skins are processed in tanneries in Australia. The Australian Government has not yet issued commercial export permits for Australian sea snakes, but sea snakeskin goods are already sold widely in northern Australia. This trade requires careful monitoring to ensure that populations of individual species do not decline to a level which threatens their survival.

The taxonomic breakdown of Australia's threatened reptiles is summarised in Appendix 1, Table 1. Marine turtles (families Cheloniidae and Dermochelyidae) top the list with all species except *Natator depressus* proposed as Vulnerable; they are followed by the freshwater tortoises (Chelidae) and endemic legless lizards (Pygopodidae), each with approximately 25% of species classified as Endangered or Vulnerable.

Genetic research has been recommended in 10 Species Recovery Outlines. The following examples illustrate the importance of such studies in determining the biological uniqueness of threatened taxa currently regarded as ecologically and morphologically distinct.

Of the reptiles classified as Endangered in this Plan the island species, *Ctenotus lanceolini*, is morphologically very similar to the mainland species, *Ctenotus labillardieri*. *Eulamprus leuraensis* was elevated from the species complex of *Sphenomorphus* (now *Eulamprus*) *kosciuskoi* on the basis of colour pattern and some scalation characters. The undescribed subspecies of *Eulamprus tympanum* in the Drecite area of Victoria may interbreed with the nominal subspecies on the edges of its range (John Coventry, pers. comm.).

Until recently *Lerista allanae* was recognised as fairly widespread species in central Queensland; in 1992 the taxon was split and a new species, *Lerista colliveri*, was described to which individuals throughout most of this range were assigned (Couper and Ingram, 1992). The range of *Lerista allanae* is now regarded as a very

small area around Clermont and its re-scoring has elevated it to Endangered status.

Generally, isolated populations could be considered less genetically distinct and thus of less conservation significance than subspecies, and the latter less distinct and significant than species. However the status of all conspecifics and congeners should be considered when assessing the extent to which a gene pool is threatened. For example, all three subspecies of *Egernia stokesii* are threatened so the species complex warrants priority in conservation actions over a threatened subspecies whose conspecifics are all considered secure.

The distribution of Endangered and Vulnerable terrestrial species by States and Territories is shown in Appendix 5.1 (summarised below). Western Australia and Queensland have the highest numbers of species in these categories.

The WORLDMAP analyses identified 13 areas of high biodiversity for Endangered and Vulnerable reptiles - four in Queensland, three each in Western Australia and South Australia, two in Victoria, one in New South Wales and one encompassing Christmas Island (Appendix 8.1, Table 3). It is recommended that priority be given to these areas in the allocation of national conservation resources and in the establishment and management of reserves by State and Territory conservation agencies.

Information compiled for Species Recovery Outlines indicated that only a few highly threatened terrestrial reptiles were adequately represented in conservation reserves: (12 out of 47 Vulnerable or Endangered species); 18 species in these categories were not recorded from any reserves. Moreover there is very little overlap of threatened species in the reserve system. Only four reserves were recorded as

	STATE/TERRITORY										
	SA	WA	NT	QLD	NSW	ACT	VIC	TAS	Norfolk Island	Lord Howe Island	Christmas Island
Endangered	1	5		2	1		2				
Vulnerable	7	10	2	10	9	2	3	1	2	2	2
Total Endangered + Vulnerable	8	15	2	12	10	2	5	1	2	2	2
Rare or Insufficiently Known	12	54	24	74	24	4	7	1			
Total Threatened Taxa	20	69	26	86	34	6	12	2	2	2	2

The WORLDMAP software package (Appendix 8) has been used to identify **priority areas for the conservation of threatened (Endangered and Vulnerable) reptiles** based on biodiversity measures which analyse the distribution of these species in 2° grid squares. The biodiversity measures include "species richness" which prioritises areas in direct proportion to the number of species present, and "endemism" which gives priority to taxa with the smallest geographic ranges. "Taxonomic root weight" assigns priority to areas containing the greatest number of early-diverging or relict species - that is, species which are genetically distinctive or unique. "Higher taxon richness" gives priority to areas with the most species from early-diverging higher taxa (irrespective of the number of surviving species) while "spanning-tree length" gives greatest weight to areas with the greatest taxonomic spread of species.

containing more than one threatened species and three of these were insular: Lord Howe Island Permanent Park Reserve and Phillip Island Forest Reserve (*Christinus guentheri* and *Pseudemoia lichenigera*) and Christmas Island NP (*Lepidodactylus listeri* and *Ramphotyphlops exocoeti*); *Notechis ater ater* and *Aprasia pseudopulchella* have both been recorded from Mount Remarkable NP in South Australia.

Lack of knowledge contributes to the difficulty of identifying the **habitat preferences** of many threatened species. Appendix 4 (summary on following page) lists the habitats used by each of the Endangered or Vulnerable terrestrial reptiles, based on the literature and field observations. Habitats have been classified by vegetation structure after AUSLIG (1990) or by the aquatic or geological features.

Isolated rocky outcrops (including offshore

islands) have the greatest number of species at risk, followed by open woodland, woodland, tussock grassland and heathland. The small geographic area of many islands and their high susceptibility to threatening processes such as ecological changes wrought by introduced animals and plants, climate change and anthropogenic fires, automatically elevate many insular endemic taxa to threatened status.

declined, the reasons for the decline (see Section 9 in the Species Recovery Outlines) are speculative. Appendix 7 lists the major threatening processes which are believed to be operating on Australia's Endangered and Vulnerable terrestrial reptiles. Because the threatening processes leading to the decline of most taxa of threatened Australian reptiles remain subjective or speculative, no attempt has

HABITAT																		
Closed forest	Low closed forest	Tall open forest	Open forest	Wood-land	Open wood-land	Low wood-land	Low open wood-land	Tall shrub-land	Tall open shrub-land	Heath-land	Low shrub-land	Hum-mock grass-land	Tussock grass-land	Littoral complex	Swamps	Rivers	Riparian habitats	Rocky isolates
5	1	3	6	9	10	2	2	6	3	8	2	2	9	1	3	4	3	12

While this Plan concentrates on identifying threatened taxa, the participants in the December 1991 workshop expressed the opinion that entire reptile communities in Australia and its Territories were also at risk. They identified communities in the following habitats and regions as being most under threat:

Fragments of original mallee (tall shrubland) and woodland habitats in the wheatbelt of south-western Western Australia and in western Victoria and western New South Wales.

Brigalow (open forest) in southern Queensland. Vine thickets and seasonally-dry rainforests (closed forests) of Arnhem Land, the Kimberley and Queensland.

Riparian habitats sensitive to changes in drainage patterns.

Heathlands of Cape York Peninsula.

Lord Howe and Norfolk Islands and their satellite islets.

Closed forests of Christmas Island, Indian Ocean.

Knowledge of the **processes threatening reptile populations** in Australia is also fragmentary, and documented in only a few cases. In most species which are known or suspected to have

been made to rank the severity of individual threats other than in terms of the number of species on which they are believed to impact (see table below).

The threats affecting the greatest number of species are habitat clearance, overgrazing by domestic stock, cropping, urban development and predation by introduced mammals (foxes, cats and rats).

The **budgets** recommended in Section 19 of the Species Recovery Outlines are based on the following rates:

Mean full-time salary	\$40K per annum
Casual rate	approx. \$20 per hour
Expenses	\$20K per annum

The salary rate follows that adopted in the Bird Action Plan (Garnett, 1992). A 50% loading on salary has been allowed for expenses (ie all non-salary costs), with higher loadings for species on islands and in remote regions. Expenses for the preparation of management strategies have been set arbitrarily at 20% of salary. The total cost of one full-time research worker averages \$60K per annum. Where post-graduate students are employed to undertake the research, salary costs could be reduced by up to 50%.

THREATENING PROCESS																		
Habitat clearance	Over-grazing by stock	Cropping	Pre-dation	Urban develop-ment	Pasture improve-ment	Fire regime	Soil degrad-ation	Visitor disturb-ance	Soil &/or water pollution	Mining	Native forest logging	Climatic vari-ation	Rabbit grazing	Habitat fragment-ation	Weed invasion	Habitat drainage	Rock removal	
30	21	21	14	14	12	10	9	8	7	6	6	5	6	5	5	4	4	

Distribution surveys can probably be accomplished most effectively within broader surveys of regional faunas utilising GIS. However we believe the detailed biological data which need to be collected for little-known species such as the Mary River chelid (*gen. nov. sp. nov.*) or *Underwoodisaurus sphyrurus*, may sometimes best be accomplished by funding post-graduate projects which can focus full-time for several years on the target species.

Implementation

The approach adopted in this Plan is intended to reflect the dynamic nature of the problem. A recurring theme is the need for further survey and research. The knowledge base necessary to identify and effectively conserve Australia's threatened reptiles is hopelessly inadequate. This became clear when attempting to provide objective answers to the biological questions posed by the Millsap *et al.* methodology. It is also reflected in the budgets - 85% of the total of \$4,848,900 being recommended for expenditure on surveys and research into basic biology and ecology.

It is our hope that by adopting a quantitative methodology, new information can be integrated rapidly into our existing database (Appendix 11). This should alert conservation managers to the changing priorities for the conservation of Australia's threatened reptiles, and to the underlying environmental causes of the changed and changing status of individual taxa.

The nomination of a few dozen taxa for Endangered or Vulnerable status and the allocation of extensive resources to their conservation will be futile if we fail to address the major cause of the decline of so many species - massive habitat modification and destruction.

References

Ahern, L.D., Brown, P.R., Robertson, P., Seebeck, J.H., Brown, A.M. and Begg, R.J. 1985. A proposed taxon priority system for Victorian vertebrate fauna. Arthur Rylah Institute for Environmental Research Technical Report 30: 1-26.

Armstrong, G. and Reid, J. 1993. The rediscovery of the Adelaide Pygmy Bluetongue *Tiliqua adelaidensis*; (Peters, 1863). *Herpetofauna* 22(2): 3-6.

AUSLIG 1990. Atlas of Australian Resources Third Series. Volume 6. Vegetation. Australian Department of Administrative Services, Canberra. 64 pp.

Australian Nature Conservation Agency and Queensland Department of Environment and Heritage. in press. Proceedings of the Australian Marine Turtle Conservation Workshop, 14-17 November 1990.

Couper, P.J. and Ingram, G.J. 1992. A new species of skink of *Lerista* from Queensland and a re-appraisal of *L. allanae* (Longman). *Memoirs Queensland Museum* 32(1): 55-59.

Garnett, S. 1992. The Action Plan for Australian Birds. Australian National Parks and Wildlife Service, Canberra. 262 pp.

Georges, A. and Adams, M. 1992. A phylogeny for Australian chelid turtles based on allozyme electrophoresis. *Australian Journal of Zoology* 40: 453-476.

Limpus, C.J. and Reimer, D. in press. The Loggerhead Turtle, *Caretta caretta*, in Queensland: a population in decline. pp. 34-41 in Proceedings of the Australian Marine Turtle Conservation Workshop, 14-17 November 1990.

Mace, G.M. and Lande, R. 1991. Assessing extinction threats: towards a re-evaluation of IUCN threatened species categories. *Conservation Biology* 5: 148-157.

Molloy, J. and Davis, A. 1992. Setting priorities for the conservation of New Zealand's threatened plants and animals. Department of Conservation, Te Papa Atawhai, Wellington.

Millsap, B.A., Gore, J.A., Runde, D.E. and Cerulean, S.I. 1990. Setting priorities for the conservation of fish and wildlife species in Florida. *Wildlife Monographs* 111: 1-57.

Sadler, R.A. 1993. A range extension for the scincid lizard *Ctenotus angusticeps* of north-western Australia. *Herpetofauna* 23(1): 7-8.

Ward, T.M. 1993. Towards monitored and sustainable commercial utilization of the sea snake by-catch of northern Australian prawn trawlers. Report to the Conservation Commission of the Northern Territory, Darwin.

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ABBREVIATIONS

The following abbreviations have been used in this document:

ACT	Australian Capital Territory
ACTP&CS	ACT Parks and Conservation Service
ANCA	Australian Nature Conservation Agency (formerly ANPWS)
ANPWS	Australian National Parks and Wildlife Service (now ANCA)
ANZECC	Australian and New Zealand Environment and Conservation Council
ANZECC List	ANZECC List of Endangered Vertebrate Fauna (April, 1991). ANPWS.
asl	above sea level
BP	before present
c.	circa (about)
CALM	Department of Conservation and Land Management
CCNT	Conservation Commission of the Northern Territory
cm	centimetres
CP	Conservation Park
CR	Conservation Reserve
CSIRO	Commonwealth Scientific and Industrial Research Organisation
DCNR	Department of Conservation and Natural Resources
DELM	Department of Environment and Land Management
EP	Environmental Park
ERIN	Environmental Resources Information Network of ANCA
ESAC	Endangered Species Advisory Committee
<i>et al.</i>	and others
FFR	Fauna and Flora Reserve
FINP	Aboriginal freehold/National Park
FLR	Flora Reserve
FP	Forest Park
FR	Forest Reserve
<i>gen. nov.</i>	new genus
GR	Game Reserve
ha	hectares
<i>in litt.</i>	in a letter
in prep.	manuscript in preparation
IUCN	World Conservation Union
km	kilometres
km ²	square kilometres
<i>op. cit.</i>	in the work cited
m	metres
MCZ	Museum of Comparative Zoology, Harvard
mm	millimetres
ms	manuscript
MSc	Master of Science
NP	National Park
NPWS	National Parks and Wildlife Service
NR	Nature Reserve
NSW	New South Wales
NT	Northern Territory
P	Park
p.a.	<i>per annum</i>
pers. comm.	personal communication
PhD	Doctor of Philosophy
pp.	pages
ODEH	QLD Department of Environment and Heritage
QLD	Queensland

RAOU	Royal Australasian Ornithologists' Union
RP	Recreation Park
SA	South Australia
SA	Scientific Area
SF	State Forest
SP	State Park
<i>sp.</i>	species (singular)
<i>sp. aff.</i>	species related to
<i>sp. nov.</i>	new species
<i>spp.</i>	species (plural)
SRA	State Recreation Area
SWR	State Wildlife Reserve
TAS	Tasmania
VIC	Victoria
W	Wilderness
WA	Western Australia
WHA	World Heritage Area
WR	Wildlife Reserve
WWF	Worldwide Fund for Nature

KEY TO THE DISTRIBUTION MAPS FOR SPECIES RECOVERY OUTLINES

Species occurring on Australian mainland and offshore islands:

Upper map: Black squares represent the 2° grids in which the species is found.

Lower map: Circles represent the collection localities of specimens held in Australian museums.

Irregular rectangular black blocks represent the larger (generally in excess of 1,000 km²) conservation reserves within the species' range. These should not be confused with the outline of the coast in maps of coastal species.

[Maps of the reserve system are derived from software provided by the Environmental Resources Information Network Unit, 1992.]

Species on oceanic islands (Norfolk, Lord Howe and Christmas Islands):

Circles represent museum specimens plus sight records.

