Australian and New Zealand Islands: Nature Conservation Values and Management

Edited by: Andrew Burbidge

OCCASIONAL PAPER 2/89

PROCEEDINGS OF A TECHNICAL WORKSHOP,
BARROW ISLAND, WESTERN AUSTRALIA, 1985

DEPARTMENT OF CONSERVATION AND LAND MANAGEMENT

Australian and New Zealand Islands: Nature Conservation Values and Management

Edited by: Andrew Burbidge

Proceedings of a Technical Workshop,
Barrow Island, Western Australia, 1985

Occasional Paper 2/89
December 1989

Published by the
Department of Conservation and Land Management
Western Australia

Front cover photo: The Barrow Island Euro *(Macropus robustus isabellinus)* differs from the mainland subspecies. It is much smaller, is differently coloured and both sexes are about the same size, unlike mainland animals where the male is much larger than the female. Continental islands often have unique subspecies or varieties of species that occur on adjacent mainlands.

Back cover photo: The Masked Booby *(Sula dactylactra)* is widely distributed in the equatorial parts of all the oceans of the world. In common with many species of seabirds, it nests only on islands.

ISSN 1031-486

Andrew Burbidge ..... Editor
Jill Pryde ..... page preparation
CALM Public Affairs ..... production and distribution

INTRODUCTION

Andrew A Burbidge

Department of Conservation and Land Management,
W.A. Wildlife Research Centre, PO Box 51, Wanneroo W.A. 6065

At its thirteenth meeting in July 1984, the Council of Conservation Ministers (CONCOM) supported a proposal for a technical workshop on the management of islands in the Australian-New Zealand region. The Western Australian Department of Conservation and Land Management (CALM) accepted the task of convening the workshop and decided that it would be held on Barrow Island, a 22 500 ha nature reserve of great importance situated off the Pilbara coast.

Barrow Island, as well as being one of the most important island reserves in the world, also supports a producing oil field. The Company that owns and operates the oil field, West Australian Petroleum Pty Ltd (WAPET) agreed to support the workshop and its conservation consultant, Mr W.H. (Harry) Butler, provided generous support and assistance to the organiser. I am most grateful to WAPET and Harry for their assistance.

The workshop was held from November 8 to 13, 1985. Its objective was to review island survey, ecology and management as it relates to nature conservation, and to publish a series of comprehensive review papers as an up-to-date statement of current island biological conservation.

The workshop was attended by representatives of a number of Australian State, Territory and Commonwealth and New Zealand nature conservation agencies and by other people involved in island research and conservation. The Queensland, New South Wales and Victorian nature conservation authorities were not represented at the workshop, although New South Wales contributed a paper. A list of participants is given below.

In addition to the presentation of review papers and workshop sessions, field excursions constituted a most important part of the workshop. Oil was discovered on Barrow Island in 1964 and by 1985 over 700 wells had been drilled. Workshop participants were able to see WAPET's management procedures in action, and this gave impetus to discussions about ways of preventing deleterious impacts on islands elsewhere.

This publication is the report of the CONCOM Technical Workshop on Island Management. As well as the papers presented at Barrow Island it includes a contributed paper from New south Wales and Workshop Reports resulting from discussions held on the island. Finally, it includes the Summary Report of the Workshop.

LIST OF PARTICIPANTS

NEW ZEALAND

Wayne Devine, Assistant Director National Parks and Reserves, Department of Lands and Survey

Paul Dingwall, Chief Scientist, Department of Lands and Survey

Dr Ian Atkinson, Botany Division, Department of Scientific and Industrial Research

Brian Bell, New Zealand Wildlife Service

AUSTRALIA

Commonwealth Government

Mike Hinchey, Australian National Parks and Wildlife Service

Wanda Filsell, Department of Territories

Dr Denis Saunders, Principal Research Scientist, Commonwealth Scientific and Industrial Research Organization, Division of Wildlife and Ecology, Perth

State and Territory Governments

South Australia

Dr Tony Robinson, Senior Wildlife Research Officer, National Parks and Wildlife Service, Department of Environment and Planning

Northern Territory

Mike Butler, Principal Planning Officer, Conservation Commission of the Northern Territory

Tasmania

David Rounsevell, National Parks and Wildlife Service (now Lands Parks and Wildlife Department)

Western Australia

Dr Andrew Burbidge, Senior Principal Research Scientist, Department of Conservation and Land Management

Angas Hopkins, Senior Research Scientist, Department of Conservation and Land Management

Keiran McNamara, Scientific Adviser, Department of Conservation and Land Management

Susan Moore, Planning Officer, Department of Conservation and Land Management

Keith Morris, Research Scientist, Department of Conservation and Land Management

Australian Committee for IUCN

John Sinclair

Private Conservation Consultant

Harry Butler, Dinara Pty Ltd, Perth

CONTENTS

INTRODUCTION - Andrew A Burbidge iii

WORKSHOP PARTICIPANTS v

PART A - PRESENTED PAPERS vii

The value of New Zealand Islands as biological reservoirs -
I.A.E. Atkinson 1

The value of Western Australian islands as biological reservoirs and the development of management priorities -
Andrew A. Burbidge 17

Management planning for island protected areas, based on New Zealand experience -
P.R. Dingwall 25

The development of management plans for islands in Western Australia -
Susan A. Moore 37

Policy considerations influencing management of nature conservation values in Australian islands territories -
W.L. Filsell 49

Interactive conservation perspectives: the prospect for aboriginal and Conservation Commission joint management of island ecosystems in the Northern Territory -
Mike Butler 59

Changes in species composition of the avifauna of Rottnest Island, Western Australia -
D.A. Saunders & C.P. de Rebeira 73

Fire on offshore islands - problems and management solutions -
A.J.M. Hopkins and J.M. Harvey 83

The removal of problem animals from islands -
Brian D. Bell 97

Feral animal control on Western Australian islands -
K.D. Morris 105

Translocation of species using islands -
Brian D. Bell 113

Nature conservation management of tropical and subtropical island territories -
Neil Hermes, John Hicks, Mike Hinchey & Barry Reville 119

Management of New Zealand's outlying island reserves -
Wayne T. Devine 131

Reservation and management of seabird islands in New South Wales -
Peter J. Smith & Michael J. Dodkin 141

Managing offshore island reserves for nature conservation in Tasmania -
David Rounsevell 157

Island management in South Australia -
A.C. Robinson 163

the Dampier Archipelago - managing people in a nature reserve -
K.D. Morris 183

Management of Barrow Island -
W.H. Butler 193

Management of Queensland's great sandy islands -
John Sinclair 201

PARK B - WORKSHOP REPORTS

Oceanic islands - differences in values and management when compared to continental islands -
Mike Hinchey 215

Management planning for islands -
P.R. Dingwall 217

Feral animals on islands - effects and control -
K.D. Morris 219

Translocation of endangered species to islands -
Brian D. Bell 221

Managing public use of islands -
Susan A. Moore 223

Developing priorities for the use of scarce resources -
Keiran J. McNamara 225

PART C - SUMMARY REPORT

Summary report of CONCOM Technical Workshop on island management -
Keiran J. McNamara 227

The Value of New Zealand Islands as Biological Reservoirs

I.A.E Atkinson

Botany Division, Department of Scientific and Industrial Research, Lower Hutt, New Zealand.

Abstract

New Zealand's islands function as biological reservoirs for native plants, animals, communities and habitats. They also contain parts of larger marine ecosystems in which ecological and evolutionary processes can be studied or monitored. About 6% of New Zealand's native vascular plant species are confined to islands. Some groups of invertebrates, for example flightless weevils and giant wetas (wingless crickets), have become partly or wholly confined to islands. About 25% of the country's native frogs and reptiles are also confined to islands as are about 50% of the species and subspecies of breeding birds. Most types of mainland communities and habitats are under-represented or absent on islands. Communities restricted to islands include those strongly influenced by seabirds or seals or by salt, those on oceanic islands that are dominated by endemic plants and animals, and some in a pristine condition. Management to maintain or increase the biological values of islands is discussed. In situ management of endemic plants and animals, limiting factors that restrict the suitability of islands for endangered species, and the problem of genetic bottlenecks that arise when founder populations of endangered species are translocated to an island are considered. In addition to continuing effort to prevent alien mammals, particularly rats, from reaching further islands, there is need for the biological restoration of large islands, including some that are inhabited, to increase opportunities for conserving species as evolving populations.

INTRODUCTION

As man continues to modify or destroy an ever-increasing area of the world's natural vegetation and the wildlife it supports, greater attention is being focused on islands as places where at least a fraction of the world's biota and natural communities can be more effectively protected than elsewhere. From this viewpoint the value of New Zealand's islands does not differ from those of Australia or many other parts of the world. This contribution reviews the extent to which the New Zealand islands (excluding the North and South Islands) have functioned as biological reservoirs and considers some of the management problems encountered in trying to maintain or increase their biological value.

New Zealand's islands are dispersed over 22° of latitude and more than 2 500 km of distance. They range in size from tiny stacks of less than a hectare up to the 172 000 ha of Stewart Island; they are frequently rugged and several hundred metres high. It is necessary to distinguish the outlying or oceanic islands (>50 km from mainland coast), which have never been connected to the New Zealand mainland, from the offshore or continental-shelf islands.

The oceanic islands occur in eight separate groups (Fig. 1). Those with subtropical or warm temperate climates are the recent and active volcanoes of the Kermadec group 1 000 km north-east of Auckland, the volcanic remnants of the Three Kings group 56 km north-west of North Cape, and the Chatham group 700 km south-east of the North Island. The remaining five island groups experience a cool temperate to subantarctic climate and are mainly volcanic in origin. With distances and directions from Stewart Island, they are: the Snares Islands (100 km °SW), Auckland Islands (300 km °S), Campbell Islands (530 km °SE), Antipodes Islands (790 km °E) and the Bounty Islands (790 km °ESE).

The continental-shelf islands are concentrated in four main regions. The northern group extends along the north-east coastline of the North Island from North Cape to East Cape (Figs. 1, 2). The majority are volcanic with one, White Island, still active. This group of islands was heavily modified during Maori occupation between 1 000 and 1 800 A.D.

The Cook Strait-Marlborough Sounds islands (Fig. 3) in the central part of New Zealand, largely of sedimentary rocks, have been separated from the mainland by rises in sea level. Many of these islands were also modified during Maori occupation.

The islands of Fiordland in the south-west of the South Island (Fig. 1) are composed mainly of metamorphic rocks. Modification by the Maori is

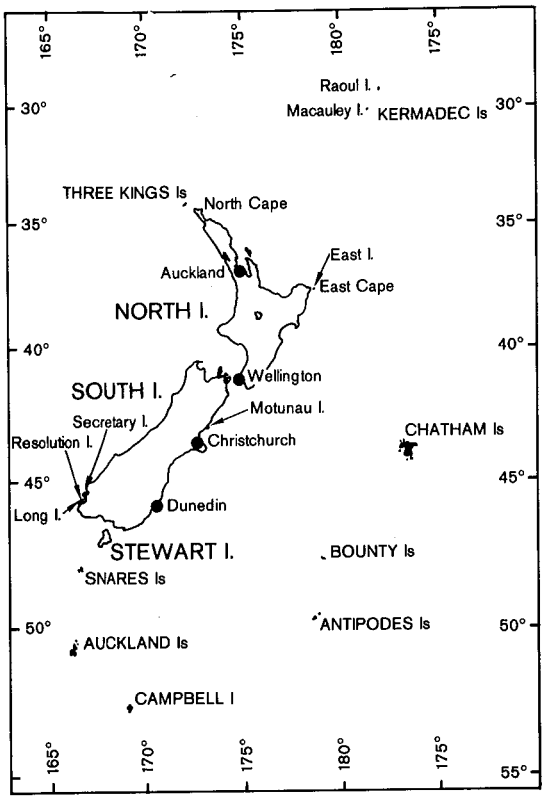


Figure 1
New Zealand and its oceanic islands (islands of Fiordland in lower case lettering)

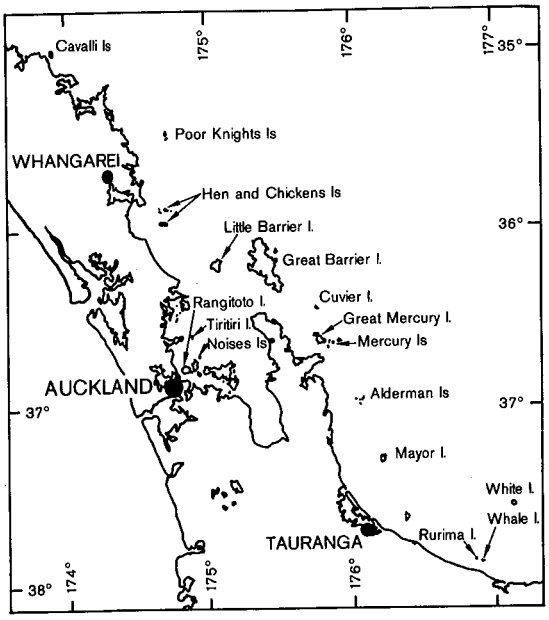


Figure 2
The northern islands

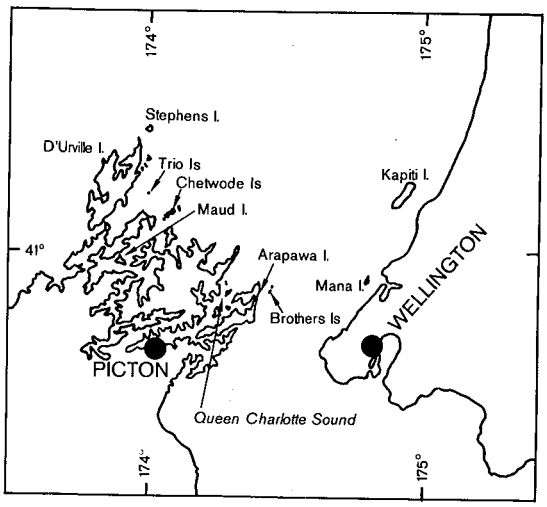


Figure 3
The Cook Strait-Marlborough Sounds islands.

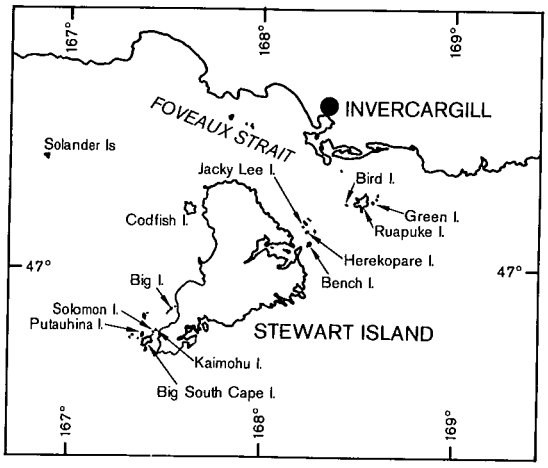


Figure 4
The southern islands surrounding Stewart Island.

seldom evident. Biologically this island group is less well known than others.

The southern or Stewart Island group include islands of Foveaux Strait and Stewart Island (Fig. 4). Gneisses and granites predominate, both rocks that are very resistant to marine erosion. Although frequently visited by the Maori for birding and other food gathering, few of these islands were permanently occupied and hence modification of their vegetation was much less than in the islands further north.

Maori occupation of islands had largely ceased by 1840 but some islands were then occupied and farmed by Europeans (Table 1). The earliest island reserves in New Zealand were established in the 1890s as bird sanctuaries and this established a tradition of Crown ownership for biologically valuable islands.

Statistics for islands quoted in Tables 1, 6 and 7 are based on islands ≥ 5 ha in area. Many very small islands, however, are important refuges for invertebrates and lizards, and some are important breeding grounds for burrow-nesting or surface-nesting seabirds.

BIOLOGICAL VALUES OF ISLANDS

Isolation has allowed many islands to function as refuges for native plants and animals as well as certain kinds of biotic communities and habitats. On a few islands the presence of strains of feral mammals may be of commercial or scientific interest. Islands provide opportunities for scientific and educational studies in which islands can be compared with each other and with the mainland.

Native Plants

Only a small percentage of the native vascular plants of the New Zealand region are confined to islands (Table 2) and most of these are endemic to the oceanic islands. Examples are the small tree *Homolanthus polyandrus* from the Kermadec Islands, the tree *Elingamita johnsonii* from the Three Kings Islands, the megaherb *Myosotidium hortensia* from the Chatham Islands, and the megaherb *Pleurophyllum speciosum* which occurs on both the Auckland and Campbell Islands.

Although more than 25% of the vascular plants occurring on the New Zealand subantarctic islands (and on Macquarie Island) are endemic to these islands as a whole (Cheeseman 1909), few species are endemic to individual island groups, e.g. Auckland Islands. However, many endemic species are associated with the oceanic island groups further north, viz. the Kermadec, Three Kings and Chatham Island groups. The latter group has about 11% of its native vascular flora endemic (Given and Williams 1984).

Native Invertebrates

New Zealand's invertebrates are far from completely known. There is, however, a tendency for larger flightless forms to be confined to islands (Table 3). This is partly related to the presence of endemic species on oceanic islands, but it also reflects the degree to which larger flightless insects have been eliminated from the mainland by introduced predators, particularly rats.

Native Vertebrates

New Zealand's herpetofauna includes 3 species of primitive frogs belonging to the endemic genus *Leiopelma*; one of these species is now confined to islands.

New Zealand's best known reptile is the tuatara *Sphenodon punctatus*, the only surviving rhynchocephalian. Now confined to a number of islands (Crook 1973) it was formerly widespread on the mainland.

The taxonomy of New Zealand's lizards is still under review so that the percentage of the herpetofauna confined to islands (Table 4) is approximate. This percentage is high, apparently a result of predators, particularly rats, that have eliminated vulnerable lizards from the mainland (e.g. Whitaker 1973).

New Zealand has 3 species of seal and sealion: the New Zealand fur seal *Arctocephalus forsteri* which ranges to Western Australia, the New Zealand sea lion *Phocarctos hookeri*, and the elephant seal *Mirounga leonina*. The latter two species breed only on islands.

The country had three species of bat at the time of European colonisation, but one species, the greater short-tailed bat (*Mystacina* sp.) had become confined to Big South Cape and Solomon Islands, off Stewart Island, prior to European settlement (Daniel and Williams 1984). This species was lost as a result of an invasion of these two islands by *Rattus rattus* in 1962 (Atkinson and Bell 1973).

The number of species and subspecies of landbirds whose breeding is now confined to islands (34% of the resident landbird fauna, Table 4) includes such species as the flightless night parrot or kakapo *Strigops habroptilus*, the black robin *Petroica traversi* of the Chatham Islands and the stitchbird *Notiomystis cincta*. Six of the landbird species now confined to islands formerly occurred on the mainland.

Table 1

Numbers, size and occupancy of New Zealand Oceanic and Continental-shelf Islands ≥ 5ha

Island size (ha)	Formerly occupied by Polynesians		Currently farmed		Total number of islands	
	Oceanic	Shelf*	Oceanic	Shelf	Oceanic	Shelf
5-10	2	9	-	-	14	50
11-100	1	26	-	15	17	110
101-1000	2	21	-	11	7	48
>1000	3	10	2	6	7	20
Totals	8	66	2	32	45	228

* Minimum numbers only because many islands have not been properly surveyed for former Maori occupation.

Table 2

Native vascular plants confined to islands

	No. of species confined to islands	Approximate % of N.Z. Flora*
Woody plants	43	8
Ferns and fern allies	8	4
Herbaceous monocots	24	4
Herbaceous dicots	56	6
Total confined to islands	131	6

* Data on flora totals for each plant group derived from Druce 1984a and b.

Table 3
Some flightless invertebrates confined to islands. Data from M.J. Meads (personal communication 1985)

	No. of species	% of Faunal group
Stag beetles (*Dorcus* spp.)	2	33
Large weevils (*Anagotis* spp.) > 20 mm	4	44
Giant wetas (*Deinacrida* spp.) (wingless crickets)	4	57
Click beetles (*Amychus* spp.)	2	100

Table 4
Some native vertebrates confined to islands

	No.	% of Fauna
Frogs, reptiles (all endemic species)	10	25
Seals, sealions	2	67
Breeding landbirds (spp. + subspp.)	38	34*
Breeding seabirds (spp. + subspp.)	60	71*
Total breeding birds (sp. + subsp.)	98	50*
Total breeding birds (species only)	61	42

* Data from Robertson 1985

The high percentage of breeding seabirds confined to islands (71%) reflects the positions of some islands within or close to the oceanic feeding areas of these birds. Furthermore, the breeding of some of the smaller petrels may always have been confined to islands because of the presence on the mainland of natural predators such as the weka *Gallirallus australis*. The introduction of alien predators to the mainland has subsequently confined a greater percentage of seabirds to islands for breeding (Moors and Atkinson 1984).

The proportion of the New Zealand avifauna confined to islands is very high (Table 4). This has been appreciated for a long time, and has been an important reason for giving New Zealand islands protected status.

Mainland Communities on Islands

Without a national classification of biotic communities or habitats in New Zealand, quantitative assessment of the representation of mainland communities/habitats on islands is not possible. However, some qualitative assessment is possible.

Most types of northern coastal forest and scrub are well represented on islands, particularly those dominated by *Metrosideros excelsa, Dysoxylum spectabile* and *Corynocarpus laevigatus*. This is true also of southern coastal forest and scrub where tree composites in the genus *Olearia* and *Brachyglottis* are important.

Excepting the dunes at Mason Bay, Stewart Island, only small areas of sand dune and salt marsh are present on islands. Large estuaries are present at Whangapoua, Great Barrier Island, and at Patterson Inlet in Stewart Island but most islands lack large estuaries.

Lowland podocarp/hardwood forest occurs on some islands >1 000 ha where rimu *Dacrydium cupressinum* is the principal podocarp and kamahi *Weinmannia racemosa* the main hardwood. Other islands of this size carry tall hardwood forests of *Metrosideros robusta, M. umbellata* or *Beilschmiedia tawa*. However, tall forests (>25 m) of *Nothofagus* spp, *Agathis australis* and podocarps are under-represented.

Wetlands are usually absent and lakes are present on a very few islands.

Montane communities are under-represented, although the southward lowering of altitudinal zones results in somewhat similar kinds of communities near sea level on the islands of Fiordland and Stewart Island and on the subantarctic islands.

With the exception of Secretary Island, subalpine and alpine communities are not represented on the continental-shelf islands. However, structural analogues of mainland alpine communities occur on the subantarctic islands even though these are floristically distinct.

Special Communities on Islands

The vegetation of most of the oceanic islands is dominated by plants that are either endemic to one of these islands or, in the case of the subantarctic islands, endemic to the whole group. This trend is most marked in the Chatham group where of the 12 species of tree that are forest dominants, only one is not endemic at the specific or infraspecific level.

A second class of communities especially associated with islands are those inhabited and produced by seabirds, seals or sealions. The seabirds may be surface-nesting or burrow-nesting. Surface nesters include the albatrosses and mollymawks, penguins, gannets, shags, terns and gulls, some of which form very large colonies. Burrow nesters include petrels, shearwaters and storm petrels and are commonly found on both shelf and oceanic islands. The local effect of the seabird activity is to retard or inhibit the regeneration of many plants, particularly woody species, through burrowing and trampling. The mineral additions from bird excreta enhance soil fertility and enable plants that do survive to grow rapidly. In some cases, particular species of herb have adapted to the chemical conditions of seabird excreta to the extent that they can form distinctive communities at seabird colonies, e.g., the subwoody herb *Cotula featherstonii* on small islands inhabited by albatrosses in the Chatham group. The outstanding example of a seabird-dominated island in the New Zealand region is the Snares Islands. Warham and Wilson (1982) estimated the size of the sooty shearwater *Puffinus griseus* population there to be 2.75 million burrow-holding pairs, equivalent to a biomass of 13.4 tonnes of shearwater/ha.

Fur seal colonies are normally located on rocky shores and little modification of the plant cover is apparent. Sealions at their breeding grounds in the Auckland Islands penetrate much further inland and at all times of the year, but Taylor (1971) considered their impact relatively slight at that time. The wallowing of elephant seals can have pronounced local effects on the plant cover (Falla *et al.* 1979).

A third class of communities that are often better developed on islands than elsewhere are those whose structure and composition are greatly influenced by salt. These include the halophytic and megaherb-tussock communities of the splash zone,

and the woody communities of seaward slopes whose canopies are channelled and sheared by wind-carried salt, particularly in regions where gale-force winds with humidities less than 50% are frequent.

A fourth class of communities associated specifically with islands are those that for reasons of various combinations of precipitous slopes, isolation, small size and chance have largely escaped the major influences of either man or introduced animals and plants. Among the shelf islands, these pristine communities occur only on a few small islands. Among the oceanic islands, however, several much larger islands can be fairly described as still in a pristine state, e.g., Adams Island (9 896 ha) and Disappointment Island (375 ha) of the Auckland group and the Snares Islands (328 ha).

Feral Farm Mammals on Islands

There are a few populations of feral farm mammals, isolated on islands since last century, that may be worthy of protection for their genetic characteristics such as fecundity, fibre quality or disease resistance. The case for conserving such populations has been argued by Rudge (1986) who points out that, whether or not they are rare breeds, they (a) may represent a more primitive stage of domestic selection and (b) are free to continue varying and adapting unconstrained by man's selection or management (Table 5).

As recognised by Rudge, the indigenous values of an island should take precedence over the value of a particular population of feral mammals and there should therefore be no unmanageable conflict. On Campbell Island this was achieved by fencing to restrict the sheep to less than a fifth of the island's total area.

There is now more recognition of the importance of maintaining the genetic diversity of livestock breeds. If, however, livestock breeders do not evaluate the genetic qualities and possible commercial significance of these populations, they cannot expect island managers to maintain these feral mammals indefinitely.

Table 5
Examples of feral farm mammals of possible genetic value on New Zealand islands

Feral mammal	Island	Status of land and animals
Merino sheep	Pitt Island, Chatham group	Scientific Reserve; managed flock (Rudge 1983)
Merino cross longwood sheep	Campbell Island	Sheep fenced within Nature Reserve (Meurk 1982)
Merino sheep	Arapawa Island, Marlborough Sounds	Scenic Reserve; sheep to be removed to another part of the island
Goats	Auckland Island	Nature Reserve; goats may be removed to the mainland
Pigs	Auckland Island	Nature Reserve; future of pigs not decided

Islands as Systems for Scientific and Educational Study

The value of islands as simplified systems for the scientific study of ecological and evolutionary processes has often been noted (e.g., Mayr 1967). Their apparently self-contained boundaries become less well defined when account is taken of inputs from the sea by marine mammals, seabirds, wave action and wind, and outputs from the island of nutrients and eroded material. Nevertheless, the frequent absence on islands of major factors operating on the adjacent mainland, and the various combinations of factors found among islands within a group, provide many opportunities for examining and comparing islands as large-scale experiments. With improved understanding of population genetics and techniques for measuring rates of molecular and chromosomal evolution, the effects of geographical isolation on the origin of species can be studied more precisely.

Islands as Monitoring Stations for Changes in the Marine Environment

Different species of seabird are dependent on marine food chains in different ways according to their food preferences, e.g., plankton, squid, fish, etc. Major changes in the numbers of these marine organisms must affect breeding success and ultimately population numbers of the seabirds they support. Many seabird censuses are already carried out on islands. If greater effort is made to identify the areas where different seabird species feed, then systematic seabird censuses could become a practical means of monitoring changes, caused both by man and other factors, in the marine ecosystem.

ISLAND MANAGEMENT PROBLEMS

A number of problems arise when trying to maintain or increase the biological values of islands. Four of current concern in New Zealand are the *in situ* management of endangered species on islands, the limited number of island options for translocating endangered animals, genetic bottlenecks, and priorities for island restoration.

In Situ Management of Endangered Species on Islands

(a) Endangered Plants. Some endemic plants of the oceanic islands have been reduced to very low numbers. No agreement has been reached about the most appropriate action for safeguarding these species. An example is the shrub *Hebe breviracemosa* (Scrophulariaceae) endemic to the Kermadec Islands. This had not been seen since early this century and was thought extinct until 1983 when, following the eradication of goats on Raoul Island, a single plant was found. Management on the island has involved 'weeding' around the plant to increase the chances of seedlings establishing and a so far unsuccessful attempt to raise seedlings at the Meteorological Station on the island. Both cuttings and seedlings have been raised on the mainland (W.R. Sykes, personal communication). If either cuttings or seedlings are transferred from the mainland to the island, special precautions will be needed to ensure that no disease is introduced.

A second example is that of the woody climber *Tecomanthe speciosa* (Bignoniaceae) which is endemic to the Three Kings Islands. This also survives only as a single plant on one island in the group, a probable result of the former presence of goats. The species is self-fertile but no seedlings have established in the wild during the 40 years since its discovery. However, seedlings have been raised from seed set by flowering plants on the mainland. This has been known since 1956 but no attempt has been made to increase the population of *Tecomanthe speciosa* on the Three Kings Islands.

Propagation of endangered plants in nurseries and gardens can secure the survival of a species as a collection of live plants. Such action by itself, however, does not ensure the survival of the species as a continuously evolving population able to respond to the selective forces operating in its original habitat. Establishing further individuals in suitable sites on the island in question, either from those propagated on the island or, with safeguards against disease, from those propagated on the mainland, appears essential. Only with this kind of action can effects of genetic bottlenecks, discussed below, be avoided and the survival of these endemic plants as evolving species be made possible.

(b) Endangered Animals. *In situ* management of endangered animals has been attempted on several New Zealand islands.

Maud Island (Fig. 3) in the Cook Strait-Marlborough Sounds region, supports a dwindling population of the large carnivorous land snail *Powelliphanta hochstetteri obscura* which is vulnerable to human trampling and predation by wekas. In June 1980 a 250 x 100 m fenced exclosure was erected to protect the snails from further disturbance but recovery of their numbers is expected to be slow (Meads *et al.* 1984 and M.J. Meads personal communication).

Most management of endangered animals on islands has centred on birds. The rearing of broods of the black robin *Petroica traversi* in the Chatham

Islands by using Chatham Island tits *P. macrocephala chathamensis* as foster parents (Merton 1983) has rescued the black robin from the brink of extinction. The use of roost boxes specially designed and placed to reduce the chances of rat predation is now being tested with the aim of assisting a population of North Island saddlebacks *Philesturnus carunculatus rufusater* to coexist with two rat species (*Rattus norvegicus* and *R. exulans*) on Kapiti Island (Lovegrove 1985).

Translocation of endangered species to islands

(a) Endangered Plants. No systematic translocation of endangered plant species to islands has been attempted in New Zealand although there are several endangered coastal and lowland species that could be established on particular islands.

(b) Endangered Animals. Translocations to additional islands of two potentially endangered invertebrates, the flax snail *Placostylis hongii* and the Cook Strait giant weta *Deinacrida rugosa*, have both been effected successfully. Translocation of some endangered lizards is now underway (Towns *et al*, in press). Translocation of endangered birds began in the 1890s but has intensified since 1960 (see Bell, this volume). A major problem with translocation is the limited number of islands that are suitable for endangered species.

Limited Availability of Islands for Translocation of Endangered Species

Some factors that limit options for translocating endangered species to islands are

(i) small size of island and the area of suitable habitat taking into account successional changes,

(ii) presence of introduced browsing mammals and introduced predators, both mammals and birds,

(iii) risk of fire and further introductions of alien mammals, particularly on islands that are settled, and

(iv) possibility of the translocated species disrupting intrinsic values of the island.

(a) Oceanic Islands. Five of the eight oceanic island groups contain one or more islands greater than 1 000 ha in size and these provide a greater diversity of habitats and presumably greater long-term security for at least some of the species present than do smaller islands.

The percentages of these islands occupied by various introduced predatory and browsing mammals are shown in Table 6.

The oceanic islands have suffered fewer introductions than have the shelf islands, but the continuing interest in rock lobster, squid and fin fisheries in southern waters by overseas and New Zealand fishermen, has put at least 8 important islands at risk from rat invasions : Auckland, Adams, Disappointment, Enderby, Ewing and Rose of the Auckland group, and North East and Broughton Islands of the Snares group. Pitt Island in the Chatham group is also continuously at risk from rat invasion by reason of its permanent settlement and transit of stores from Chatham Island which is rat-inhabited.

Introducing a mainland species could change the distinctive biological character of an oceanic island. Each supports a unique combination of plants and animals, and these intrinsic qualities should not be modified without very good reason.

(b) Continental-shelf Islands. Of the 20 shelf islands greater than 1 000 ha, 10 have permanent settlements. Nearly half of the 228 shelf islands considered have browsing mammals of one kind or another and more than a third have introduced predators (Table 7). Only 13% of these islands are completely free of all introduced mammals as well as wekas, and most of them are small. Seven important island reserves require particular vigilance against invasions by *Rattus rattus* or *R. norvegicus* because these islands are frequently visited by people: Little Barrier, Tiritiri, Kapiti, Mana, Stephens, Maud and Codfish Islands.

The limited options for translocating endangered species to islands can be seen more clearly when island size as well as farming modification and the presence of introduced mammals and wekas are all considered together (Fig. 5). The largest islands (>1 000 ha) with the greatest potential as biological reservoirs drop from a total of 20 down to one island (Little Barrier) when those settled and farmed and those with browsing mammals are excluded from the list of options. No shelf island larger than 1 000 ha is without any introduced mammals. Nevertheless it is important to note that apparently no island of the 228 considered has **all** the introduced mammals that are widespread in lowland native vegetation on the mainland : pigs, goats, possums, stoats, cats, ship rats *R. rattus* and Norway rats *R. norvegicus*. For example, Stewart Island, the largest considered, has deer, possums, cats and three species of rat. But the absence of stoats has probably been of critical significance in allowing the survival on the island of a breeding population of kakapo. Thus, although the widespread modification of islands by introduced mammals has greatly reduced the options for translocating and protecting endangered species, the absence of some mammals determines that no island

Table 6

Percentages of New Zealand Oceanic Islands (≥ 5ha) currently affected by introduced mammals and other modification

Modifying Factor	No. of Islands affected	% of Total
Settled and farmed	2	4
With browsing mammals	6	13
With cats	5	11
With rats or rats and mice	9	20
With mice but no rats	4	9
Free of all introduced mammals	35	78
Currently at risk from rat invasion	9	20
Total islands > 5 ha	45	

Table 7

Percentages of New Zealand Continental-shelf islands (≥ 5ha) currently affected by introduced mammals and other modification

Modifying Factor	No. of Islands affected	% of Total
Settled or farmed	31	14
With browsing mammals (or within swimming distance of deer)	108	47
With cats or stoats or within swimming distance of stoats	84	37
With wekas *Gallirallus australis*	32	14
With either *Rattus rattus* or *R. norvegicus*	65	29
With *Rattus exulans*	41	18
Free of rodents	50	22
Free of all introduced mammals and wekas	30	13
Currently at risk from rat invasion	7	3
Total islands ≥ 5 ha	228	

can be regarded as simply another part of the mainland.

(c) Swimming distances for certain introduced mammals and wekas. Effort in eliminating alien vertebrates on some islands (see Bell, this volume) can be wasted if an island is subsequently reached by the vertebrate simply swimming from the mainland or a nearby island. Available information about the distances these animals can swim in New Zealand seas is summarised in Table 8, but much more investigation is needed of circumstances such as sea conditions, food availability at the place of departure, and attractive cues, (e.g., plant smells, bird calls) on the island in question, before we can predict the frequency with which such swimming activity is likely to occur.

Genetic Bottlenecks

These occur whenever there is a sudden collapse of population numbers within a single generation. The immediate effects can be some loss of genetic heterozygosity and losses of specific alleles, particularly those at low frequencies in the original population. The impact of a genetic bottleneck is directly related to the effective population size, i.e., the number of breeding individuals. The total amount of genetic variation lost during a bottleneck depends on how quickly the population can return to moderate (several hundred or more) size (Frankel and Soule' 1981).

Genetic variation is correlated with short-term fitness, i.e., factors which affect reproductive output, fertility, developmental rate, etc. Inbreeding in small populations can result in loss of genetic variation and thus reduced fitness. Franklin (1980) has noted that an inbreeding rate (rate at which genes become fixed as identical alleles) as high as one per cent increase per generation is accepted by breeders of domestic animals. From this he considers that an effective population size of 50 may be regarded as a minimal size to maintain fitness.

Retention of genetic variation is also seen as essential for a population to retain the capacity to adapt to new conditions. Franklin (1980) and Frankel and Soule' (1981) suggest an effective population size of 500 individuals as a 'rule of thumb' criterion if the

Table 8

Swimming distances in sea of certain introduced mammals and Wekas in New Zealand

Introduced Animal	Sea-distances Swum	Source of Information
Red deer	At least 1.1 km	Deer swam to Secretary Island from mainland
Goats	Not known to cross sea gaps	
Possums	Incapable of crossing sea gaps	
Cats	Incapable of crossing sea gaps	
Stoats	Up to 1.1 km	Taylor and Tilley (1984)
Wekas	At least 860 m in special circumstances	Wekas swam to Maud Island, Pelorus Sound from mainland
Rattus rattus and *R. norvegicus*	< 300 m in cool southern waters.	R.H. Taylor, pers. comm.
Rattus exulans	< 200 m, possibly < 50 m	Atkinson (1986)

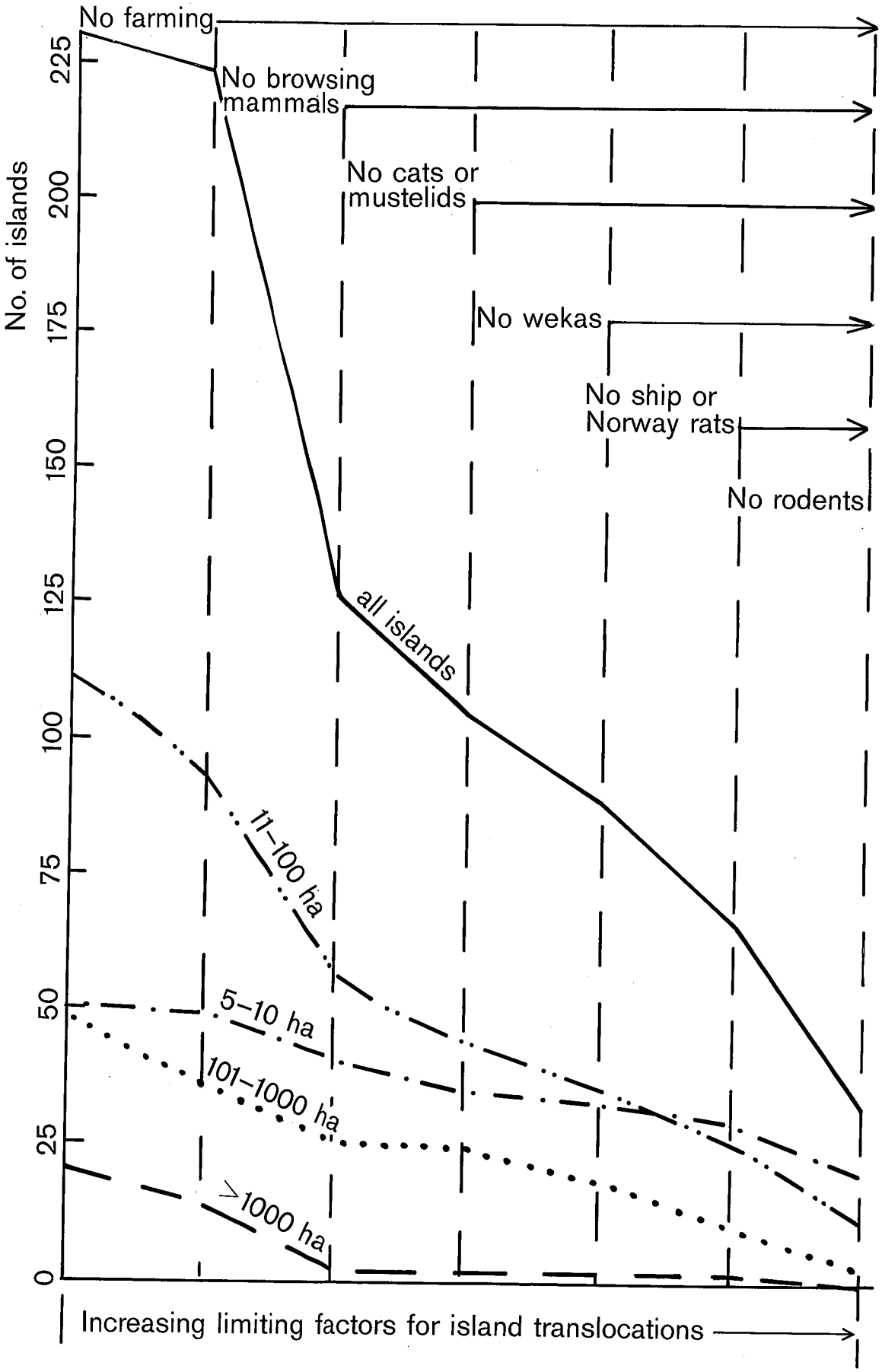


Figure 5
Limiting factors for translocating species to islands.

evolution of a species is to continue. At this size, losses of genetic variation through random fixation of genes are thought to be approximately balanced by gain in genetic variation from mutation.

Translocating an endangered species to a new island will frequently inflict a genetic bottleneck on the population although the source population may already be at very low numbers. If the population increases quickly in its new habitat, man's intervention has done no more than replicate the many thousands of founder events that occur when islands are colonised naturally by species. Not all translocations are successful however, so that if the risks of genetic impoverishment are to be avoided, further intervention during the initial stages of establishment, to boost numbers as rapidly as possible, should always be included in the recovery plan.

There are still uncertainties about the minimum effective population sizes that species can tolerate without serious loss of genetic variation. The guidelines have been developed from work with domestic animals and *Drosophila* fruit flies and they may not be appropriate for wild populations of birds, some mammals, reptiles, invertebrates and various groups of plants. For example, the effective population size of the Chatham Island black robin has remained below 25 individuals for nearly a century and at present there are no obvious signs of reduced short-term fitness (D.V. Merton, personal communication). In terms of retaining long-term adaptability, the available evidence from animals and higher plants that have been studied is pointing to effective population sizes of hundreds if not thousands of individuals rather than tens. This underlines the importance of large effective size for a reserve (Frankel 1984) and suggests two strategies for avoiding genetic impoverishment in small populations on islands: (i) use of islands large enough to support a species population of several hundred individuals without further intervention and (ii) use of several small islands which together can provide sufficient habitat for an effective population size above the required minimum. In this second case, intervention by means of periodic exchanges of individuals between islands would be needed to ensure that genetic variation is maintained.

Priorities for Island Restoration

The foregoing discussion of problems of island management has focused on endangered species. The irreversible finality of extinction makes it imperative to focus on endangered species but other problems of island management cannot be forgotten. Of particular importance are those associated with restoring an island depleted by man of its native flora, fauna and biotic communities. In pursing restorative action the assumption is that a state of the system can be reached which is closer to that operating before depletion or other modification began. In fact the original state of the system is often not known and whatever model is used, it is based often largely on inference.

Nevertheless, there are strong reasons for attempting the biological restoration of some islands. Providing habitats for endangered species has been a primary motivation for restoring islands, but such action also increases the habitat for other plants and animals of restricted distribution. With certain kinds of restorative action, particularly the removal of introduced browsing and predatory mammals, the recovery of whole communities becomes possible.

Details of restorative action involving the removal of various introduced mammals from islands are given by Bell (this workshop), but New Zealand is not the only country that has applied a multiple-step approach to island restoration. In the Bermuda Islands, Wingate (1985) has described his pioneer work is restoring the tiny (6 ha) island of Nonsuch from a desert condition to a point where it is now supporting examples of many of Bermuda's original habitats.

Notwithstanding the high value of many small island reserves, larger areas of habitat will be needed for many larger species of plants and animals. This underlines the importance of restoring the biotic communities of large islands. Four of the most intensive eradication campaigns, all now successfully completed in New Zealand, concern islands larger than 1 000 ha : the eradication of goats from Raoul Island (2 938 ha), Kermadec group; the eradication of cats from Little Barrier Island (2 917 ha), and the eradications ridding Kapiti Island (1 970 ha) of possums and Codfish Island (1 396 ha) of both wekas and possums. There are, however, other large islands whose biological values or potential for supporting endangered species is very high and all are in need of restorative action. These include Great Barrier Island (28 510 ha), Rangitoto Island (2 333 ha), Great Mercury Island (1 718 ha) and Mayor Island (1 277 ha) among islands of the continental shelf. Among the oceanic islands restorative action is needed particularly for Auckland Island (45 975 ha). Pitt Island (6 203 ha) has a greater potential for protecting wildlife in the Chatham Islands than any other island.

The future conservation role of islands such as Great Barrier and Pitt depends very much on the understanding and good will of their human inhabitants. Here lies a great challenge because, in

protecting nature, society often tends to exclude rather than involve the local people. It remains to be proved to what extend the cultural and economic needs and expectations of a farming community can be accommodated with conservation in an island context.

The imaginative conservation plan proposed for Pitt Island by B.D. Bell in 1984 is a unique opportunity to test this idea. Pitt Island lies some 20 km south-east of the main Chatham Island and has a population of about 50 people, most of whom are farmers and fishermen. It is a close-knit, self-reliant community with a considerable interest in its natural heritage. Most of the endangered birds (but not the endangered plants) of the Chatham group are now dependent for their future on two small islands (219 and 113 ha), together with several very small islands none of which is larger than 20 ha. If birds such as the Chatham Island snipe *Coenocorypha aucklandica pusilla*, black robin, Chatham Island pigeon *Hemiphaga novaeseelandiae chathamensis*, Chatham Island oystercatcher *Haematopus chathamensis,* New Zealand shore plover and Chatham Island taiko *Pterodroma magentae* can be established on Pitt Island, their future will be very much more secure than it is at present.

Pitt Island is free of rats and could remain so if adequate steps are taken to prevent them establishing. The presence of three introduced predators restricts the value of the island for native fauna. These are cats, wekas and pigs. The conservation plan proposes that feral cats (but not neutered house cats) and wekas are removed. It may prove necessary to either confine pigs to parts of the island using conventional and electric fencing or alternatively control them at low numbers. Success with the Pitt Island plan will depend on a close working relationship and good communication between the Pitt Islanders, island managers, and researchers studying the requirements of particular endangered species.

CONCLUSION : THE FUTURE CHALLENGE

Our most immediate task in New Zealand is to maintain the biological values of what we have in our islands. A high priority must be to implement practical precautions that will prevent rats from establishing on any of our valuable islands (Atkinson 1985, 1986) But maintaining the *status quo* is not going to be sufficient to meet either the need for conserving plant and animal species as continuously evolving populations or the need to protect a wider range of habitats on islands than so far achieved. We must, therefore, give more attention to improving techniques for restoring the biological values of islands, using greater scientific and technical input where appropriate, and giving preference to larger islands, sometimes including those inhabited, whenever it is practical to do so.

ACKNOWLEDGEMENTS

I thank Mr M.J. Meads, Dr M.R. Rudge, Mr W.R. Sykes and Dr R.E. Beever for information and discussion of several aspects of this paper, Mrs Marjolane Ball for typing it, and Ms Carolyn Powell for preparing the maps and diagram. The final text benefited from critical comments made by Messrs B.D. Bell and P. Dingwall and Drs W. Harris, C. Meurk, and R.M.S. Sadleir. I am grateful to D.S.I.R. for making funds available for my attendance at the CONCOM island management workshop on Barrow Island where the paper was presented.

REFERENCES

Atkinson, I.A.E. (1985). The spread of commensal species of *Rattus* to oceanic islands and their effects on island avifaunas. *In* Moors, P.J. (ed.) *Conservation of Island Birds*. International Council for Bird Preservation Technical Publication 3, 35-81.

Atkinson, I.A.E. (1986). Rodents on New Zealand's northern offshore islands : distribution, effects and precautions against further spread. *In* Wright, A.E., and Beever, R.E. (eds.). *The Offshore Islands of Northern New Zealand* Lands and Survey Department Information Series No. 16, 13-40.

Atkinson, I.A.E., and Bell, B.D. (1973). Offshore and outlying islands. *In* Williams, G.R. (ed.) *The Natural History of New Zealand* pp. 372-392 (A.H. and A.W. Reed, Wellington).

Bell, B.D. (this volume). Translocation of species using islands.

Bell, B.D. (this volume). Eradication of problem animals on islands.

Cheeseman, T.F. (1909). On the systematic botany of the islands to the south of New Zealand. *In* Chilton, C. (ed.) *The Subantarctic Islands of New Zealand* Vol. II, 389-471 (Government Printer, Wellington).

Crook, I.G. (1973). The tuatara, *Sphenodon punctatus* Gray, on islands with and without populations of the Polynesian rat, *Rattus exulans* (Peale). *Proceedings of the New Zealand Ecological Society* 20, 115-120.

Daniel, M.J., and Williams, G.R. (1984). A survey of the distribution, seasonal activity and roost sites of New Zealand bats. *New Zealand Journal of Ecology* 7, 9-25.

Druce, A.P. (1984a). Indigenous higher plants (psilopsids, lycopods, quillworts, ferns, gymnosperms, flowering plants) of North West Nelson. D.S.I.R., Botany Division report (available from Botany Division, DSIR, Private Bag, Christchurch, New Zealand).

Druce, A.P. (1984b). Indigenous higher plants of New Zealand (psilopsids, lycopods, quillworts, ferns, gymnosperms, flowering plants) not in North West Nelson. D.S.I.R., Botany Division report (available from Botany Division, DSIR, Private Bag, Christchurch, New Zealand).

Falla, R.A., Taylor, R.H., and Black, Colleen (1979). Survey of Dundas Island, Auckland Islands, with particular reference to Hooker's sea lion (*Phocarctos hookeri*). *New Zealand Journal of Zoology* 6, 347-355.

Frankel, O.H. (1984). Genetic diversity, ecosystem conservation and evolutionary responsibility. *In* Castri, F. di, Baker, F.W.G., and Hadley, M. (eds.) *Ecology in Practice* Pt 1, 414-427 (Unesco, Paris).

Frankel, O.H. and Soule', M.E. (1981). *Conservation and Evolution* (Cambridge University Press).

Franklin, I.R. (1980). Evolutionary change in small populations. *In* Soule', M.E., and Wilcox, B.A. (eds.) Conservation Biology : an Evolutionary-Ecological Perspective, pp. 135-149. (Sinauer Associates, Sunderland, Mass.).

Given, D.R., and Williams, P.A. (1984). Conservation of Chatham Island Flora (Botany Division, DSIR, Christchuch).

Lovegrove, T. (1985). Saddlebacks on Kapiti Island. Fourth Annual Report 1984-85 season (Report obtainable from Department of Conservation, Wellington).

Mayr, E. (1967). The challenge of island faunas. *Australian Natural History* 15, 369-374.

Meads, M.J., Walker, K.J., and Elliott, G.P. (1984). Status, conservation, and management of the land snails of the genus *Powelliphanta* (Mollusca:Pulmonata). *New Zealand Journal of Zoology* 11, 277-306.

Merton, D.V. (1983). Chatham Island black robin. *Wildlife - A Review* 12, 42-46.

Meurk, C.D. (1982). Regeneration of subantarctic plants on Campbell Island following exclusion of sheep. *New Zealand Journal of Ecology* 5, 51-58.

Moors, P.J., and Atkinson, I.A.E. (1984). Predation on seabirds by introduced animals, and factors affecting its severity. *In* Croxall, J.P., Evans, P.G.H., and Schreiber, R.W. (eds.) Status and Conservation of the World's Seabirds. International Council for Bird Preservation Technical Publication No. 2, 667-690.

Robertson, C.J.R. (ed.) (1985). *Complete Book of New Zealand Birds* (Reader's Digest, Sydney).

Rudge, M.R. (1983). A reserve for feral sheep on Pitt Island, Chatham group, New Zealand. *New Zealand Journal of Zoology* 10, 349-364.

Rudge, M.R. (1986). A role for feral mammals in conserving the genetic diversity of livestock. *Animal Genetic Resources Information.* 5, 7-23. UNEP/FAO, Rome.

Taylor, R.H. (1971). Influence of man on vegetation and wildlife of Enderby and Rose Islands, Auckland Islands. *New Zealand Journal of Botany* 9, 225-268.

Taylor, R.H., and Tilley, J.A.V. (1984). Stoats (*Mustela erminea*) on Adele and Fisherman Islands, Abel Tasman National Park, and other offshore islands in New Zealand. *New Zealand Journal of Ecology* 7, 139-145.

Towns, D.R., Daugherty, C.H. and Pickard, C.R. (*in press*). Developing protocols for island transfers : a case study based on endangered lizard conservation in New Zealand. International Workshop on Herpetology of the Galapagos. (University of New Mexico Press, Alburque).

Warham, J., and Wilson, G.J. (1982). The size of the sooty shearwater population at the Snares Islands, New Zealand. *Notornis* 29, 23-30.

Whitaker, A.H. (1973). Lizard populations on islands with and without Polynesian rats, *Rattus exulans* (Peale). *Proceedings of the New Zealand Ecological Society* 20, 121-130.

Wingate, D.B. (1985). The restoration of Nonsuch Island as a living museum of Bermuda's pre-colonial terrestrial biome. *In* Moors, P.J. (ed.) *Conservation of Island Birds*. International Council for Bird Preservation Technical Publication 3, 225-237.

The Value Of Western Australian Islands As Biological Reservoirs And The Development Of Management Priorities

Andrew A. Burbidge

Department of Conservation and Land Management, Western Australian Wildlife Research Centre,
PO Box 51, Wanneroo, W.A. 6065

Abstract

Many of Western Australia's 3 400 islands have high nature conservation values. Of particular importance are those which harbour relictual populations of mammals, some of which are now restricted to islands and others of which are endangered on the mainland. In addition, islands contain endemic taxa and distinct populations; they provide breeding places for 29 species of seabird, 20 of which breed only on islands, and for seals and turtles. An examination of the values of islands has led to the development of three categories of management priorities. The highest category includes four islands - Barrow, Bernier and Dorre - which protect mammalian species now extinct on the mainland.

INTRODUCTION

Off the Western Australian coastline are a great number of continental islands. If an island is defined as any feature above high water mark shown on a 1:100 000 map (Department of Land Administration, W.A.) then there are 862 named islands with another 2 562 still to receive the attention of the nomenclature authorities.

In relation to islands the Western Australian coast can be conveniently divided into 15 zones (Fig. 1, Table 1). Only two of these, A and I, are devoid of offshore islands; the coastline of both is comprised of extensive limestone cliffs which drop abruptly into comparatively deep seas.

ISLAND ORIGINS

Most Western Australian islands were separated from the mainland by rising sea levels from 8 000 to 14 000 years ago. The oldest substantial island appears to be Salisbury Island in the Recherche Archipelago (Burbidge *et al.* in press) (channel depth 82 m) which was separated *ca.* 14 000 years BP. Most other islands have channel depths of >50 m and appear to have been separated 8-11 000 years BP. Some cays, accumulations of sand or coral rubble on reefs, are of more recent origin.

ISLAND VALUES

In common with many similar continental islands elsewhere in the world, Western Australian islands possess a number of general nature conservation values:

1. They provide examples of mainland ecosystems cut off by rising sea-levels during the Pleistocene, modified by various influences such as the effects of the surrounding area (eg salt spray), changing climates, loss of species due to reduced area, immigration and so on. Such islands have been the subject of a variety of scientific studies relating to biogeographic theory.

2. Most Western Australian islands, unlike the continent they were derived from, have suffered little or no impact from either Aboriginal or European man. Many Kimberley and some Pilbara islands have been occupied or visited by Aboriginal people, who in this part of Australia possessed the ability to travel across small areas of the ocean via rafts (Abbott 1980) South of the Pilbara the only evidence of Aboriginal occupation on islands predates separation. Some islands, especially the larger ones, have been affected by European and Asian use (Table 2), and often this has had major impacts. The fact that most islands have not been used means that they have not suffered introductions of herbivores such as the rabbit, sheep and goat, or predators such as the Red Fox, Feral Cat or Black Rat.

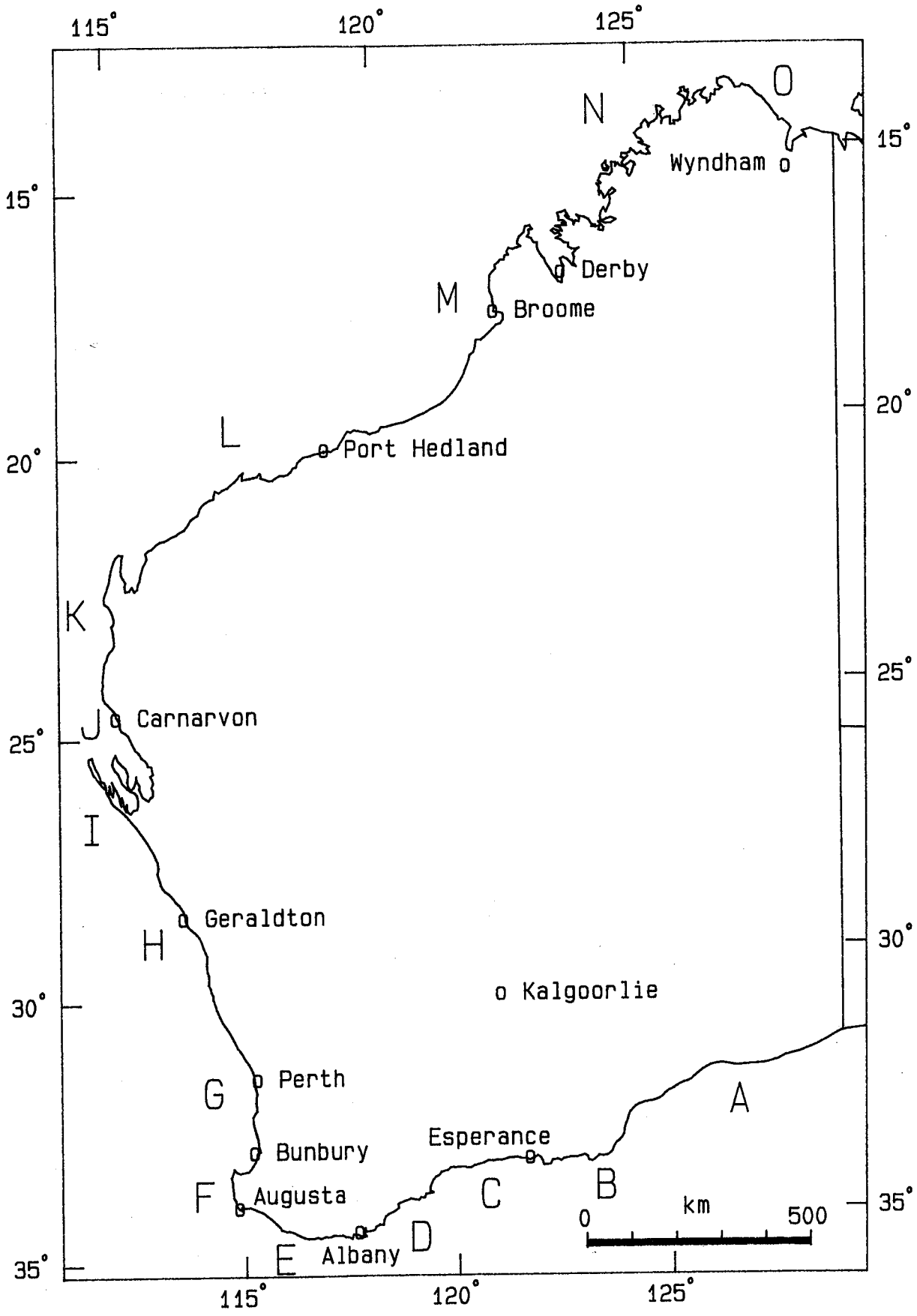


Figure 1.
Island zones in Western Australia, see Table 1.

Table 1
Western Australian Coastline and Islands (see Fig 1)

Coastal Zone	Geology	No of Islands	Comments
A	-	Nil	-
B	migmatite, limestone	many	Recherche Archipelago - mammals, seals, seabirds
C	migmatite	few	-
D	migmatite	few	mammals, seals, seabirds
E	migmatite	few	seals, seabirds
F	limestone, migmatite	few	seabirds
G	limestone	few	mammals, seabirds
H	limestone, cays	many	Houtman Abrolhos - mammals, seabirds
I	-	nil	-
J	limestone, sand	many	Shark Bay - mammals, seabirds, turtles
K	sand	few	-
L	limestone, meta-igneous, sand	many	Pilbara - mammals, seabirds, turtles
M	sand	few	Lacepedes - seabirds, turtles
N	sandstone, basalt	many	Buccaneer and Bonaparte Archipelagos - mammals, turtles, seabirds
O	sandstone, sand	few	seabirds, turtles

Table 2
Some Western Australian Islands Affected by Man

Island(s)	Use/impact	Effects
Woody (Recherche)	introduction of *Rattus rattus*	extinction of *Rattus fuscipes*
Garden	timber cutting, recreation, naval base	minor
Rottnest	recreation, over-burning, military base	major changes in vegetation, disappearance of seabird colonies, and some land birds
Houtman Abrolhos (various islands)	(a) presettlement wrecks	(a) extinction of sealion colonies, introduction of rats
	(b) guano mining	(b) extinction of seabird colonies,introduction of cats
	(c) fishermen's settlements	(c) introduction of rabbits, mice
Dirk Hartog	pastoral station, introduction of sheep, goats, mice	extinction of CWR mammals, erosion
Faure	pastoral station, introduction of sheep, goats	erosion, overgrazing
Bernier	introduction of goats	erosion, overgrazing
Thevenard	tourist resort	minor
Boodie	introduction of *Rattus rattus*	decline and extinction of *Bettongia lesueur*
Barrow	oil field	minor
Varanus (Lowendals)	oil facilities	minor
Monte Bellos	(a) introduction of cats, *Rattus rattus*	(a) extinction of CWR mammals
	(b) nuclear weapons testing	(b) erosion
Dolphin	arrival of fox from mainland	decline of Rothschild's Rock-wallaby
Depuch	arrival of fox from mainland	extinction of Black-footed Rock-wallaby
Bedout	introduction of *Rattus rattus*	?extinction of some seabird colonies
Lacepedes	introduction of *Rattus rattus*	?extinction of some seabird colonies
Adele	introduction of *Rattus exulans*	none known
Sir Graham Moore	introduction of pig	not documented

3. Islands are used by marine species such as seals, seabirds and turtles as breeding places free from the interference such activities often receive on the mainland.

In addition, Western Australian islands have some particular values:

1. Some contain relictual populations of mammals once widespread on the Australian mainland but which are now either very rare or have disappeared there. Main (1961) and Main and Yadav (1971) have discussed the distribution of macropod marsupials on islands off Western Australia. Table 3 is developed from their data while Table 4 shows the proportion of macropods represented on islands when compared with the adjacent mainland. Species in other mammal groups also have island populations.

2. Many other plants and animals occur on islands where they are protected from deleterious mainland influences. Only one vertebrate species is known that is naturally restricted to an island - the skink *Ctenotus lancelini*, which occurs on the 7.6 ha Lancelin Island 120 km north of Perth. However, many other vertebrates have evolved distinctive island forms, some of which have received taxonomic recognition. Examples are given in Table 5.

3. Some 29 species of seabirds breed on over 200 Western Australian islands. Most (20) breed only on islands. One species, the Lesser Noddy *Anous tenuirostris*, has its only breeding stations in Australia at the Houtman Abrolhos where there are two colonies, one on Pelsaert Island and the other on the adjacent Morley and Wooded Islands (Fuller and Burbidge 1981). The only other colonies, of a different subspecies, are in the Seychelle Islands (Serventy *et al.* 1971).

4. Apart from the seabirds and the endemic subspecies, two other species of birds breed only on islands - these are the Western Australian subspecies of the Cape Barren Goose (*Coreopsis novaehollandiae grisea*), which nests on islands in the Archipelago of the Recherche, and the Rock Parrot (*Neophema petrophila*), which nests on islands from Shark Bay southward. Several other species nest predominantly on islands, e.g. White-breasted Sea-eagle, Osprey, Reef Heron and Beach Curlew (or Thick-knee).

5. The Western Australian population of the New Zealand Fur Seal breeds only on islands between Cape Leeuwin and the Recherche Archipelago. Except for small colonies at the base of cliffs along the Great Australian Bight, the Australian Sea-lion breeds only on islands, from the Beagle Islands southward.

Table 3
W.A. Islands with Macropods

Name	Area (ha)	Macropod
Simpson	60	Macropus robustus
Westall (Combe)	100	Petrogale lateralis hacketti
Wilson	130	Petrogale lateralis hacketti
North Twin Peaks	280	Macropus eugenii
Salisbury	340	Petrogale lateralis lateralis
East Wallabi	360	Macropus eugenii
Dixon	530	Macropus robustus
West Wallabi	600	Macropus eugenii
Borda	605	Petrogale concinnus
Bald	780	Setonix brachyurus
Boodie	780	*Bettongia lesueur
Wollaston	850	Petrogale sp.
Depuch	880	*Petrogale lateralis lateralis
Mondrain	930	Petrogale lateralis hacketti
Hermite	1 010	*Lagorchestes conspicillatus
Middle	1 090	Macropus eugenii
Rosemary	1 130	Petrogale rothschildi
Garden	1 170	Macropus eugenii
Rottnest	1 550	Setonix brachyurus
Katers	1 780	Petrogale burbidgei
Enderby	3 000	Petrogale rothschildi
Dolphin	3 200	Petrogale rothschildi
		Macropus robustus
Uwins	3 300	Petrogale sp.
Bernier	4 430	Lagorchestes hirsutus
		Lagostrophus fasciatus
		Bettongia lesueur
Dorre	4 640	Lagorchestes hirsutus
		Lagostrophus fasciatus
		Bettongia lesueur
Darcy	4 800	Petrogale sp.
Boongaree	4 880	Petrogale burbidgei
Bigge	17 190	Petrogale burbidgei
Augustus	17 950	Petrogale concinnus
Barrow	22 250	Petrogale lateralis lateralis
		Bettongia lesueur
		Lagorchestes conspicillatus conspicillatus
		Macropus robustus isabellinus
Dirk Hartog	54 630	*Lagostrophus fasciatus
		*Bettongia lesueur

*now extinct

Table 4
Macropods On W.A. Islands

Area	No Of Macropods On Islands	No Of Macropods Adjacent Mainland	%	No Of Islands With Macropods	Max Island Size (ha)
SOUTH WEST	3	12	25%	11	1 550
SHARK BAY	3	6	50%	3	54 630
PILBARA	5	6	83%	9	22 250
N.W. KIMBERLEY	2	8	25%	8	17 950
W.A.	10	21	48%	31	54 630

Table 5
Examples Of W.A. Island Vertebrate Populations Which Have Been Described As Separate Taxa

GROUP	TAXON	ISLAND
Mammals	Macropus robustus isabellinus	Barrow
	Lagorchestes conspicillatus conspicillatus	Barrow
	Petrogale lateralis hacketti	Westall, Wilson, Mondrain
	Isoodon obesulus nauticus	Daw
	Isoodon auratus barrowensis	Barrow
Birds	Coturnix varia scintillans	Houtman Abrolhos
	Malurus leucopterus leucopterus	Dirk Hartog
	Malurus leucopterus edouardi	Barrow
Reptiles	Ctenotus lancelini	Lancelin
	Ctenotus angusticeps	Airlie
	Ctenotus pantherinus acripes	Barrow
	Egernia stokesii stokesii	Houtman Abrolhos
	Egernia stokesii aethiops	Baudin (Shark Bay)
	Egernia pulchra longicauda	Boullanger, Whitlock, Escape, Favourite
	Aprasia rostrata rostrata	Hermite

Table 6
Western Australian Islands With Native Mammals And Exotic Predators

Island	Area (ha)	Predators	Mammals	Mean Adult Body Wt (g)	Status
Dirk Hartog	54630	cat	Lagostrophus fasciatus	1800	extinct
			Bettongia lesueur	1500	extinct
			Sminthopsis dolichura	14	stable
			Pseudomys albocineres	31	stable
			P. hermannsburgensis	12	stable
Hermite	1010	cat	Lagorchestes conspicillatus	3000	extinct
			Isoodon auratus	450	extinct
Depuch	880	fox	Petrogale lateralis	3700	extinct
Dolphin	3200	fox	Macropus robustus	23500	stable
			Petrogale rothschildi	5250	declined
			Dasyurus hallucatus	525	stable
			Zyzomys argurus	45	stable

6. Four species of marine turtle breed along the Western Australian coastline from Shark Bay northward. Data on island use are far from complete but it appears that almost every island with a beach north of North West Cape is used to some extent. Known islands of special importance include the Muiron Islands, Barrow, the Lowendals, the Monte Bellos, the Dampier Archipelago, the Lacepedes and Browse.

DEVELOPING PRIORITIES FOR MANAGEMENT

With a large number of island nature reserves in addition to a large area of mainland National Parks, Nature Reserves and Conservation Parks, Western Australia has made a major commitment to nature conservation. However, a small human population means that few resources can be allocated to management and therefore the development of priorities assumes great importance.

How can we develop priorities for both research and operations for island nature reserves in Western Australia? There are number of ways of approaching this question.

TERRESTRIAL MAMMALS

Recent research by Burbidge and McKenzie (1983, and in press) has shown that declines and extinctions of mammals on mainland Western Australia is restricted to those species which have mean adult body weights between 35 g and 4.2 kg, termed the Critical Weight Range (CWR). Disturbances on islands have also affected species within the CWR, eg the introduction of predators (Table 6). Thus it can be assumed that islands that contain species within the CWR (Table 7) are going to become increasingly important and management to prevent the introduction of predators, or to eradicate them if introduced, is vital. Already some CWR mammals are totally restricted to islands (Table 8), and the

Table 8
Australian Mammal Species In CWR now Restricted to Islands

Species	Islands
Dasyurus viverrinus	Tasmania
Perameles bougainville	Bernier, Dorre
Bettongia lesueur	Bernier, Dorre, Barrow
Bettongia gaimardi	Tasmania, Bruny
Lagostrophus fasciatus	Bernier, Dorre
Thylogale billardierii	Tasmania and 16 Tasmanian islands
Pseudomys praeconis	Bernier
Leporillus conditor	Franklin

Table 7
W.A. Terrestrial Mammals In CWR On Islands

Tachyglossus aculeatus	Bigge
Dasyurus hallucatus	Dolphin, Caffarelli, Hidden, Koolan, Augustus, Unwins, Boongaree, Bigge, Wollaston, Carlia
	Parantechinus apicalis
	Boullanger, Whitlock
Antechinus flavipes	Michaelmas, Middle, Doubtful
	Isoodon obesulus
	Daw
Isoodon macrourus	Saint Andrew
Isoodon auratus	Middle, Barrow, Augustus
Perameles bougainville	Bernier, Dorre
Petaurus breviceps	Augustus
Trichosurus arnhemensis	Barrow
Wyulda squamicaudata	Boongaree, Bigge
Bettongia lesueur	Bernier, Dorre, Barrow
Lagorchestes conspicillatus	Barrow
Laporchestes hirsutus	Bernier, Dorre
Lagostrophus fasciatus	Bernier, Dorre
Petrogale lateralis	Salisbury, Mondrain, Westall, Wilson, Combe, Barrow
Petrogale burbidgei	Bigge, Boongaree, Katers
Petrogale ?sp.	Uwins, Wollaston, Darcy
Peradorcas concinna	Augustus, Borda, Hidden, Long
Macropus eugenii	Middle, North. Twin Peaks, Mondrain, Garden,
	East Wallabi, West Wallabi
	Setonix brachyurus
	Bald, Rottnest
Hydromys chrysogaster	Barrow, Hermite
Melomys burtoni	Sir Graham Moore, Melomys
Conilurus penicillatus	Conilurus
	Mesembriomys macrurus
	Wollaston, Carlia, Uwins
Zyzomys woodwardii	Bathurst, Irvine, Augustus, Darcy, Bigge, Katers, Middle Osborne, Osborne, Boongaree, Borda
Pseudomys praeconis	Bernier
Pseudomys nanus	Barrow
Rattus fuscipes	Salisbury, Mondrain, Chatham, Bald,
	East Wallabi, West Wallabi
Rattus tunneyi	Middle Mangrove, Weld, West Lewis, Legendre, Enderby, Boongaree, Saint Andrew.

proper management of these islands - Bernier, Dorre, Barrow, in Western Australia, Franklin in South Australia, and Tasmania - is of paramount importance. Islands that contain the only island population of a CWR mammal are more important than those which protect species occurring on two or more islands. For Western Australia only, additional islands in this category are Bigge (*Tachyglossus aculeatus*), Michaelmas (*Antechnus flavipes*), Daw (*Isoodon obesulus*) and Saint Andrew (*Isoodon macrourus*). To these should be added Boullanger and Whitlock (*Parantechinus apicalis*) since they are joined at low tide.

ENDEMIC TAXA

Islands with endemic taxa, eg Lancelin, Dirk Hartog, Barrow, Airlie, some islands in the Houtman Abrolhos and Baudin Island in Shark Bay, must be given high priority.

SEABIRDS

Among the more than 200 seabird nesting islands a few stand out. In some cases seabirds have very few breeding stations in Western Australia (Table 9), and these colonies need to be monitored and managed if necessary. Some islands with large colonies or with many breeding species are also important, eg Pelsaert, Sandland and Buller.

Table 9
Seabirds With Few Western Australian Breeding Colonies

Species	Island(s)
Masked Booby	Bedout, Adele
Brown Booby	Bedout, Adele, 2 islets in Lowendals, Lacepedes, White
Lesser Frigate-bird	Bedout, Adele, Lacepedes
Short-tailed Shearwater	Figure of Eight
Black-faced Cormorant	Middle (Recherche), Lion
Red-tailed Tropic-bird	Sugarloaf Rock, Pelsaert
Lesser Crested Tern	Bedout
Sooty Tern	Pelsaert, Wooded, Morley, Alexander
Common Noddy	Pelsaert, Bedout
Lesser Noddy	Pelsaert, Wooded, Morley

SEALS

The New Zealand Fur Seal suffered a massive decline from over-hunting last century and only now seems to be recovering. Any island with a colony of this species should be monitored. Islands of special importance are Salisbury (Archipelago of the Recherche (Burbidge *et al.* in press) and Middle Doubtful Island near Bremer Bay (Abbott 1979).

TURTLES

Islands of special importance have been listed above. The priority at present is to find out which islands are used, and to document migration patterns and any harvesting which might be taking place outside Australia.

DISTURBANCE

Most islands which are being or have been disturbed need management. Some of the disturbances of the past can be removed, eg by control of rats, rabbits, cats and foxes, and some of the disturbances of the present can be managed so as to minimise impact and prevent loss of species (eg Butler this publication). Islands subject to disturbance which are of value must be managed.

CONCLUSIONS

From the above I have developed three orders of management priority (within a priority islands are listed alphabetically):

1. Extremely valuable

   Barrow, Bernier, Dorre.

2. Very high value

   Adele, Airlie, Baudin, Bedout, Bigge, Boullanger, Browse, Buller, Daw, Dirk Hartog, Middle Doubtful, Figure of Eight, Lacepede Islands, Lancelin, Morley, Pelsaert, Saint Andrew, Salisbury, Sandland, White, Wooded and turtle beaches in the Dampier Archipelago, Lowendal Islands, Monte Bello Islands, and Muiron Islands.

3. High value

   Augustus, Bathurst, Bald, Boongaree, Borda, Carlia, Chatham, Darcy, Dolphin, East Wallabi, Enderby, Garden, Hidden, Irvine, Katers, Legendre, Long (Bucaneer Archipelago), Melomys, Middle (near Barrow), Middle (Recherche Archipelago), Middle Mangrove, Middle Osborne, Mondrain, North Twin Peaks, Rottnest, Sir Graham Moore, South West Osborne, Uwins, Weld, Westall, West Lewis, West Wallabi, Wilson and Wollaston.

Islands within these categories which are subject to disturbances require immediate or ongoing management. These include Adele, Airlie, Barrow, Boodie, Dirk Hartog, Lacepede Islands, Varanus

(Lowendal Islands), Dolphin, Garden, Middle (near Barrow), Rottnest, Sir Graham Moore and West Wallabi. Islands - Boodie, Hermite and Depuch - could be added to Category 3 if populations of exotic mammals could be eradicated and the indigenous mammals reintroduced.

REFERENCES

Abbott, I. (1979). The past and present distribution and status of Sea Lions and Fur Seals in Western Australia. *Records of Western Australian Museum* 7, 375-390.

Abbott, I. (1980). Aboriginal man as an exterminator of wallaby and kangaroo populations on islands around Australia. *Oecologia (Berl.)* **44** : 347-54.

Burbidge, A.A. and McKenzie, N.L. (1983). Patterns of decline in Western Australian vertebrates. ANZAAS Congress, Perth. Zoology Abstracts.

Burbidge, A.A. and McKenzie, N.L. (in press). Patterns in the modern decline of Western Australia's vertebrate fauna: causes and conservation implications. *Biological Conservation*.

Burbidge, A.A., Fuller, P.J., Hopkins, A.J.M., Kinnear, J.E. and Mckenzie, N.L. (in press). The Wildlife of Salisbury Island, Archipelago of the Recherche, Western Australia. Technical Report, Department of Conservation and Land Management, W.A.

Fuller, P.J. and Burbidge, A.A. (1981). The birds of Pelsart Island, Western Australia. Dept. Fish. Wildl. Rept No. 44. (Dept. Fish. Wildl. : Perth.)

Main, A.R. (1961). The occurrence of Macropodidae on islands and its climatic and ecological implications. *Journal of Royal Society of Western Australia.* 44, 84-89.

Main, A.R. and Yadav, M. (1971). Conservation of Macropods in reserves in Western Australia. *Biological Conservation* 3, 123-133.

Serventy, D.L. Serventy, V. and Wareham, J. (1971). *The handbook of Australian Sea-birds*. (A.H. and A.W. Reed).

Management Planning for Island Protected Areas, Based on New Zealand Experience

P.R. Dingwall

Department of Lands and Survey, Head Office, Wellington, New Zealand[1]

Abstract

A review of the management planning process for island protected areas reveals the many benefits provided for managers including particularly, the contribution of information to decision-making and problem solving, translation of policy into management action, and the opportunity for public consultation and education. The mandatory procedures for management planning in New Zealand under the Reserves Act are outlined, and management strategies are illustrated from the Auckland Islands Nature Reserve to show solutions to problems of human and introduced animal impacts, and the protection of historical and archaeological sites.

INTRODUCTION

Management planning is at the heart of successful problem solving in protected area management, and is especially vital for islands which are characteristically so vulnerable to disturbance from external influences. Therefore, it is somewhat surprising that planning is an often neglected or inadequately developed component of management practice. Indeed, recognition of the need for management planning - the first step in the planning process - is not universal among protected area managers. For example, there is a commonly held belief that management planning is required only where protected areas are freely available to public access and use, and unnecessary in strictly protected nature reserves from which the general public is normally excluded. Thus, in the case of protected areas on the 22 major oceanic island groups of the Southern Ocean, most of which are nature reserves or their equivalent, officially approved and published management plans exist for only two island groups - though some others are known to be in various stages of preparation (Clark and Dingwall, 1985).

In New Zealand the Reserves Act 1977, the principal statute for establishment and management of protected areas, establishes management planning as a mandatory requirement of the administering authorities. In explaining the principles and procedures involved, a principal objective of this paper will be to demonstrate that management planning is multi-purpose, and provides many benefits which apply to all classes of protected areas.

THE MANAGEMENT PLANNING PROCESS

Management planning is a multi-faceted process for guiding management and directing actions toward the successful attainment of predetermined goals (Eidsvik, 1977). Management plans, though they may take many forms and may apply to protected areas of widely varying size and character, all provide a vehicle for the rational and systematic application of knowledge to management actions and decision-making. They serve many purposes at all levels and phases of management, as follows.

1. Problem Solving

   Resolution of conflicts among competing elements or uses of natural resources is often regarded as the principal purpose of management planning. Such conflicts are usually human-induced, so assume greatest prominence where protected areas are readily accessible for recreation and use by the public. Conflict may also exist, however, where human influence is an indirect one, perhaps expressed through the deleterious modifying influences of deliberately introduced plants and animals. In New Zealand island nature reserves the former introduction of mammalian herbivores and predators, in particular, has had a widespread and often

1 Current address: Conservation Sciences Centre, Department of Conservation, PO Box 10-420 Wellington New Zealand.

catastrophic impact on native biota such that restoration of natural communities may be impossible or at best extremely difficult.

2. Translating policy into action

The management plan, in effect, expresses legal management responsibilities and policies as an action strategy. The planning process has its genesis in legislation, which establishes the fundamental statutory requirements and objectives governing the management of a protected area. These legal requirements are, in turn, elaborated by policies, or statements of the general principles applying to management. Policies represent the administering agency's interpretation of the legal requirements and, as such, are dynamic and may change according to changing attitudes or priorities. The management plan translates policies into action programs, which reveal the way in which activities will be implemented to solve problems and achieve intended objectives.

3. Contributing information to decision-making

Wise decision-making presupposes an adequate understanding of the resources being protected. The planning process affords an opportunity for the systematic application of knowledge about natural resources to decisions on their protection and use. However, the management plan is not intended to provide an exhaustive account of the protected landscapes and biota. Rather the information is tailored to facilitate an adequate assessment and evaluation of the natural ecosystems in management terms, and to establish their conservation status. Thus, species lists are not as important as knowledge of the existence of special, rare or threatened species; the habitat requirements of plants and animals and their critical threshold conditions; the condition and trend of populations; and the interrelations of plants and animals, especially the impacts of alien species.

Information on protected cultural resources and their values will also be required to a level dependent upon their relative conservation importance, and an assessment of socio-economic variables will ascertain the demands and aspirations for resource utilisation.

Where research is inadequate, additional field work may be required to fill data gaps. Alternatively, interim management guidelines may be established which deal with values and principles only, pending further investigations.

4. A public consultation process

Protected areas are managed ultimately in the interests of, and for the benefit of the public, so some form of public involvement in the planning process is both inevitable and desirable. While public consultation in protected area management planning is now common practice and often sophisticated (Eidsvik, 1978), it is a relatively recent phenomenon. In North America, for example, an authoritarian management style was discarded in favour of public involvement only in the late 1960s (Winge, 1978).

Involving the public in management planning is a complex, costly and often glacially slow process which can be frustrating for management. But experience shows that, where there is an adequate level of awareness and interest, a partnership between government and the public can prove highly beneficial in terms of additional information gained and for enhancing mutual trust and the acceptability of management decisions.

In New Zealand, public consultation in the management planning process is a legal requirement and it involves the public in the broadest sense - individuals, professional and non-governmental societies and interest groups, commercial interests, and other affected government agencies. Public involvement also occurs at all levels of planning; beginning with the public advertising of the intention to prepare a plan, continuing through the preparation and submission of a draft plan and allowing for the hearing of objections prior to final approval. The procedures are discussed in more detail below.

5. Communication, education and training

Public consultation is fundamentally an exercise in communication and can be widely mutually beneficial. Managers gain benefit from new information about resources and are exposed to public attitudes and interests in the process of gaining understanding and support for policies. The latter often require an increased public educational effort so that public submissions can be informed and constructive. Education is especially important if the protected area in question is remotely located and either infrequently visited or closed to general public access - as many island protected areas are. Thus, management plans should be written, in part, as educational tools, providing sufficient resource information and analysis to justify

decisions. Above all, emphasis in the plan should be given to evaluation of the scientific and conservation significance of the natural and cultural features being protected, in a regional, national and international context.

Preparation of a management plan can also be an important training exercise for managers. It is best conducted as a multi-disciplinary task through teamwork, and involving not only specialist planners and scientists but also administrators, and in particular the rangers (or wardens) who are ultimately responsible for implementation of the plan.

6. Other benefits from management planning

While the principles discussed above are among the key universal elements in the management planning process, there are many other benefits to be derived which assume varying degrees of importance depending on the circumstances. These include the opportunity given for the setting of management priorities; the calculation of financial budgets and establishment of manpower and equipment requirements; the exposing of information gaps as a catalyst for further research; and the enhancement of external support, through fund raising for example. Some of these considerations may be made through the preparation of sub-plans which augment the principal document.

DISCUSSION

Management planning is a widely accepted and proven aid to protected area management and it is almost unthinkable that a protected area should lack a professionally prepared management plan.

Planning is not however, a panacea for all management problems. Without active and effective implementation of planning proposals, there can be no real success.

Planning, of itself, does not provide decisions; rather it guides decisions and directs changes towards intended goals. Planning, of itself, does not solve management problems; rather it brings the best available information, in the most rational form, into the problem solving arena.

While planning has perhaps its most important role in involving the public in protected area management, the planning team must judge carefully between public apathy on one hand and vested interests on the other.

Management plans are not exhaustive scientific texts; rather they sift, assemble and interpret knowledge for application to management issues.

For maximum impact plans must be straightforward and contain objectives and action strategies which are realistic, measurable and attainable.

MANAGEMENT PLANNING PROCEDURES

In this section procedures for management planning are illustrated by the example of reserves in New Zealand managed under the Reserves Act 1977[2]. The planning process described is a legally binding one which operates through formal consultative mechanisms and comprises several phases, some of which occur simultaneously.

The procedures are established by the Act which stipulates that plans are to be prepared by the administering authority and approved by the Minister within 5 years of either the commencement of the Act or gazettal of the reserve (with provision for extension).

Prior to instigation of the formal planning process, reserves are classified (or reclassified) according to their principal purpose, through a process involving public notification and the consideration of public submissions and objections.

Commencement of management planning occurs with the issuing of a public notice of the intention to prepare a plan, and an invitation for public comment, with the requirement that comments received are given full consideration in plan preparation. Ideally, though rarely in practice, this notification should be accompanied by the distribution of some information on the character of the reserve, its conservation significance and the essential objectives for protection and use - as a means of increasing the awareness and stimulating the involvement of the public.

Following preparation of a draft plan, its availability is required to be publicly notified, by publication in the Gazette and appropriate newspapers, and it is to be made freely available for inspection for a notified period of at least two months. As far as is practicable, written notice is to be given to those who made submissions when the intention to prepare the plan was advertised. In

2 From 1st April 1987 administration of the Reserves Act passed to a new Department of Conservation, responsible to the Minister of Conservation.

practice, copies of the draft plan for important reserves are made available for purchase, and a complimentary copy may be sent directly to knowledgeable or interested individuals or organisations. A foreword may be included in the draft plan to specify the procedures for making submissions or lodging objections, and for approval of the plan. There may also be an outline of the key issues raised by earlier public submissions.

Written submissions on the plan become public information, subject to the Official Information Act, and can be published. Members of the public also have the right to request a hearing before the Director-General of Conservation or his nominee, to speak to their submission. The substance of submissions must be taken into account in redraft of the plan, and the final document may be accompanied by a summary of the public comments and objections and some indication of how far they influenced the contents of the final plan.

Formal approval of the plan is achieved through signature by the Director-General under delegated authority from the Minister, on an approval certificate which is incorporated in the published plan.

The administering authority is also legally bound to keep the management plan under constant review to ensure that objectives and policies remain relevant in the face of new knowledge or changing circumstances. Whenever the plan is comprehensively reviewed, then the review procedure parallels that taken for preparation of the original plan, allowing full public consultation.

In New Zealand, oversight of policy and planning approval for national parks, and most classes of reserves administered under the Reserves Act, is the responsibility of the National Parks and Reserves Authority and its 12 regional boards. These are statutory bodies widely representative of individuals agencies and organisations with interest or involvement in protected areas at regional or national levels. Boards have the task of recommending the approval of management plans (or reviews) to either the Authority or the Director-General, and the Authority may exercise approval rights where there is a disagreement between a board and the Director-General.

In the case of outlying island nature reserves an Outlying Islands Reserves Committee[3], composed of representatives of various governmental scientific and management agencies, assumes the role of a board. In practice, this committee works in partnership with the Director-General in all phases of the management planning process for outlying island nature reserves.

Many offshore islands in three regions of New Zealand are administered collectively, along with coastal mainland reserves, within maritime parks - the Hauraki Gulf Maritime Park, Bay of Islands Maritime and Historic Park, and Marlborough Sounds Maritime Park. The first of these has its own legislation while the others are administered under the Reserves Act, and each is managed through a statutory board comprising governmental and private representatives. This administrative structure enables co-ordinated planning for wide-ranging management of protection and use of islands (NZ Department of Lands and Survey, 1982).

MANAGEMENT PLANNING IN PRACTICE - THE EXAMPLE OF THE AUCKLAND ISLANDS NATURE RESERVE

Character and status of the islands

The Auckland Islands comprise one of New Zealand's five island nature reserves in the Southern Ocean. The eroded remnants of basaltic volcanoes, some 62 500 ha in extent, they are situated at 50°S latitude, or 460 km south of mainland New Zealand. Ecologically they are among the most important of the world's oceanic island groups, supporting a diverse assemblage of animals and plants, which includes at least 46 species of breeding birds and 228 species of vascular plants. The forest here is among the southernmost in the world and the islands have the most significant breeding grounds of the Hooker's Sea Lion, and the wandering and white-capped albatross. The island group is entirely free of rats and two islands - Adams and Disappointment are in an essentially pristine state, the former being perhaps the largest island in the world without alien mammals. Human contact over a period of 180 years has left a legacy of sites and artefacts which are of value as a record of human enterprise and misfortune in the southern regions of New Zealand. However, it is the consequences of plant and animal introductions, mostly associated with the former shipwreck era, a colonial settlement, and pastoral farming activities, which pose the greatest problems for protected area management.

The islands were declared a reserve in 1934 (Adams Island in 1910) and are now classified as a nature reserve under the Reserves Act. This class of reserve has the degree of security and scope of

3 This Committee was abolished in 1987 and new arrangements are under consideration.

protection which comply with criteria established for scientific/strict nature reserves by the International Union for the Conservation of Nature and Natural Resources (IUCN) (CNPPA, 1984). The overriding aim of management is to safeguard the numbers, natural distributions and interactions of native plants and animals while allowing limited and carefully controlled access for research, monitoring and tourism.

Content for Format of the Plan

An outline of matters addressed in the plan (NZ Department of Lands and Survey, 1987) and their arrangement within it are shown by the table of contents at Appendix I. Administrative details and resource information are relegated to the final sections of the plan to avoid detracting from management objectives, policies and action programs which are the key elements of the plan. The quality and scope of available resource information are excellent for the purposes of planning and compare favourably with the situation at other nature reserves, even those on the mainland. This is a by-product of a long research history beginning with scientific exploration in the mid-19th century and including intensive research effort by coastwatchers during World War II and by expeditions in the past 15 years. Principal remaining gaps in resource information are in the fields of littoral and nearshore marine ecology, human history and archaeological survey.

In describing natural and cultural resources particular attention is given to highlighting their significance for management. For example, the impact of weather on safety is stressed, the presence and status of rare, endemic, or threatened species of plants and animals are emphasised, and the impacts of alien species on native species are assessed.

OBJECTIVES

Management objectives for the reserve stem from requirements established by legislation, and its classification as a nature reserve.

The case for including all or part of the reserve within the category of scientific reserve was carefully considered in drafting the plan, and will probably arise again from public comments. Scientific reserves normally have less restricted access, and there is also provision for the deliberate manipulation of natural ecosystems for experimental scientific purposes, including the retention of man-modified conditions. Some islands in the group offer fascinating opportunities for investigating the interplay of native and introduced species and communities. However, the intrinsic conservation values of the reserve's indigenous elements are considered to outweigh their research potential, so management will encourage reversion of modified environments towards their natural state.

Thus, the principal management objectives are:

1. To preserve and maintain the indigenous flora and fauna, ecological associations and natural environment of the Auckland Islands in a natural state and to allow the operation of natural processes and accept their effects as far as possible.
2. To manage the reserve as an integral part of the natural and international system of protected areas with emphasis on the protection of its special or unique natural features.
3. To protect and manage any biological, scenic, historic, archaeological, geological, or other scientific features to the extent compatible with the primary objective (1, as above).
4. To prevent human interference which causes undue modification or acceleration of natural processes or the alteration or destruction of natural features on the islands.
5. To allow and encourage research and studies, which will have no permanent detrimental effects especially where it has been demonstrated the results will contribute directly to the effectiveness of protection and management of the reserve.
6. To promote public appreciation and enjoyment of the features of the reserve consistent with the primary objective (1, as above).
7. To promote understanding of the specialised and vulnerable subantarctic ecosystems and pursue the protection of the habitat and food source of mammals and sea birds in the surrounding sea.

EXAMPLES OF POLICIES AND THEIR IMPLEMENTATION

Public entry and use of the reserve

Human activities in the reserve must remain secondary to, and be compatible with, the principal protection objectives. But this implies controlled access and use, not total prohibition. Of greatest concern are disturbance or destruction of native species or habitats, and the potential for introduction of undesirable alien species, especially rats.

In practice, policy requires that access and use are limited essentially to activities involving research, conservation management and regulated tourism.

Scientific research, especially where it will enhance management, is encouraged and vigourously pursued insofar as limited logistical support allows. Active surveillance of field research is required to ensure avoidance of detrimental impact, particularly the undue depletion of the numbers of species which are rare or of restricted distribution.

The natural features of the reserve hold great tourist appeal, and there is justification for controlled tourist visits, especially because of the positive benefits that can accrue from increased awareness and sympathy for management objectives. Conversely, tourist visits carry inherent dangers, both for the safety of visitors in a remote and often hostile environment, and for environmental impact through overcrowding at critical sites, tracking and erosion, interference with plants and animals, littering and introduction of foreign materials.

Implementation of the limited public entry and use provisions therefore requires:

(1) Regulation of the number and purpose of visits by use of a permit system. Permits, which are granted for a specified period, comprehensively state conditions of entry, such as the rodent-proofing of stores; approved landing sites and mooring restrictions; supervision and safety; disturbance of biota; erection of facilities; and post-expedition reporting procedures. Where appropriate, a separate permit is issued which stipulates conditions for the taking, use and disposal of scientific specimens.

(2) Prohibition of the shore mooring of transporting vessels, as a precaution against rodent entry.

(3) Selective application of entry restrictions within the reserve to increase security for specific islands. Thus entry to Adams, Disappointment and Dundas Islands, which are pristine and support important breeding colonies, is limited to scientific and management personnel for approved activities.

(4) Restriction of tourist visits to designated islands or sites, and encouragement of water-based sightseeing as far as possible. Enderby Island, the most modified of the group, is the principal tourist destination but several other sites on the main island are nominated as possible tourist venues. All visits are required to be under direct supervision from a departmental official, and "wilderness-type" visitor codes are strictly enforced.

Protection of Historical and Archaeological Sites and Antiquities

The Auckland Islands record in microcosm the history of human endeavours in the southern regions of New Zealand (Dingwall, 1981). Since their chance discovery in 1806 by a whaling expedition, the islands have experienced successive waves of human intrusion for settlement and resource exploitation; whaling and sealing; Maori occupation; scientific exploration; a short-lived and ill-fated British colonial settlement in the mid-19th century; a rash of shipwrecks during the sailing era; unsuccessful attempts at pastoral farming until the early 1930s, wartime occupation by coastwatching parties; and sporadic visits by scientific and reserve management expeditions especially over the past 30 years.

All events have left their mark, some of which such as mammals introduced as castaway food or farming stock are undesirable for reserve management. Others, however, including occupation and shipwreck sites, grave sites, castaway provisioning depots and boatsheds, and coastwatcher lookouts, are of considerable interest and cultural value as a record of episodes of New Zealand's history.

The preservation of historical and archaeological features in a remote and incompletely supervised island reserve is an extremely difficult task. Threats of loss or destruction exist from unlawful removal of relics and disturbance of sites both by people and animals - pigs and seals in particular. Many important artefacts are already scattered among various museum and private collections in New Zealand. Policies are established to ensure the protection and integrity of historic features as far as is possible, and these include:

(1) Surveying, recording and preserving, where practicable, archaeological remains and sites of cultural significance.

(2) Leaving relics in their original locations unless their significance warrants custody by the National Museum - thus avoiding the past unsatisfactory practice of shifting relics within the island group.

(3) Restoration of buildings and other structures where this is considered warranted, retaining the original character and materials where possible.

(4) Allowing abandoned sites or structures of lesser significance to age and decay naturally while preventing human and wildlife impacts.

(5) Encouragement of historical and archaeological research and the development of an historic

conservation plan, and to treat such research in the same manner as ecological research projects.

CONTROL OF INTRODUCED ANIMALS AND PLANTS

Animals

When Abraham Bristow, the discoverer of the Auckland Islands, released pigs as a source of food for castaways he unwittingly initiated a long process of environmental modification. Later in the 19th century, further introductions of pigs along with rabbits, goats, sheep, cattle, cats and mice to islands where the indigenous plant and animal communities had evolved free from mammalian herbivores and predators, intensified the scope and pace of change to one of ecologically catastrophic proportions (Taylor, 1971).

Today pigs are ubiquitous on the main island and are held responsible for the elimination from all accessible areas of large leaved herbaceous plants such as *Pleurophyllum, Stilbocarpa,* and *Anisotome* spp. Together with cats, which are similarly distributed, pigs are also implicated in the reduction or absence from the main island of several species of burrowing petrel. Sheep have not survived, but approximately 50 cattle remain on Enderby Island. Here, the impact of cattle, along with that of thousands of rabbits (also present on Rose Island) and the past influence of fires during the farming era, have markedly reduced the extent of natural tussock and forest in favour of a close-cropped sward dominated by liverworts and mosses, and induced communities of the less palatable herb *Bulbinella rossii.*

A population of about 100 feral goats survives in the Port Ross region of the main island. Formerly largely restricted to the coastal fringe of forest and lower slopes, the goats now appear to be extending their range to higher ground where they have the potential for spreading throughout the island and, in combination with pigs, accentuating the destruction of higher altitude tussock grasslands (Campbell and Rudge, 1984).

Pigs and goats in particular, have also contributed to the damaging of sites of historical significance, especially that of the colonial settlement at Erebus Cove in Port Ross.

The presence of feral mammals has profound implications for management of the reserve which is committed to halting the trend toward depletion of native plant and animal communities. The management plan includes policies for the extermination of feral mammals as soon as possible. This is a monumental task, but one which assumes varying proportions throughout the island group.

Elimination of cattle, rabbits and goats which are present either in low numbers or on small islands should be a relatively straightforward task. But extermination of cats and pigs will require a huge commitment of resources, given the widespread distribution of the populations throughout a large island of rugged terrain and, in parts, virtually impenetrable vegetation cover.

Research and testing will undoubtedly be required to develop feasible extermination methods and strategies, and to avoid deleterious consequences for non-target species. It may be necessary ultimately to confine the effort to a program of intensive control at particularly sensitive sites such as seabird breeding colonies. Post-control monitoring will also be required to ensure, for example, that the reduced cat population does not favour an undesirable increase in the number of mice.

The extermination programs may prove to be controversial. There have been expressions of interest in the retention of a gene pool of the goats, which are among the southernmost herds of goats in the world and appear to be at the limits of their ecological tolerance. The rabbits are an unusual strain and may be of commercial interest in New Zealand. Prior public notification of the control programs will allow removal of animals for research and other purposes. In the summer of 1986/87 approximately 50 goats were captured and relocated on the New Zealand mainland for gene preservation and research, breeding, and assessment of commercial traits of wool and meat.

There is no possibility of achieving eradication of mice from such a large area using currently available methods. Policy, therefore, is aimed at preventing the spread of mice from their present locations on the main Auckland Island, Enderby Island and Masked Island to other rodent-free island and avoiding the introduction of any new rodent species. Current practice for rodent control includes; the establishment of poison bait stations in the vicinity of permanent huts, when occupied; strict rodent surveillance and prevention conditions in permits granted to enter the reserve, covering the transporting vessel, packing, loading and unloading of stores, landings of personnel, travel between islands, and regular hut or camp maintenance practices. A critical element in the proposed rodent control program is the development of a contingency plan to ensure that adequate equipment and resources are available for urgent implementation of inspections following

shipwrecks or control action if evidence of rat introduction is reported.

Plants

Although there are more than 40 alien species of vascular plant on the Auckland Islands, none threatens indigenous plants at present. Policy requires the eradication of exotic plants, but practical considerations dictate the use of selective controls.

Olearia lyallii presents an interesting case. The plant occurs naturally elsewhere in southern regions of New Zealand but it appears to be a recent immigrant and probably arrived at the islands with people (Johnson and Campbell, 1975). It has established vigourously in areas of cleared forest and coastal grassland of the Port Ross region, and its active spread has raised concern that, if left unchecked, it could replace the existing forest of rata (*Metrosideros umbellata*). However, recent monitoring and research (Lee *et al.*, 1983) has revealed that *Olearia* is invading coastal tall tussock grassland, mega-herbfield, shrubland and dwarf mixed forest, but does not threaten tall rata forest. Subject to further monitoring, a policy of limited control is considered appropriate. Thus, the plant will be cleared from all but Ewing Island and the main Auckland Island, and on the latter it will be confined within specified outer limits.

CONCLUSION

The examples cited above illustrate the way in which management policy has evolved and action programs have developed through the management planning process to cope with problems in the Auckland Islands Nature Reserve. The planning process is in a constant state of flux in response to continuing application of new information derived from research and monitoring and the maturing of policies through the public consultation process. Professional assistance from an advisory committee has been a valuable adjunct to reserve management and planning. The planning approach is proving successful and is commended for wider adoption in the management of island nature reserves.

REFERENCES

Campbell, D.J. and Rudge, M.R. (1975). Vegetation changes induced over ten years by goats and pigs at Port Ross, Auckland Islands (Subantarctic). *New Zealand Journal of Ecology* 7, 103-18.

Clark, M.R. and Dingwall, P.R. (1985). Conservation of islands in the Southern Ocean - a review of protected areas of Insulantarctica. IUCN, Cambridge, UK, 188p.

CNPPA (1984). Categories, objectives and criteria for protected areas. p. 47-53. *In* National Parks, conservation and development. McNeely, J.A. and Miller, K.R. (eds.), Smithsonian Institution Press, USA.

Dingwall, P.R. (1981). The changing image of the Auckland Islands. *Landscape* 9, 14-21. (NZ Department of Lands and Survey, Wellington).

Eidsvik, H.K. (1977). The park planning process *Parks* 2(3), 8-12.

Eidsvik, H.K. (1978). Involving the public in park planning: Canada. *Parks* 3(1), 3-5.

Johnson, P.N. and Campbell, D.J. (1975). Vascular plants of the Auckland Islands. *New Zealand Journal of Botany* 13, 665-720.

Lee, W.G. *et al.* (1983). The ecology and distribution of *Olearia lyallii* on the Subantarctic Auckland Islands. *New Zealand Journal of Ecology* 6, 150 (resume only).

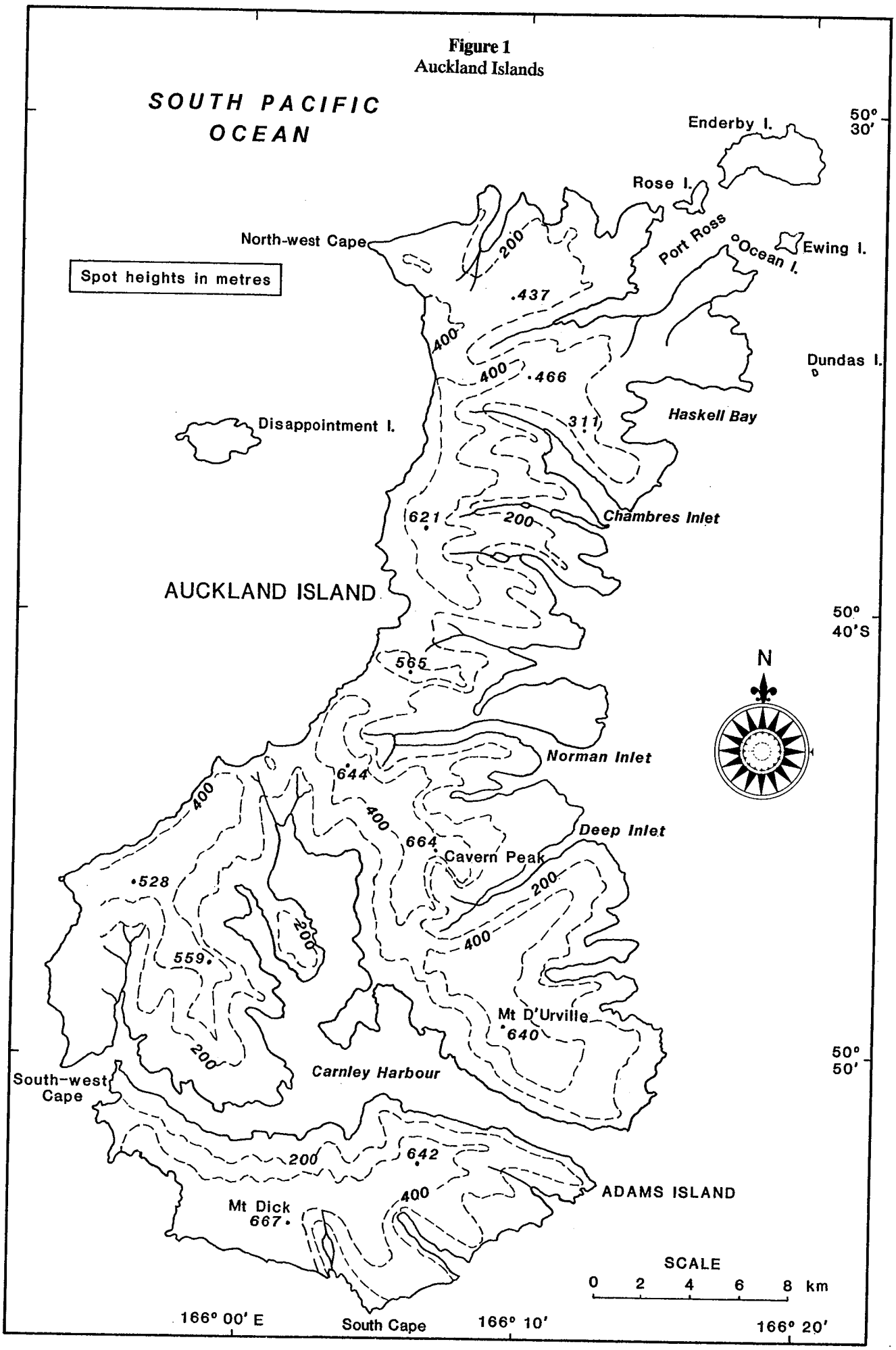
NZ Department of Lands and Survey (1982). Hauraki Gulf Maritime Park Management Plan. NZ Department of Lands and Survey, Auckland, 128p.

NZ Department of Lands and Survey (1987). Management plan for the Auckland Islands Nature Reserve. NZ Department of Lands and Survey, Wellington, 78p.

Taylor, R.H. (1971). Influence of man on vegetation and wildlife of Enderby and Rose Islands, Auckland Islands. *New Zealand Journal of Botany,* 9, 225-68.

Winge, E.N. (1978). Involving the public in park planning: USA. *Parks* 3(1), 1-3.

Figure 1
Auckland Islands



Contents

		Page
Introduction and Management Concept		1
PART ONE: RESOURCE SYNOPSIS AND CLASSIFICATION		3
1.	Resource significance	3
	1.1 Ecological	3
	1.2 Scientific	3
	1.3 Educational	4
	1.4 Scenic and Recreational	4
	1.5 Historic	4
	1.6 Economic	4
2.	Resource Evaluation and classification	5
PART TWO: MANAGEMENT OBJECTIVES		6
PART THREE: MANAGEMENT POLICIES AND IMPLEMENTATION		7
Preamble		7
1.	Administration	8
	1.1 Management	8
	1.2 Support of Other Government Agencies	8
2.	Public Entry and Use	9
	2.1 General	9
	2.2 Scientific Research	10
	2.3 Historical and Archaeological Sites, Antiquities and Research	12
	2.4 Survey Control Stations	13
	2.5 Magnetic Stations	13
	2.6 Tourism	14
3.	Management of Flora and Fauna	15
	3.1 General	15
	3.2 Feral Goats	15
	3.3 Feral Pigs	17
	3.4 Feral Cats	17
	3.5 Feral Cattle	18
	3.6 Feral Rabbits	19
	3.7 Precautions Against the Further Introduction of Rodents and Rodent Control	19
	3.8 Control of Exotic Plants and Precautions Against Further Introductions	20
	3.9 Manipulation of Indigenous Taxa	22

4.	Monitoring Ecological Changes and Human Impacts	22
5.	Management Facilities and Controls	23
	5.1 Tracks, Buildings and Structures	23
	5.2 Wharf and Shore Mooring Facilities	25
	5.3 Land Vehicles	25
	5.4 Domestic Animals	26
	5.5 Waste Disposal	26
	5.6 Fires and Fire Control	27
	5.7 Emergency Entry	27
	5.8 Use of Helicopters	28
6.	Commercial Development	29
7.	Adjacent Sea	29
	7.1 Marine Buffer Zones	29
	7.2 Marine and Coastal Pollution	31
8.	Information and Education	32
	8.1 Interpretation	32
	8.2 Management Plan Review	33
PART FOUR: RESOURCE INFORMATION		34
1.	Legal Description	34
2.	Tenure, Classification and Administration	34
3.	Location, General Description, and Access	34
4.	History	35
5.	Present Use	40
6.	Geology, Geomorphology and Soils	41
7.	Bathymetry and Seafloor Sediments	42
8.	Oceanic Circulation	43
9.	Climate	43
10.	Flora	44
	10.1 Plant Species	44
	10.2 Plant Communities	45
11.	Fauna	48
	11.1 Indigenous Mammals	48
	11.2 Introduced Mammals	49
	11.3 Birds	51
	11.4 Freshwater Fauna	56
	11.4 Terrestrial Invertebrates	56

12. Littoral and Marine Communities 58

13. Tracks, Buildings and Structures 58

14. Economic Resources 59

REFERENCES

APPENDICES 61

1. Standard Entry Permit 64

2. Permits to take specimens 72

3. Relevant Statutes 73

FIGURES

Figure 1 Map of Auckland Islands 4

Figure 2 Historic sites 39

Figure 3 Hooker's sealion and New Zealand fur seal colonies 49

Figure 4 Breeding locations of southern royal albatross, wandering albatross and white-capped mollymawk 55

TABLES

Table 1 Status of birds recorded at Auckland Islands 52

The Development of Management Plans for Islands in Western Australia

Susan A. Moore

Planning Branch, W.A. Department of Conservation and Land Management, Murdoch House, 5 The Esplanade, Mt. Pleasant W.A. 6153.

Abstract

A discussion of the development of management plans is essentially a discussion of the management planning process. This process is based on a clear definition of objectives followed by the development of a management plan and plan implementation. Public involvement in this planning process is highly desirable. The planning process has been generally applied to the development of management plans across Australia and New Zealand. Over the last five or so years most agencies involved in the management of land for conservation in these two countries have produced one or more management plans for islands or groups of islands. In this paper two Western Australian examples (management plans for Rottnest Island and for the Lancelin-Dongara Islands) are used to emphasise three aspects of the planning process which deserve special consideration in the development of management plans for islands. These are public involvement in planning and its educative function, planning in a regional context; monitoring.

The development of management plans is part of the management planning process (Fig. 1). Planning is an interactive process, beginning with a clear definition of objectives, followed by the development of a management plan and plan implementation. Development of the management plan is based on input of available knowledge and strong public involvement. Plan implementation involves not only operational activities, but also the instigation of definite research and monitoring programs to provide additional information which can then be fed back into the planning process. The whole process is linked by feedback loops which ensure that management decisions and management itself make use of all available information (Fig. 1).

The planning process draws together and is dependent on input from planning, management, research and education/information staff. Planning staff are responsible for co-ordinating the planning process, particularly the production of the management plan. Planners should also be involved in planning research and monitoring programs.

Management staff should not only interpret and implement plans, they should also be involved in the initial formulation of objectives and plan preparation. Early involvement in the planning process is essential as managers are familiar with local community attitudes and environmental constraints, both of which may be unfamiliar to planning and research staff. Managers should also implement monitoring and research programs, and become involved in the interpretation of results.

Researchers should carry out the necessary relevant research. Research data is required not only on the biophysical resources and processes of the area under consideration, but also the socioeconomic resources and processes. This necessitates social research, for example, research into the recreational resources and expected demands for recreation. Researchers should also liaise with planners and managers on the design of monitoring and research programs, and interpreting monitoring and research findings.

In general the information/education function, as part of the planning process, becomes the responsibility of planning and management staff. Planning staff become involved by encouraging public input into the planning process, and through site design and the development of interpretive facilities. Management staff are involved in daily interactions with the public. Most staff involved in the management of conservation reserves spend the majority of their time on 'people' management and interacting with people rather than on 'biological' management.

Obviously, in many instances all four functions - planning, management, research and information dissemination - are achieved by one or two people. Alternatively, one or more of these functions may be left out of the planning process.

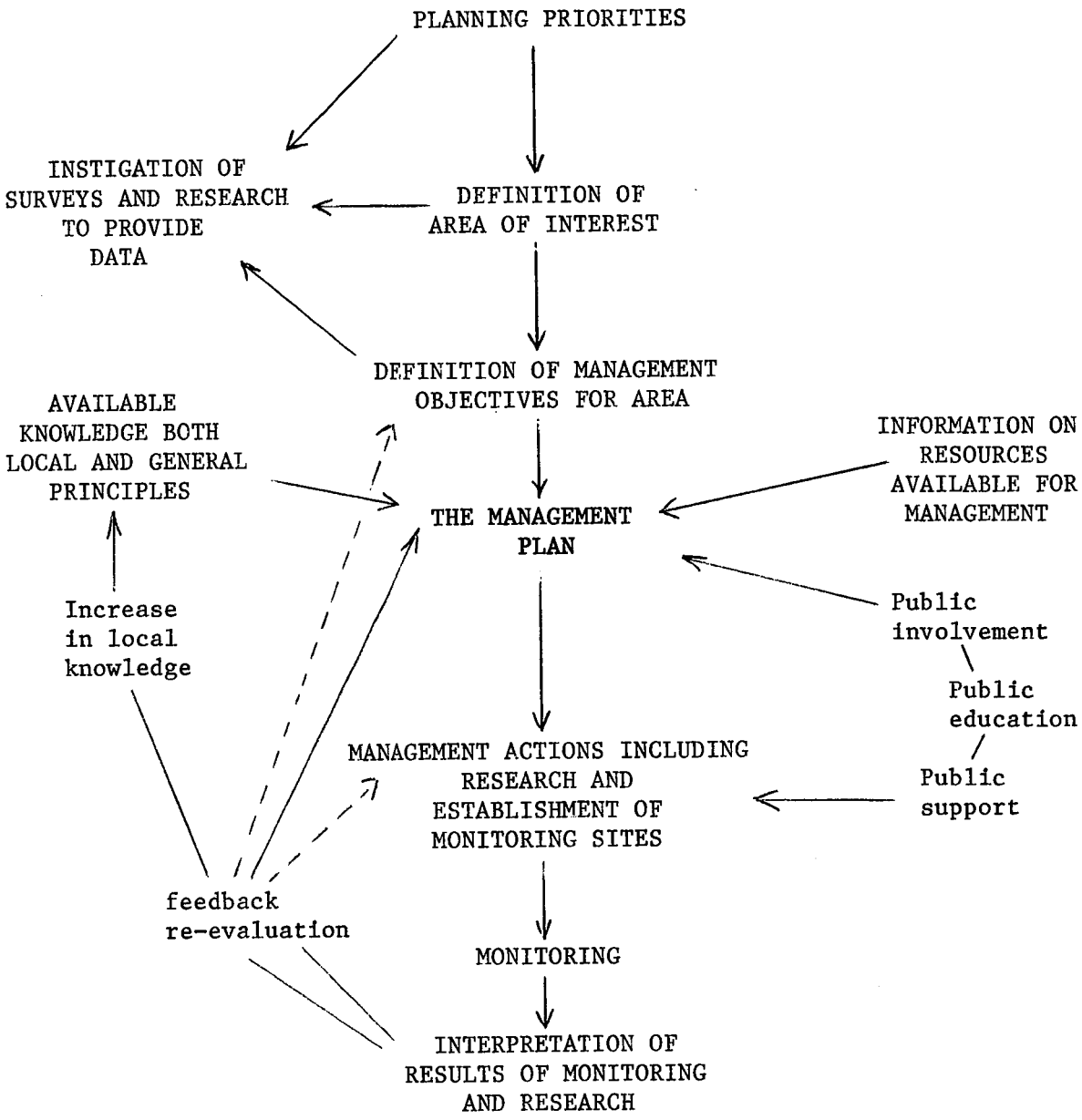


Figure 1.
The management planning process (Source: Hopkins and Saunders 1987).

Also, staff additional to those already mentioned become involved in the planning process. This serves to emphasise the co-ordinating and integrative function of the planning process.

Having introduced the planning process, it is an opportune time to ask the question:

Why bother with such a process?

There are seven reasons:

1. The planning process encourages a clear statement of management objectives. This ensures that all those involved clearly rationalise and agree on the purposes and values for which the area is being managed.
2. The planning process ensures the incorporation and utilisation of all existing data.
3. The planning process enables the identification of areas in which information is lacking.
4. Once the areas in which information is lacking have been identified, the framework is available within which recommendations for research and the establishment of monitoring programs can be made.
5. Regular revision, which is an integral part of the planning process, allows reassessment using the findings of research and monitoring programs. Revision may lead to reassessment of objectives.
6. The planning process allows public input into the planning and management of conservation areas, the vast majority of which, in Australia and New Zealand, are part of the public estate.
7. The process allows a consideration of a range of management issues and their interactions. For example, there is little point in considering the management of fairy tern breeding sites if other management issues such as public or recreational use are not taken into account. This point was succinctly made by Kelleher in 1983, quoting from McHale:

"The changing context for management in all sectors of society requires a shift of viewpoint from considering one problem or one issue as isolated phenomena in time towards a more systematic 'process' orientation in which events, trends, changes may be seen as interactive aspects of the whole."

These seven reasons in themselves rationalise the production of a management plan as part of the process. However, two further reasons deserve special emphasis. These are:

1. Management plans are written statements of intent, both in terms of the objectives given and the strategies advocated to achieve these objectives. Plans also allow documentation of existing knowledge on the geophysical and man-made environment. Thus a permanent record is ensured.
2. Management plans, as a written document, are easily and readily circulated to the public to encourage their comments and involvement in the planning process.

Public participation in planning is a natural extension of informing the public and increasing their awareness of nature conservation. There are 3 reasons for encouraging public participation in the planning process. These are:

3. By an open approach to land management, members of the community will accept provisions and restrictions with which they may not initially agree, or which may affect them personally, providing the provisions are applied fairly and the reasons for them are logically argued and explained. It is a logical extension of this approach to invite the community to contribute to the development of management recommendations.
2. Successful management is dependent on the active support of the community. Conservation areas, and this includes islands, should be considered as much a part of the local community as they are of the landscape. It is well accepted that the successful management of natural areas for conservation requires, at the very least, the understanding and sympathy of the community at large.
3. Better decisions result from the consideration of as wide a range of viewpoints as possible.

The planning process and the associated production of management plans is employed by most of the agencies involved in the management of conservation areas across Australia and New Zealand. Over the last five years every state in Australia (with the exception of Victoria) and New Zealand have produced, or are in the process of producing, at least one management plan for an island or island group. All involved some level of public participation.

A brief description of these plans provides a background to the Western Australian context. All examples discussed have been prepared according to the relevant State or Commonwealth legislation. The following information was collated for the Workshop in 1985.

New South Wales (National Parks and Wildlife Service)

This Service produced one island management plan to date, (as of November 1985) this being the draft plan of management for Lord Howe Island Permanent Park Reserve. This plan was made available for public comment for 2 months from August 1985.

The plan has been divided into 3 sections - background, scheme of operations and implementation. The background section includes information on the natural environment, history and cultural resources, the landscape and land use. This section also includes information on all relevant legislation. Such inclusion is necessary because of the complex legal status of the management plan, with the plan being prepared for the Lord Howe Island Board, by the New South Wales National Parks and Wildlife Service, with the plan to be implemented by the Board. This background section is well covered as it is based on comprehensive survey work.

The scheme of operations is also comprehensive, and most importantly places environmental management in a regional context. The importance of such a management consideration is discussed in detail later in this paper, in the Western Australian context. One short-coming within this section is the lack of emphasis on monitoring.

The third section - implementation - is essential in any management plan if the management prescriptions are to be implemented.

South Australia (Department of Environment and Planning)

This agency produced three management plans for islands prior to 1985. These are a management plan for Seal Bay and Cape Gantheaume Conservation Parks (Kangaroo Island, South Australia), and draft management plans for Conservation Parks of Kangaroo Island and for the Island Conservation Parks of Backstairs Passage and Encounter Bay. The last of these is the example discussed in this paper.

The draft management plan for the Conservation Parks of Backstairs Passage and Encounter Bay was made available for public comment for one month from 9 October 1980. Each island was discussed separately under 3 headings: background information; management objectives; implementation. The background information for most islands was brief, however greater detail was included on aspects such as tern usage on which comprehensive studies have been made. In the second and third sections the management objectives and plan implementation respectively, were clearly stated. A final summary of management proposals detailed monitoring and research requirements.

Tasmania (National Parks and Wildlife Service)

One management plan for an island had been completed by 1985 - that for Sarah Island Historic Site. This plan was made available for public comment for one and a half months from 19 February 1983. The plan was divided into two parts background, and management objectives, policies and strategies. The plan focussed on the historical context.

In 1985 in addition to the Sarah Island plan, a management plan for Maria Island was in draft form and a plan for Macquarie Island in preparation.

Northern Territory (Conservation Commission)

A draft management plan for the Coburg Peninsular (which is essentially an island) was being prepared in 1985.

Queensland (Great Barrier Reef Marine Park Authority and Queensland National Parks and Wildlife Service)

The major group of islands in this state is the Great Barrier Reef. The area the Great Barrier Reef Marine Park Authority (GBRMPA) is responsible for developing management and zoning proposals for the marine areas and the Queensland National Parks and Wildlife Service is responsible for the planning and management of terrestrial areas.

Over the period 1980-1985 GBRMPA has produced zoning plans covering much of their area of responsibility. Recent phases of planning by GBRMPA, cover the Central Section of the Great Barrier Reef, began with the publication of an Information Summary for the Section. This gave detailed information on geomorphic and biological features, human usage and adjacent land use. This document was made available with a pamphlet titled "Help Zone the Central Section of the Great Barrier Reef Marine Park". Both were widely distributed.

The end product of this process is documents such as the "Cairns Section Zoning Plan and the Cormorant Pass Section Zoning Plan" which are attractive glossy-covered documents complete with colour maps.

Australian National Parks and Wildlife Service

Two island management plans have been produced to date (as at 1985) draft management plans for Mount Pitt Reserve and Norfolk Island Botanic Garden (in 1982) and for Christmas Island National Park (in 1985). Both plans are similarly structured, being divided into three major sections description, objectives and management. Each section is based on detailed information and the need for research and monitoring is clearly stated.

New Zealand

The development of management plans for islands off the New Zealand coastline has been discussed in detail in the preceding paper by Paul Dingwall.

Western Australia

In Western Australia, five separate government departments have produced, or are in the process of producing, management plans for islands. These are as at 1985:

Department of Premier and Cabinet

Rottnest Island Management Plan (draft, 1984)

Department of Conservation and Land Management (CALM)

Islands between Lancelin and Dongara (in preparation)

Nature Reserves of the Dampier Archipelago (in preparation)

Department of Conservation and Environment and the National Parks Authority (now part of CALM)

Penguin Island Management Plan (draft, 1984)

Department of Defence

Garden Island Management Plan (1980)

Having provided a national setting, the remainder of this paper covers the development of management plans in the Western Australian context. Management plans for Rottnest Island and the Lancelin to Dongara islands are used as examples.

Firstly however, an introduction to plan formulation in the Western Australian context.

Published management plans for conservation areas were first produced by the Department of Conservation and Environment in the late 1970s. All plans were for coastal areas and were produced in conjunction with local government authorities. The Department of Fisheries and Wildlife developed a management planning process in the period 1979-81, with the first management plan being published in 1981. Management plans within the Department had been written as early as 1971, however they were never widely available. National Parks Authority plans suffered a similar fate, with many plans written, but none were ever published.

A review of land resource management, which culminated in a report presented to the Premier in January 1984, led to the formation of the Department of Conservation and Land Management. This Department is an amalgamation of the Forests Department, the National Parks Authority and the Wildlife section of the Department of Fisheries and Wildlife. One of the main functions of this new department is the production of management plans. This function was embodied in the Conservation and Land Management Act (1984), as was the process of plan approval. One of the most important components in the legislation is the requirement to make plans available for public comment for a minimum of two months. This ensures public involvement in the planning process.

The Rottnest Island Management Plan, and the associated planning process, is one example of the development of management plans in Western Australia.

Rottnest Island lies 18 km west of Fremantle, the port of the Western Australian capital city, Perth (Fig. 2). The island is 10.5 km long and up to 4.5 km wide and has an area of approximately 1,850 ha. It is the largest of a chain of islands extending south, parallelling the metropolitan coastline. The island has two settlements, one at Thomson Bay and another at Geordie/Longreach Bay. Up to a quarter of a million people visit the island each year either for day trips or overnight stays.

The marine environment surrounding Rottnest is also subject to intense visitor usage. Skindiving, fishing, windsurfing and surfing are all popular pastimes of visitors based on or adjacent to the island. In their own way, each has an effect on the marine and terrestrial areas. The plan covers the terrestrial areas and nearshore waters, generally defined to the 15 m contour, of Rottnest.

The planning process began in 1984 with the publication of a development strategy for Rottnest Island. Over 8,000 submissions were received in response, with many of these submissions highlighting the need for a management plan. In response the Western Australian Government formed the Rottnest Island Management Planning Group under the auspices of the Department of Premier and Cabinet.

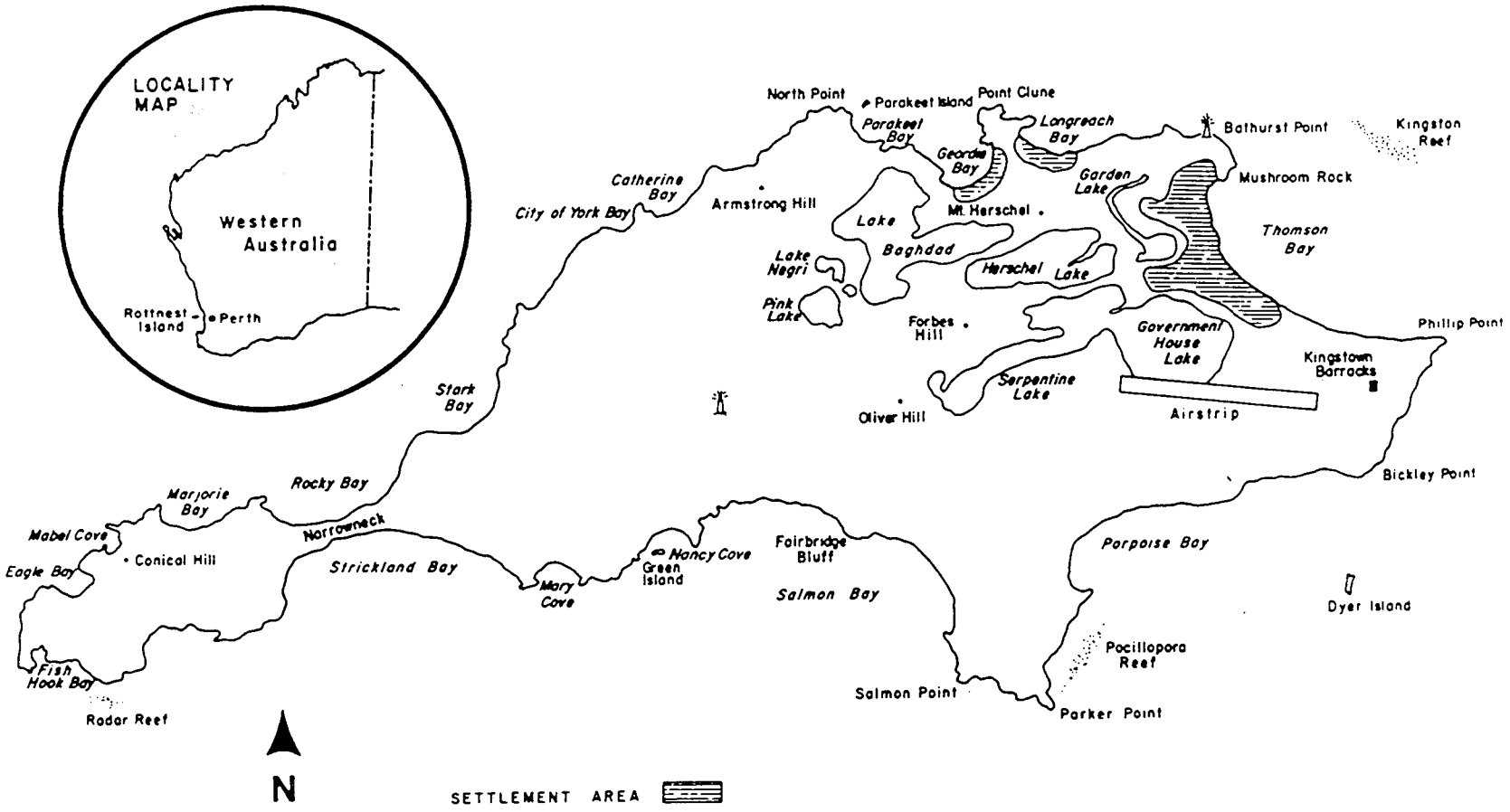


Figure 2.
Location of Rottnest Island, Western Australia. (Source: Anon. 1985c.).

The management plan was prepared for both the Department of Premier and Cabinet and the Rottnest Island Board. The Rottnest Island Board has responsibility for the management of the island and therefore for implementation of the plan.

The plan is based on comprehensive management recommendations which deal with the majority of management problems on the island.

Recommendations for land management emphasised the importance of conserving and protecting all lakes, swamps and freshwater seeps. The importance of rehabilitation of eroding and potentially erodible sites was also emphasised. The following objectives were suggested for vegetation management:

1. The island is well vegetated and does not require 'revegetating' but rather requires vegetation conservation and some reafforestation.
2. Vegetation conservation and reafforestation should aim to: (i) conserve and enhance faunal habitats; (ii) conserve the island's fragile landforms; (iii) conserve and improve landscape aesthetics and the recreational amenity; (iv) facilitate multiple use of the resource.
3. Native Rottnest vegetation should be favoured, revegetation should complement the existing ecosystem and the 'least maintenance' option should be followed where-ever possible.

Fauna management focussed on the management of the quokka, *Setonix brachyurus*. This is a small herbivorous macropod. As the only surviving native terrestrial mammal on Rottnest they are of scientific and educational interest. However, this species is present in such high numbers that it is leading to degradation of the vegetation. The quokka also harbours the *Salmonella* bacteria. Management strategies focussed on overcoming these two problems.

Recommendations for the management of the wide diversity of birds were based on closing important or fragile habitat to public access. Limiting the artificial food supply (from rubbish bins and the tip) was advocated as a control measure for nuisance birds such as silver gulls and ravens. Recommendations for fauna management also covered rodents, feral cats and introduced animals.

Management of the marine resources aimed to optimise the conservation and recreational values of the marine environment.

The recommendations regarding land use advocated limiting settlement because of the fragility of the environment and its low capability to support development. Recommendations also covered lighthouses, ruins, shipwrecks, aboriginal sites, transport and services. Fire management was also covered in some detail, including recognition of the need to formulate fire emergency plans for the island.

Education, research and monitoring were all emphasised as important facets of the management plan.

The planning process for Rottnest was highly interactive, with all interested groups and individuals being encouraged to comment both before and after the formulation and publication of the draft. To encourage public comment three workshops were run - the topics being wildlife management, the terrestrial environment and the marine environment. This allowed consultation with interested groups and members of the scientific community, enabling compilation of existing knowledge and its inclusion in the draft plan. The workshops were held in the last quarter of 1984, followed by release of the draft for public comment for 3 months from February 1985.

A visitor survey was also conducted in the last quarter of 1984, with both day and longer term visitors surveyed. Ferry and plane passengers and private boats were surveyed to determine visitor characteristics, activities and attitudes.

The draft was reviewed in the light of submissions received and a final plan prepared. The final plan was presented for State Cabinet approval in late 1985.

The other example of development of management plans for islands in Western Australia is the draft management plan, currently in preparation, for the islands between Lancelin and Dongara. Lancelin and Dongara lie 120 and 320 km respectively, north of Perth on the west coast of Western Australia (Fig. 3). The 36 islands in this area vary in size from 0.04 ha to 25.9 ha and lie from approximately 50 m offshore to 8 km offshore. The islands are aeolian limestone in origin, with a number being overlain by dune sand. All are low and flat, with some having sandy beaches on the leeward side. The islands are used as breeding sites by at least 20 bird species. In addition, 16 reptile species have been recorded including one gazetted rare and endangered skink, *Ctenotus lancelini*.

There were two main reasons why a management plan was needed. First, conservation values are being lost because of a lack of management. The rapid settlement of the northern suburbs of Perth and the proliferation of four-wheel-drive vehicles and boats over the last five years have led to a rapid increase in use of the islands. The effects of this increase in usage are both broadscale - across all islands and

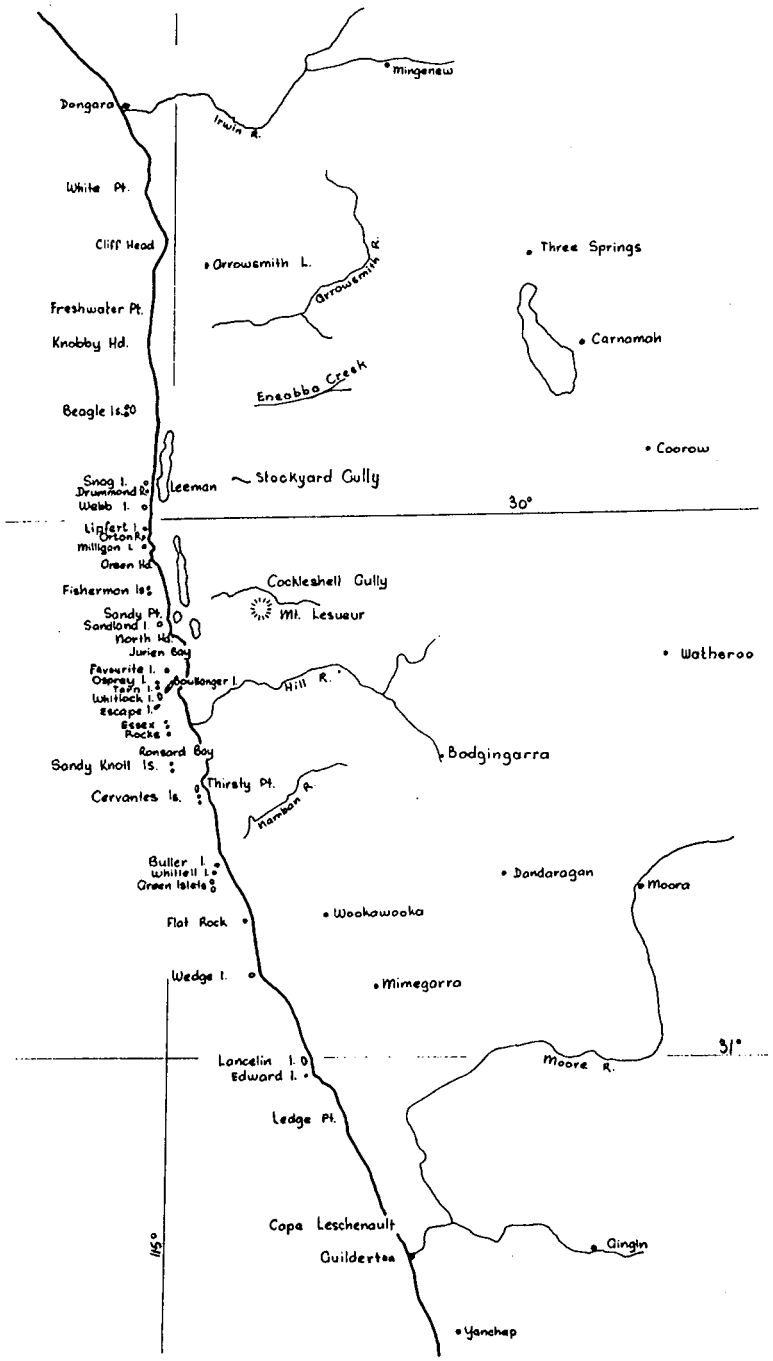


Figure 3.
Location of the Lancelin-Dongara Islands, Western Australia. (Source: Anon. 1963.)

localised, on particular islands such as Wedge and Lancelin (which are large and close to the mainland). Erosion is occurring on all islands heavily used by the public. Second, the islands are subject to increasing pressure from conflicting land-uses. This includes use by recreationists, crayfishermen and amateur fishermen.

Development of the plan has been based on a definition of management objectives and associated multidisciplinary surveys. The survey team included a botanist, mammologist, herpitologist, ornithologist, planning officer (concentrating on rationalisation of public use), regional management officer and an enforcement officer. The on-site presence of this diverse group enabled management options to be discussed and assessed, and recommendations for both biological and 'people' management made.

The next stage in the planning process will involve the determination of management strategies for fire protection, pest and weed control, rehabilitation and public use. All strategies will be guided by the management objectives; the main objective being the maintenance of the conservation values of the islands.

Management strategies will be determined in consultation with the public. This will serve to both involve the general community in the planning process and inform the community about the conservation values of the islands.

Finally, there are three aspects of the planning process which require special emphasis in the context of island management. These are public involvement in planning and the educative function of planning, planning in the regional context and monitoring. These three aspects are discussed in the context of the Lancelin to Dongara islands plan.

Firstly, public involvement in planning and the educative function. Public involvement in the Lancelin to Dongara islands planning process will be encouraged by widely distributing the draft plan. Use of this low key approach, in comparison to the workshop and 'promotional' approach used in the Rottnest project, is a function of the dispersed nature of the user groups as well as a hesitancy to widely promote these islands which should be regarded primarily as sanctuaries.

The remote nature of many offshore islands requires a special approach to public interpretation and education. Once people have set off in a boat with certain expectations it is almost impossible to prevent them fulfilling these expectations once they reach their destination. One of the best ways of encouraging appropriate public use is by erecting information signs at boat launching ramps, and then repeating the messages on the islands. For example, if managers wish to keep pets off an island they should make it clear at the mainland launching spot that pets are not allowed on the island. This sign should be positively worded and explain briefly why pets are not allowed. This mainland sign should be reinforced by a similar sign on the island.

A further consideration is the difficulty of patrolling offshore islands for enforcement purposes. Therefore public education is the only way in which management objectives can be achieved. This approach is used by GBRMPA who advocate that:

> *"The Authority's policy is to achieve management goals largely by education and by obtaining the co-operation of the public, rather than by direct enforcement."*

Secondly, planning in a regional context is one of the most desirable outcomes of the planning process and one of the most difficult to achieve. The Lord Howe Island Management Plan (produced by NSW National Parks and Wildlife Service) is one of the best examples as it considers not only the island-wide impacts of certain management decisions, it also considers the Lord Howe Island Permanent Preserve in a broader regional and state context. This has been achieved through a discussion of the distribution of plant species, particularly endemics and plants with a restricted distribution. A wider context again is obtained by discussing the preserve in an international context.

The same approach will be used in the management plan for the Lancelin to Dongara islands. Within this group the capability exists, in terms of both the biophysical and human environment, to compare between islands, as well as reviewing their broader values and use, at a regional, state and international level. Within the group an island such as Lancelin Island, with the only known population of rare and endangered skink, *Ctenotus lancelini*, warrants special attention. In a broader context the regional value of the islands as nesting sites for numerous sea birds is recognised. An analysis of recreational use of the islands in a regional context is also important. This will enable recreation to be directed away from the more sensitive conservation areas, while at the same time ensuring that recreational needs are recognised. At the national and international level, the value of the islands as sea-lion (*Neophoca cinerea*) nurseries is an important management consideration.

Thirdly, it is now widely recognised that monitoring is a vitally important part of the planning process. However, the value of monitoring recreational use deserves a mention, particularly in

the island environment. This is important, for example where shifting sand bars may connect island and mainland, allowing the movement of four-wheel-drive vehicles onto previously untouched areas. If the problem is recognised early enough, minimal damage is done before the appropriate management action is taken. Also, much of the site work implemented to guide public use is experimental, and it therefore should be closely monitored so that if necessary, modifications can be made.

To conclude, the development of management plans for islands in Western Australia, and in the wider Australian/New Zealand context, is well on the way towards recognising the needs of public involvement, planning in the regional context and 'social' monitoring (as well as biophysical monitoring). Meeting these needs should be a fundamental objective of any management planning process.

REFERENCES

Anon. (1978). Workshop on the Northern Sector of the Great Barrier Reef. GBRMPA. Workshop Series No. 1. (Great Barrier Reef Marine Park Authority: Townsville.)

Anon. (1980a). Great Barrier Reef Marine Park Capricornia Section. Understanding the Zoning Plan. (Great Barrier Reef Marine Park Authority: Townsville.)

Anon. (1980b). Great Barrier Reef Marine Park Capricornia Section Zoning Plan. (Great Barrier Reef Marine Park Authority: Townsville.)

Anon. (1982). Draft Plan of Management Mount Pitt Reserve, Norfolk Island and Draft Plan of Management Norfolk Island Botanic Garden. (Australian National Parks and Wildlife Service: Canberra.)

Anon. (1983a). Coastal planning and management in Western Australia. A Government Position Paper. (Dept of Premier and Cabinet: Perth.)

Anon. (1983b). Cairns Section Zoning Plan and the Cormorant Pass Section Zoning Plan. (Great Barrier Reef Marine Park Authority: Townsville.)

Anon. (1983c). Sarah Island Historic Site Management Plan. (Tasmania National Parks and Wildlife Service: Hobart.)

Anon. (1983d). Management Plan for the Campbell Islands Nature Reserve. (Department of Lands and Survey: Wellington.)

Anon. (1984a). Draft Management Plan. Conservation Parks of Kangaroo Island. (S.A. National Parks and Wildlife Service - a division of the Department of Environment and Planning: Adelaide.)

Anon. (1984b). Task Force on land resource management in Western Australia. A report to the Government of Western Australia. (Dept. of Premier and Cabinet: Perth.)

Anon. (1984c). Great Barrier Reef Marine Park. Zoning the Far Northern Section. (Great Barrier Reef Marine Park Authority: Townsville.)

Anon. (1984d). Great Barrier Reef Marine Park. Far Northern Section Zoning Plan. For public review. (Great Barrier Reef Marine Park Authority: Townsville.)

Anon. (1985a). Auckland Islands Nature Reserve Draft Management Plan. (Department of Lands and Survey: Wellington.) (Unpublished.)

Anon. (1985b). Lord Howe Island Permanent Park Preserve Draft Plan of Management. (NSW National Parks and Wildlife Service: Sydney.)

Anon. (1985c). Rottnest Island Draft Management Plan, Volume 1, the Plan. (Rottnest Island Management Planning Group: Perth.)

Anon. (n.d.a). Management Plan. Seal Bay and Cape Gantheaume Conservation Parks, Kangaroo Island, South Australia. (National Parks and Wildlife Division of the Department for the Environment: Adelaide.)

Anon. (n.d.b). Island Conservation Parks of Backstairs Passage and Encounter Bay, South Australia, Draft Management Plans. (National Parks and Wildlife Service - a division of the Department for the Environment: Adelaide.)

Anon. (n.d.c.). The Great Barrier Reef Marine Park Central Section information summary. (Great Barrier Reef Marine Park Authority: Townsville.)

Chape, S. (1984). Penguin Island Draft Management Plan'. (National Parks Authority and Department of Conservation and Environment: Perth.)

Ford, J. (1965). The Avifauna of the Islands between Dongara and Lancelin, Western Australia. *The Emu* 64(2), 129-144.

Ford, J. (1963). The reptilian fauna of the islands between Dongara and Lancelin, Western Australia. *The Western Australian Naturalist* 8(6), 135-142.

Ford, J. (1963). The distribution and variation of the skinks *Egernia pulchra* and *E. bos* in Western Australia. *The Western Australian Naturalist* 9(2), 25-29.

Ford, J. (1965a). The reptilian fauna of the islands between Dongara and Lancelin, Western Australia: additional notes. *The Western Australian Naturalist* 9(7), 174-175.

Ford, J. (1965b). The avifauna of the islands between Dongara and Lancelin, Western Australia. *The Emu* 64(3), 181-203.

Hopkins, A.J. and Saunders, D.A. (1987). Ecological studies as the basis for management. In, *Nature Conservation: The Role of Remnants of Native Vegetation.* (Eds. Saunders, D.A., Arnold, G.W., Burbidge, A.A., and Hopkins, A.J.M.) pp 15-28. (Surrey Beatty and Sons : Sydney).

Kelleher, G. (1983). Informational needs for managing the Great Barrier Reef Marine Park. In Proceedings of the Great Barrier Reef Conference. (Eds. Baker, J.T., Carter, R.M., Sammarco, P.W. and Stark, K.P.) pp. 43-60. (James Cook University : Townsville).

Policy Considerations Influencing Management of Nature Conservation Values in Australian Island Territories

W.L. Filsell

Department of the Arts, Sports, the Environment, Tourism and Territories,
GPO Box 787 Canberra, ACT, 2601.

Abstract

Given the diverse cultural heritage and environmental factors in each of the island Territories within the responsibility of the Department of Territories, any decision regarding nature conservation requires consideration of a wide range of different issues. In consultation with Territory authorities and conservation specialists, in particular the Australian National Parks and Wildlife Service, thought is given to determining the most appropriate measures to be taken to achieve the desired level of protection.

INTRODUCTION

The Department of Territories is responsible for land management matters in Norfolk Island, the Cocos (Keeling) Islands, Christmas Island, the Coral Sea Islands Territory and the Ashmore and Cartier Islands. Maps of those Territories are included at Attachment 1. Australia's other island Territory - Heard Island and the McDonald Islands - is administered by the Department of Science.

To gain an appreciation of the factors which influence decisions relating to nature conservation, it is necessary to outline the legislative position, discuss the constitutional development and be aware of the current position with respect to reserved areas in each of those Territories.

LEGISLATIVE POSITION

The various legislative and administrative arrangements in place in each of the Territories can be summarised as follows:

- Norfolk Island - Commonwealth Acts extend if expressed to do so. The Norfolk Island Act 1979 provides the Norfolk Island Government with executive and legislative authority over a wide range of matters.
- Coral Sea Islands - Commonwealth Acts extend if expressed to do so. Under the Coral Sea Islands Act 1969, the Governor-General may make Ordinances for the Territory. The Application of Laws Ordinance 1973 applies the laws of the Australian Capital Territory, so far as applicable, to the Territory.
- Cocos (Keeling) Islands and Christmas Island - the Cocos (Keeling) Islands Act 1955 and the Christmas Island Act 1958 provide that Commonwealth Acts extend to the Territories if expressed to do so and give the Governor-General power to make Ordinances for the Territories. All laws of the former Colony of Singapore in force before the acceptance of the Territories continue to apply in the Territories although some of these laws have been modified by local Ordinances.
- Ashmore and Cartier - all Commonwealth Acts extend and the laws in force in the Northern Territory as at 30 June 1978 apply. A Bill presently in the Senate will apply up-to-date laws in the Territory based on Northern Territory laws in force from time to time.

CONSTITUTIONAL DEVELOPMENT OF THE TERRITORIES

The level of constitutional development attained in each Territory influences the way in which nature conservation decisions are implemented.

Norfolk Island for instance is different from the other external Territories in that it has attained a much higher level of local control. The Norfolk Island Government's responsibilities include recreation areas, forestry and timber, coastlines and foreshores and it can make laws in relation to each of those matters. The Commonwealth retains responsibility for environment protection and conservation but exercises this responsibility in close co-operation with the Norfolk Island Government.

The Norfolk Island Legislative Assembly is however able to introduce and pass its own legislation in the environmental sphere and has for instance introduced its own Migratory Birds Act to give effect to the Australia - Japan Migratory Birds Agreement. Laws such as these must however be reserved for assent by the Governor-General of Australia.

Although Christmas Island is proceeding towards a greater level of constitutional development with the recent election of an Assembly with limited powers, that Assembly has no law making powers and conservation remains the responsibility of the Australian Government.

The Cocos (Keeling) Islands Council is responsible for municipal matters on Home Island, where the indigenous Cocos Islanders reside, and can make "local government" type by-laws regulating activities in the kampong area on Home Island. Following the Act of Self-Determination of 6 April 1984, by which the Cocos Malays chose full integration with Australia, the Australian Government transferred approximately 6/7 of the land in the Territory to the ownership of the Cocos (Keeling) Islands Council. The Council acknowledged the special need to protect the environment of North Keeling Island, and the Government gave a commitment to respect the religious beliefs, traditions and culture of the Cocos Malay people. It is within this broad context that nature conservation operates in the Territory with the Commonwealth having overall responsibility for conservation matters.

As the Ashmore and Cartier Islands and the Coral Sea Islands are virtually uninhabited, the question of constitutional development is not relevant. Conservation matters are solely the responsibility of the Commonwealth.

Significant Commonwealth enactments which provide mechanisms for protection of Australian flora and fauna and extend to all the external Territories include the Wildlife Protection (Regulation of Exports and Imports) Act 1982, the National Parks and Wildlife Conservation Act 1975, the Environment Protection (Impact of Proposals) Act 1974 and the Continental Shelf (Living Natural Resources) Act 1968. In addition, some legislation has been promulgated in each of the Territories to afford protection to a range of flora and fauna. Those enactments are summarised at Attachment 2.

CURRENT POSITION WITH RESPECT OF RESERVED AREAS IN EACH TERRITORY

Various degrees of protection have been afforded to areas in the external Territories.

Approximately one-quarter of Norfolk Island has been declared as reserves or commons under the Commons and Public Reserves Ordinance 1936. However most of these reserves have been proclaimed for purposes other than conservation and many have been used for pasturage (purposes include recreation, landing and shipping, forestry and quarantine). It is ironic that Philip Island, which was almost totally denuded by grazing animals and is now undergoing regeneration due to the exclusion of rabbits, was originally declared as a forestry reserve in 1937.

The most significant development of recent times has been the declaration of the former Mount Pitt Reserve under Norfolk Island legislation as the "Norfolk Island National Park" and the moves to declare that Park under the National Parks and Wildlife Conservation Act 1975. At the same time action is being taken to declare two small portions which have been declared under local legislation as the "Norfolk Island Botanic Garden" as a reserve under the National Parks and Wildlife Conservation Act 1975.

The importance of the Coral Sea Islands Territory as a seabird and turtle nesting area was recognised with the declaration of the Lihou Reef and Coringa-Herald National Nature Reserves on 3 August 1982 under the National Parks and Wildlife Conservation Act 1975. This action provides protection for a wide variety of terrestrial and marine wildlife such as the common noddy, red-footed, masked and brown boobies and the green turtle.

Christmas Island has a unique environment and is home to a variety of endemic species including the Abbotts Booby, a shrew, two bats and some twenty plant species. The Island as a whole is recognised as being of high conservation value. The Christmas Island National Park gives formal protection to 135 square kilometres of the south-western part of the Island. About 12% of the extant Island rainforest lies within its boundaries. Resident Australian National Parks and Wildlife Service officers manage the

National Park and are engaged in monitoring the numbers of the Abbotts Booby (*Sula abbotti*), which is found only on Christmas Island. There is currently a proposal to extend the National Park to include some of the Island's other sites of heritage importance.

There are currently no reserved areas in the Cocos (Keeling) Islands. Active consideration is being given to the appointment of a Conservator during 1986 to assist the Cocos Malay people with conservation matters. It is envisaged that a management plan for North Keeling Island will be prepared.

In 1983 Ashmore Reef and its three islets were proclaimed a National Nature Reserve under the National Parks and Wildlife Conservation Act 1975. This action was taken to protect marine and terrestrial environments and the wildlife dependent on them, such as common noddies, sooty terns, turtles and a variety of seasnakes. Regular visits are made to Ashmore Reef by officers of the Australian National Parks and Wildlife Service and the Service is preparing a management plan for the National Nature Reserve.

Co-operation between the Department of Territories and other Commonwealth Departments and authorities is important for the effective management of these reserved areas. The Australian National Parks and Wildlife Service in particular, provides a wide range of services from the preparation of management plans through to the provision of officers to manage the reserved areas. Officers of the Service residing on Christmas Island and Norfolk Island also provide advice on a range of conservation matters to the Island authorities.

FACTORS INFLUENCING DECISION MAKING

Conservation policies in respect of the external Territories are often influenced by Australia's obligations under international conventions, treaties or agreements. Where Australia becomes a party to an international convention for instance, any obligation incurred under such a convention will bind all of Australia including the external Territories unless they are expressly excluded by the Australian Government when acceding to that convention. By entering into such conventions, Australia undertakes to take whatever measures are necessary, including legislative action, to meet its obligations.

Nature conservation conventions which therefore apply to the external Territories include the Convention on International Trade in Endangered Species of Wild Fauna and Flora and the Agreement between the Government of Australia and the Government of Japan for the Protection of Migratory Birds and Birds in Danger of Extinction and their Environment.

The Department is also involved in Commonwealth/State forums eg CONCOM and AEC and involvement with such organisations influences our policy development for the island Territories. The development by CONCOM of a Memorandum of Understanding between State and Territory Governments for the control of possession and movement of protected fauna could, for instance, have ramifications for the Territories. While the intent of that Memorandum of Understanding is to provide an effective means of achieving national control over possession of and interstate trade in live protected fauna, there is a need to determine whether measures need to be developed to regulate trade between island Territories and the mainland and possession in those Territories of protected fauna. The need for uniformity on such matters is recognised and, if it is deemed necessary and feasible, complementary action will be taken in the Territories.

The Department and its Minister are obviously affected by the conservation policies of the Commonwealth Government. In regard to the phosphate mining operation on Christmas Island, less rainforest has been cleared than otherwise may have been the case in a less sensitive locality. Indeed, reserves of high grade phosphate rock will never be mined as they form the basis for the habitat of endangered avian species like Abbotts Booby.

A major consideration in our conservation policy development is the need to balance the Government's responsibility to protect and promote the interests of the inhabitants of each of the Territories. For example, the Government's commitment to preserve the traditional culture of the Cocos Malay residents of Home Island has ramifications for conservation policy in the Territory. Traditionally the Cocos Malays have made periodic visits to North Keeling Island, which is about 24 kilometres north of the main group, to harvest seabirds for food. The Department of Territories and the Australian National Parks and Wildlife Service have begun a conservation education program at Cocos, complemented by a visit made by the Cocos leaders to Norfolk Island where they gained knowledge of the conservation regimes practiced there. The leaders themselves have undertaken an education program within the community.

The Coral Sea Islands Territory and the Territory of Ashmore and Cartier Islands are virtually uninhabited but each has its own peculiar pressures on the environment. Reports were received for

instance in 1981 that foreign fishing vessels were suspected of taking sedentary organisms from reefs in the Coral Sea Islands Territory. This led to the declaration under the Continental Shelf (Living Natural Resources) Act 1968 of an area in the Coral Sea in which the taking of certain sedentary organisms is strictly controlled.

Ashmore Reef has been degraded by traditional Indonesian fishermen who visit the area every year to collect trochus and beche-de-mer. Although the 1974 Memorandum of Understanding with Indonesia specifically limits the activities of those fishermen, there have been numerous breaches of the agreement over the years. For example, fishermen have landed on the Islands for purposes other than to obtain freshwater, have killed birds, taken turtles, smashed or eaten eggs.

Action is proceeding towards the negotiation of a new Memorandum of Understanding. In the meantime, the Department of Territories has established a presence on the Ashmore Islands during the fishing season (March to November) mainly for the purpose of advising Indonesian fishermen of their obligations under the present Memorandum of Understanding. The Department's presence was only established in October this year and indications are that the "warning off" program is achieving results.

Economic factors also impinge on conservation policies. Christmas Island for example, has been mined for phosphate since the late 1890's - long before the importance of the Island's flora and fauna was recognised. Despite the significance of the unique Island ecosystem, the closure of a $450 m per annum mining operation employing 800 people was not practical. A set of Rainforest Clearing Guidelines has been negotiated between the Director of the Australian National Parks and Wildlife Service and the General Manager of the Phosphate Mining Company of Christmas Island. These guidelines protect conservation interests yet permit some mining. In this way long term conservation objectives can be achieved side by side with other land uses.

In relation to the long term future of Christmas Island, the Australian Government has recognised that the present phosphate operation has a limited life. The feasibility of continuing commercial enterprises on the Island is being examined.

The discovery of hydro-carbons in the offshore Adjacent Area to the Territory of Ashmore and Cartier Islands has meant that the Islands have attained greater importance. These discoveries have resulted in approximately 200 people at any one time residing in the Territory during the drilling season and this has an obvious impact on the reef ecosystem. New legal and administrative arrangements are being put in place. As mentioned earlier, action is currently in hand to extend to the Territory selected laws in force in the Northern Territory from time to time.

ACKNOWLEDGEMENTS

I would like to thank the various officers in the External Territories and Legislation Division of the Department of Territories who provided information and/or assistance with this paper. Those officers are Dr C. Clark, Mr D. Lawrance, Mr J. Hunt, Ms A. Davis, Ms Q. Naylor, Mr G. Byrnes, Mr D. Smith and Ms J. Blackburn.

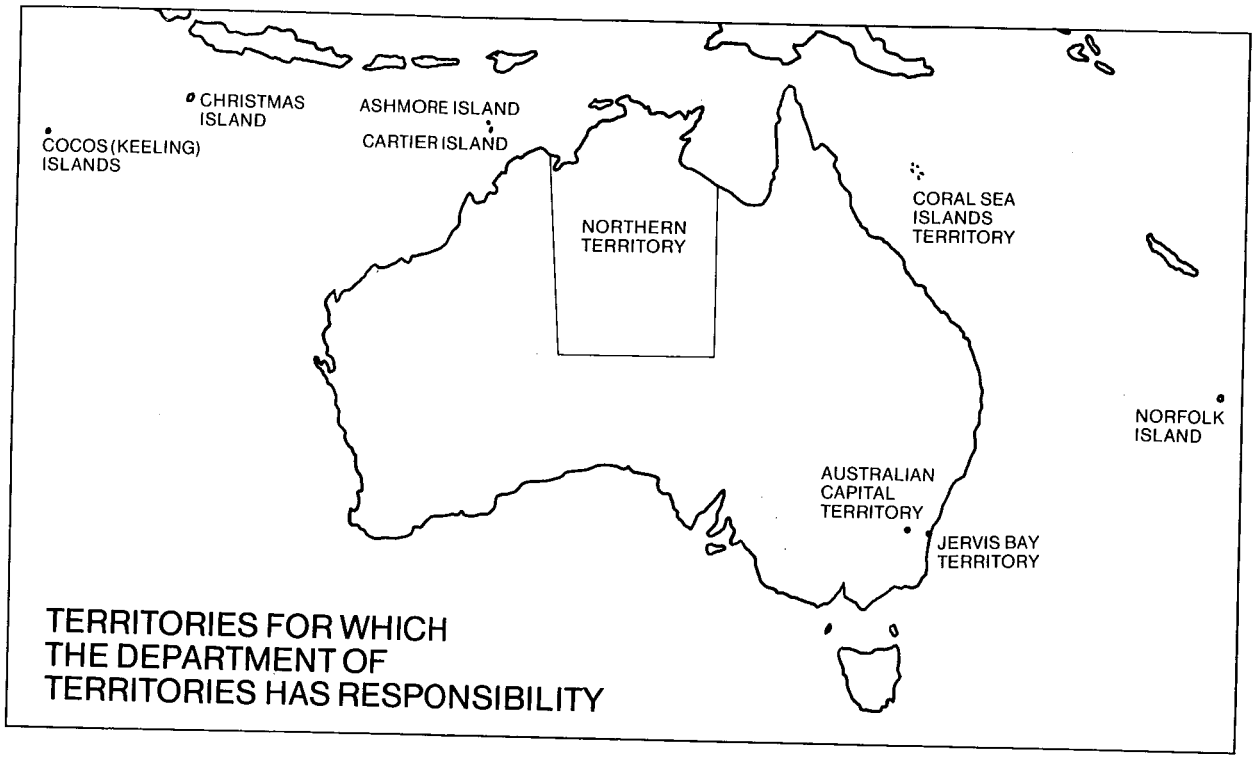


Figure 1
Locale map of Territories for which the Department of Territories has responsibility.

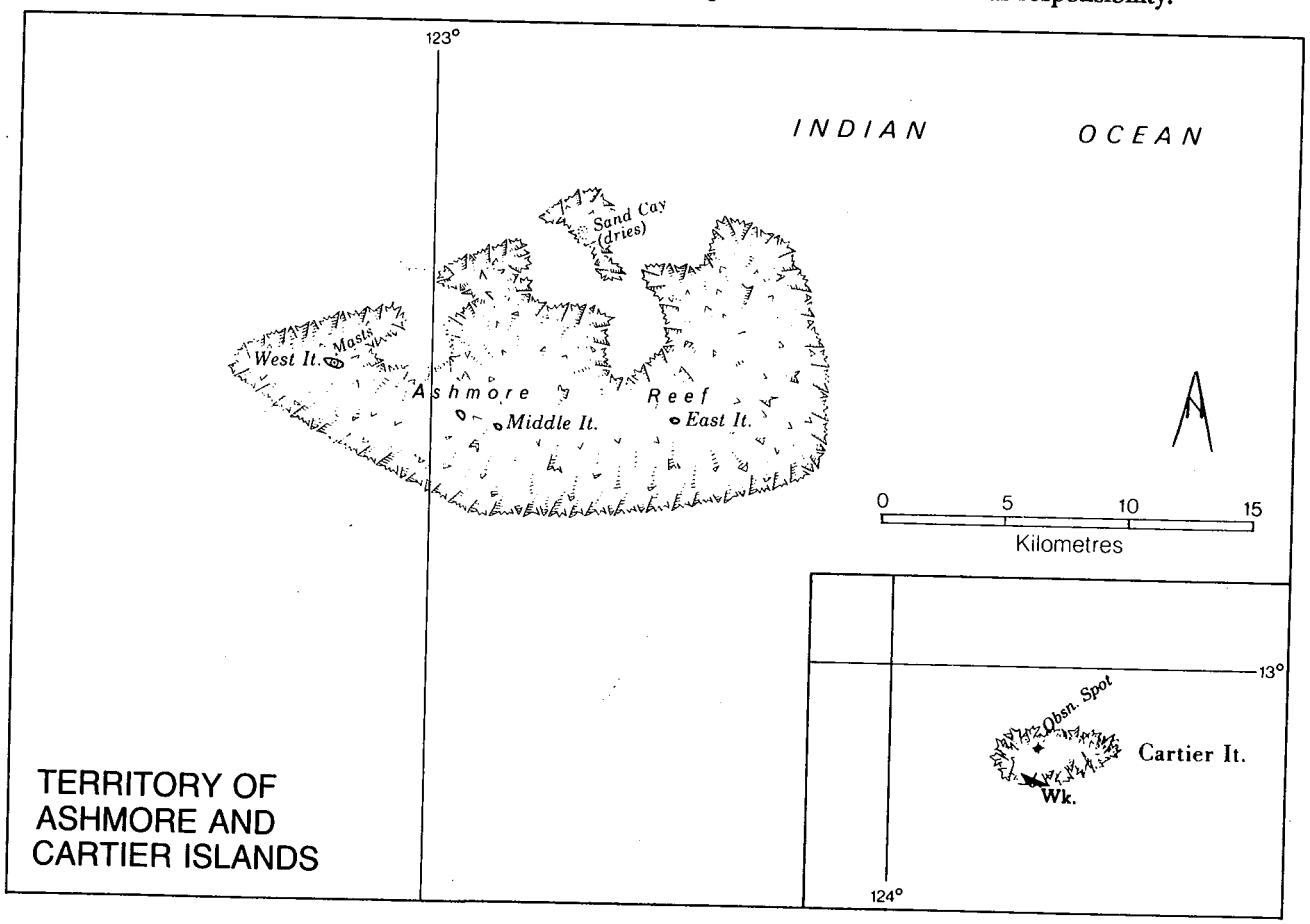


Figure 2
Territory of Ashmore and Cartier Islands.

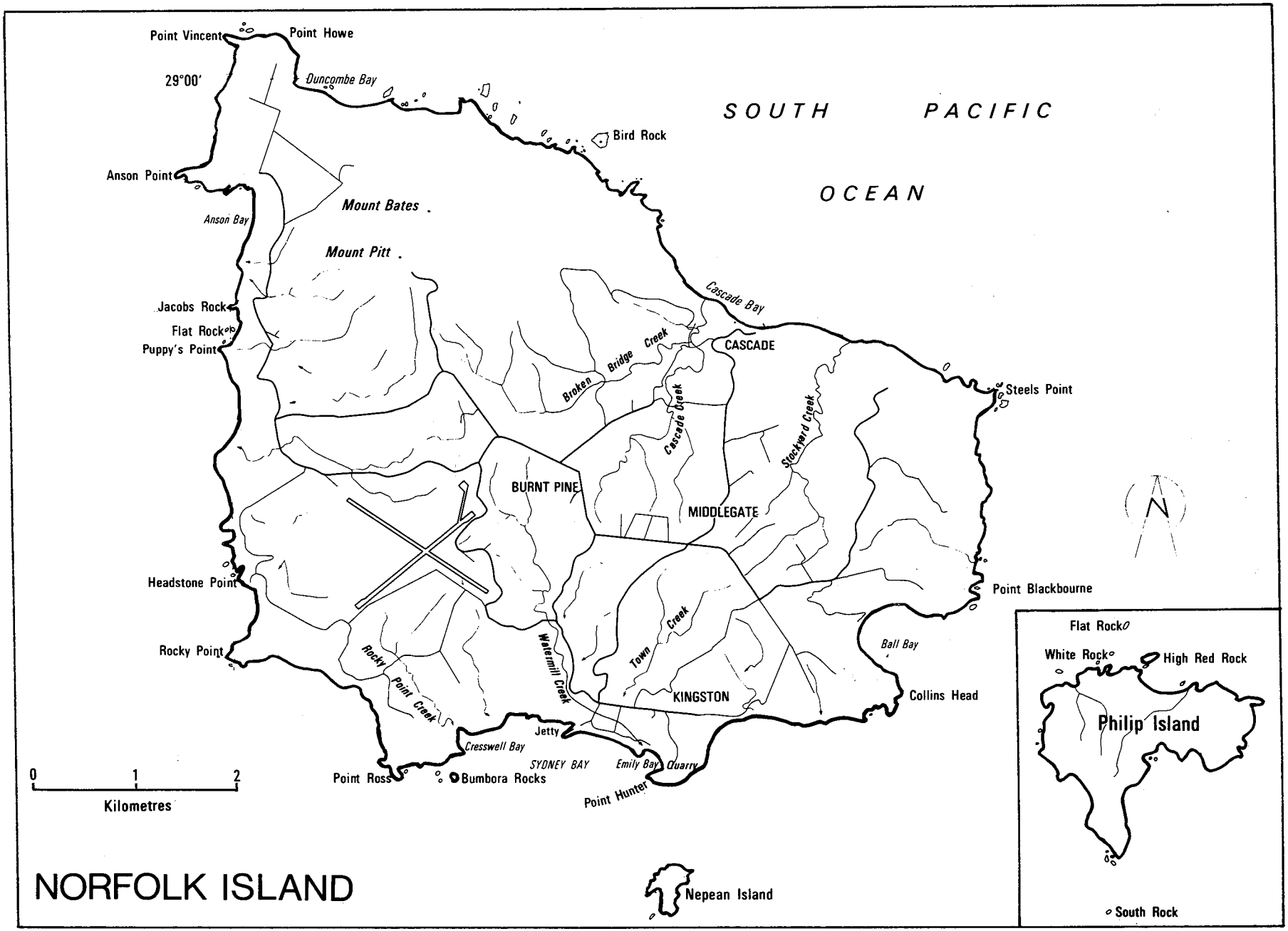


Figure 3
Territory of Norfolk Island.

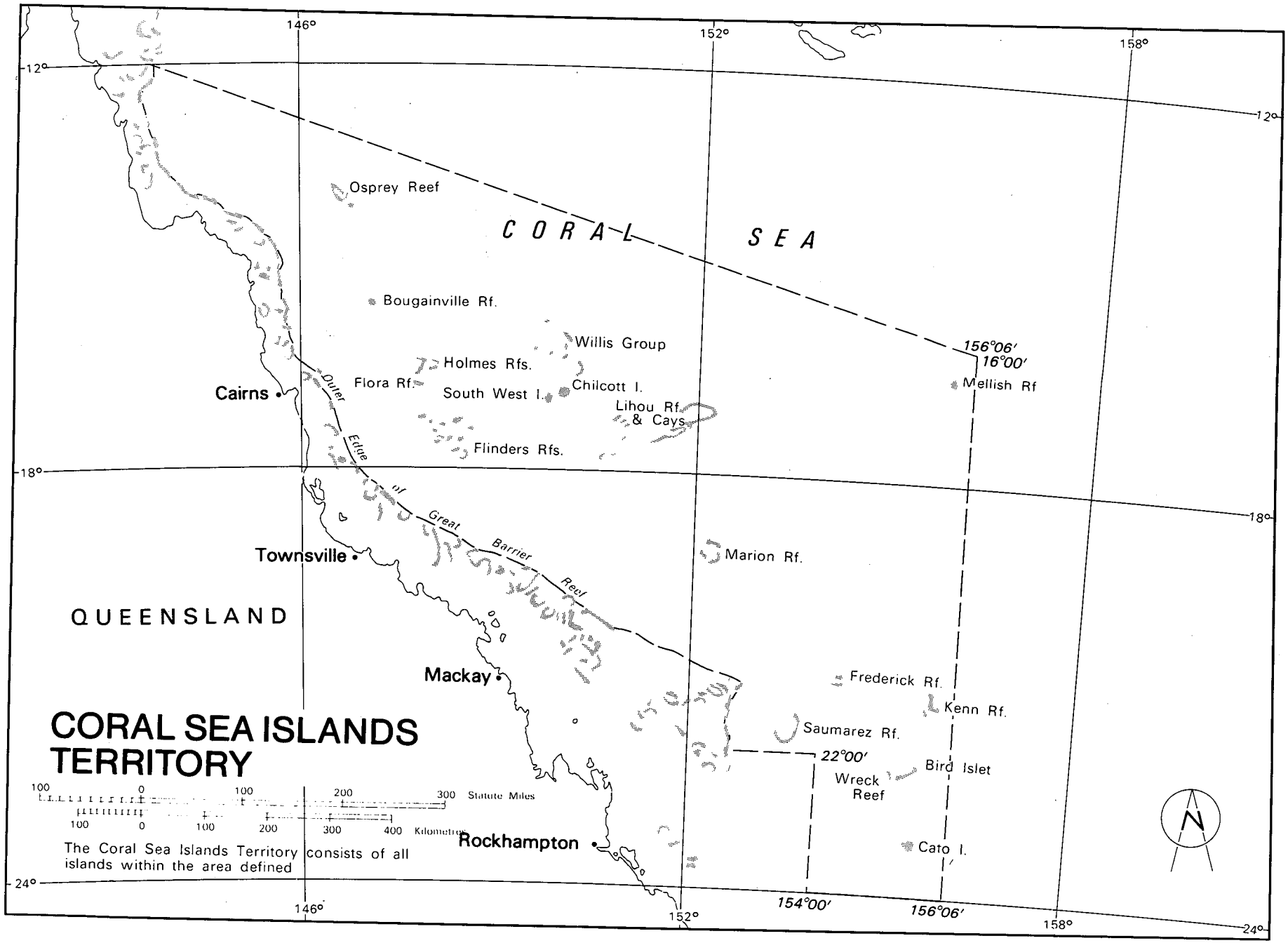


Figure 4
Coral Sea Island Territory.

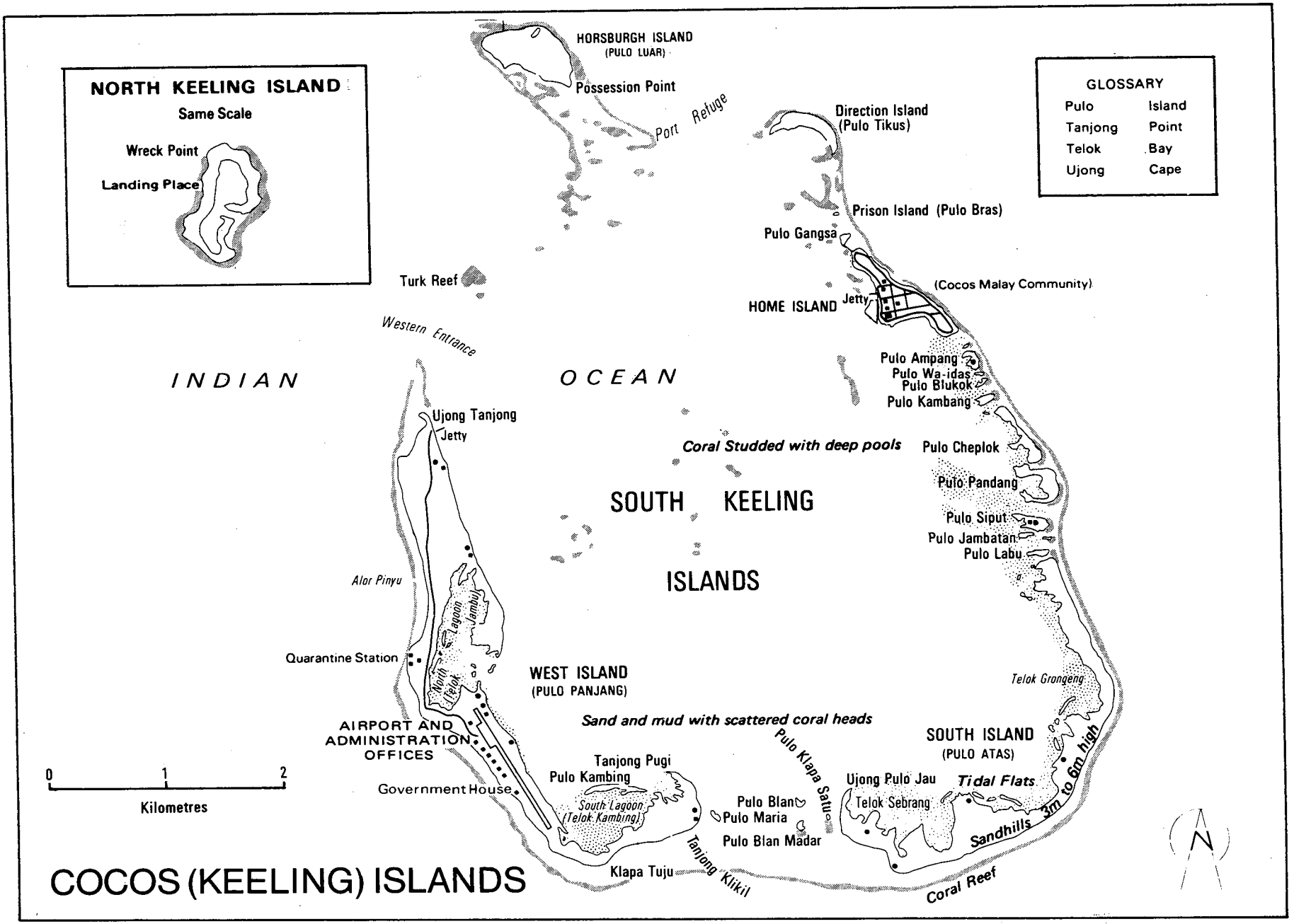


Figure 5
Territory of Cocos (Keeling) Islands.

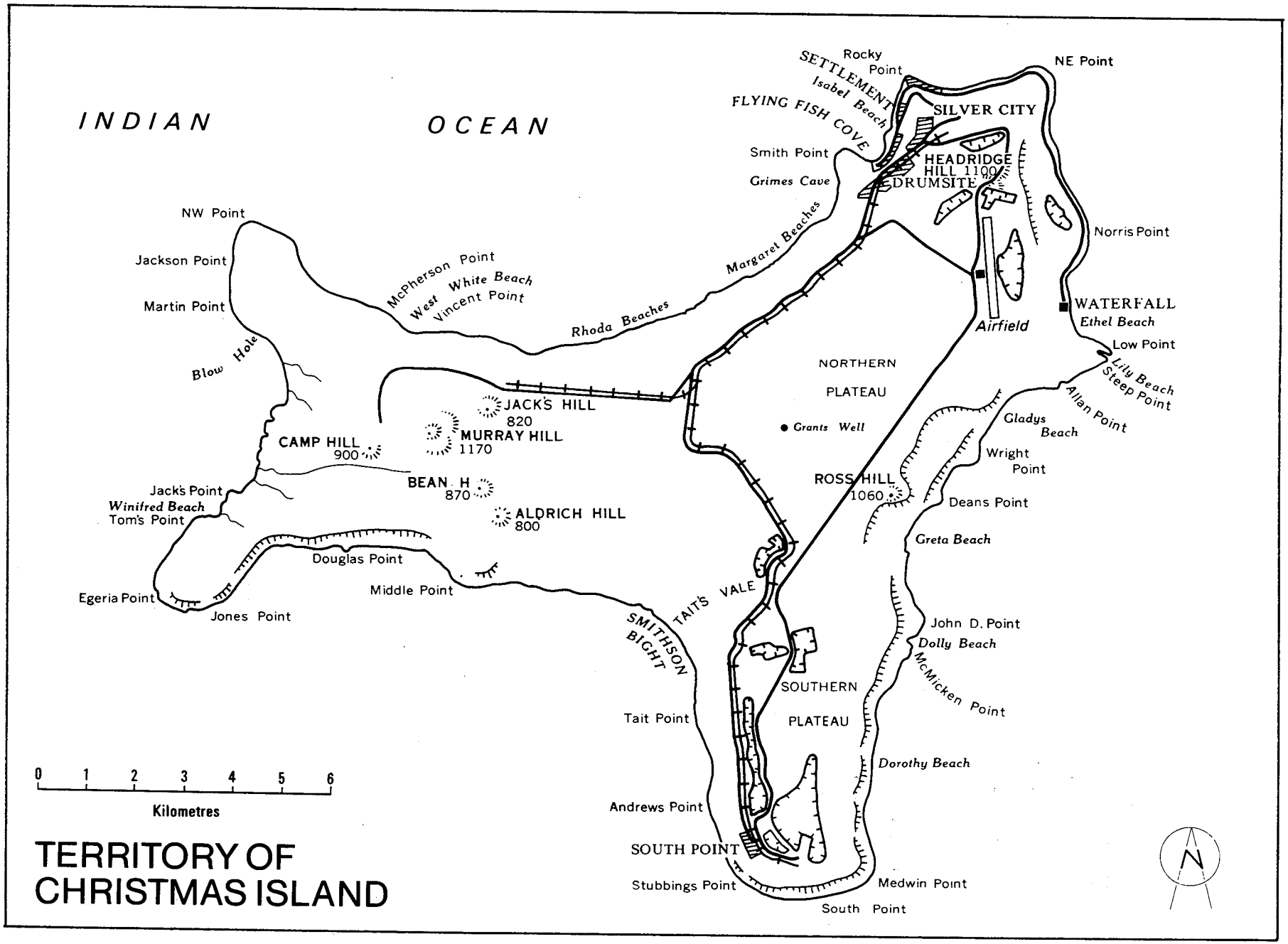


Figure 6
Territory of Christmas Island.

Attachment 2
Summary of Nature Conservation Legislation in force in each Territory

In addition to the Commonwealth legislation cited in the body of the paper, the following Territorial legislation affords protection to a range of flora and fauna.

Norfolk Island

Birds Protection Ordinance 1913

Commons and Public Reserves Ordinance 1936 Endangered Species Act 1980

Fish (Export Control) Act 1984

Migratory Birds Act 1980

Norfolk Island National Park and Norfolk Island Botanic Garden Act 1984

Timber Licences Ordinance 1913

Trees (Preservation) Act 1985

Coral Sea Islands

Migratory Birds Ordinance 1980

Cocos (Keeling) Islands

Crown Lands Encroachments Ordinance Ch No 245 of Laws of Colony of Singapore

Export of Plants (Control) Ordinance Ch No 233 of Laws of Colony of Singapore

Foreshores Ordinance Ch No 246 of Laws of Colony of Singapore

Nature Reserves Ordinance Ch No 235 of Laws of Colony of Singapore

Protected Places Ordinance Ch No 30 of 1955 of Laws of Colony of Singapore

Wild Animals and Birds Ordinance Ch No 238 of Laws of Colony of Singapore

Migratory Birds Ordinance No 1 of 1980 (Territory Ordinance)

Christmas Island

Wild Animals and Birds Ordinance 1958 Migratory Birds Ordinance 1980

Protected Places and Areas Ordinance 1955

Ashmore and Cartier Islands

Relevant Northern Territory laws in force as at 30 June 1978 include:

Fisheries Ordinance

Territory Parks and Wildlife Conservation Ordinance.

However current Northern Territory laws relating to conservation matters are expected to apply in the near future when assent is given to the Ashmore and Cartier Islands Acceptance Amendment Bill 1985 eg the Territory Parks and Wildlife Conservation Act.

Interactive Conservation Perspectives: the Prospect for Aboriginal and Conservation Commission Joint Management of Island Ecosystems in the Northern Territory

Mike Butler

Conservation Commission of the Northern Territory, PO Box 496, Palmerston, NT 0830.

Abstract

Although the island ecosystems of the Northern Territory are known to be ecologically important, to date they have been little managed. The reason is that the vast majority of them are either under Aboriginal ownership or are currently being claimed under the Aboriginal Land Rights Act (Northern Territory) 1976. The conservation of the island ecosystems in the Northern Territory will therefore depend entirely on the establishment of a satisfactory working relationship between Aboriginal interests and the Conservation Commission. Cooperative management may be seen as a long term investment in future conservation for the Northern Territory. Without cooperative management there is a danger that island ecosystems may suffer irreversible environmental degradation. The successful management of island ecosystems in the Northern Territory will depend upon the continuation of a process which is evolving towards a cooperative endeavour with Aboriginal people. Developments which have occurred at Kakadu National Park, Gurig National Park (Cobourg Peninsula) and Kings Canyon provide some insights into approaches which might be adopted in the joint management of the Northern Territory's island ecosystems. All of these examples depend upon cooperative endeavour and goodwill between the Conservation Commission and the Aboriginal people. In addition, they depend upon a sharing of conservation perspectives and a mutual learning process. The practical application of this with respect to North Island will have an important bearing on the future management of the Northern Territory's island ecosystems.

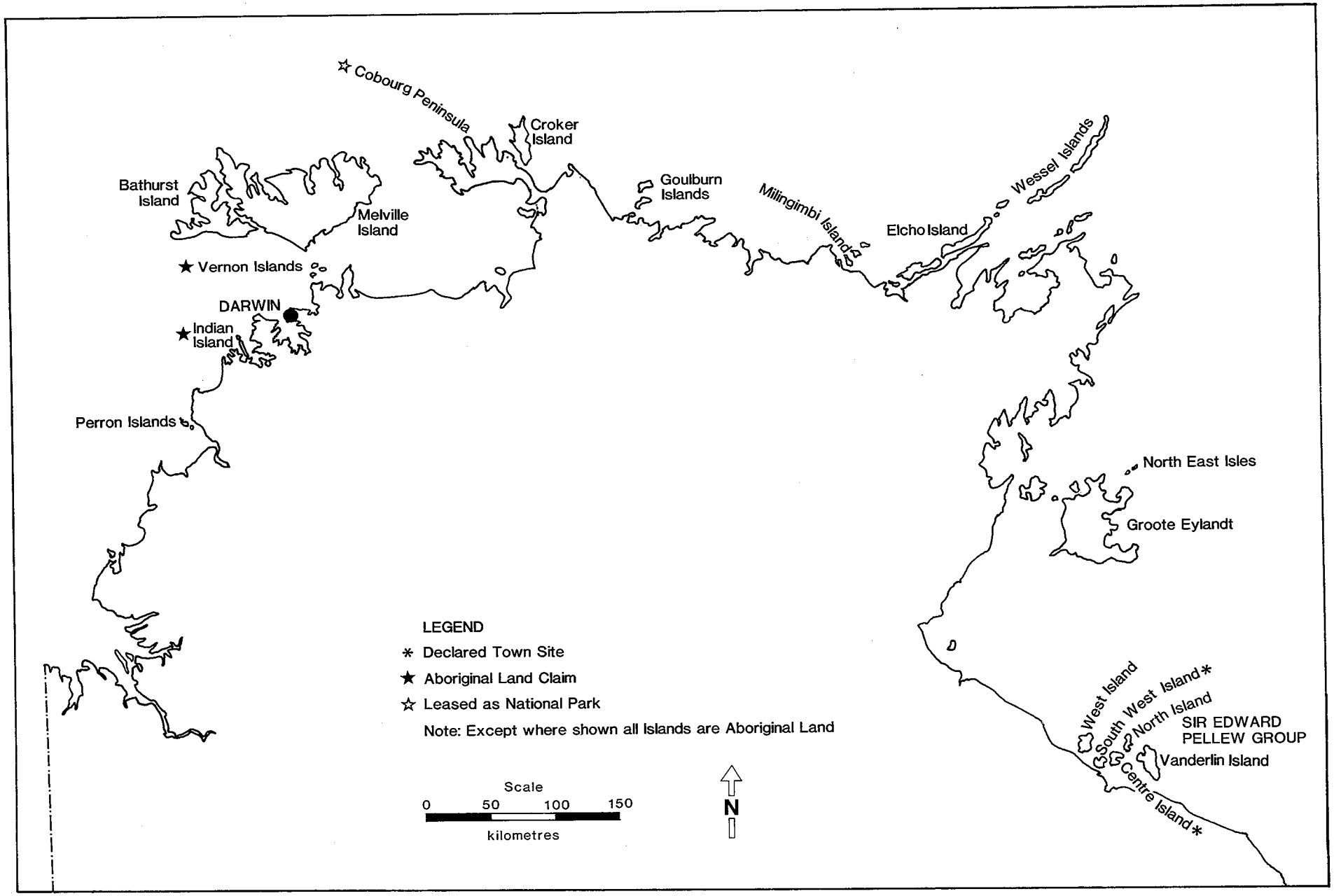
INTRODUCTION

The island ecosystems of the Northern Territory are little known and little managed. The limited information available about them does, however, suggest that they are very important ecologically, especially as they provide important dugong habitats and turtle feeding and nesting grounds. The Conservation Commission of the Northern Territory, in discharging its responsibility for conservation in the Northern Territory, is now looking more closely at marine environments and island ecosystems. It is also facing up to the reality of Aboriginal ownership of or interest in the majority of offshore islands along the Northern Territory coastline. In so doing, it is coming to grips with alternative Aboriginal conservation perspectives and is seeking ways of incorporating these perspectives in joint management arrangements or other forms of cooperation. This paper documents this process.

BACKGROUND

The Northern Territory coastline is fringed by a number of small island groups and several quite large islands (Map 1). The small island groups include the Sir Edward Pellew Group, the Wessel Islands, the Goulburn Islands, the Vernon Islands, Indian Island, and the Perron Islands. The larger islands include Croker Island, Melville Island, Bathurst Island, Groote Eylandt with its surrounding small islands, and Cobourg Peninsula (Gurig National Park). While Cobourg Peninsula is not strictly speaking an island as it is connected to the mainland by the narrowest of necks, it features what is essentially an island ecosystem and shares management problems common with offshore islands.

Most of these islands (Groote Eylandt, the Wessel Islands, Goulburn Islands, Croker Island, Melville Island, and Bathurst Island were Aboriginal Reserves for many years) were converted to Aboriginal land under the **Aboriginal Land Rights Act (N.T. 1976).** Indian Island and the Vernon Islands are currently under claim by Aboriginal people under the same Act. Cobourg Peninsula (Gurig National Park) became Aboriginal land under the **Cobourg Peninsula Aboriginal Land and Sanctuary Act, 1981.** Under this Act, the area is leased back to the



Map 1 – N.T. ISLANDS

Conservation Commission for management as a National Park which is controlled by a Board with an Aboriginal majority. Following the outcome of the Borroloola Land Claim, the situation with respect to the Sir Edward Pellew Group of islands is complex. Two islands, Vanderlin and West Islands were successfully claimed as Aboriginal land and Commonwealth freehold title will be handed to the claimants. Two other islands, Centre Island and South West Island, have been gazetted as town sites by the Northern Territory Government with a view ultimately to provide port facilities in the area for Mt Isa mines. The remaining island, North Island, was not granted to Aboriginals, but it was recommended that the Northern Territory Government negotiate with Aboriginals concerning its future and these negotiations are proceeding at the moment.

It is clear that with the exception of Vanderlin, West and North Islands within the Sir Edward Pellew Group, nearly every other island in the Northern Territory is under Aboriginal ownership or is being claimed under the Aboriginal Land Rights Act. This applies also to the parks and reserves currently managed by the Conservation Commission. Cobourg Peninsula (Gurig National Park) is under Aboriginal ownership, and the Vernon Islands Conservation Reserve and the Indian Island Forest Reserve are both currently under claim. In addition, it is likely that title to North Island within the Sir Edward Pellew Group will be vested in the Aboriginal people with some arrangement for lease back to the Conservation Commission for conservation purposes.

It is self evident that the conservation of island ecosystems in the Northern Territory will depend entirely on the establishment of a satisfactory working relationship between Aboriginal interests and the Conservation Commission. Success or failure in achieving this will have a big bearing on the ability of the Conservation Commission to discharge its responsibility for the management of the Territory's ecosystems, in this case the island ecosystems. Cooperative management may be seen as a long-term investment in future conservation for the Northern Territory. The Conservation Commission is awakening to the fact that this is where the future of conservation in the Northern Territory lies and that often it will be the case that *some* conservation is better than no conservation.

In some respects, Aboriginal ownership has contributed to the conservation of the Northern Territory's island ecosystems. For the most part, the islands have not been open to exploitation, sub-division etc., although there is a major mining development on Groote Eylandt. In some other respects, however, Aboriginal ownership has led to a deterioration of island ecosystems, but this is not well documented. In some cases, particularly where there is a feral animal population, lack of management has led to the multiplication of feral animals within the confines of an island with resulting severe destruction of vegetation and soil erosion.

WHAT HAPPENS WITHOUT COOPERATIVE MANAGEMENT: THE CASE OF NORTH-EAST ISLAND

North East Island[1] is the largest of a small group collectively called the North East Isles (Map 1). These are small islands in the vicinity of Groote Eylandt. North East Island is 14 kilometres north-east by boat from Umbakumba Settlement. Rainfall is around 1 500 millimetres per year with significant falls occurring in the 'dry season'. It has an automatic weather station and a lighthouse.

The island is formed from ancient uplifted coral, sandstone and conglomerate rock overlay with sand. The eastern end has a high dune system covering 2 square kilometres and rising to 63 metres at the lighthouse. Slopes are steep and because of the recent erosion, exposed rock and coral is common on the windward or eastern side. Vegetation, now almost totally gone, consists of large clumps of *Spinifex longifolius* and the odd small tree and pandanus in the swale areas.

Coral, exposed by wind and water erosion, takes the form of sharp pinnacles up to 0.7 metres high. On the leeward side of the high dunes, a steep sloping face of deep sand is creeping eastwards, gradually covering mangroves, low shrub and other trees of the low lying areas.

An adjoining small area of the southern tip gives an excellent reference for the vegetation and soil status which would have existed before the degradation.

The lowlands to the east consist of approximately 3 square kilometres of low sand dunes to 20 metres elevation, covering sandstone and conglomerate rocks which are exposed at the shore line. Mangroves, casuarinas, eucalypts and rainforest species form low

1 This case study is drawn from a Report by Ian Melville, Soil Conservation Officer, Land Conservation Unit, Conservation Commission, N.T.

forest and woodland. Pandanus clumps are common in low areas which are not saline. A few permanent fresh water soaks occur within this area.

Feral animals

Goats and deer were introduced from Umbakumba some 50 years ago. Except for spasmodic shooting, their numbers have been sufficiently maintained to destroy most of the palatable grasses and forbs.

Monitoring from 1970 onwards reveals marked changes in degradation and erosion. A black and white print taken on the headland of the weather station site in August, 1970 shows a good ground cover of *Spinifex longifolius*. Similarly prints taken in November, 1972 show a serious decline in the amount of spinifex cover and an increase in dead scrub land. At the same time, the higher dune system is showing signs of degradation on its leeward face. Photographs taken in 1983 show greater degradation of vegetation and wind erosion and a marked increase in the degradation of the high dune system.

Commission Involvement

In April, 1985 the Senior Wildlife Ranger reported that traditional owners were expressing a desire to relocate feral animals to neighbouring islands where they would also exist in feral state. Because of the monitoring which has occurred on North East Island, following a rehabilitation project at the Bureau of Meteorology's automatic weather station, it is quite apparent that the populating of other islands with feral animals would be ecologically disastrous.

Recently a Soil Conservation Officer and Senior Wildlife Ranger visited the island to discuss the problem with the traditional owners and to determine their attitudes to destocking and rehabilitation. So far these discussions have been inconclusive, but it is apparent that to the traditional owners the feral animals are seen as a valued resource. Although, under the Soil Conservation Act, the Conservation Commission could demand the destocking of the area, this would not assist any future negotiations for the management of the Northern Territory's island ecosystems. Consequently, the Conservation Commission is faced with the need to accommodate Aboriginal aspirations while at the same time providing for proper management for conservation. In this case, the possibility might be the retention of a small herd of deer on the low lands separated from the high dunes by a deer proof fence. However, considering its degraded condition, the carrying capacity of the low lands should not exceed about 20 head in order to prevent further ecological decline. It would be necessary to maintain this level for many years to come.

It is quite clear that some form of well established cooperative management mechanism is required to protect island ecosystems similar to that of North East Island. It is from this point of view that the initiatives being taken at Cobourg Peninsula (Gurig National Park) and in other inland parks where Aboriginal people are involved, should be regarded as of critical significance for the management of the Northern Territory's island ecosystems.

JOINT MANAGEMENT FOR CONSERVATION IN THE NORTHERN TERRITORY: THE EVOLUTIONARY PROCESS

The ultimately successful management of the island ecosystems in the Northern Territory will depend upon the continuation of a process which has been developing over recent years. This process is an evolutionary one beginning with strong European ethnocentrism in conservation matters and gradually leading through the establishment of a park estate which makes provision for Aboriginal involvement and for joint management, to cooperative endeavour/joint management for conservation of threatened and/or significant ecosystems on Aboriginal land (Figure 1).

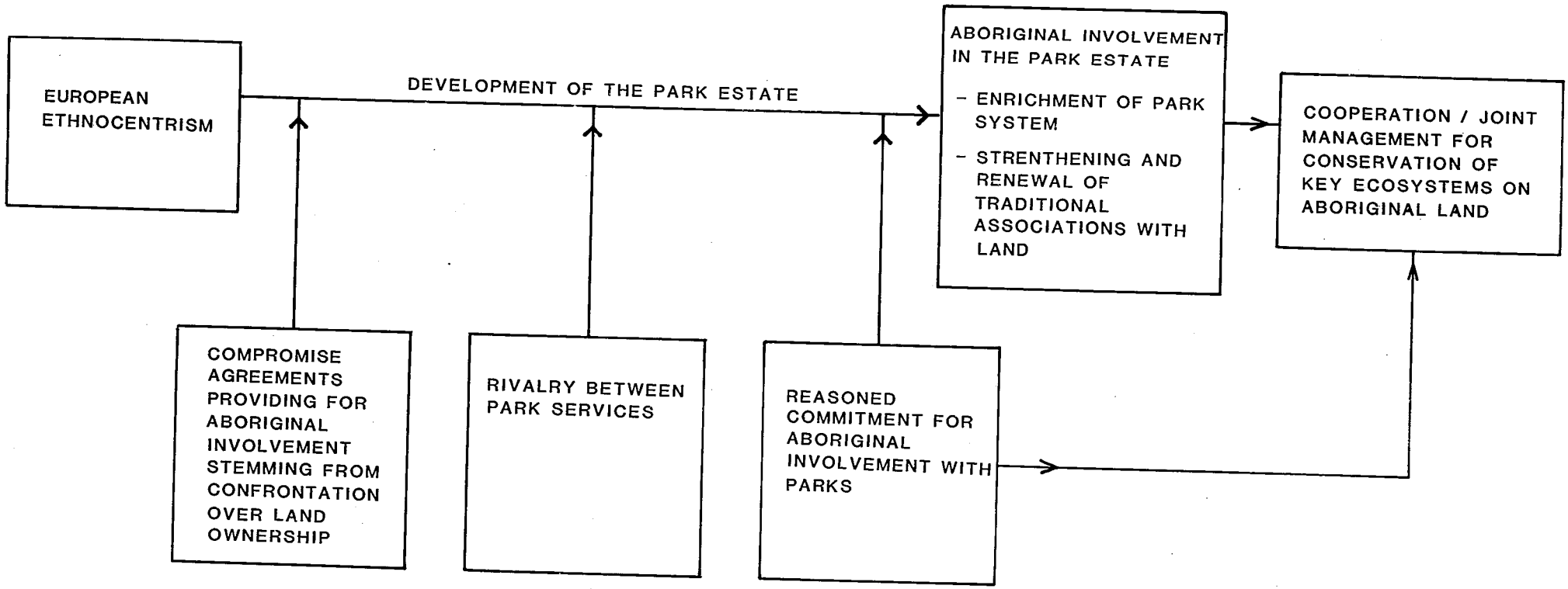
Ethnocentrism is a common human trait. Dominant cultures tend to do things and see things their way. So, despite the fact that approximately one third of the Northern Territory's population is Aboriginal, management for conservation in the Northern Territory does not reflect this; it is largely a system of management which has derived from 19th century European thinking about the preservation of nature. By and large, it does not recognise traditional Aboriginal ties and responsibilities; nor does it recognise the fact that the so called beauty which has often formed the basis for an area to be conserved, is a result of many centuries of traditional habitation and management. Our parks and reserves, derived in concept largely from 19th century American experience, are regarded for the most part as areas with no room for people other than as visitors.

It is possible to recognise an evolutionary process which has occurred in recent years and which is leading away from European ethnocentrism in management for conservation in the Northern Territory, toward close involvement of Aboriginal people in that management. Although this process was initially concentrated on the development of parks and was sparked off by conflict/compromise over land ownership and has been spurred on by

Fig. 1

JOINT MANAGEMENT FOR CONSERVATION IN THE NORTHERN TERRITORY

– THE EVOLUTIONARY PROCESS



rivalry between park services, reasoned commitment to the idea is growing in both conservation agencies in the Northern Territory. Increasingly, deliberate attempts are being made to involve Aboriginal people in the management of parks and to recognise that their traditional ecological knowledge and resource management practices can be used to good effect. There is every hope that with some of the initiatives currently being taken in the Northern Territory, the necessary imagination and effort will be deliberately applied to ensure that the ethnocentrism inherent in existing management for conservation is overcome. The full involvement of Aboriginals in the policy planning and management of the park estate, the recognition of their skills and their involvement in other conservation management should be seen as a logical development and as making a positive contribution to the development of a system of conservation management which better reflects the population characteristics of the Northern Territory. It may also be used as a yardstick against which to measure the success or otherwise of initiatives taken.

The evolutionary process may be traced through the development of several major parks.

Kakadu National Park

The establishment of Kakadu National Park lies somewhere at the beginning of the evolutionary process. Established in 1979, it was the first major Northern Territory park with an officially recognised Aboriginal involvement. However, despite the fact that Kakadu Park is owned freehold by the traditional owners through the Kakadu Aboriginal Land Trust, Aboriginal involvement in the first Plan of Management, (1980-1985), was minimal. The required consultation with the Northern Land Council was perfunctory, and many important issues relating to the lifestyle of the Aboriginals resident on Kakadu Park were not addressed in the Plan of Management. It is clear that the Aboriginals were seen at the time as something to be allowed for and tolerated, but there is certainly no indication of a movement to integrate Aboriginal culture and lifestyle with the Park in a positive sense or to encourage Aboriginal contributions to park management.

Despite the limitations of the first Plan of Management, on-ground dealings with the Aboriginal people have extended well beyond mere tolerance but not as far as genuine involvement in park management. There is no formal mechanism providing for joint management of the Park with the traditional owners. The Advisory Committee established under the plan of management has proved to be entirely ineffectual and largely non-operative. But there has been some involvement through employment both as rangers and as cultural advisors and through the judicious selection of staff who have established friendly informal relations on a day-to-day basis with the traditional owners.

Cobourg Peninsula (Gurig National Park): A step further

As mentioned above, Cobourg Peninsula, linked tenuously to the mainland by a very narrow neck, shares many of the characteristics of island ecosystems. As it is also the area where the greatest efforts have been made in the attempt to development an appropriate mechanism for joint management for conservation, it may point the way for the management of the Northern Territory's island ecosystem.

The Park occupies an area of some 2 207 square kilometres and include the Cobourg Peninsula and most of the surrounding islands. A deeply indented coastline with seemingly endless curved sandy beaches provides a key attraction for visitors to the area. The interior of the peninsula is largely a wilderness of mixed eucalypt forest including in some areas dominant stands of the Kentia palm (*Gronophyllum ramsayi*), tidal swamps and lagoons fringed by paperbark forest, numerous small patches of monsoon forest/vine thicket in areas where there is a local abundance of moisture, coastal plains of grass and sedge, and dunes colonised by casuarinas.

Scattered through Cobourg Peninsula are reminders of the past history and occupation of the area. Tamarind trees around the coastline often indicate sites used for the processing of trepang (sea slug) by the Macassan traders who regularly visited Cobourg Peninsula shores during the monsoon season. The historic ruins, especially those of Victoria Settlement on the shores of Port Essington, serve as a reminder of previous futile attempts by Europeans to take over and 'develop' Cobourg Peninsula. The ruins, now surrounded by forest convey very well the sense of isolation and desperation that must have prevailed in those early days.

For the traditional owners, Cobourg Peninsula is more than a beautiful area; it is productive land which provides them with valued resources. Their traditional management practices, including burning, have over the centuries, ensured the maintenance of this productivity. For them, the Park has a variety of values. they perceive an essential intimacy between themselves and their land involving a complexity of rights, benefits, responsibilities and obligations. The land (natural environment) and may specific sites within the Gurig Park are invested with spiritual and

other significance. In addition, as the setting for their cultural development and adaptation, the Park provides for the traditional owners a range of natural resources supplying food and other material requisites.

Under the **Cobourg Peninsula Aboriginal Land and Sanctuary Act, 1981**, the land of Cobourg Peninsula is declared a sanctuary to be held in perpetuity and managed as a national park for the benefit and enjoyment of all people. the Act also acknowledges and secured for the future the right of Aboriginal people traditionally associated with the area to use and occupy the land and to participate in the management of the Park. In terms of Aboriginal involvement, Gurig National Park may be seen as a further stage in the evolutionary process. Aboriginal participation in the management of the Park is guaranteed under the Act.

The Act sets out a formal structure for Aboriginal involvement and participation in management and policy for Gurig National Park. The Park is administered by the Cobourg Peninsula Sanctuary Board. The Board consists of eight members appointed by the Minister, four of whom are traditional owners with the remaining four being members of the Conservation Commission. The Chairman, who is a traditional owner, has the casting vote. The functions of the Board are: (a) to prepare plans of management for the control and management of the Park; (b) to protect and enforce the rights of the traditional owners to use and occupy the Park; (c) to determine, in accordance with the Plan of Management, the rights of access to parts of the Park of persons who are not traditional owners; (d) to ensure adequate protection of sites on the sanctuary of spiritual or other importance in Aboriginal tradition; and (e) such other functions in or in relation to the Park as are imposed by or under the Plan of Management.

The functions of the Conservation Commission in relation to the Park include, on behalf of and subject to the directions of the Board; (a) the preparation of plans of management; and (b) the control and management of the Park. For the use of the Park, the Northern Territory Government pays to the traditional owners an annual fee of $20 000 indexed to the CPI.

This movement towards the formalisation of Aboriginal involvement in the park enterprise is framed in the Act, which came into existence as the negotiated settlement of the traditional owners' land rights claim on the Cobourg Peninsula under the federal **Aboriginal Land Rights (Northern Territory) Act, 1976**. So, even this progress towards the formalisation of Aboriginal involvement on Cobourg Peninsula may be seen as a political compromise stemming from confrontation over the ownership of land.

Gurig National Park also provided for increased Aboriginal involvement in the planning process. A Plan of Management for Gurig Park was prepared by the Conservation Commission after extensive consultation with the traditional owners.

The Plan of Management for Gurig National Park reflects lessons learned from the Kakadu experience. It does address questions of Aboriginal lifestyle, living areas, recreation areas, employment, training, economic opportunities, resources. Aboriginal views and concepts were incorporated throughout the planning process and are reflected throughout the Plan of Management document.

Some lessons were not learned. The document is lengthy and complex and as such is unusable by the traditional owners. Despite an effort to encourage the involvement of all the traditional owners in developing the final Plan of Management through a video explaining the recommendations of the Plan of Management in both the Iwaidja language and English, the complexity of the document defies easy understanding by the traditional owners, and it certainly does not translate easily into their own language. All that can be said about the video is that it covers the main recommendations of the Plan of Management to the point were the community should not be surprised by anything which the Plan of Management contains or by any development which occur as a result of implementation of the Plan of Management.

Kakadu and Gurig: Launching pads for greater commitment

The basis for Aboriginal involvement in both Gurig National Park and in Kakadu National Park has been a political compromise stemming from confrontation over land ownership. This has coloured and substantially influenced models developed in those two parks and raises some questions about the level of commitment to real Aboriginal involvement. Both park agencies however give every indication that their level of commitment in this area is increasing not just as a matter of political expediency but because the experience of Kakadu and Gurig has highlighted the value of involving Aboriginal people in the planning and management of a national park and has sensitized increasing numbers of staff of those agencies to the environmental knowledge and skills which the Aboriginal people have at their disposal. Both agencies give every indication that they are prepared

to learn from the Gurig and Kakadu experiences, and expand their commitment in this area. Although the political backdrop remains, its influence is now less, and the Aboriginal presence is being increasingly seen as adding an important dimension to the concept of a park.

According to Professor Sally Weaver, from the Department of Anthropology, University of Waterloo, Canada, there is a clearly discernable trend from Kakadu to Gurig. "This trend appears to have moved from informal (Kakadu) to formal (Cobourg) mechanisms for Aboriginal participation, from advisory to authorative roles for Aboriginal owners, from a management focus to a policy and planing focus for Aboriginal input, and from the absence of formal boards to boards composed of Aboriginals and non Aboriginals with policy as well as planning functions." She goes on to point out however that, although Cobourg set the legal precedent for joint management in its Act, in practice it has not yet achieved a joint operational status. In fact, the general conclusion is that neither Kakadu nor Cobourg measure up to the yardstick of real Aboriginal participation in policy, planning or management. Although the mechanisms have been put in place, the implication that the Aboriginals have the resources to bring to the decision-making process (knowledge, skills, authority etc) and the capacity to use these resources, is not well founded.

The respective experiences of Gurig and Kakadu have heightened the sensitivity of both park services towards Aboriginal involvement in general. With not a little sense of rivalry, both services are now looking toward further endeavours in this area and both are actively pursuing new models based upon those earlier ones.

Kings Canyon: Aboriginal involvement from the ground up

Although located in the desert region of Central Australia, the model for Aboriginal involvement being developed for the proposed Kings Canyon National Park is furthest along the evolutionary scale, and holds the most relevance for the conservation management of the Northern Territory's island ecosystems. the area set aside by the Northern Territory Government to be declared as Kings Canyon National Park encompasses 725 square kilometres of outstanding scenery, varied ecosystems with important vegetation and fauna, and fascinating cultural history. Located some 325 kilometres south-west of Alice Springs by road, the proposed park includes the western end of the George Gill Range and features the dramatic landscapes of Kings Canyon and Carmichael Crag, as well as a number of interesting gorges with lush vegetation and shady rock pools. It also extends into the surrounding sandy plains and desert dune country. The area has a very special significance for the Luritja people whose long and intimate association with the land continues into the present with the establishment of three freehold living areas within the boundaries of Kings Canyon National Park. In addition, it is an important centre for recreation and tourism, attracting local, interstate and international visitors in increasing numbers each year. These features combine to make the park a very significant addition to the Northern Territory park system.

Planning, with and for

For the first time in the Territory's history, Aboriginal people are being fully involved in the planning of a park from the ground up.

A Plan of Management was recently prepared jointly by the Aboriginal people with ties to the area, the Conservation Commission and the Central Land Council. These groups have been sitting down at Kings Canyon, a week at a time, discussing issues and working on the draft for the Plan of Management. The resulting document sets management objectives, address current issues, and propose appropriate measures to guide management and development. Because of the significance of the area to the Luritja people, and the establishment of living areas in conjunction with Kings Canyon National Park, it also takes into account the Aboriginal people's wishes and make provision for their involvement in park management and for the maintenance of Aboriginal values.

The presence of the Aboriginal people and their involvement in park management will give a distinct emphasis to the management of Kings Canyon National Park. It is intended that the park should provide Aboriginal people with opportunities for the protection and strengthening of cultural values and for the current expression of their culture on land with which they have been traditionally associated and for which they are regarded amongst Aboriginal communities as having certain rights and responsibilities. Within this context, and against the backdrop of management for the conservation and protection of natural, cultural and scientific values traditionally associated with national parks, the Aboriginal people have expressed their willingness to enable park visitors to have meaningful and positive contact with Aboriginal culture both in its historical dimension and its current expression, to understand more about this culture and chosen lifestyle, and to appreciate Aboriginal conservation perspectives. Within this framework, and in association with a proposed 'wilderness lodge' development, the

Aboriginals propose to run tours for visitors which will explore various aspects of the park and highlight its Aboriginal character.

There is a deliberate attempt here to recognise and incorporate the Aboriginal perspective and even to build the concept of the proposed park around the Aboriginal contribution. It is recognised that there is a need to provide tourists with a counter-balance to the rather negative impressions gained of Aboriginals living in deprived circumstances in and around Alice Springs. It is intended that visitors to the proposed park should have positive encounters with Aboriginal people and gain some appreciation of the cultural history of the region and of the tenaciousness of Aboriginal culture despite the many obstacles over the years. A major conclusion of the Northern Territory Tourism Priorities Plan prepared by the Tourist Commission was that visitors to the Northern Territory expected and looked for an encounter with Aboriginal culture but that, at the movement, this was something they did not find. Developments in this Park are aimed at the partial rectification of this.

A prime aim of management for the park is to reconcile the expressed objectives and aspirations of the Aboriginal people with the conservation objectives normally associated with a national park. A key planning tool in this regard has been a compatibility matrix in which Aboriginal aspirations and objectives are assessed against normal conservation objectives for degree of potential conflict. After much discussion in the field, Aboriginal aspirations and objectives were defined for the areas of (a) culture/Tjukurpa (Aboriginal law)/caring for the country; (b) involvement in park management/ultimate aspirations with regard to Park management; (c) income/employment/economic enterprises; (d) housing/community facilities; (e) education; (f) lifestyle; and (g) health. Each of these categories was further broken down into a number of specific objectives. Table 1 shows a sample page from the matrix. As a planning tool it is proving to be extremely useful. It clearly shows that for the most park there is no real conflict between Aboriginal aspirations and normal conservation objectives, but it does highlight those areas of potential conflict which must be addressed by the Plan of Management, and much of the discussion at Kings Canyon has been concerned with finding appropriate ways to resolve such conflict in a park context. This has led to solutions such as the development of an agreed zoning plan, and the establishment of agreements reached between the Conservation Commission and the Aboriginal people on such things as voluntary restrictions of traditional hunting to specific areas.

Caring for the land - A common goal

It is the common interest in caring for the land which draws the Aboriginal people and conservation interests together in the management of a national park such as Kings Canyon. The land is the single and most important aspect of Aboriginal culture. It is the key to a harmonious way of living which involves residing on, taking care of and maintaining the land. If for some reason, for example dispossession or foreign occupation, Aboriginal people cannot care for and maintain their land, all other aspects of their lifestyles fall out of kilter and eventually collapse. Aboriginals have always known this. It is now recognised as the basic premise in all arguments for the granting of land rights and right of access to land with which Aboriginals have traditional affiliations.

The search for a management model

During all the time spent sitting down and talking at Kings Canyon, a constantly recurring theme has been the search for an appropriate management model for the park, and this matter is still being actively pursued. There is a general commitment on the park of the Conservation Commission to the involvement of the Aboriginal people in the management of the park and the formalisation of that involvement in the Plan of Management. Present thinking is that the Plan of Management should provide for a Local Management Committee which would include in majority Aboriginal representation and would have, within a prescribed ambit, a decision-making role in relation to park management issues of specific concern to the local community. It is intended that the Local Management Committee will be fully involved in future park management planning, including future revisions of the Plan of Management. It will also be represented on interview panels for the selection and promotion of staff in the park, and have a range of other decision-making powers. The extent of Aboriginal representation on the Local Management Committee and the extent of that committee's powers are still matters for discussion. The Minister for Conservation has indicated to the Aboriginal residents of Kings Canyon that the Government would accept a Local Management Committee with an Aboriginal majority. There is a general preference for a local body tailored to local requirements, avoiding the highly structured and rather cumbersome character of the Gurig Board and placing real local decision-making power in the hands of the resident Aboriginal community.

Although these issues are as yet unresolved, the fact that an active search is going on for appropriate solutions, and that the Aboriginal people are taking part in this search, shows how far we have come along the evolutionary trail from the days when Aboriginal associations with parks were merely tolerated or worse.

TABLE 1: SAMPLE SHEET FROM COMPATABILITY MATRIX.

○ NO POTENTIAL CONFLICT
* LOW POTENTIAL CONFLICT
✚ HIGH POTENTIAL CONFLICT

ANANGU OBJECTIVES / CONSERVATION OBJECTIVES	INCOME/EMPLOYMENT/ECONOMIC ENTERPRISES CONTD/2					
	For anangu to establish a fuel depot and retail outlet in one of the living areas.	To establish an art and craft retail centre within the Park.	To provide for controlled stabling of horses in the Wunmera living area and adjistment in another area of the Park for use in a horse trail-riding enterprise.	On a commercial basis, to provide bush tucker tours for visitors in the Lila living area.	On a commercial basis, to provide wild-life photographic expeditions for visitors to the Ulpanyali living area.	In the long term to substantially increase the level of anangu ranger staff in the Park.
To preserve the natural, cultural scientific and educational values of the park.	*	*	✚	○	○	○
To conserve the present distribution and diversity of native plant and animal species in the park.	*	*	✚	○	○	○
To give special protection to vulnerable, endangered, uncommon and rare species of native plants and animals in the park, and also to species which are locally significant.	*	*	✚	○	○	○
To rehabilitate landscapes disturbed by Man's activities, where appropriate.	*	*	✚	○	○	○
To minimise the impact of commercial utilization of park resources on other park values	✚	*	✚	○	*	○
To record and preserve sites of archeological and historical importance. To control exotic plants and animals.	○	○	○	○	○	○
To protect the park and adjacent areas from injury by fire.	○	○	○	○	○	○
To preserve the recreational values of the area and provide for the recreational use and enjoyment of the park by the public.	○	○	○	○	○	○
To monitor and, where necessary control the recreational use of the park.	○	○	○	○	○	○

TABLE 1 continued

CONSERVATION OBJECTIVES \ ANANGU OBJECTIVES	INCOME/EMPLOYMENT/ECONOMIC ENTERPRISES CONTD/2					
	For anangu to establish a fuel depot and retail outlet in one of the living areas.	To establish an art and craft retail centre within the Park.	To provide for controlled stabling of horses in the Wunmera living area and adjistment in another area of the Park for use in a horse trail-riding enterprise.	On a commercial basis, to provide bush tucker tours for visitors in the Lila living area.	On a commercial basis, to provide wild-life photographic expeditions for visitors to the Ulpanyali living area.	In the long term to substantially increase the level of anangu ranger staff in the Park.
To provide opportunities for solitude and adventure in a natural environment by maintaining remote areas largely free from disturbance by man.	O	O	O	O	O	O
To promote a better understanding of the park and its various aspects by providing appropriate interpretation and education facilities and programs.	O	O	O	O	O	O
To provide for the safety of visitors.	O	O	*	O	O	O
To offer a balanced diversity of tourist and recreational opportunities consistent with the conservation of the park's natural values.	O	O	O	O	O	O
To provide an appropriate framework and necessary administrative mechanism and safeguards to ensure the smooth and efficient operation of the park for the achievement of the other objectives.	O	O	O	O	O	O
To encourage appropriate research into the natural environment and cultural history of the park, and into past and present land uses.	O	O	O	O	O	O

COMPATIBILITY MATRIX - ANANGU/CONSERVATION OBJECTIVES

INTERACTIVE CONSERVATION PERSPECTIVES

If it is true that the conservation of the Northern Territory's island ecosystems can only be effectively achieved through some form of co-operative management, it is equally true that much is to be gained in this respect by a sharing of conservation perspectives between the Aboriginal people and the Conservation Commission. Without over romanticising the Aboriginals conservation ideal, it is true to say that the Aboriginal conservation perspective contains lessons for the management of sensitive ecosystems such as those found on islands. Equally, proper conservation will be enhanced by an Aboriginal understanding of modern conservation techniques. A joint management arrangement provides an ideal framework within which the Conservation Commission may learn to incorporate Aboriginal perspectives in its management of island ecosystems and Aboriginal people may learn some of the benefits of modern conservation management.

Because Aboriginals have cared for this country for many centuries, it is often assumed that they are natural conservationists. This is not always a valid assumption. Aboriginals with modern technology at their disposal can be equally as destructive of their environment as other social groups. Nevertheless, it is true to say that Aboriginal culture embodies a deep commitment to caring for their country and it would be difficult to find an individual Aboriginal person without some underlaying empathy for the philosophy of conservation. Within the framework of a co-operative management arrangement these deep commitments may contribute positively towards the common endeavour.

One must, however, be prepared to accept that Aboriginal culture is not always guided by Aristotelian logic preoccupied as it is with cause and effect, and often exhibits apparent inconsistencies. So, for example, the people of Cobourg Peninsula will argue that the marine resources (turtle, dugong, crabs etc) are inexhaustible. They have an unfailing belief of never-ending abundance, and when questioned about the possibility of over-exploitation, invariably reply with "Can't finish him up". Yet, they are conscious at the same time that some of the marine resources are dwindling. They are aware, for example, that dugong are now very scarce, and blame the prawn trawlers for frightening the dugong away, but are not prepared to listen to suggestions that their hunting of the dugong may be responsible for dwindling numbers on the northern shores. They are also very responsive to arguments for conservation for their children and grandchildren. It is a clear tenet of Aboriginal culture that abundance available to one generation should be passed on to the succeeding generation. It is this argument which holds most sway in drawing Aboriginal people into co-operative management for conservation. They see that, from many points of view, the objectives of the Conservation Commission and their own objectives coincide. However, they don't always understand our concept of a national park. Often, they regard the developments that are part of a national park, for example, toilets, picnic areas, walking trails, as an unnecessary clutter and often see pastoral properties without this clutter as being closer to their concept of a conserved area than our national parks.

NORTH ISLAND: WHERE THE FUTURE LIES?

As mentioned above, the resolution of the Borroloola Land Claim resulted in complex provisions for the Sir Edward Pellew Group of islands with the Land Commissioner recommending that the future of North Island should be the subject of negotiations between the Northern Territory Government and the Aboriginal people. These negotiations are continuing and have been protracted. They are taking place on the basis of a possible offer of freehold title to the traditional owners, but with provision for a lease-back to the Conservation Commission for conservation purposes.

Following fauna surveys conducted by the CSIRO Division of Wildlife Research in 1966-67, the CSIRO recommended that North Island and other islands in the Sir Edward Pellew Group should be reserved as high security fauna sanctuaries. It was noted that North Island had never been grazed and had suffered very little burning. The adjacent mainland had been extensively burnt annually and was being grazed by cattle with resultant catastrophic effects on the native species of wildlife.

North Island has some special features. It contains small areas of stunted monsoon forest that is found in this region only on islands in the Sir Edward Pellew Group. This vegetation is the habitat of certain bird species such as the Red-crowned Pigeon (*Ptilinopus regina*) and the Emerald Dove (*Chalcophaps indica*). This vegetation and the birds that inhabit it are found nowhere else in the McArthur River region. One species of small mammal, the red-eared marsupial mouse (*Antechinus macdonnellensis*) was found on North Island and not elsewhere in the region. This is an outlying population of a Central Australian species. A substantial colony of rock-wallaby (*Petrogale brachyotis*) occurs on North Island. This species has suffered a great decline in the region during the last sixty years and it was found

only on North and Centre Islands and in one small colony on Bauhinia Downs Station.

The marine fauna is also of special interest. These islands and surrounding islets and stacks are breeding grounds for seabirds. North Island, including Paradise Bay, and small sandy islets nearby are breeding grounds for marine turtles, one of which, the flatback turtle (*Chelonia depressa*) is an endemic Australian species. Marine turtles have been heavily exploited for food in most parts of the world and the largest populations are now found in northern Australia. The dugong *Dugong dugong*) is another species that is common in the Sir Edward Pellew Islands. It as also been heavily exploited for food in the rest of its range around the northern Indian Ocean and the Southwest Pacific. the populations at the bottom of the gulf are believed to be the largest now existing. The marine turtles and the dugong are listed as endangered fauna by IUCN. As far as possible, these animals should not be disturbed, and the seagrass beds protected.

It is not surprising that the CSIRO continues to believe that these are compelling reasons supporting their original recommendation that North Island should be gazetted as a high security nature reserve, and that, should people be allowed entry to the island, no burning of vegetation be allowed, firearms and domestic animals, especially dogs and cats, be banned, and disturbance to the rock wallabies, nesting colonies of turtles, seabirds and dugongs be avoided.

Of course, all this is easier said than done. If the Aboriginal people are to be granted title with a lease-back arrangement to the Conservation Commission, then either the existing legislation will need to be changed to enable this to occur, or the area would need to be managed under a separate Act as at Cobourg Peninsula (Gurig National Park). There is general agreement that a multitude of such Acts is undesirable, and therefore the Northern Territory Government is exploring the possibility of amending **The Territory Parks and Wildlife Conservation Act** to enable the Conservation Commission to declare a park or reserve on Aboriginal-owned land, should such an agreement be reached with the traditional owners.

It is clear that, if the interests of all parties are to be looked after, an appropriate mechanism for joint management of North Island by the Conservation Commission and the Aboriginal traditional owners needs to be put into place. The priorities of the two groups differ somewhat.

Conservation Commission priorities for management of North Island include protection from fire, exclusion of dogs, cats, cattle and other animals and plants exotic to North Island, prevention of illegal hunting, restricting of occupancy to that required in the interest of management or enjoyed as a matter of prior right, and general environmental protection precluding any major habitat disturbance.

For the Aboriginal people, North Island has other significance. The Sir Edward Pellew Group is regarded as forming part of the traditional lands of the Yanyuwa people, and for these people the islands are important cultural and religious areas. They rely on them for traditional economic pursuits. The islands also contain important sacred sites and burial areas, as well as providing the Yanyuwa with a large percentage of their traditional 'bush food' intake. Plants, fish, sea turtle and dugong are still hunted and collected regularly and this activity also provides an important social activity of the Yanyuwa. None of these resources are exploited indiscriminately. Techniques are by and large traditional, and the capture, butchering, preparation and distribution are governed by strict rules of social behaviour. On a yearly average, the Yanyuwa take approximately thirteen dugongs and a slightly higher number of sea turtles. By comparison, there are reports of up to five dugongs drowned in barramundi nets in one tidal period and others shot with high powered rifles by professional fishermen operating in the area.

In this case where there are two clear sets of values, adequate conservation of North Island will depend upon a sharing of conservation perspectives and reconciliation of those values. If the Conservation Commission can accept this challenge and achieve effective joint management of North Island, then it augurs well for the conservation of other Northern Territory islands.

CONCLUSION

The conclusion is a very simple one. Because of the Northern Territory's islands largely belong to Aboriginal people, the adequate conservation of island ecosystems is dependent upon the Northern Territory Government joining with Aboriginal people, learning together with Aboriginal people, sharing conservation perspectives, reconciling differences, and reaching agreements for the joint management of these important ecosystems.

Changes in Species Composition of the Avifauna of Rottnest Island, Western Australia

D.A. Saunders and C.P. de Rebeira

CSIRO, Division of Wildlife and Ecology, LMB, No. 4, PO Midland, W.A. 6056

Abstract

Rottnest Island (1900 ha) is an A class Reserve and is one of more than 200 islands larger than 10 ha off the coast of Western Australia. The island is gazetted for "Public Recreation" and since 1917 has been a popular tourist resort. The island is unique in that it has a chain of hypersaline lakes which occupy 10% of the surface of the island and attract large numbers of wading birds, including several species of transequatorial migrant.

Over the last 100 years changes in land use and poor management have resulted in extreme degradation of the island's ecosystem with consequent changes to the island's avifauna. There have been 3 recorded extinctions of land bird species breeding on the island and ten land bird species have established themselves on the island since 1904. Of these changes, only 3 of the immigrations were not directly influenced by human activities.

The changes in composition of the island's avifauna we discussed and the need for ecologically based management is pointed out.

INTRODUCTION

There are more than 200 islands larger than 10 ha off the coast of Western Australia. Rottnest Island is one of the medium sized islands (1 900 ha) but is unique for two reasons; one social and the other environmental. The island is an A class Reserve whose gazetted purpose is "Public Recreation". It lies 18 km off the coast of Perth and is a major tourist resort run by a Government utility, the Rottnest Island Authority. The island is one of a chain of three (Fig. 1), the other two being restricted in access. This is because the smallest (Carnac Island, 16 ha) is an A class "Flora and Fauna Reserve" with a thriving colony of the Tiger Snake *Notechis scutatus* and the other island (Garden Island, 1 100 ha and 2 km off the coast) is owned by the Department of Defence and is the site of H.M.A.S. Stirling. Visitors are only allowed ashore during daylight and only if they visit by boat.

Rottnest Island features largely in the Western Australian ethos (Seddon 1983) and is a very popular tourist resort for both day trippers and overnight visitors. As a result, the island is under considerable pressure from humans and over 200 000 visit the island annually. During peak periods (Easter, long weekends, etc.) over 9 500 may be present (i.e. 5 people/ha or 296/km of coast) during the day. The continued existence of the island as a tourist resort has resulted in increasing demands for the development of the island to provide more facilities for holiday makers (Rottnest Island Management Planning Group 1985). This pressure is increasing all the time.

The environmental reason for the island's unique status is the existence of a chain of hypersaline lakes which occupy 10% of the surface of the island and dominate the eastern end (Fig. 2).

Over the past 100 years, changes in land use on the island and poor management of the resources of the island have resulted in extreme degradation of the ecosystems functioning on Rottnest Island. This paper explores the results of this degradation as reflected by the avifauna of the island.

MANAGEMENT HISTORY

The management of the island has had several distinct phases. The island was separated from the mainland about 6 500 years ago (Playford 1983) and since then the sea level has changed several times. During these changes the island consisted of several islands, then assumed its present shape. As far as records can determine, Aborigines did not occupy Rottnest Island after its isolation, referring to it as Wadgemup (= place across the water). The first Europeans to visit the island gave descriptions which indicate that much of the island was covered by *Melaleuca, Callitris* and *Acacia* woodland, essentially similar to that covering Garden Island today (Seddon 1972). After an

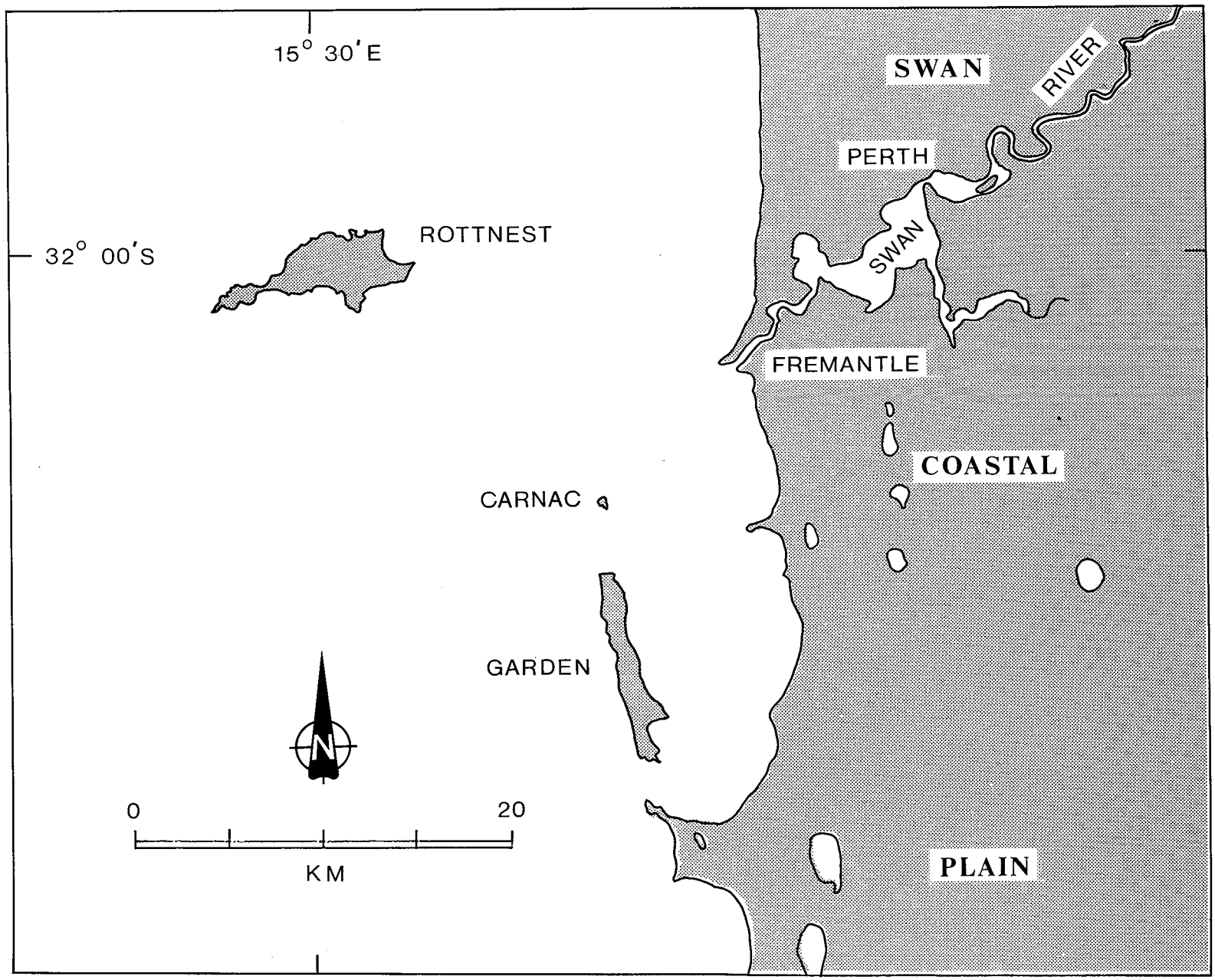


Figure 1.
Map of Swan Coastal Plain and adjacent sea showing position of Rottnest, Carnac and Garden Islands

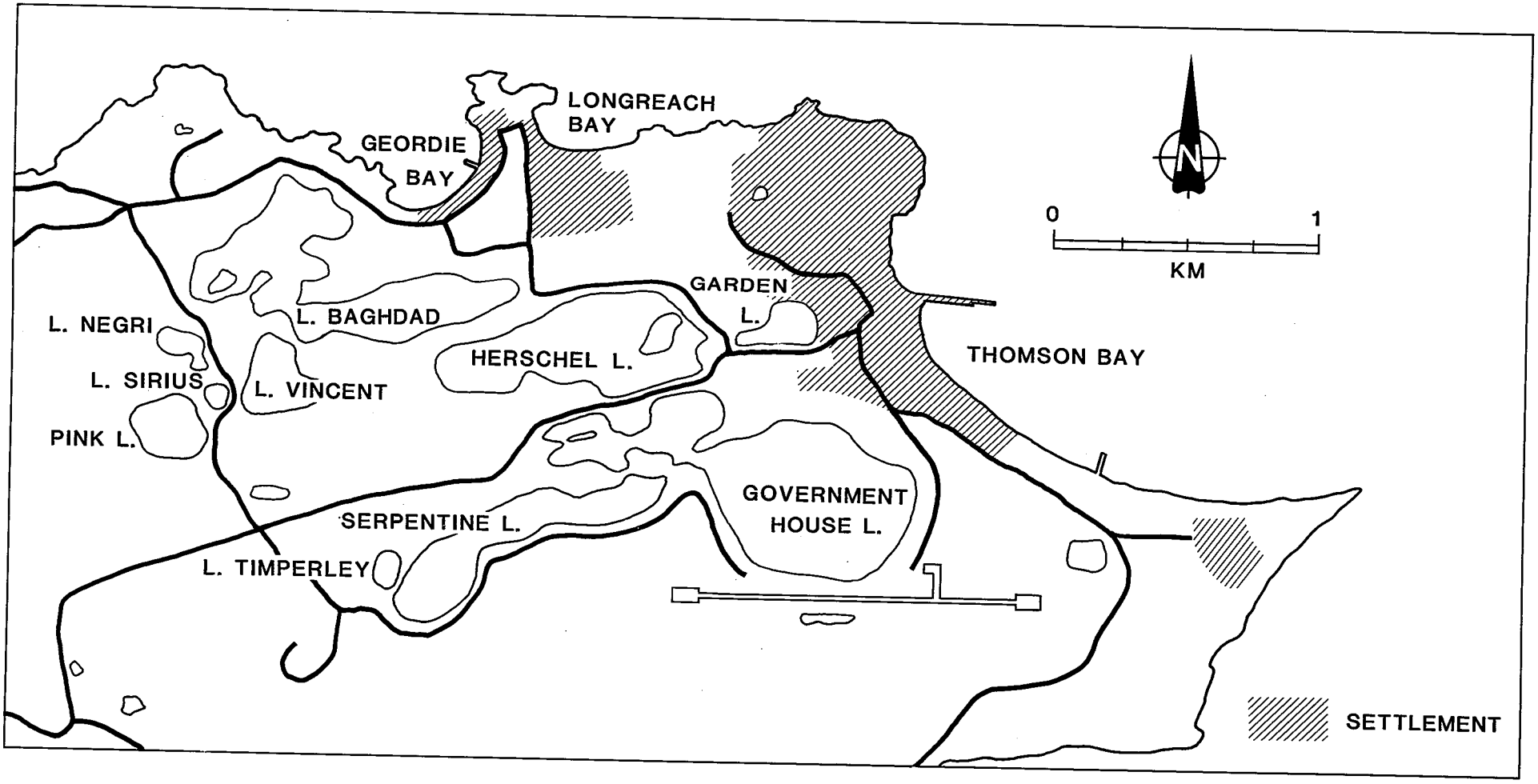


Figure 2.
Map of the eastern half of Rottnest Island showing the salt-lake complex.

unsuccessful farming venture, in 1838 the island was designated as an Aboriginal prison with various prison superintendents erecting limestone buildings at the eastern end of the island (Thomson Bay). Most of these buildings form the historic precinct of the present day main settlement. During this era, which lasted until 1903 the vegetation was extensively modified as clearing took place; first for agricultural venturers, then to improve visibility for the governor of the Swan River Colony. He visited the island for holidays and took out shooting parties. These parties hunted the quokka *Setonix brachyurus* and the banded stilt *Cladorhynchus leucocephalus*. This species was known as the "Rottnest Snipe" and prisoners were used as beaters to drive the birds towards the guns lurking in brushwood hides besides the lakes.

In 1903, a far-sighted governor declared the island an A-class Reserve for public recreation, and the second stage of management began. This has continued until the present day with the exception of two discrete periods when the island was controlled by the Department of Defence. During the Great War, there were 1 300 German prisoners of war held on the island for 15 months and during the World War there was a large garrison of troops housed on the island. The remains of the barracks, gun emplacements and dugouts may be seen at various points over most of the island.

During the 1960s and 1970s there was a period of development with the settlement at Thomson Bay being expanded and a second settlement being established at Geordie and Longreach Bays.

At no stage during the development, until 1983, was there any apparent plan for the management of the island as a whole. This oversight has resulted in the present degradation of the island and several managerial acts of ecological vandalism.

Basically, since April 1917 the management of the island has been the direct responsibility of a Board of Control (now called the Rottnest Island Authority) which has its own set of by-laws which include the protection of all flora and fauna and the island's land surfaces. Apparently this particular charter has been consistently ignored.

CHANGES IN VEGETATION

The changes in the vegetation of the island have been well documented by several authors. Pen and Green (1983) provide a detailed account of these together with a comprehensive reference list. The extent of the change is illustrated by the fact that in 1919 about 66% of the island was believed to have been covered by *Melaleuca* and *Callitris* woodland or *Acacia* scrub. By 1941 this was reduced to 23%, by 1956 to 18% and is less than 8% at present (Pen and Green 1983). The extent of the former woodland can be appreciated by walking through most of the areas of heath on the eastern two-thirds of the island and seeing the size of the dead trees still littered on the ground. *Melaleuca* now dominates the remnant woodland and the few *Callitris* that remain are dying. In fact, this species may soon become extinct on the island. *Acacia rostellifera* still occurs in patches the length of the island. Both *Melaleuca* and *Callitris* are fire-sensitive species and this is the cause of the elimination of most of the woodland.

At present the island consists of small areas of *Melaleuca* woodland, *Acacia* scrub, heath (dominated by exotic species) and various areas of plantation mostly consisting of exotic species like *Tuart, Eucalyptus gomphocephala* and coastal Moort *E. platypus* with smaller areas of *Melaleuca* and *Callitris*.

SURVEYS OF THE AVIFAUNA

Rottnest Island is the best studied island around the coast of Western Australia and is, in fact, one of the best surveyed islands in the world as far as birds are concerned. The first documented account of the avifauna was given by Lawson (1905) who spent several weeks collecting specimens in 1904 and most of these are lodged in the Western Australian Museum. In 1929 Glauert published an annotated list based on his observations and those of other ornithologists visiting the island, including D.L. Serventy. The most well documented list was published by Storr (1964, 1965a and 1965b) who made 62 trips to the island over nine years until 1962, spending a total of 275 days there. Storr's records included those of his colleagues and he had a copy of Glauert's 1929 paper in which Glauert had noted records made after he published the paper.

Between 19 December 1981 and September 1984 we made over 30 trips to the island at approximately monthly intervals in 1982, 1983 and the first half of 1984. Since then we have visited the island irregularly. Our visits lasted from two to five days and during each visit we identified and counted the birds around the salt-lakes and swamps, around the coast, visited each of the habitats and caught and banded birds in some woodland areas, the heath and among caves and buildings. The results of this work have been published in Saunders and de Rebeira (1983, 1985a, 1985b, 1986). In addition Storr provided us with the species cards forming the data set for his three papers of 1964/65 and these data allowed us to compare the changes in abundance of waders on the island in the 22 years between his surveys and those made by us (Saunders and de Rebeira 1986).

CHANGES IN THE AVIFAUNA

MacArthur and Wilson's (1964, 1967) theory of island biogeography proposed that the number of species existing on an island is in dynamic equilibrium between immigrations and extinctions and that this process results in the turnover of the species existing on the island. The rate of this change is dependent on the rate of immigration and the rate of extinction. There has been a great deal of discussion about turnover rates and methods of evaluating these rates. We have discussed this subject elsewhere (Saunders and de Rebeira 1985a) so we will not dwell on it here except to note that between 1904 and present there have been three recorded extinctions and 10 immigrations of land bird species on or to Rottnest Island. None of the extinctions and only three of the immigrations could be regarded as valid for calculating natural turnover rates. In other words, all of the extinctions and seven of the immigrations have been directly or indirectly attributable to human influence. Basically, for the 80-odd years since 1904, the avifauna extinction rate (for non-marine species) for the island was zero; the immigration rate for non-marine species of bird was 0.04%/year and the relative turnover rate was 0.12% of species/year. That is, immigrations and extinctions are infrequent and turnover of breeding species is also infrequent, especially when compared with figures obtained from other areas (e.g. Diamond 1971).

It is worth examining the extinctions and immigrations to see the effect of mismanagement on the change in species composition.

The first recorded extinction occurred sometime in the 1920s when the brush bronzewing *Phaps elegans* disappeared from the island. Although this species has never been seen on the island by any ornithologist, it undoubtedly occurred there (Storr 1965b) and there are records of pigeons being trapped and sold for food to the crews of visiting ships. A combination of trapping and habitat destruction almost certainly removed this species.

Both the rufous whistler *Pachycephala rufiventris* and the golden whistler *P. pectoralis* have occurred on the island but the rufous whistler was last seen in 1925 (Storr 1965b). Storr believes that its extinction was connected with the decline of *Callitris preissii* which is now nearly extinct. This is due to increased frequency of fires and direct cutting for various purposes. The golden whistler is still a conspicuous resident of the remnant woodland but habitat degradation and destruction has made this species vulnerable and its total populations is probably small (Saunders and de Rebeira 1985b).

The only other known extinction of land birds was a pair of the Australian magpie *Gymnorhina tibicen* which bred on the island in 1922 (Storr 1965b), and disappeared soon afterwards. The fact that there was only one pair involved, and they only remained for one breeding season indicate they were vagrants which found the island unsuitable.

As mentioned earlier, there have been 10 immigrations of land bird species since 1904. The pied oystercatcher *Haematopus ostralegus* was a rare visitor to the island before the 1930s yet it was resident on the adjacent mainland (Alexander 1921). By the late 1950s it had become a breeding resident as a result of a natural immigration into suitable available habitat. The banded plover *Vanellus tricolor* underwent a major expansion onto the Swan Coastal Plain in the late 1920s as a result of clearing of native vegetation for agriculture (Seventy and Whittell 1976). Prior to the changes wrought by Europeans, Rottnest Island would not have had any suitable habitat for this species. Initially, clearing for agriculture and, latterly, grazing by horses (since removed) and mowing (runways and golf course) have maintained habitat suitable for the banded plover. This species colonized the island in 1934 as a result of the range expansion, due almost entirely to human influence. The red-necked avocet *Recurvirostra novaeholandiae* became established as a breeding resident (in small numbers) in the late 1970s or early 1980s, having been a rare visitor. The areas it frequents do not appear to have been modified in any way and there is no apparent human influence in this immigration. The two turtle doves (laughing *Streptopelia senegalensis* and spotted *S. chinensis* both colonized the island in the 1930s (Sedgwick 1958), and both were a direct result of deliberate introductions of exotic species into the Perth metropolitan area. The sacred kingfisher *Halcyon sancta* is an interesting species because of its choice of nesting site. Up until the 1960s this species was of uncertain status (Storr 1965b) and it did not appear to breed on the island. By the 1980s this species had become a breeding resident and it nests in the exotic palm trees scattered around the settlements. There are caves around the coast of the island and some of these may be suitable nest sites but there is no evidence of the birds breeding there. It appears that the establishment of this species on the island is due to the provision of suitable nest sites by humans. The rainbow bee-eater *Merops ornatus* is another species which has established itself comparatively recently, almost certainly as a result of the effects of human disturbance. This species was first recorded on the island in December 1977 (Abbott *et al.* 1978) and is now a breeding migrant. It digs its nesting burrows in areas like road cuttings, sand-pits and the golf course;

all sites which would not have been available before European settlement. The tree martin, *Cecropis nigricans* was an uncommon visitor until the 1970s when it started visiting the island in hundreds during the summer. In 1983 a small colony established itself in the roof of a wooden tower. This species normally nests in holes in trees but there are few, if any, such sites on the island and it was only the provision of an artificial nest site which allowed this species to establish itself. In 1950 the western warbler *Gerygone fusca* colonized the island and spread quickly to all suitable woodland habitat (Storr 1965b). At that period about 18% of the island was clothed in woodland and this colonization represents a natural immigration into unmodified habitat suitable for this species. The tenth immigration was the pair of the Australian magpie mentioned earlier which made on attempt to breed before disappearing from the island.

Turnover rates of breeding birds on islands are calculated from changes in composition of species of land birds and marine species are not taken into account. Nevertheless, marine species may be affected by changes in habitat as these may affect the suitability of the island as a breeding platform. There have been two recorded extinctions of marine birds on the island and both are believed to be the direct result of human interference. The little shearwater *Puffinus assimilis* was recorded as breeding on a small islet off the main island between 1922 and 1928 (Robinson 1935). Storr (1976) believes that its disappearance was a result of human interference with the small breeding colony. The red-tailed tropic bird *Phaethon rubricauda* made several unsuccessful attempts to breed on the island in the late 1950s (Storr 1964). Although their immigration was probably a natural event, their extinction was not. Unfortunately they chose to breed on the island's airport and the aeroplanes interfered with these attempts. It has not been recorded from the island since then.

While two marine species have become extinct on the island, two have established themselves as breeding species since 1904. The little pied cormorant *Phalacrocorax melanoleucos* was an uncommon visitor to the island until comparatively recently, despite the fact that it was common on adjacent mainland. In 1983 a small breeding colony was established on an offshore islet and small numbers are resident all year; the result of a natural immigration. (Natural is used in the sense of Lynch and Johnson 1974; i.e. human influence has not been responsible for the event). The Caspian tern *Hydroprogne caspia* was not recorded by early ornithologists (Glauert 1929) yet it was a resident on the adjacent mainland (Alexander 1921). Sometime prior to Storr's survey it had become a breeding resident and it retains this status today.

There have been two deliberate introductions of birds to Rottnest Island; ring-necked pheasant *Phasianus colchicus* and peafowl *Pavo cristatus*. Both species appear to be maintaining breeding populations and have done so for the last 50 years.

The changes in species breeding on the island are summarized in Table 1 and of 20 such changes only 6 (30%) are due to natural changes. All of the remaining 14 cases result from changes created by management or failure to manage in such a way to prevent the change.

IMPORTANCE OF ROTTNEST ISLAND AS A CONSERVATION AREA

The fact that the island has 10% of its area taken up with a series of super saline lakes and brackish swamps has considerable influence on the avifauna of the island. Of course, Rottnest Island should not be considered in isolation from the rest of the Swan Coastal Plain. The Swan Coastal Plain has long been regarded as prime habitat for urban development and extensive agricultural practices. As a result many changes have been carried out and by 1966 nearly 50% of the wetlands between Yanchep and Rockingham had been drained (Riggert in Seddon 1972) and since then the loss of wetlands has continued, e.g. the causeway area on the Swan River (Tarburton 1974). This loss of habitat for wading species has made the island increasingly more important as a conservation area because many of the non-breeding migrants visiting the island are transequatorial migrants breeding in the Northern Hemisphere. The importance of the island to these species is indicated by the ruddy turnstone *Arenaria interpres*. The fact that there are extensive areas of suitable feeding habitat around the lakes, and that there is no tidal influence, means that these areas are available throughout the day and night. The island is visited by mobs of turnstones and during the summer there may be more than 400 present. During 1983 a survey of waders around Australia estimated there were 5 347 turnstones in the country (Minton and Lane 1984) and during February 1983 the island held about 9% of that figure (Saunders and de Rebeira 1986).

Similarly the island is an important feeding area for the red-necked stint *Calidris ruficollis* and curlew sandpiper *C. ferruginea*, both transequatorial migrants and the banded stilt, a local migrant which breeds on the seasonal lakes of the arid and semi-arid zones of the mainland. The conservation value of Rottnest Island is maintained by considerable productivity of

Table 1.
Extinctions and immigrations of bird species breeding on Rottnest Island (1904-1984)

Species	Change	Probable reason for change in status
a) Marine birds		
Little shearwater	Extinction	Direct human interference with breeding colony
Little pied cormorant	Immigration	Natural expansion into suitable habitat
Red-tailed tropic bird	Immigration	Natural expansion
Red-tailed tropic bird	Extinction	Direct human interference with breeding colony
Caspian tern	Immigration	Natural expansion
b) Land birds		
Pied oystercatcher	Immigration	Natural expansion
Banded plover	Immigration	Range expansion as a result of human activity
Red-necked avocet	Immigration	Natural expansion
Laughing turtledove	Immigration	Feral colonizer
Spotted turtledove	Immigration	Feral colonizer
Brush bronzewing	Extinction	Trapping and habitat destruction
Sacred kingfisher	Immigration	Range expansion using human alteration of habitat
Rainbow bee-eater	Immigration	Range expansion using human alteration of habitat
Rufous whistler	Extinction	Habitat destruction
Tree martin	Immigration	Range expansion using human alteration of habitat
Western warbler	Immigration	Natural expansion
Australian magpie	Immigration	Range expansion using human alteration of habitat
Australian mapgie	Extinction	Human interference
c) Deliberate introductions		
Peafowl) Ring-necked pheasant)		Deliberate release of caged animals brought to the island for that purpose

these salt-lakes which support a varied avifauna; on occasions, well over 5 500 birds may be feeding in or around the lakes. Of interest here, from a management perspective is that peak numbers of birds are present on the island between December and February and this is the peak period of human occupation.

In addition to the wading birds there is a small population of osprey *Pandion haliaetus*. Over the last 25 years there have been from two to four pairs breeding around the coast and these spectacular birds attract a great deal of attention. On occasion more than 20 birds have been present on the island and there are at least 12 known nest sites (Saunders and de Rebeira 1985b). In fact the island probably has the largest concentration of osprey around Cockburn Sound.

As Rottnest Island has been isolated for about 6 500, years does it possess any endemic species? The red-capped robin *Petroica goodenovii* has an isolated population on the island and this species is not present on any of the other islands in Cockburn Sound, nor is it present on the adjacent mainland. This population has probably been isolated since the island separated from the mainland but at present not enough is known of the animal to determine if it is an endemic race. The red-capped robin depends on woodland for its survival and its population is most dense in the remnant woodland areas where it forages on the ground. This species is territorial and the reduction of woodland areas would almost certainly have led to a reduction in total population on the island. This species must be regarded as vulnerable because of this fact.

The only known endemic race of bird on the island is the singing honeyeater *Meliphaga virescens*. Widely distributed on mainland Australia and present on many offshore islands including Barrow Island, the singing honeyeater throughout its range is a striking example of Bergmann's rule when mainland populations are examined (Wooller *et al.* 1985) with regard to body mass. The singing honeyeater is not as vagile as is widely believed as it shows a remarkable degree of endemism in body mass; the birds on Rottnest Island are 21% heavier than the birds from Perth, only 18 km away, and an extensive banding campaign has shown no evidence of movement over Cockburn Sound. In fact the birds on Rottnest Island

are so much larger than the birds at Perth that they take a size 4 leg band instead of a 3 over the rest of mainland Australia. Interestingly the birds on Barrow Island are 18% heavier than the populations in the adjacent Pilbara. The fact that Rottnest Island has an endemic race of the singing honeyeater makes an assessment of the future management of the island's resources imperative.

The rock parrot *Neophema petrophila* is the only other isolated population on the island; in that it is not present on surrounding islands, nor on the adjacent coast of metropolitan Perth. This species is present in small numbers having been subject to pressure from residents of the island who were illegally harvesting the young. By the 1960s this species had almost become extinct on the island but has started to increase and small flocks are often seen. Protection from illegal trading has probably had most to do with the increase in this population. This management has been "de facto" as there has never been any active protection of the flora and fauna of the island by any of the successive Rottnest Island Boards. While management plans have been produced (one in 1972 and one in 1984) they were for the future development of the island and not for management of the existing ecosystems (R.I.P.M.G. 1985).

MANAGEMENT OR MISMANAGEMENT?

Rottnest Island has been managed since 1917 by a Board of Control which resembles a small town council. It manages the settled areas which constitute the tourist areas and has degraded the remainder of the island, an area which constitutes a national park with a residential complex. Their rape of this area has resulted in the loss of many of the values visitors hold of the island. There is absolutely no reason why the island can not be managed as a holiday resort and retain the wildlife values which enhance the area's tourist image. To do that requires a complete change of management policy - radical if necessary. The easiest method would be to change the legislation, retain the A-class reservation and the proposed "Public recreation" but placing the island firmly under the control of a competent management authority who is capable of treating the island as an entity.

The logical authority is the Department of Conservation and Land Management. There is an enormous amount of information published about the ecology of the island as it has been a study centre for generations of students. Unfortunately much of this study has had no direction other than esoteric scientific interest. With planning, much of this work could have had management implications which could have been incorporated in a management plan by a competent authority, which could have upgraded the plan as new information became available. Such an authority could highlight areas of research necessary for filling gaps in the knowledge of the island's ecosystems if it was a clearing house for projects to be undertaken on the island. The island is far too valuable a recreational, educational and scientific resource to be squandered as it is now by a Board of Control which is incapable of understanding ecological theory and using it to manage the island.

REFERENCES

Abbott, I., Black, R. and Gueho, N. (1978). Notes on Rainbow Birds and Fairy Terns on Rottnest Island. *The West.ern Australian Naturalist* 14, 64-5.

Alexander, W.B. (1921). the birds of the Swan River district, Western Australia. *Emu* 20 : 149-68.

Diamond, J.M. (1971) Comparison of faunal equilibrium turnover rates on a tropical and a temperate island. Proc. Natl. Acad. Sci. U.S.A. 68 : 2742-45.

Glauert, L. (1929). Contributions to the fauna of Rottnest Island No. 1. Introduction and vertebrates. *The Journal of Royal Society Western Australia* 15 : 37-46.

Lawson. F. (1902). A visit to Rottnest Island, W.A. *Emu* 4 : 129-32.

Lynch, J.F. and Johnson, N.K. (1974). Turnover and equilibria in isular avifaunas, with special reference to the California Channel Islands. *Condor* 76 : 370-84.

MacArthur, R.H. and Wilson, E.O. (1963). An equilibrium theory of insular zoogeography. *Evolution* 17 : 373-87.

MacArthur, R.H. and Wilson, E.O. (1967). "The theory of island biogeography". (Princeton University Press : Princeton.)

Minton, C.D.T. and Lane, B.A. (1984). Counting and banding waders in Australasia (pp. 43-54) in *Methods of censusing birds in Australia* (Ed. S.J.J.F. Davies). (Dept. Conservation and Environment Bulletin No. 153 : Perth.)

Pen, L.J. and Green, J.W. (1983). Botanical exploration and vegetational changes on Rottnest Island. *The Journal of Royal Soc.iety Western Australia 66 : 20-4.*

Playford, P.E. (1983). Geological research on Rottnest Island. *The Journal of Royal Society of Western Australia 66 : 10-15.*

Robinson, A. (1935). Little shearwater breeding on Rottnest Island. *Emu* 34 : 314.

Rottnest Island Management Planning Group (1983). Rottnest Island Draft Management Plan. (Dept. of Premier and Cabinet : Perth.)

Saunders, D.A. and de Rebeira, C.P. (1983). The birds of Rottnest Island. *The Journal of Royal Society Western Australia* 66 : 47-52.

Saunders, D.A. and de Rebeira, C.P. (1985a). Turnover in breeding bird populations on Rottnest Island, Western Australia. *Australian Wildlife Research* 12 : 467-77.

Saunders, D.A. and de Rebeira, C.P. (1985b). The birdlife of Rottnest Island. (D.A. Saunders and C.P. de Rebeira: Guildford, Western Australia.)

Saunders, D.A. and de Rebeira, C.P. (1986). Seasonal occurrence of members of the sub-order Charadrii (waders or shorebirds) on Rottnest Island, Western Australia. *Australian Wildlife Research* 13 : 325-44.

Seddon, G. (1972). *Sense of place.* (University of Western Australia Press : Perth.)

Seddon, G. (1983). The Rottnest experience. *The Journal of Royal Society Western Australia* 66 : 34-40.

Sedgwick, E.H. (1958). The introduced turtledoves in Western australia. *The Western Australian Naturalist* 6 : 92-100 : 112-27.

Serventy, D.L. and Whittell, H.M. (1976). *Birds of Western Australia.* 5th edition. (University of Western Australia Press : Perth.)

Storr, G.M. (1964). The avifauna of Rottnest Island, Western Australia. I. Marine birds. *Emu* 64 : 48-60.

Storr, G.M. (1965a) The avifauna of Rottnest Island, Western Australia. II. Lake and littoral birds. *Emu* 64 : 105-13.

Storr, G.M. (1965a) The avifauna of Rottnest Island, Western Australia. III. Land birds. *Emu* 64 : 172-80.

Storr, G.M. (1965a) Rottnest Island, Western Australia. *The Australian Bird Bander* 14 : 35-8.

Tarburton, M.K. (1974). The birds of the now non-existent Causeway salt marshes, Perth, W.A. *The Western Australian Naturalist 13 : 1-7.*

Wooller, R.D. Saunders, D.A., Bradley, J.S. and de Rebeira, C.P. (1985). Geographical variation in size of an Australian honeyeater (Aves : Meliphagidae) : an example of Bergmann's Rule. *Biol. J. Linn. Soc.* (Lond.) 25 : 355-63.

FIRE ON OFFSHORE ISLANDS - PROBLEMS AND MANAGEMENT SOLUTIONS

A.J.M. Hopkins and J.M. Harvey

Department of Conservation and Land Management, Western Australian Wildlife Research Centre, PO Box 51, Wanneroo, W.A. 6065

Abstract

As is the case for much of mainland Australia, fire is important in the management of most offshore islands in the Australia-New Zealand region. Wildfire can seriously diminish nature conservation and other scientific values of islands; some examples of how this may occur are given here. Because of the potential threat that unplanned fire poses to these values, it is recommended that nature conservation agencies urgently develop contingency plans for islands in their jurisdiction.

INTRODUCTION

The islands of Australia and New Zealand incorporate a great range of physical environments and biotas as well as land-uses (past and present). It seems, however, that fire is an important management consideration for most islands set aside for nature conservation or other compatible purposes. The exceptions would be those islands that have snow and ice cover for a significant part of the year (e.g. some Antarctic islands), those that are too wet, as is the case with some tropical islands or those that are scarcely vegetated as is the case with some rock stacks and Phillip Island in the Lord Howe Island Group. While it may be that not all of the remainder have been burnt in historical times, or have fire management problems at present, contingency planning for wildfire is now generally necessary.

FIRE AND CONSERVATION VALUES

Many of the offshore islands in the Australia-New Zealand region have experienced severe wildfires since the times of early European exploration of the coastline. Some fires have been as a direct consequence of the exploration process. For example, as Matthew Flinders sailed the 'Investigator' from Plymouth to Sydney in 1801, 1802 he visited Mondrain Island (Archipelago of the Recherche) where he reported the island was accidentally or deliberately fired to the extent "of a general blaze ... all over the island" (Bechervaise 1954). But many more fires have resulted from visits of tourists and fishermen over recent years (e.g. see Table 1 for fire history details of 12 islands of the Archipelago of the Recherche). Other islands have been partially settled and subsequently burnt off to protect property values (e.g. Magnetic Island, Sandercoe 1980).

The changes in fire regime occasioned by the activities of European man, particularly over the last 20-30 years have given rise to concern about the impact on the native biota. Perhaps the greatest concern is that unchecked wildfire can burn out the entire island and cause local extinctions. At present, fires that start on nature conservation islands often go undetected for long periods and, even when they are reported, control measures are rarely implemented because of logistic constraints.

Dorre Island in Shark Bay, Western Australia, for example, is an important island nature reserve partly because it has populations of the Banded Hare Wallaby *Lagostrophus fasciatus*, the Western Barred Bandicoot *Perameles bouganville*, the Mala or Rufous Hare Wallaby *Lagorchestes hirsutus* and the Boodie *Bettongia lesueur*. The last fire on Dorre Island was reported in early September 1973. By late October it had consumed about 54% of the vegetation of the island (Figure 1. Note that much of the remaining area is bare sand dune). This fire selectively burnt the habitat of *L. fasciatus* to the extent that fears were expressed about continued persistence of that species on Dorre Island. Subsequent monitoring by Drs. R. Prince and A. Weston has revealed a very slow rate of recovery of flora and fauna and both scientists consider that the fire has caused some irreversible deterioration in the conservation values of the island.

Two previous fires are known for Dorre Island. The first was deliberately lit by Julius Brockman in

Table 1.
Details of fires reported from islands of the Archipelago of the Recherche from Hopkins *et al.* (in press). Historical records for all islands of the Archipelago were examined for information related to landuse.

Island	Date of fire and probable cause
Boxer Island	pre-1950 perhaps several fires associated with grazing 1974 - northern two thirds of island
Charley Island	pre-1950 fire(s) probably associated with grazing
Daw Island	pre-1950 fire
Figure of Eight Island	1971 fire lit by stranded fishermen
Goose Island	pre-1950 fire
Long Island	1930s fire probably associated with sealing
Middle Island	1972/73 fire possible fishermen camping 1977 fire ?lightning
Mondrain Island	1802 fire Flinders crew 1944 - three fifths of island burnt ? 1972
North Twin Peaks Island	ca. 1936 fire
Remark Island	major wildfire prior to 1950
Sandy Hook Island	pre-1950 and more recently, perhaps several fires of unknown origin
Woody island	1949/50 - major wildfires of unknown origin 1974 prescribed burn

the 1860s. He recorded in his diary that the fire made a grand sight. In 1908 a small fire began close to the hospital that was established on Dorre Island for Aboriginal people. The scars of this 1908 fire are still visible in 1973 aerial photographs (R.I.T. Prince, pers. comm.).

On Magnetic Island, in Queensland, four settlements with a total resident population of about 2000 have been established in bays surrounding the National Park. In one of these bays (Horseshoe) there was extensive pineapple farming in the 1950s. Fires emanating from the settlement areas used to, until recently, burn into the National Park with the result that areas of the Park were being burnt every 5 years on average (Sandercoe 1980). This frequent burning caused degradation of the vegetation, particularly a loss of shrubs and an increase in grasses (especially *Heteropogon* spp.) and could be correlated with an increase in the incidence of landslips.

FIRE AND SCIENTIFIC VALUES

As well as being important nature conservation areas, islands can provide valuable insight into aspects of evolution and ecology of the biota including the effects of fire. The science of biology was reborn as a result of observations on the plants and animals of islands (Darwin, Wallace, Von Buch and so on). That this role of islands has continued through to the present is evidenced by the wealth of literature covering topics such as island biogeography and by the detailed and comprehensive work on places like Rottnest Island (e.g. Bradshaw 1983).

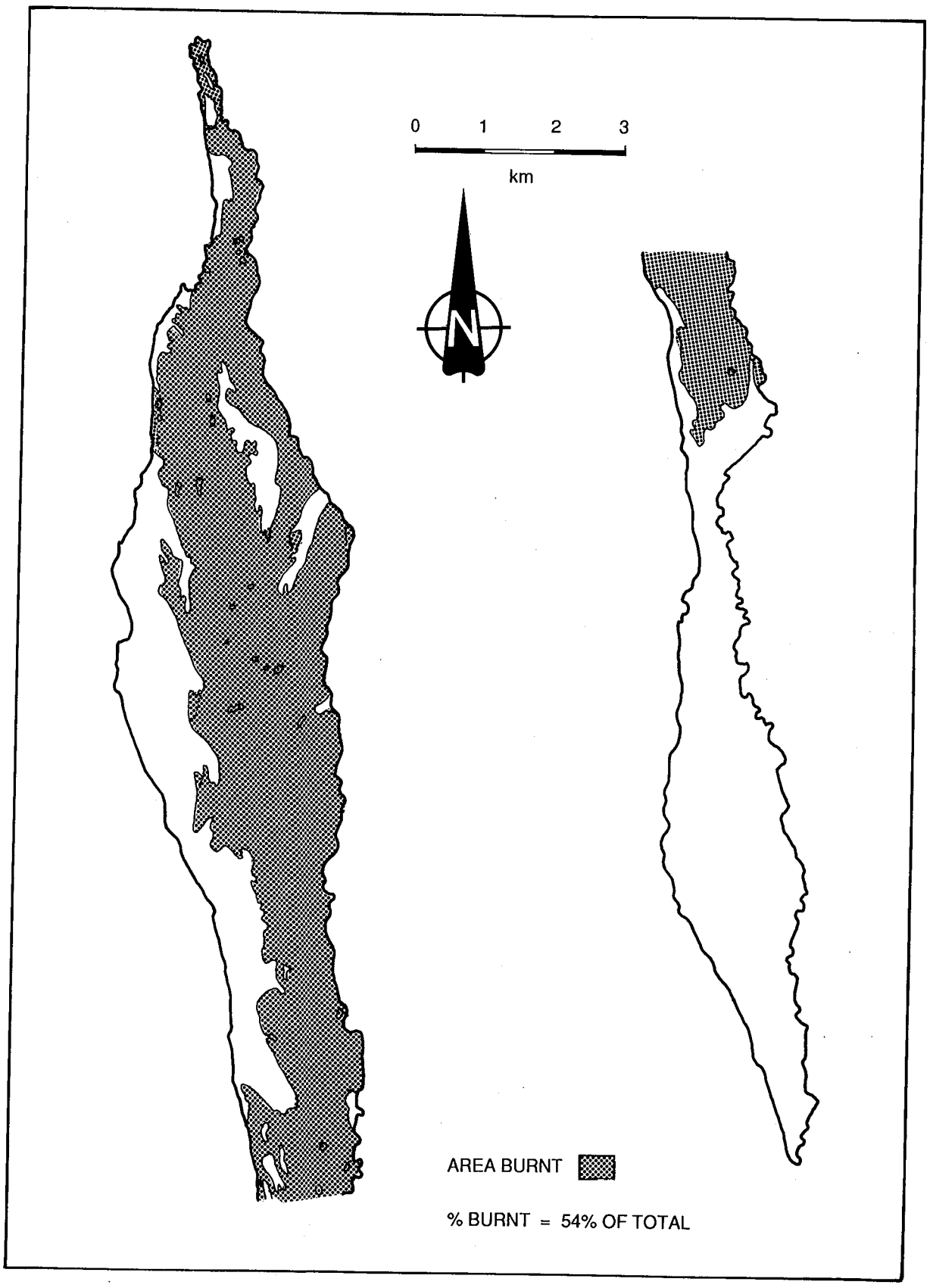


Figure 1.
Extent of the 1973 fire on Dorre Island, Western Australia as determined from subsequent aerial photography. The fire began near the northern tip of the island and burnt slowly but intensely towards the south and into the wind.

Invariably the discussion of evolutionary, ecological and biogeographical generalizations is built on the survey data available in the literature. There is now quite a body of island survey data although, as mentioned by Atkinson (this proceedings), much more survey work remains to be done. We suggest, however, that future surveys should be more rigorously structured than those in the past and that the emphasis should be on comprehensive surveys of a few islands rather than a continuation of the more generalized surveys of large numbers of islands. In our view it is only by developing a comprehensive data base on the biota of the islands that good, reliable interpretations can be made and new insights gained.

To briefly cite an example, we refer again to the botanical collecting in the Archipelago of the Recherche. In November 1950, the Australian Geographical Society conducted a 3 week expedition in the Archipelago, during which time they visited 20 islands. The botanical work was done by J.H. Willis and the results subsequently published in Willis (1953). Results of this expedition have been used in a number of biogeographical studies including Main (1961), Main and Yardav (1971) and Armstrong (1979). This last author looked at the relationship between island size, insularity and angiosperm species richness. However, since 1950, two of the islands have been subjected to more detailed botanical study. In the case of Woody Island, the floristic richness has increased from the 87 species recorded by Willis to 121 species (Goodsell *et al.* 1976). For Middle Island, the change was from 143 species to 235 species (Weston, Trudgen and Hopkins, in press). Clearly, changes of the magnitude of these cited can make a mockery of many interpretations of the data set as a whole (Figure 2).

A comprehensive data set from the Archipelago of the Recherche could cast some light on the genesis of the flora of south-western Australia as a whole. The islands were cut off from the mainland by rising sea levels at different times and thus under different climatic conditions and it may be that the floristic composition reflects these factors. For example, Salisbury Island is estimated to have been isolated from the mainland at around 13-14000 years Before Present, a time when southern Australia was experiencing very arid conditions (Figure 3). Its flora is relatively rich in species of arid zone families and depauperate in typical south-western elements (Myrtaceae, Proteaceae). In contrast, Middle Island was separated more recently and during a mesic phase. The flora of Middle Island contains at least 16 species in the families Myrtaceae and Proteaceae (Table 2).

These islands also contain potentially valuable information about the development of some so-called fire adaptive traits (Gill 1979). So far as is known, the Aboriginal people of the region did not possess sea-going craft (Figure 4). Therefore when each island was separated from the mainland it was no longer subject to Aboriginal burning practices; however these practices would have continued to affect the adjacent mainland. It is of some interest to note, therefore, that in the study of post fire regeneration of vegetation on Middle Island to be discussed shortly, only about 10% of species in study plots resprouted and, even for those, seedlings were generally abundant. The low contribution of resprouting to overall regeneration patterns on Middle Island is in marked contrast with observations on sclerophyllous shrublands and woodlands elsewhere in southern Australia where resprouting species have comprised about 70% of total species present (Bell *et al.* 1984). A program of survey to explore life histories of plant species on the islands and adjacent mainland in relation to fire is warranted.

Disentangling the relative influences of Aboriginal man, palaeoclimate and sea level changes (isolation) on the structure and composition of the biota of islands is not a simple matter. Usually the evidence is scanty and equivocal. One interesting recent attempt is that reported by Noble (1986) for Kangaroo Island, South Australia. In that case a principal source of data was a charcoal and pollen core from Lashmar's Lagoon on the eastern tip of the island which indicates a change in vegetation from an *Allocasuarina* dominated woodland with a grassy understorey in the wet, early part of the Holocene to a *Eucalyptus-Acacia* woodland in the later, drier part of the Holocene. At about 2 500 Before Present the incidence of major wildfires increased. It is speculated that this coincided with the local extinction of Aboriginal people and thus a change from regular, low-intensity fires to infrequent, major conflagrations. It is known that the island was isolated from the mainland by rising sea levels about 9 000 years ago and that Aboriginal people persisted there for at least another 5 000 years. In this case, therefore, floristic/vegetation changes were most likely related to climatic changes although the transformation was rather abrupt and also coincided with a major fire event.

One further research opportunity that relates to fire exists because some islands have been relatively little-affected by European man. Some islands have remained unburnt for a long period or have been burnt very infrequently. The opportunity exists, therefore, to study dynamics of plant communities in the absence of fire. One pertinent question is how do species regenerate in the absence of a major

Table 2

Details of floristic composition of selected islands of the Archipelago of the Recherche in relation to size, isolation and habitat diversity factors. Floristic data are from Willis (1953) except for figures in brackets which reflect results of more recent survey work (see text for details). Selected vascular plant families are Chenopodiaceae (ch), Aizoaceae (aiz), Myrtaceae (myr) and Proteaceae (pro).

ISLAND	Time of isolation (years B.P.)	Distance from mainland (km)	Area (ha)	Maxmimum evaluation(m)	No of vascular plants in selected families					Notes on geology soils and vegetation
					Total	ch	aiz	myr	pro	
TERMINATION		52.8	90	124	12	2	2	0	0	Granite rock. Albizia (prostrate) in rock crevasses Low succulent perennials; Disphyma. Hardy annual herbs; Lepidium, Lobelia
SALISBURY	13,000-14,000	43.2	320	130	30[+2]	3	2	0	0	Granite rock and limestone. Halophytic flora on limestone cliff; Atriplex, Carpobrotus. Heath on granitic soils; Leucopogon, Spiridium, Acacia, Boronia, Pimelea
WESTALL	11,000-12,000	16.9	95	24	23	5	5	0	0	Calcareous sand over granite. Well developed salt bush scrub; Atriplex, Rhagodia (spp) Enchyleana.
FIGURE OF EIGHT ISLAND	10,500-11,500	14.5	275	127	56	4	3	0	0	Granite. Acacia cyclops, Albizia, Myoporum Heath; Pimelea, Eutaxia, Leucopogon.
MONDRAIN	10,000-11,500	15.0	790	247	135[+2]	5	3	12	3	Granite no limestone. Eucalypt woodlands. Melaleuca woodlands; M. lanceolata, M. globifera Sand Heath; Dryandra, Xanthorrhoea, Casuarina Calothamnus
SANDY HOOK	10,000-10,500	9	270	153	100[+34]	3	3	9	1	Granite no limestone Eucalypt woodland. Shrubs of Acacia (6spp) Gastrolobium, Bossiaea,Templetonia, Boronia Calothamnus, Dampiera
MIDDLE	9,000-10,000	9	1,060	190	143[+92]	4	3	13 [+1]	2	Granite, Limestone, sand dunes Eucalypt woodlands, (4 spp.) Mixed heath on granite, Kunzea, Calothamnus, Acacia. Melaleuca globifera woodlands. Limestone heath; Melaleuca pentagona, Pomoderis
NORTH TWIN PEAKS	8,000-9,000	8	310	205	90	4	3	8	1	Granite, no limestone. Eucalypt woodlands, (3spp), Melaleuca globifera, Acacia, Kennedia, Leucopogon
WOODY		8	188	130	58[+112] 87[+60]	1	3	6 [+2]	[8]	Granite Eucalypt woodland and Low open heath - Astartia, Melaleuca lanceolata

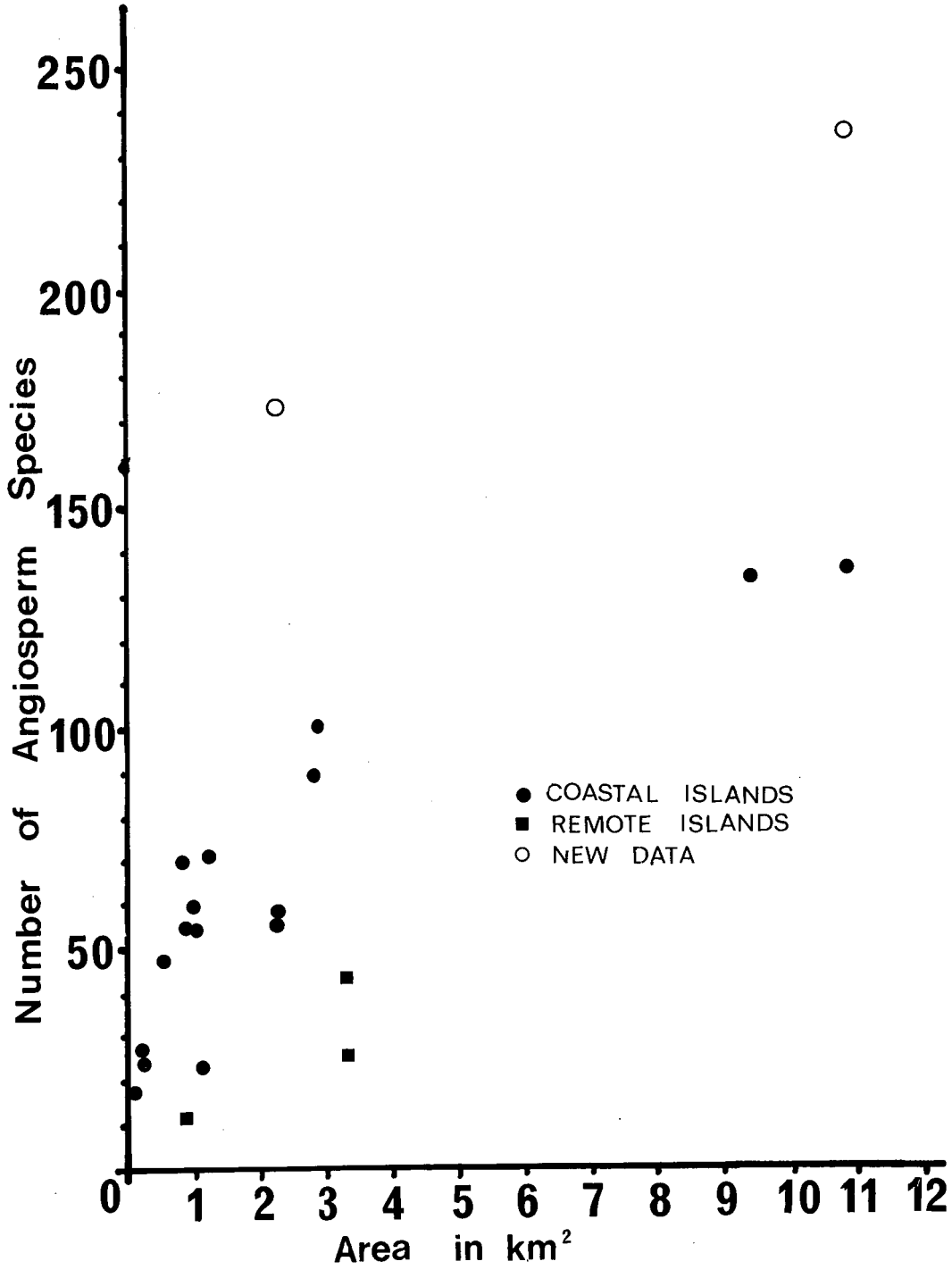


Figure 2.
Species richness of islands of the Archipelago of the Recherche in relation to size and insularity. Original data are from Willis (1953) as plotted by Armstrong (1979). New data are from Goodsell *et al.* (1979) for Woody Island and from Weston *et al.* (in press) for Middle Island.

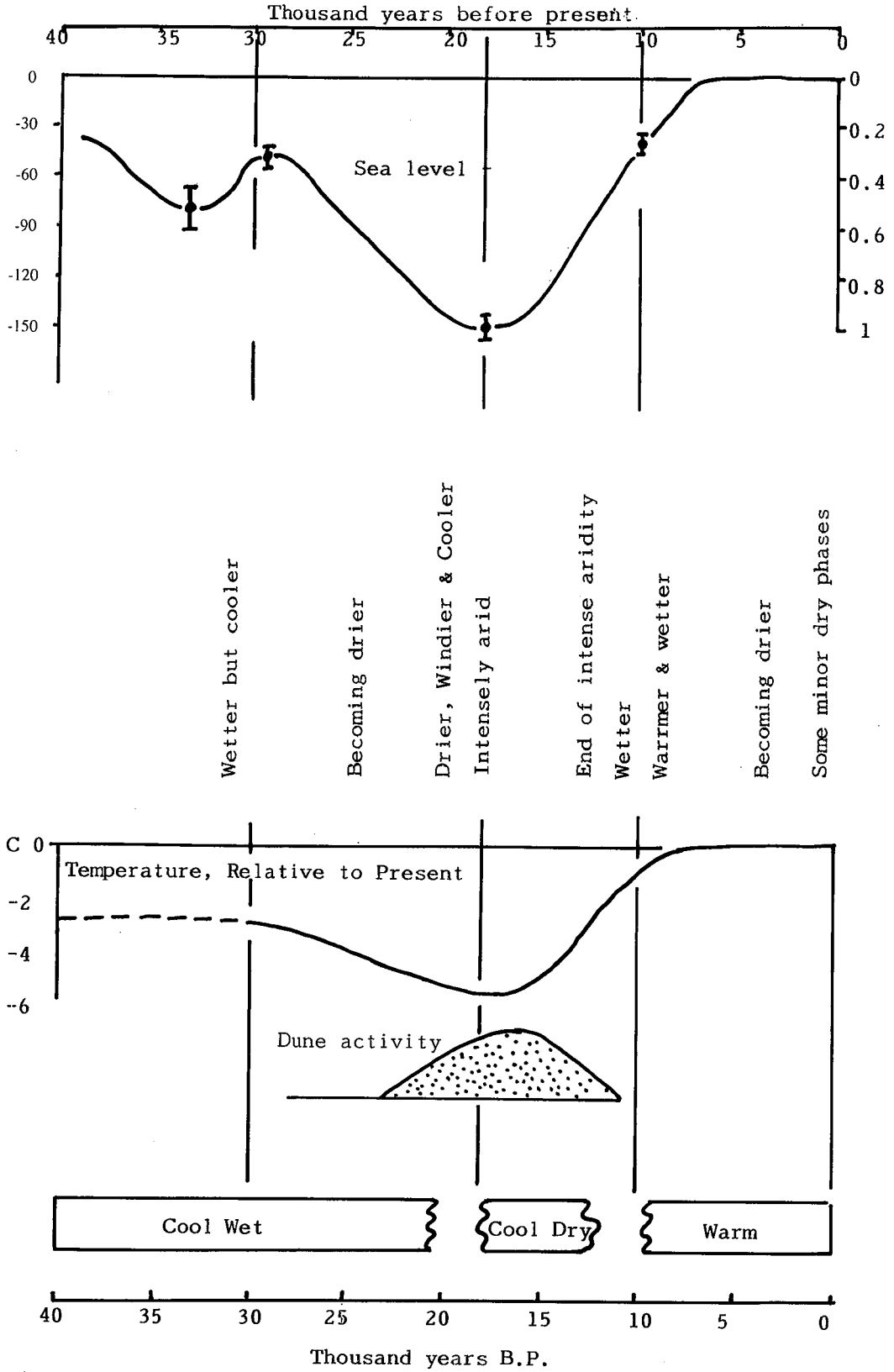


Figure 3.
Selected indicators of environmental change in the Australian region in the last 40,000 years. A. Sea level in the northern Australian region from Chappell (1983a). B. Climatic trends in south-western Australia relative to the present (from Balm *et al.* 1978). C. Average temperature estimates for the Australian region with an indication of the major phase of inland dune activity (from Chappell 1983b).

Figure 4.
Australia and the larger continental islands showing coastal areas where Aboriginal people did not possess watercraft and thus, it can be assumed, the islands were little affected by Aboriginal burning patterns once isolated by rising sea levels. Note though that Aborigines persisted as insular populations on some larger islands for some time (eg Kangaroo Island, Noble 1986). (Original figure from Abbott 1980)

disturbance event like fire? It is often said that the Australian sclerophyllous flora is fire dependent - here is one opportunity to test the hypothesis underlying this paradigm.

FIRE MANAGEMENT PLANNING

Given the very obvious conservation and scientific values which many islands in the Australia-New Zealand region have and the vulnerability of those values to wildfire, it is essential that wildfire contingency plans be prepared for all nature conservation islands. Several of the categories of information already discussed can be utilized to develop such contingency plans. Much of the information is readily available and merely awaits collation. It is best that this collation of information and planning is done pro-actively rather than at the time of a fire.

Available information can be used to develop contingency plans in the following ways:

i) Islands that have been inaccessible to Aboriginal people for extended periods through the Holocene, as identified from Figures 3 and 4, are likely to support a relatively fire sensitive biota. Fire management should emphasise rapid containment. In contrast, islands occupied or visited by Aboriginal people have probably been burnt from time to time throughout the Holocene and it is reasonable to assume that the present biota is resilient in the face of occasional fire.

ii) Information on the landforms and vegetation of each island will be useful in assessing likelihood of complete burn out. For example, islands with large expanses of rock or sand dunes are better protected than those with continuous cover of sclerophyllous vegetation. This information is also essential for developing detailed fire suppression plans.

iii) Islands with a history of recent fire may be less susceptible to total burn out than those that are long unburnt because of the likelihood of low, discontinous fire fuel loadings. Again, fire history information is fundamental when planning fire suppression strategies.

iv) The presence of rare and endangered species on an island or special, fire-sensitive plant (and animal) communities such as rainforest will dictate a fire management policy of containment.

FIRE STUDIES ON MIDDLE ISLAND

Middle Island is the largest and most physiographically diverse island of the Archipelago of the Recherche. It has an area of about 1060 ha. and conspicuous features include the granite Flinders Peak (174 m) at the western end, a hypersaline lake containing the red *Dunaliallia* algae and a series of granite headlands which, on the northern side of the island, enclose sandy beaches. On the southern side limestone cliffs of up to 50 m in elevation occur (Figure 5). The diverse biota includes 235 species of vascular plants, 1 mammal species (the tammar *Macropus eugenii*), 12 species of reptiles and 1 frog, and 37 species of birds. The vegetation of the island was mapped at a scale of 1:12000 and 20 associations have been delineated.

In the summer of 1972/73 a severe wildfire burned the eastern portion of the island. A series of studies was initiated because of concerns about the effects of this fire on the biota (Hopkins 1981, Weston 1985). These studies have involved a number of researchers as well as us; we particularly acknowledge the work of Dr. A.S. Weston and Mr. M.E. Trudgen. The results of the work so far may be summarized thus:

i) The vegetation in most areas is regenerating after the fire well but slowly (Figure 6); it is estimated it may take up to 60 years for it to return to something like the original structure.

ii) Some of the vegetation boundaries appear to have moved as a result of the fire. We suggest that this may be because the fire killed both the living plants and the seed in the seed bank of some physiognomically important species.

iii) Fire ephemerals were very conspicuous in some vegetation association for about 2-3 years after the fire and all had disappeared within 6 years. As an example, *Alyogyne hakeifolia* contributed 25% of the canopy cover in *Eucalyptus angulosa* woodland two years after the fire but declined to nothing by year 6 (Figure 6).

iv) *Alyogyne hakeifolia* was one of six plant species, now known to be fire ephemerals, collected by Robert Brown in 1802 (with Flinders on the 'Investigator') and not collected again until after the recent fire. This evidence, together with observations on the unburnt part of the island, suggests that the island was last burnt in about 1800, i.e. 172 years before the most recent fire.

v) The long-unburnt vegetation in the remaining part of the island which included some savanna woodlands of a type no longer seen on the mainland was studied in an attempt to understand the dynamics in the absence of fire. There was no evidence of extinctions as a result of the long absence of fire on Middle Island.

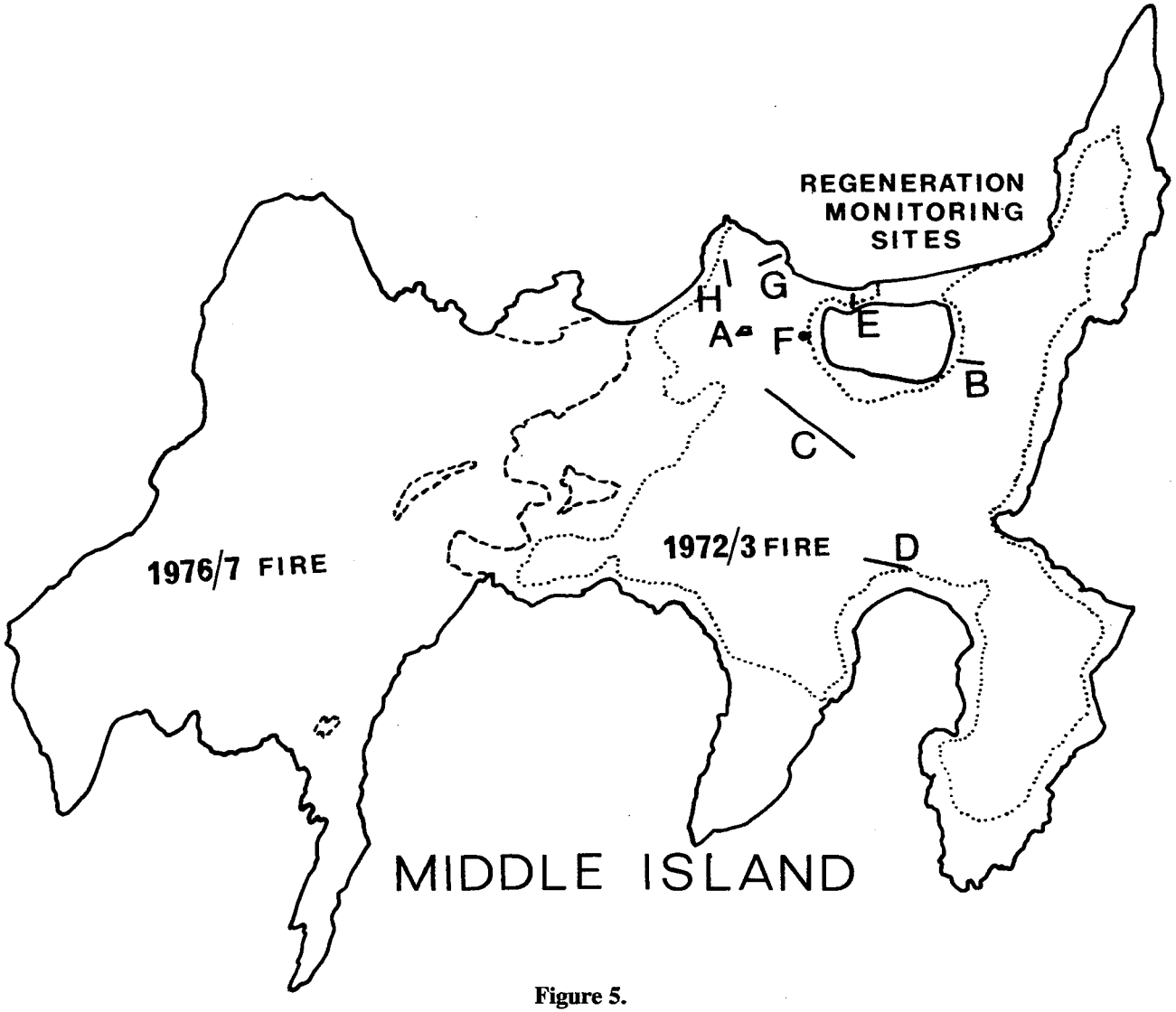
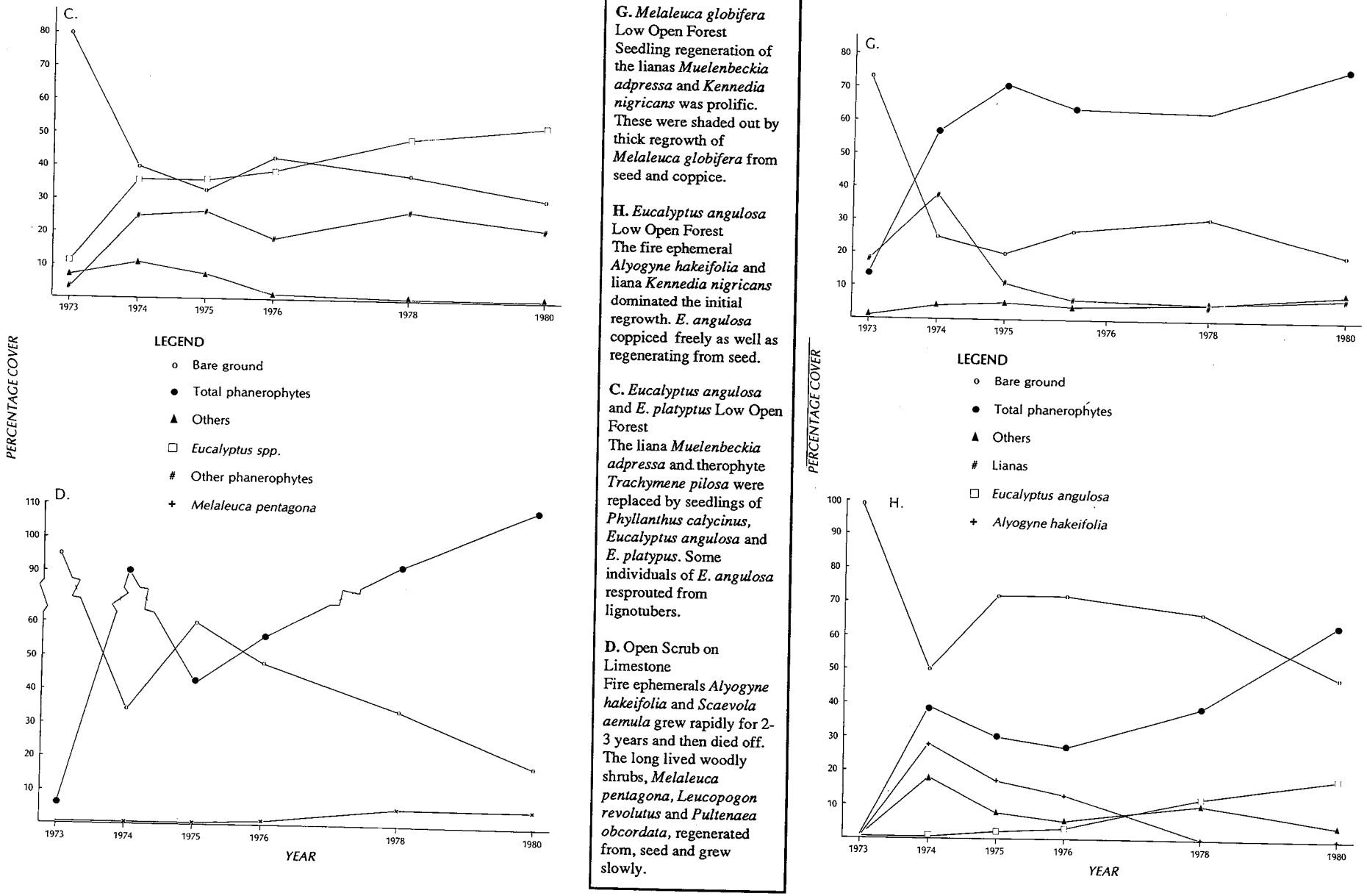


Figure 5.
Topographic map of Middle Island (Archipelago of the Recherche) showing the development and final extent of the 1972/73 fire.



G. *Melaleuca globifera* Low Open Forest
Seedling regeneration of the lianas *Muelenbeckia adpressa* and *Kennedia nigricans* was prolific. These were shaded out by thick regrowth of *Melaleuca globifera* from seed and coppice.

H. *Eucalyptus angulosa* Low Open Forest
The fire ephemeral *Alyogyne hakeifolia* and liana *Kennedia nigricans* dominated the initial regrowth. *E. angulosa* coppiced freely as well as regenerating from seed.

C. *Eucalyptus angulosa* and *E. platyptus* Low Open Forest
The liana *Muelenbeckia adpressa* and therophyte *Trachymene pilosa* were replaced by seedlings of *Phyllanthus calycinus*, *Eucalyptus angulosa* and *E. platypus*. Some individuals of *E. angulosa* resprouted from lignotubers.

D. Open Scrub on Limestone
Fire ephemerals *Alyogyne hakeifolia* and *Scaevola aemula* grew rapidly for 2-3 years and then died off. The long lived woodly shrubs, *Melaleuca pentagona*, *Leucopogon revolutus* and *Pultenaea obcordata*, regenerated from, seed and grew slowly.

Figure 6.
Regeneration of the vegetation in the *Eucalyptus angulosa* woodland on Middle Island after the 1972/73 fire. Species have been grouped by life form according to the scheme of Raunkiaer for ease of interpretation of vegetation trends.

vi) The distribution of the tammar wallabies in relation to the fire boundaries was studied using a scat distribution measure. There was no statistically significant difference between numbers of scats in old, unburnt vegetation and young, regenerating vegetation.

In 1976 a second fire swept the island and destroyed the vestiges of old vegetation. Some effects of this fire are now being studied as work on the original regeneration plots continues.

CONCLUDING REMARKS

In this paper we have put the view that fire is an important management consideration when dealing with islands because of its interaction with conservation and scientific values. Consequently we believe that islands should be afforded special planning and management for fire. The following guidelines are proposed:

i) Contingency plans should be drawn up for each (and every) nature conservation island to be used in the event of a reported wildfire on that island.

ii) The basis of each contingency plan should rest on an evaluation of such things as the evolutionary history, recent fire history, information on rare and endangered species and other land-use factors (e.g. using data derived from Figures 3 and 4).

iii) A major feature of each contingency plan should be prompt containment of any wildfire to ensure that no island reserve is ever burnt completely by a single fire.

iv) Fuel-reduction burning on uninhabited islands is seldom justifiable; on settled islands it should probably be kept to a minimum level.

v) In order to ensure that due regard is given to the importance of islands, each conservation agency should establish an islands management group with special skills in, and equipment for, tasks for managing islands including fire control.

vi) There should be improved surveillance of islands and reporting of fires. Commercial airlines should be approached to co-operate in a fire surveillance program.

vii) Fires that do occur on islands should be carefully documented and the effects of such fires should be monitored.

viii) Research on islands should continue. However, greater emphasis should be given to detailed and comprehensive surveys and studies as an avenue to improving our understanding of evolutionary and ecological processes.

REFERENCES

Abbott, I. (1980). Aboriginal man as exterminator of wallaby and kangaroo populations on islands round Australia. *Oceologia* (Berl.) 44 : 347-54.

Armstrong, P. (1979). Biogeography ; themes and case studies. pp. 88-105 In : *Western Landscapes.* J. Gentilli ed., University of Western Australia Press; Nedlands.

Balm, J., Merrilees, D. and Porter, J.K. (1978). Late Quaternary mammal remains, spanning about 30,000 years, from excavations in Devil's Lair, Western Australia. *Journal of Royal Society Western Australia* 61: 33-65.

Bechervaise, J.M. (1954). General history. Part 1a. In : *The Archipelago of the Recherche.* J.H. Willis ed., Repts. Aust. Geog. Soc. (Melbourne) No. 1.

Bell, D.T., Hopkins, A.J.M. and Pate, J.S. (1984). Fire in the kwongan. pp. 178-204. In : *Kwongan. Plant Life of the Sandplain.* J.S. Pate & J.S. Beard eds. University of Western Australia Press; Nedlands.

Bradshaw, S.D. (ed.). (1983). Research on Rottnest Island. *Journal of Royal Society Western Australia.* 66 : 1-61.

Chappell, J. (1983a). Sea level changes, 0-40KA. pp. 121-2. In : *CLIMANZ.* J.M.A. Chappell and A. Grindrod, eds. Australian National University Press, Canberra. 99-101.

Chappell, J. (1983b). Cool wet to cool dry to warm: one cause or many. pp. 129-131. In In : *CLIMANZ.* J.M.A. Chappell and A. Grindrod, eds. Australian National University Press, Canberra.

Goodsell, J.T., Tingay, A. and Tingay, S.R. (1979). A resource survey of Woody island, Archipelago of the Recherche. Dept. Fish. Wildl. West. Aust. Rept. 21.

Hopkins, A.J.M. (1981). Studies on Middle Island in the Recherche Archipelago. S.W.A.N.S. 11(12) : 6-10.

Hopkins, A.J.M., M.G. Trudgen and A.S. Weston (in press). Physical environment and history. In : The Results of Studies on Middle Island (Archipelago of the Recherche). CALM Research Bulletin.

Noble, I.R. (1986). Fire. pp. 224-32 In : *The Ecology of Forests and Woodlands of South Australia.* H.R.

Wallace ed. South Australian Government Printer; Adelaide.

Sandercoe, C. (1981). Fire occurrence and fire research in Queensland National Parks. pp. 137-150. In : Working Papers of the Queensland Fire Research Workshop. Toowoomba. December 1980.

Weston, A.S. (1985). Fire - and persistence of the flora on Middle Island, a south western Australian offshore island. pp 111-118. In : *Fire Ecology and Management in Western Australian Ecosystems.* J.R. Ford ed. WAIT Environmental Studies Group Rept No. 14. Western Australian Institute of Technology; Perth.

Weston, A.S., Trudgen, M.E. and Hopkins A.J.M. (in press). The vascular flora. In : The Results of Studies on Middle Island (Archipelago of the Recherche). CALM Research. Bulletin.

Willis, J.H. (1953). Land flora. Part 3A. In : *The Archipelago of the Recherche.* J.H. Willis ed. Reptorts Aust. Geog. Soc. (Melbourne) No. 1.

The Removal of Problem Animals from Islands

Brian D. Bell

Department of Internal Affairs, Wellington, New Zealand.

Abstract

The reasons for eradication of problem animals are considered plus the preparation and planning before beginning. The methodology is examined as well as some likely effects.

Too often the term feral animal is used in relation to problem animals on islands. I have adopted the latter term as it embraces all classes of animals, not only those once domesticated. This enables us to include animals such as rats (*Rattus* spp.), which present the greatest problem. It also overcomes the use of "exotic" in relation to these animals thus including local indigenous species, such as weka (*Gallirallus* spp.) which can be a problem on islands.

REASONS FOR ERADICATION

In suggesting the removal of problem animals we must have sufficient reason for this in addition to the "problem". Often the reasons become confused by persons with specific interests. The main reason should be to restore the intrinsic values of the island itself. Every island has its own special values involving the natural communities it possesses, the special assortment and assemblage of plant and animal species and in the case of the more remote islands their own endemics. It must be acknowledged that no modified habitat will return to its original pristine condition once problem animals are removed. However, it can revert to something resembling it over a long period of time. Immediate results may be spectacular in some instances but a very long time is required to reach the maturity of vegetation that will reflect the original community.

In addition to protecting and enhancing the island's own values, removing problem animals can provide special habitats for endangered plant or animal species which can then be liberated there (Bell, 1989). However as indicated some islands have a very high ecological value and should not be meddled with after the removal of animals. Great Island, in the Three Kings Group to the north of New Zealand, where goats (*Capra hircus*) were removed in 1946 would be a case where one has to consider the special communities on that island as well as the endemics, both plant and animal.

The heavily modified islands where animals and man have had a very long and profound influence are often the best choice if an island is to be rehabilitated and used for more intense management for security and recovery of endangered species.

Atkinson (1989) outlines the biological significance of islands but he also draws attention to the limited number that were free of predators and competitors. There is a planned and systematic rehabilitation of those already affected. While there are limitations to what can be achieved there is a growing pool of experience in methodology and technology in the area of eradication. This will expand with time and will make possible objectives currently unattainable.

Eradication or Control?

It is essential right from the beginning that the objectives for the operation be set and that these objectives are attainable. Usually this should be total eradication and only very occasionally can partial control be acceptable. Total eradication has obvious advantages. It has an end point which means, that even if initially more costly, in the long term it will be less expensive as it will not swallow up funds indefinitely.

Control on the other hand can only be justified to achieve a very specific objective such as protecting an endangered species when perhaps total eradication is impractical at the present time. Examples of this are the predator control programs for endangered species such as takahe (*Notornis mantelli*) and a black stilt (*Himantopus novaeseelandiae*) in the South Island of New Zealand. Often control programs can be more

damaging than the problem itself as the temporary control can upset balances which have established over a period and may cause fluctuations in predator numbers which could prove disastrous. It also has to be recognised that once started they may have to be maintained indefinitely with continuing costs. There is room for some partial removal of animals if the area can be isolated and the animals maintained there by some physical barrier e.g. fencing, such as on Campbell Island where sheep (*Ovis aries*) are now restricted to the south west corner.

Necessity for total commitment

Once the objectives are established there has to be a commitment made to make the necessary funds and staff available to achieve them. The selection of staff is extremely important because they, above everything else, must have the commitment and persistence to achieve the objective. The challenge is as much a mental problem as it is a physical one. It is relatively easy to maintain interest and application when the kill rate is high but much more difficult in the latter stages of a campaign when very few animals remain. The kill of feral cats (*Felis catus*) on Little Barrier Island was 35 cats for 5 459 trap nights, about 1 cat per 156 trap nights in 1979 but in the final year, 1980, only 5 cats were caught for 32 165 trap nights, 1 cat, 6 per 500+ trap night (Veitch 1981). Only the right mental approach and a dedication to the objective gives a successful result.

Necessity for detailed planning and research

In any eradication program planning is an essential element, the better the planning the more chance of success. All the information available on the island should be gathered together to assist the planning. The general topography, plant cover, availability of water, etc. are all vital. Knowledge of the climate, wet and dry seasons, temperature and the like will assist in deciding the best time to conduct a campaign either because it will be more amenable to the work force or it may concentrate the animals into specific areas e.g. snow may force some animals down to a lower altitude or dry conditions may concentrate them near water.

Research relating to the problem animals has to be directed to specific objectives. It is not necessary toward study the situation to prove you have a problem. This, in most cases, is obvious. What is needed are studies to show when the population is at a low point and will be more vulnerable to eradication. The reasons for this could be many but times when food is short, water is at a premium or when the population is at its lower limit are examples.

Research to monitor the effectiveness of eradication methods is also important. The less visible the animal is, the more emphasis on this is required. This enables one to know the effectiveness of a specific control method or where any particular method is failing.

Some islands have a single animal problem but others have several. In the latter case it is important to plan the removal of the animals in the correct order. The removal of one animal can often trigger the increase of another. However most campaigns to date have been planned for the ease with which the job could be done; the larger animals are removed first, and smaller islands are tackled before the larger ones. Planning has to be a little more involved when several animals are to be eradicated. Two factors have to be given serious thought.

The first deals with facilitating the work. The removal of species in the wrong order could make any operation more difficult, and in extreme cases virtually impossible. If goats, burros (*Equus asinus*) and pigs (*Sus scrota*) all occur on the one island as they do on Santiago (Galapagos Islands) then the two major herbivores should be removed after the pigs have been killed. If removed before, the vegetation will tighten up and make the pigs even more difficult to get at. A small number of the herbivores could be used to provide a bait source although in this specific case there could be a complication with the local endangered hawk (*Buteo galapagoensis*) which is a known scavenger.

The other relates to making the habitat less attractive to one of the species. On Campbell Island sheep have been removed from much of the island and the resulting regrowth of vegetation has made this part of the island less suitable for feral cats. This is particularly applicable in wet climates. It also means the animals can be attracted onto artificially cleared tracks and thus become more vulnerable.

Publicizing eradication programs

The question is often raised of whether or not we should publicize eradication programs. In our experience we have always found it best to do so. A more adverse reaction from the public arises if something is done behind closed doors as they become suspicious and do not trust the agencies involved. Today there is growing pressure from animal welfare groups against eradication programs.

In the United States and Britain such welfare and animal rights groups have made it nigh on impossible to run an effective eradication campaign. Often it has been necessary at tremendous expense to move the offending animals rather then destroy them - e.g. the removal of burros from Grand Canyon National Park. Most island rehabilitation programs other than on the very remote islands have been stopped.

Preservation of feral farm animals

A further group which has to be considered is the feral animal preservation groups. These people want to save rare primitive breeds of domestic livestock - goats, sheep, etc. for their possible genetic value to the livestock industry as well as for pure sentiment. The protection of genetic stock has much merit and those interested from a scientific viewpoint generally agree that the breed should be preserved but it usually comes down to a question of where? Again most agree that if it comes to a toss up between preserving indigenous species and habitats or the exotic then there is only one answer and that is the indigenous species. These questions need to be resolved before action is taken and any necessary research on transfers must be made before final eradication. Examples in New Zealand are the black merino sheep on Pitt Island which are now confined to part of their former range which has been designated a scientific reserve, and the removal of goats from the Auckland Islands for breeding research and development before eradication begins.

Methods for eradication

The methods selected for any eradication campaign are part of the planning but must be the best available to achieve the objective. Almost invariably it will be necessary to use a combination of methods. Usually there is one primary method complemented by one or more other methods to achieve specific results and to ensure final eradication. The methods can be divided into five general groups (i) hunting and shooting (ii) poisoning (iii) trapping (iv) habitat manipulation (v) biological control. Each has to be carefully assessed and the right choice made. They also need to be used in the correct sequence to get the best results.

Biological control

Biological control is often considered the simple answer to an eradication or control program. This can be very effective if the population has been isolated from the "disease" (virus) for a long time or in some circumstances has never been exposed to it. A kill of up to 90-95% can be achieved in such circumstances. Despite this it has to be recognised that a good deal has to be known about the "disease" regarding its spread, infection, rapidity of spread and time taken to kill the animal. It is also necessary to know the behaviour of the animals being infected and their reaction once infected. The success of such operations depends very much on contact between individuals - directly or by vector - and may be impaired if a diseased animal "goes to ground" before it has contact with other animals during the infectious stage.

The most important aspect to consider is the small percentage that will remain unaffected and those which develop an immunity. This means that biological control may only be really effective once and much less effective (although still helpful) on future occasions. In some cases biological control may hold the population down to a lower level than it was before. This depends on the "disease" and species involved. It is essential that if biological control is being used then plans must be made to complete the eradication i.e. to eliminate the surviving small percentage immediately after the biological control has run its course. This must be included in the overall plan right from the beginning.

There are some words of caution which must be made. Extreme care must be taken to ensure that the "disease" is host specific. The target population must be totally isolated from any domestic or desired wild population which could be affected. It also has to be appreciated that the use of biological control methods is repugnant to animal lovers who will vigourously oppose such measures.

While most biological control usually refers to "disease" it does not have to be solely this. Fitzgerald (1978) proposed a novel way of possible rodent eradication by the release of single sex stoats (*Mustela erminea*). There is one historical example of this in New Zealand but it is not well documented. It relates to cats released on Mangere Island to control rabbits (*Oryctolagus cuniculus*) about 1900. The cats did eliminate the rabbits (but I suspect they were never firmly established) and much of the birdlife. However as most of the birds were seabirds which only visited the island seasonally there was nothing to sustain the cats during the rest of the year and they died out. Evidence indicates that carnivores need a small mammal present to sustain a permanent population on a small island.

Habitat manipulation

Habitat manipulation is a less obvious eradication/control method but can be very valuable in reducing or confining problem animals. Islands

do not always make this option an easy choice. The main value probably lies in the advantage that can be gained where one or two animal species are removed from an island where there is a combination of animals. The changes in vegetation resulting from this can be quite dramatic and can be most disadvantageous to some species. This is more likely to be the case in wetter climates. Taylor (1968) studied the rabbits on the neighbouring islands Rose and Enderby (Auckland Islands) and found that the removal of cattle (*Bos taurus*) on the former allowed the vegetation to become unsuitable for rabbits over much of the island. They are now confined to very restricted areas where they could be quickly eliminated and may even die out naturally.

Poisoning

The most obvious control tool is poison but many people regard it as the answer to all problems. It is not a "cure all" but rather an efficient tool if used properly. There is a need to use the most effective poison for the species being removed. What is suitable for one species may be impractical for another. The susceptibility of some species to certain poisons is well known. Also some poisons can be detected by some species e.g. the Norway rat (*R. norvegicus*) can detect 1080 in bait (I. McFadden pers. com.)

Possibly the most important part of any poisoning campaign is the selection of a suitable bait or carrier for the poison. This selection has to have two objectives, it must (i) be very attractive to the target species and (ii) if possible, unattractive to non-target species. In the latter case the presentation can be made to avoid non-target species. Considerable success has been achieved by the use of green dyed baits which are less attractive to birds. In other cases the baits can be presented in tunnels so that they are available to one species (e.g. rats) but not others. The actual preparation of baits is also important. It was found that bird kills associated with 1080 carrot poisoning for possum (*Trichosurus vulpecula*) occurred primarily as a result of poorly cut carrot with a high percentage of "fines" or "chaff". Once these were removed bird kills were reduced dramatically.

In addition to direct poisoning of non target species one also has to be aware of the chances of secondary poisoning. Most poisons remain in the carcass of the poisoned animal for some time. The type of poison used will determine what species are likely to be the most vulnerable. Dogs (which may be required for follow up hunting) are highly susceptible to 1080 and birds of prey to the modern second generation anticoagulants. These are all factors to be considered in planning. As well as the obvious non-targets we also have to consider less obvious species, lizard, crustacea, insects and other invertebrates, and contamination of food chains.

Another aspect which has to be considered in poisoning, and also for trapping, is that the baits or traps have to be placed so that every animal has access to them. This means that every territory must have at least one bait site or trap which the local resident has access to. To achieve this is it necessary to get an even spread of bait by aerial or ground laying. In the latter case it often means an extensive track network is required. This can add considerably to the cost and length of time needed for an eradication program. Half-measures will not work.

Lures may be used in association with poison baits (or traps) but here again it is necessary to be aware of what attracts the target species but does not attract non-target ones. Fruit-based lures often attract bird species such as honeyeaters. Trials in New Zealand with kiwi (*Apteryx* spp.) have shown that the reactions are not always consistent and there could be a certain amount of curiosity in investigating a new smell in the territory. It is also possible to use more novel methods. The last cat caught on Little Barrier Island was attracted to the trap by urine impregnated saw-dust from a cat-boarding home. The prey can also be attracted to the area by using a caged, live female in oestrus. Oestrus can be artificially induced with hormone injections but needs to be done under veterinarian supervision.

Trapping

Trapping is the integral part of any hunting program along with shooting. Trapping methods vary considerably but generally large to medium sized animals are shot or trapped. Medium to small animals are trapped usually alive in cage or leg traps and small animals are taken in kill traps. Small animals can be taken in live traps for sampling methods or biological studies but in extermination kill traps are used exclusively.

Success in trapping depends very much on a thorough knowledge of the animal's behaviour and habits. A good knowledge of the animal's behaviour exposes its weaknesses which can be exploited. For example cats will use a track if it is available to them and therefore can be funnelled through a trap. Stoats find tunnels irresistible and tunnel traps can be highly successful.

Traps can be used whether baited or unbaited depending on the target species. The bait may be

displayed either on the trigger mechanism of the trap - as in the back-breaker rat or mouse trap or may be displayed beyond the trap but in such a way that the animal has to trigger the trap in order to reach it - as in the case of cat trapping on Little Barrier Island (Veitch 1985). In some cases it is necessary to conceal the trap very carefully when dealing with a very sensitive or cautious species. On the other hand it can be quite unnecessary with a curious or non-cautious species.

There are a multitude of trapping methods from which one can choose, such as large enclosures which provide a one way entrance. These can be as large as required or may be a small simply constructed funnel trap. These trap the quarry live and they have to be subsequently destroyed. Variations on the simple snare can be used very effectively and as this is a "kill" trap it can be left for longer periods unattended. It can be a very effective method on trails as many poachers have proved.

Other traps include a variety of mechanical, usually spring loaded, devices of various designs. These usually catch the animal by the leg and restrain it (it must therefore be securely tethered) or it can be one that kills instantly. Any trap which either confines or holds the animal must be serviced at least every 24 hours. Kill traps on the other can be left for longer periods. Nets may have some place in a few specialized control programs.

Hunting and shooting

While either biological control or poisoning will take out the bulk of a population, it is often necessary to complete the eradication by direct physical involvement, trapping as covered above, and shooting. Shooting takes considerable skill because you are dealing with a very small number of animals which are under stress and may already have been subjected to considerable disturbance. While anyone can shoot animals when they are common, a hunter has to be very familiar with his quarry and the country it lives in if it is rare. He must be able to predict where it may live (i.e. preferred habitat) and when it is likely to expose itself while feeding, drinking, etc. some spotlighting at night may be necessary.

Hunting may be aided by using dogs to locate and hold the quarry or to flush it out and make it visible to shooters. Other methods such as using a "judas" goat (a goat released with a bell) to link up with surviving herds so that they can be found in heavy cover can also be used.

Non-target species

With either poisoning or trapping one has to accept that in addition to destroying the target species there will be a non-target kill. What has to be assessed and accepted is the level of the non-target kill. For example on Little Barrier island the non-target catch was relatively high. however 800+ of this was the Polynesian rat (*R. exulans*) which were all killed. The non-target catch of birds was 160 of which half were brown kiwis (*A. australis*). In this case the kill rate was much lower as gin traps were being used and serviced regularly. Many of the birds had only minor injuries or bruising and could be released. Had humane kill traps been used it would have meant all animals caught would have been killed.

Factors helping eradication

While I have stressed the need for different approaches, the difficulty of the operation and the need for persistence, there are a few factors which help the eradication program. Once animal numbers get to a very low level and are under constant pressure, their social structures and sex ratios often become upset. Breeding is often disrupted through insufficient time to develop mutual acceptance, or even difficulty in finding a partner. Several campaigns on different species in New Zealand (possums, cats, wekas) have found that the last few female animals have not carried foetuses i.e. have failed to breed. In some instances the animal becomes more vulnerable as it tends to move about in search of other animals to associate or mate with. The more we know about the biology of the species we are eradicating the better we will be placed to predict such breakdowns.

The removal of problem species can result in unexpected and often dramatic recoveries such as occurred in Hawaii when a totally unknown legume plant *Canavalia kauensis*, appeared after goats were excluded from an area in Volcanoes National Park on Hawaii Island (St John 1972).

Weed problems

However all the results may not be beneficial. Often weed species spring up and become a problem. (Taylor 1968). While this may be an argument for doing nothing, normally the problem is only short term and natural succession allows a stable community, similar but not identical to the original, to develop. In some instances some short term management may be warranted.

Prevention better than cure

Eradication programs are usually costly operations and prevention is better than cure. Much greater effort, and in particular publicity and care, must be directed against further islands being invaded by problem animals either deliberately or by accident. The deliberate release of problem animals must be seen as a very serious offence. One may consider the latter as something which should have ceased in our more enlightened society but the record suggests otherwise. More pigs were released after the major shooting of those present on the Chetwode Islands and the same occurred with goats and rabbits on Whale Island. Goats have been put back on Stephenson Island after stock had been removed from the island for some years. Wekas are still being released on islands by "well-meaning" people. Natural, or accidental, invasions are more difficult to control but where the introduction is the result of carelessness then it is inexcusable. Several near misses involving rodents have occurred with expeditions. The most recent was the near-introduction of mice to Mangere Island. In the mid 70s a nest of mice and an adult female were discovered in equipment during a landing and were destroyed. The equipment had been stored in a non-rodent proof shed over winter. Ship-wrecks present a continuing problem.

Natural invasions on islands free of problem animals are less frequent today since the major peaks in populations following introductions, which tended to overflow onto nearby islands, have ceased. More stable population levels do not appear to offer the same threat. However some species do have population peaks following good food years and this may have been the reason why stoats reached Maud island which is at their extreme range for swimming. Table 1 gives a list of problem animals on islands in New Zealand.

SUMMARY

1. Eradication of problem animals is feasible and can be very beneficial.
2. Establish the reasons for eradication and the priorities.
3. Set the objectives and make a total commitment of resources.
4. Plan in detail to achieve objectives and monitor success or otherwise.
5. Prevention of problem animals establishing is better and much cheaper than cure.

REFERENCES

Atkinson, I.A.E. (1989). The Value of New Zealand Island as Biological Resevoirs. This publication.

Bell, B.D. (1989). The Translocation of Species Using Islands. This publication.

Fitzgerald, B.M. (1978). A Proposal for Biological Control. Ecology and Control of Rodents in Nature Reserves : Department of Lands and Survey Information Series No. 4.

St John, H. (1972). *Canavalia kauensis* (Leguminosae), a New Species from the Island of Hawaii. Hawaiian Plant Studies No. 39 : Pacific Science Vol. XXVI No. 4.

Taylor, R.H. (1968). Introduced Mammals and Islands: Priorities for Conservation and Research. Proceedings of New Zealand Ecological Society No. 15.

Veitch, C.R. (1981). The Eradication of Cats on Little Barrier. Report, Department of Internal Affairs File WIL. 30/3/14 Part 4.

Veitch, C.R. (1985). Methods of Eradicating Feral Cats from Offshore Islands in New Zealand. Conservation of Island Birds : I.C.B.P. Technical Bulletin No. 3.

Table 1
Problem Animals

Recent Liberations (1) Accidental Introductions (2) Invasions over past 25 years (3)

SPECIES	ISLANDS	
Pig	*Chetwode	(1)
Goat	*Whale	(1)
	*Rurima	(1)
	*Herekopare	(1)
	Bird (Fouveaux Strait)	(1)
	Stephenson	(1) farm stock
Wallaby	*Great Barrier	(1)
Rabbit	Whale	(1)
Possum	D'Urville	(1)
	Great Barrier	(1) rumoured
Stoat	*Adele	(3) temporary clearances achieved
	*Maud	(3)
	Motukawanui (Cavalli)	(3)
Rat	Big South Cape **r**	(2)
	Somes **r**	(2)
	*Lizard **e**	(3)
	*Codfish **n**	(2)
	*Whenuakura **n**	(3)
	*Poutama **r**	(2) or (3)
	Duffers Reef **r**	(3)

n = norvegicus **r** = rattus **e** = exulans

Mouse	*Mangere	(2)
Weka	*Trio	(1)
	*Rabbit (French Pass)	(1)
	Blumine	(1)
	Allport	(1)

*Since removed in some cases before species became really established.

Appendix 1
Problem animals on New Zealand Islands

Problem Animal	Islands cleared of problem animals over last 50 years. (-) approximate size in ha. [-] eradication not yet complete	Some islands where problem animals still remain. In recommended order of priority for eradication.
Cattle	Campbell (11 216) [Pitt (6203)]	Enderby (Auckland Islands) (710)
Sheep	South East (219) Mangere (113) [Campbell] [Pitt]	
Pig	Aorangi (Poor Knights Islands) (106) Chetwodes (242/81) [Mayor (1288)]	Blumine (377), Pitt, Auckland (45 975), D'Urville (16 782), Great Barrier, (28 510) Mayor
Goat	Great King (Three Kings) (c.435), Cuvier (181), Nukutaunga (Cavalli Islands) (c.10), Whale (140) East (c.8), Maud (309), Macauley (306), Rurima (c.6) Herekopare (28) Raoul (2938)	Auckland, Great Barrier, Bird (c.30)
Wallaby	Great Barrier	
Rabbit	Inner Chetwode (242) Native (Stewart Island) (c.66) Sugarloaf (New Plymouth) (< .5), Motupuna (Wellington) (< .5), Motunau (c.4) Whale Browns (c.60) Korapuki (Mercury islands) (18)	Rose (75), Enderby, Stanley (Mercury Group c.120), Ohinau (c.45) Slipper (210)
Possum	Codfish (1336) Kapiti (1970)	Tarakaipa (< 5)
Cat	Cuvier, Herekopare (28), Putahina (141), Little Barrier (2817) Motuihe (179)	Pitt, Raoul, Auckland, Campbell, Mayor
Rats	Noises, Maria (1) David Rocks (< 1) Otata (22) [Motuhoropapa (10)] n; Titi (32) n; Tawhitinui (5) r; Rurima e; Lizard (Mokohinau) (0.8) e; Codfish n; Whenuakura (2) n; [Whale] n; Poutama (c.20) r; Breadsea (150) n; Korapuki e n = norvegicus r = rattus e = exulans	Numerous: priority should be set on (a) importance and practicability (b) future use of island (c) proximity of island to other rodent free and very valuable islands
Weka	Trio (17), Rabbit (French Pass (> 5), Maud, ([Blumine], Codfish, Kundy (19) Herekopare	Blumine, Pitt, Chetwodes, Open Bay (15), Jacky Lee (30), Motinui (c.35), Solander (111), Allport (< 5), Arid (c.345)

Feral Animal Control on Western Australian Islands

K.D. Morris

Department of Conservation and Land Management, Karratha, W.A. 6714

Abstract

Feral mammals occur on many of the islands off the W.A. coast, and control has been undertaken on four species the rabbit, rat (*Rattus rattus*), goat and fox. Rabbits were deliberately introduced to Carnac and Mistaken Islands in the 19820s and 1830s, prior to their arrival in the south west of W.A. by migration from the eastern states. They overgraze vegetation causing loss of cover and erosion, and in some cases compete with nesting seabirds for burrow sites . They have been effectively eradicated on some islands using trails of carrot cubes impregnated with 1080. The rat occurs on many north west islands, predating nesting seabirds and competing with native fauna for shelter and food. On islands of less than 100 ha they have been eradicated using oats impregnated with Pindone. Despite the goat surviving on Bernier Island for nearly 90 years and overgrazing the vegetation, the six species of native mammal on the island have survived and not showed any sign of decline in numbers. The goat has now been eradicated using an experienced shooter operating from a helicopter. The decline of rock wallabies on offshore islands has been attributed to predation by the fox, however fox eradication is difficult as these islands are connected to the mainland at some stage allowing post baiting invasion to occur. Control of fox numbers at acceptably low levels through continuous baiting with fresh meat and 1080 is possible

INTRODUCTION

Many of the 3 000 or so islands off the Western Australian (W.A.) coast support populations of feral animals (Table 1). Seven species of feral mammal are known, however in most cases only one species has become established on an island. Since many of the affected islands are nature reserves with high conservation values, the Department of Conservation and Land Management, with advice and assistance from the Agriculture Protection Board, has been undertaking control and eradication programs on them. In this context the objective of eradication is to eliminate all individuals, while that of control is to reduce the population to acceptable low levels. This paper describes the control and eradication programs conducted since 1965 on four species of feral animal, the rabbit (*Oryctolagus cuniculus*), black rat (*Rattus rattus*), goat (*Capra hircus*) and fox (*Vulpes vulpes*).

Rabbit (*Oryctolagus cuniculus*)

Between 1965-1980 rabbit eradication programs have been undertaken on islands of 4 nature reserves off the south and west coast of W.A. The islands concerned are Carnac Island, Wooded, Morley and Leo Islands in the Houtman Abrohlos, Green Islets (north and south) and Mistaken Island.

All these islands are important breeding sites for sea birds. At least 5 species breed on Carnac Island (19 ha), and this is the only area of overlap between the breeding ranges of the Little Penguin (northern limit) and Wedge-tailed Shearwater (southern limit) (Watson 1959). A population of the Tiger Snake (*Notechis ater*) also inhabits the island and Australian Sea Lions rest on the beaches. Wooded, Morley and Leo Islands support at least 15, 8 and 5 species of nesting sea bird respectively (Storr, *et al.* 1986). The two Green Islets, each 3 ha, have had 7 species recorded breeding on them, and a colony of Australian Sea Lions on their beaches. Mistaken Island, also referred to as Rabbit Island, has had 4

Table 1.
Feral animals on W.A. Islands

Island Name	Land Status	Conservation Value	Feral animal(s)
Sir Graham Moore	vacant Crown land	native mammal	pig
Adele	Commonwealth	seabird nesting	*Rattus exulans*
Browse	mineral reserve	turtle nesting	*Mus musculus*
Lacepede	nature reserve	seabird/turtle nesting	*Rattus rattus*
Bedout	nature reserve	seabird nesting	*Rattus rattus*
Depuch	W.A. Museum reserve	native mammals	fox
Dolphin, Angel Gidley, Keast	nature reserve	turtle nesting, native mammals	fox, cat
Monte Bello	Commonwealth	turtle nesting, native mammals	cat *Rattus rattus*
Prince, Double, Pasco, Boodie, Middle	nature reserve	seabird nesting, native mammals	*Rattus rattus*
Bernier	nature reserve	native mammals	goat
Dirk Hartog	pastoral lease	native mammals	goat, cat, *Mus musculus*
Wooded, Morley Leo	Fisheries reserve	seabird nesting	rabbit,
Rat	Fisheries reserve	seabird nesting	cat
Green	nature reserve	seabird nesting, seals	rabbit
Rottnest	recreation reserve	native mammals, bird nesting	cat
Carnac	nature reserve	seabird nesting	rabbit, *Mus musculus*
Mistaken	nature reserve	seabird nesting	rabbit, fox, *Rattus rattus*
Breaksea	nature reserve	seabird nesting	rabbit
Michaelmas	nature reserve	seabird nesting	rabbit
Recherche Archipelago	nature reserve	flora, seals, seabirds, native mammals	goat

species recorded breeding (Serventy and Whittell, 1976), however 3 of these, the Fleshy-footed Shearwater, Great-winged Petrel and White-faced Storm Petrel have not been recorded in recent times. This island also has the Black Rat (*Rattus rattus*) and fox on it.

The earliest introduction of rabbits was onto Carnac Island in the 1820s supposedly by early American or French whalers as a source of food (Young 1981). Their presence on the island was noted by Charles Fraser, a colonial botanist who visited Carnac Island in 1827. The rabbits were viewed as a valuable asset at this time and were not to be shot or removed from the island without the permission of the Fremantle Harbour Master. It is believed that more rabbits were released onto Carnac Island in 1934, suggesting that the population may have declined naturally at some stage. Rabbits were introduced to Mistaken Island in 1830 by George Cheyne who rented the island for that purpose (Department Fisheries and Wildlife file 192/71). These early introductions of rabbits pre-date the spread of rabbits from eastern Australia to the south of W.A. around 1900. The Leo Island rabbit population originated from two pairs imported by a fisherman from Wooded Island in 1971. The rabbits on Green Islets, and Wooded and Morley Islands were probably released by fishermen for food, however the dates for this are unknown.

The most obvious damage caused by rabbits is the overgrazing of vegetation which ultimately leads to erosion and removes cover for nesting seabirds and terrestial fauna. Aerial photography taken 3 years after rabbit eradication on Carnac Island showed a marked recovery in the islands vegetation, although it was suggested that the plant species composition may have changed as less palatable species increased in abundance (Abbott 1980). Some of the nesting seabirds which burrow, such as Wedge-tailed Shearwater, Fleshy-footed Shearwater and White-faced Storm Petrel, were probably also affected by rabbits through competition for burrow sites.

Population estimates of rabbits on these islands have only been obtained by counting carcasses above ground immediately following baiting and extrapolating to a total population. On Green Islets the population was estimated to be 140 on each of the 3 islets prior to baiting, and on Mistaken Island (14 ha), a population of 300 rabbits was estimated. After baiting on Carnac Island, 60 carcasses were found and removed.

Initial attempts at rabbit eradication were on Carnac Island in 1965 using the one-shot oat method. This was the method used at the time for rabbit control on the mainland and involved setting an oat trail with one oat in a hundred impregnated with a lethal dose of 1080 (sodium monofluoroacetate) (Gooding and Harrison 1964). However, this was not successful on Carnac Island. Attempts at control using myxomatosis in 1968 were also unsuccessful. Subsequent bait preference trials suggested that carrot would be a suitable medium as no other fauna would take the bait. Other advantages included that carrot would not grow on the island, the baits were more attractive because of their higher water content, and they broke down quickly.

Carrot was cut into small cubes, impregnated with 1080 and, in May 1969 laid in bait trails on the island. This was preceded by two nights of prebaiting with unpoisoned carrots. Rabbits have an LD50 for 1080 of approximately 0.5 mg 1080/kg (Wheeler and Hart 1977) and need to eat 10-12 cubes of carrot to receive a lethal dose. This method proved successful in eradicating rabbits on Carnac Island and was subsequently used on the other islands.

All subsequent baiting was also undertaken in late summer or autumn as the moist carrot baits were more attractive and mortality was enhanced by cold and starvation. Wooded and Morley Islands were baited in February 1973, Green Islets in May 1974, Leo Island in May 1976, and Mistaken Island in March 1980.

With the exception of Mistaken Island, all these eradication programs have been successful. Mistaken Island is connected to the mainland by a sandbar and reinvasion occurs from the adjacent peninsula. In this situation, rabbit control rather than eradication is required.

Rabbits are also known from other island nature reserves along the south coast including those in the vicinity of Mistaken Island, however no control or eradication programs have yet been undertaken on these.

Black Rat (*Rattus rattus*)

This species, together with *Rattus norvegicus* and *R. exulans* has been introduced to many islands around the world and these have often had a severe impact on native birdlife (Atkinson 1977, Taylor 1979, Moller 1983) as well as reptiles and invertebrates (Ramsay 1978, Whitaker 1978). In W.A., *R. rattus* occurs on many islands off the north west coast, and *R. exulans* is known from Adele Island off the Kimberley coast.

Since 1981 eradication programs have been under taken for *R. rattus* on five islands including Bedout Island, north of Port Hedland, and Prince, Double,

Pasco and Boodie Islands, all in the vicinity of Barrow Island. The rats are believed to have been introduced between 1860 and 1900 from pearling and fishing vessels which were regularly careened on the islands.

Many of these islands are also important seabird breeding sites. Seven species have been recorded nesting on Bedout Island (Tunney 1902, Bush and Lodge 1977). The vegetation on this island consists almost entirely of *Spinifex longifolius* and the seeds and leaves of this species were heavily grazed by the *R. rattus*, thereby reducing vegetation cover. Predation of eggs and chicks of the seabirds possibly also occurred, although this was not documented prior to the eradication. Tunney (1902) recorded the Common Noddy nesting on Bedout Island in May 1901, however subsequent visits in May 1972 and 1975 and, June 1982 and 1984 have failed to record further nesting by this species.

Boodie Island (470 ha) has a small population of the Burrowing Bettong, *Bettongia lesueur* confined to the limestone portion of the island. This is one of the "critical weight range" mammals which has declined drastically on the Australian mainland and is now restricted to four island populations (Burbidge, this publication). A preliminary survey of Boodie Island suggested that the rat was competing with the *B. lesueur* for burrows in the limestone area.

Prince Island is connected to Barrow Island at low tide and when *R. rattus* were discovered on the island in 1982 it was feared that they may have also occupied the adjacent area of Barrow Island. Fortunately this was not so, however Prince Island became a priority for rat eradication. Native mammals such as the Northern Brushtail Possum *Trichosurus arnhemensis* and the Golden Bandicoot *Isoodon auratus* also occur on the island and presumably move between Barrow and Prince Islands.

Based on headtorching transects on Bedout and Boodie Islands, population estimates of between 7 and 100 *R. rattus* per hectare have been obtained.

The baiting for *R. rattus* on all the islands followed the same procedure. Oats were impregnated with the anticoagulant Pindone (2 pivalyl 1,3 - indandione, 0.17 mg/oat) and placed either in a sealed plastic bag or loose in a 50 m grid pattern, with a bait also placed in the centre of the 50 m square. Baits ranged from 150-230 g. On all the islands except Boodie, the bait stations were left uncovered. Because of the presence of *B. lesueur* on this island, the bait stations were covered with plastic basins with holes cut in the sides to allow access for the *Rattus* but not *Bettongia*. These were partially effective, however the *Bettongia* did obtain access to the oats once they had been dragged to the openings by the *Rattus*.

Ideally this type of baiting should be done when natural food is scarce, that is at the end of the cooler dry season. Bedout Island was baited in September/October 1981, and Double and Pasco Islands were baited in September 1983. Prince Island was baited in April 1983, and Boodie Island was baited in May 1985 for funding reasons.

All the eradication programs were successful. Initially it was suspected that the program on Boodie Island was unsuccessful as *Rattus rattus* tracks were still evident four months after the baiting. However, more recent inspections indicate that this residual population is no longer present. Unfortunately it also appears that efforts to restrict access of the Boodie to bait stations was unsuccessful and the Boodie has also been eradicated. It is anticipated that the Boodie will be re-introduced to the Island in the near future.

Many islands off the W.A. coast still require *Rattus* eradication programs to be undertaken. Middle Island, between Boodie and Barrow Islands supports *R. rattus* and the gazetted rare Golden Bandicoot *Isoodon auratus*. Both species are similar in size and habit and eradication of the *Rattus* will be difficult without some *Isoodon* mortality. Many of the 100 or so islands in the Monte Bello groups, north of Barrow Island, also support *R. rattus*. The two largest islands are each over 500 ha and a major operation will be required to eradicate the rats. The feral cat is also present on some islands. If eradication of these two species is successful, it is proposed to reintroduce the Spectacled Hare Wallaby *Lagorchestes conspicillatus* and Golden Bandicoot *Isoodon auratus*, both of which occurred on the islands until the early 1900s (Burbidge 1971).

With the increase in use of north west islands as bases for oil exploration and production, one concern is the introduction of *R. rattus*, and other exotic plants and animals through equipment brought from the mainland. The oil companies on Barrow and Lowendal Islands are required to fumigate equipment and materials with methyl bromide, and wash larger equipment with high pressure water.

Goat (*Capra hircus*)

Goat eradication has only been conducted on one island off the W.A. coast, Bernier Island, 40 km west of Carnarvon, although they also occur on several islands off the south coast, particularly in the Recherche Archipelago. Bernier Island is one of the largest islands off the W.A. coast (5000 ha) and is an important nature reserve. Six species of mammal occur on the island. Four of these, the Western Hare-wallaby *Lagorchestes hirsutus*), Banded Hare-wallaby (*Lagostrophus fasciatus*), Boodie

(*Bettongia lesueur*), and Western Barred Bandicoot (*Perameles bougainville*) are gazetted rare. Of the two rodents *Pseudomys albocinereus* and *P. praeconis* which also occur on the island, *P. praeconis* is now only known on Bernier Island, after having originally been collected on the adjacent mainland in 1858.

Goats were introduced to Bernier Island in 1899 by Mr G. Baston who took up a pastoral lease on the island. Four female and one male Angora goat were taken to the island for milking. When the Aborigines and Medical Department opened hospitals on Bernier and Dorre Islands in 1907 for aborigines suffering from venereal and other diseases, the goats remained and were encouraged as a source of food and milk. The goats remained when the hospitals closed in 1917.

When Bernier and Dorre were gazetted as an A Class reserve for the Conservation of Fauna in 1957, the goats were declared vermin on the islands. Goats did not become established on Dorre Island.

After the first detail ed biological survey of Bernier and Dorre Island in 1959 (Ride *et al.* 1962) a comparison was made between the vegetation of goat free Dorre Island and Bernier Island. the widespread occurrence of sand drift on Bernier Island was attributed to the effects of grazing by the goats and it was recommended that the goat population be exterminated without delay.

The trampling of vegetation by goats may also have had some effect on the fauna, however despite the goats presence on Bernier Island for nearly 90 years, there has been no evidence of decline of the native mammals resident on the island.

Between 1962-1972 several ground shooting expeditions were made to Bernier Island and over 550 goats were either shot or removed alive from the island. Even Gurkha troops were used in one operation (Waldon 1971). At one stage during this period the population of goats was estimated to be 350. In 1981/2 estimates of the population, after another 60 had been shot or removed, was between 60-80. Ground shooting parties never succeeded in eradication because some of the goats were able to escape into the rugged cliffs and caves on the west coast.

In 1976 it was suggested that shooting from a helicopter was the only way that complete eradication could be achieved. However it was not until 1984 that Commonwealth funds became available to charter a helicopter to undertake this work. The eradication operation was programmed for May 1984 and used an experienced helicopter pilot and an Agriculture Protection Board shooter. Prior to this, the Department of Agriculture mustered 43 goats and removed them from the island for research into developing Angora wool strain. Subsequently another 37 goats were shot from the air or removed alive giving a total population of 80 goats on the island prior to eradication.

For 12-18 months following the eradication program the District Wildlife Officer at Carnarvon had reports from fishermen that goats were still present on the island. However inspection in 1986 and 1987 by helicopter and foot have failed to find any trace of goats on Bernier Island and the eradication program is now regarded to have been successful.

Fox (*Vulpes vulpes*)

Foxes occur on only a few islands off the W.A. coast and only on those which retain some connection to the mainland. Fox control has been undertaken on several islands in the Dampier Archipelago, adjacent to the Burrup Peninsula (Dolphin, Angel Gidby, Keast, Collier Rock and Legendre Islands). All, except Legendre Island, are nature reserves.

Foxes arrived in the coastal Pilbara in the early 1930s and have spread to the Burrup Peninsula and adjacent island through low tide connections, since then. Patrols by fisheries vessels through the Dampier Archipelago in the 1950s reported foxes on Dolphin Island (Ces Piesse, pers comm). Cats probably arrived with the first settlers in the Pilbara in the 1860s and many have since become feral and spread to the Burrup Peninsula and adjacent islands. Feral cats have probably increased in number since Dampier was constructed in 1966.

Both the cat and fox are efficient opportunistic predators and their diet closely follows the abundance of prey species (Coman and Brunner 1972, Green and Osborne 1981). The decline of the rock wallabies *Petrogale rothschildi* and *P. lateralis* on north west islands and mainland reserves has been attributed to predation by the fox (Kinnear *et al.* 1984). Dolphin Island now supports an estimated population of only 50 *P. rothschildi* while similarly sized, but fox free Enderby Island supports an estimated 1 500 *P. rothschildi.* Foxes also dig up turtle nests and consume eggs and hatchlings. Other native fauna, such as small rodents, lizards and birds are probably also preyed upon by the fox and cat.

In October 1980, fresh meat baits impregnated with 1080 were laid on 39 beaches around Dolphin Island, however foxes were still present one month later. In May 1981, bait preference trials were conducted using fresh meat and factory prepared baits. Fresh meat baits were preferred by foxes.

Table 2.
Summary of feral animal control on W.A. islands.

	RABBIT	RAT	GOAT	FOX
1. ISLANDS	Carnac Is. 19 ha Wooded Is. Morley Is. Green Is. 6 ha Mistaken Is. 14 ha	Bedout Is. 31 ha Prince Is. 4 ha Double Is. 100 ha Pasco Is. 1 ha Boodie Is. 470 ha	Bernier Is. 5 000 ha	Dampier Archipelago
2. SOURCE/DATE OF INTRODUCTION	whalers and fishermen 1820-1971	pearlers and fishermen 1860-1900	pastoral lease 1899	natural spread 1930s
3. DAMAGE	overgraze vegetation causing erosion, competition with nesting seabirds for burrow sites	predation of nesting seabirds, competition with native mammals	overgraze and trample vegetation	predation of native fauna including rock wallabys and turtle eggs
4. POPULATION ESTIMATES AT TIME OF BAITING	20-50/ha	7-100/ha	80 total	?
5. METHOD OF CONTROL	carrots/1080 prebaiting and bait trails	oats/pindone 50 m grid for bait stations	ground and aerial shooting	meat/1080 ground and aerial baiting 100 grid
6. DATE OF CONTROL	1965-1980 April/May	1981-1985 Sept/Oct April/May	1965-1984 (May)	1980-1984 Sept/Oct
7. RESULTS OF CONTROL	successful except Mistaken Island	successful except Boodie Island	successful?	successful for 4 months then foxes re-appeared.

These baits weighed approximately 400 g and contained 2 mg 1080. The fox has an LD 50 of 0.15 mg 1080/kg (King, pers comm) and the cat 0.4 mg 1080/kg (McIlroy 1981). The native predator on the islands, the Little Northern Native-cat *Dasyurus hallucatus* has a significantly higher tolerance to 1080 with an LD of 5.7 mg 1080/kg (McIlroy 1981). In September 1984, 2 500 fresh meat baits each of 250 g and containing 1.5 mg 1980 were dropped from an aircraft in a 100 m grid pattern over the Burrup Peninsula and adjacent islands. Another 1 000 baits were laid from the ground around facilities on the Burrup Peninsula. The baiting of the Burrup Peninsula was seen as an effective way of creating a fox free buffer zone between the mainland and islands.

No fox activity on the islands was observed for four months after the baiting, however by February 1985 fox tracks were again evident and turtle nests were dug up. Another baiting program was undertaken in November 1987 with similar results. Effective control will require more frequent baiting than has been undertaken in the past as reinvasion of the islands by foxes occurs from the adjacent mainland. A control program for exotic predators will be included in the plan for management of the nature reserves of the Dampier Archipelago presently being prepared.

COST OF ERADICATION AND CONTROL

Feral animal eradication and control programs are often labour intensive and require equipment that is expensive to purchase and/or operate. Access to some of the islands is also expensive, as either charter vessel or helicopter must be used.

Estimate of costs for some of the programs undertaken to date are presented below:

Black Rat (*Rattus rattus*)

1. Bedout Island: (baiting and follow-up inspections) helicopter hire - 6 hours $2 400
   bait $500 personnel travel allowance $600

   $3 500

2. Boodie Island: (ANPWS funding) including charter vessel, bait, travel allowances (3 persons) and equipment

$9 600

Goat (*Capra hircus*)

Bernier Island: (ANPWS funding) May 1984 helicopter hire $25 000 travel allowance, equipment April 1985- follow-up inspection by helicopter $10 000

$35 000

Fox (*Vulpes vulpes*)

Dampier Archipelago: aircraft hire, meat baits (per baiting program)

$2 000

REFERENCES

Abbott, I. (1980). The distribution and cover of plant species on Carnac Island, Western Australia. *Journal of the Royal Society Western Australia*. 63 (2). 39-45.

Atkinson, I.A.E. (1977). A reassessment of factors, particularly *Rattus rattus*, that influenced the decline of endemic forest birds in the Hawaiian Island. *Pacific Science* 31, 109-133.

Burbidge, A.A. (1971). The fauna and flora of the Monte Bello Island. Dept. Fisheries and Fauna Report No. 9.

Bush, T.E., and Lodge, G.A. (1977). Birds of Bedout Island. *The Western Australian Naturalist* 13 (8) 189-190.

Coman, B.J., and Brunner, H., (1972). Good habits of the feral house cat in Victoria. *Journal Wildlife Management*, 36 848-853.

Gooding, C.D., and Harrison, L.A. (1964). "One-shot" baiting. Journal of Agriculture Western Australia 5, 12-15.

Kinnear, J.A., Onus, M., and Bromilow., B. (1984). Foxes, feral cats, and rock wallabys. *SWANS* 14 (1) 3-8.

McIlroy, J.C. (1981). The sensitivity of Australian mammals to 1080 poison I. Marsupial and Eutherian carnivores. *Australian Wildlife Research* 8 (21) 385-402.

Moller, A.P. (1983). Damage by rats *Rattus norvegicus* to breeding birds on Danish Islands. *Biological Conservation* 25, 5-18.

Ramsay, G.W. (1978). A review of the effects of rodents on New Zealand invertebrate fauna In Dingwall, P.R. Atkinson I.A.E., and Hays, C. (eds.). The ecology and control of rodents in New Zealand

Nature Reserves. New Zealand Dept. Lands and Survey Information Series 4 : 89-95.

Ride, W.D.L., Mees, G.P., Douglas, A.M., Royce, R.D. and Tyndale-Biscoe, C.H. (1962). The results of an expedition to Bernier and Dorre Islands. Shark Bay W.A. in July 1959. Dept. of Fisheries publication, Ed. A.J. Fraser.

Serventy, D.L., and Marshall, A.J. (1964). A natural history reconnaissance of Barrow and Monte Bello Islands, 1958. CSIRO Division of Wildlife Research Technical Paper No. 6.

Serventy, D.L. and Whittell, H.M. (1976). Birds of Western Australia (5th edition). University of Western Australia Press.

Taylor, R.H. (1979). Predation on Sooty Terns at Raoul Island by rats and cats. Notornis 26 (2), 199-202.

Tunney, J.T. (1902). Field notes on Bedout Island. *Emu* 1 (2), 73.

Waldon, A.C. (1971). Goat eradication, Bernier Island. *SWANS* 2(3) pp 60-61.

Watson, J.A.L. (1959). The birds of Carnac Island Western Australia. *The Western Australian Naturalist*, 6 (8) 185-190.

Wheeler, S.H. and Hart. D.S. (1979). The toxicity of sodium monofluoroacetate to wild rabbits *Oryctolagus cuniculus* (L.) from three sites in Western Australia. *Australian Wildlife Research*, 6 57-62.

Whitaker, A.H. (1978). The effects of rodents on reptiles and amphibians In Dingwall, P.R. Atkinson, I.A.E. and Hay, C. (eds). The ecology and control or rodents in New Zealand Nature Reserves. New Zealand Dept. Lands and Survey Information Series 4 75-86.

Young, C. (1981). Rabbit eradication on islands off the W.A. coast *SWANS* 11 (1), 13-16.

Translocation of Species using Islands

Brian D. Bell

Department of Internal Affairs, Wellington, New Zealand.

Abstract

The principles, objectives and procedures of translocation are examined and illustrated by some case studies.

INTRODUCTION

The moving of animals from one place to another is not new. It occurred with the early expansion of native peoples, e.g. the Polynesians in the Pacific took the dog (*kuri*) (*Canis familiaris*) and the rat (*kiore*) (*Rattus exulans*) with them. The pattern continued with European explorers and colonists. These transfers of species had the specific aim of providing food and sport or were for purely aesthetic reasons. Today translocation of species is being successfully used as a management technique for conservation.

The use of islands for this work has distinct advantages over mainland or continental situations because they are isolated from external influences or can be rehabilitated (Bell, 1989). New Zealand is particularly fortunate in this regard as it has wide variety of islands and most reflect similar habitats to that on the neighbouring mainland. However, when we come to select an island for a particular requirement the choice is still very limited (Atkinson 1989). The value of islands is also evident in the number of species which have survived on them but which have succumbed to habitat modification, competition and predation on the mainland. These populations are a source for translocation programmes.

Historically, translocation for conservation purposes began in New Zealand just prior to the turn of the century when Richard Henry transferred c. 400 kakapo (*Strigops habroptilus*) to Resolution and other islands in Dusky Sound, Fiordland, (Williams) 1956). His efforts were thwarted by the invasion of these islands by stoats (*Mustela erminea*). In the early part of the century (although records are far from complete) kiwi (*Apteryx* spp.) were transferred to Little Barrier and Kapiti Islands and buff weka (*Gallirallus australis hectori*) were moved to the Chatham Islands. These latter moves were designed more to enhance the island rather than to conserve the species. In retrospect two of the transfers saved the species; little spotted kiwi (*Apteryx owenii*), and the buff weka, have subsequently disappeared from the mainland. In the 1920s-1950s efforts were made to transfer North Island saddleback (*Philesturnus carunculatus rufusator*) then confined to Hen Island, but these failed probably because an insufficient number were transferred. Later moves were successful.

Translocation has become a recognised tool of management but today there are some major differences as many of the species are endangered, some critically. Several moves have been emergency operations. The major differences between these and earlier operations are, that whereas earlier transfers could afford to have some losses because they could be repeated, in a number of more recent cases we had only one chance; any loss would have been total extinction for the species involved.

PRINCIPLES AND OBJECTIVES

Before undertaking any translocation it is necessary to set the objectives. These should be both immediate and long-term. The primary objective is usually the security of the species. In achieving this policy one should consider some principles. Wherever possible, the species should be maintained in its existing habitat; for example, the North Island kokako (*Callaeas cinerea wilsoni*) should be retained in its North Island forest habitat. Moves to Little Barrier Island are only for additional security.

Where moves are contemplated, islands where the species formerly occurred should be used if this is practical, that is, if the original problems which resulted in local extinction are removed. For example, the removal of cats (*Felis catus*) from Little Barrier Island preceded the re-introduction of saddleback. If such a habitat is not available then one should be selected within the geographical range if possible. North Island species should be restricted to North Island islands and, similarly, South Island

species to South Island islands unless there are compelling reasons for doing otherwise.

Obviously not all requirements can be met and sometimes it will be necessary to move outside these guidelines in the case of a critically endangered species, or where the species is confined to an isolated island group and there is no alternative, for example, the Antipodes Island green parakeet (*Cyanoramphus unicolor*). Some islands must be specifically excluded from translocation programmes as they are too important in their own right because of their unmodified nature or very specialised ecology, the Poor Knights for example.

Longer term objectives could include reinstating the species back in its original habitat. This presumes that some of the problems facing it originally have been removed. The usual reason is to provide a secure habitat for species endangered elsewhere. A new island population can also be used as a reservoir for future transfers either to other island habitats or to its original mainland habitat, again presuming the cause for the demise of the species locally has been corrected.

The programme could also be used to "teach" a species to cope with a wider range of predators. In effect, this is a process of speeding up natural selection but it is wasteful as it involves a succession of liberations to compensate for high mortality. The introduction of North Island saddleback to Kapiti is an example of this. Aiming to get saddlebacks to a stage where they could survive in the presence of Norway rats (*Rattus norvegicus*) 300 birds were released over a 3 year period but as anticipated few of these survive today. Although the project showed some promise it was abandoned, primarily because of a shortage of resources which had to be directed to more urgent priorities.

A further reason can be to make rare and endangered species available to the public by transferring them to a more accessible "open" island. This reduces the pressure on the critical habitats and at the same time encourages the support of the public, a very necessary element in any conservation programme. A final objective could be to maintain the diversity of the gene pool. This could apply to both offshore and mainland (ecological) islands isolated by habitat modification.

PROCEDURES

Over the first few years of the programme the Wildlife Service developed a number of operating procedures as a guide to such translocation work. At the same time the Survival Service Commission published a set of guidelines for such work and for taking species into captivity (Anon 1969). These are summarised as follows:

1. The project should be under the supervision of the appropriate conservation agency.
2. It must be thoroughly planned through all stages and under the direct supervision of experienced personnel.
3. Removal of birds from a population should not jeopardise the viability of the original population unless it is in imminent danger of extinction.
4. A sufficient number should be transferred to ensure there is a reasonable chance of a population establishing.
5. Relocations should be made only into suitable habitats or to one which has been prepared to receive the species concerned.

When time permits, and often this is not possible, research should be carried out to determine the species' requirements and use of the habitat. It is also essential to assess the new habitat to see if it provides all these requirements or as many as possible.

In emergency situations it may be necessary to take an intuitive guess (Bell 1978) but even then the process contains the same elements of assessment if reduced to the bare minimum.

A word of warning needs to be sounded with regard to habitat studies. In many cases where a species has retreated in range or has been reduced to low numbers, its present habitat is not necessarily the preferred one. The species may have persisted there because some factors are absent or have had less effect than in its former preferred habitat, e.g. a habitat less favoured by predators or competitors.

Much of the research will have to be of an experimental nature to determine the adaptability of the species involved and to see what techniques can be used. Such questions as means of capture, the species' reaction to trapping, handling and temporary captivity, acceptance of food in temporary confinement, and ability to expand from the small founder population have to be answered. This experimental work can be tested with a commoner related species if one is available. A source of considerable skill in this field is available from avicultural and zoological people, many of whom have had long experience in handling birds, including such techniques as anaesthetics and stress suppressants.

The actual methods of catching and moving species varies from one to another. They can range from the use of mist nets, drift-traps, clap-traps,

cannon nets etc through to the use of dogs and hand nets. Irrespective of the method, the well-being of the individual bird is paramount. The caging and transfer of the birds falls into two main categories. Quick capture and immediate transfer is possible if using islands close by. This reduces the stress to a single period involving capture, transfer and establishment in the wild.

The second, where the translocation site is more distant, involves the stress associated with capture followed by a period in captivity while the birds adjust to confinement. This is followed by a further period of stress when the species is transferred and released. The actual transfer can be done in small confined boxes where feeding is difficult but the bird is kept in a dark environment with a minimum of disturbance. The alternative is to use a larger cage where the birds are able to feed. If the species will adapt to this it has many advantages. We have even had some birds which have increased in weight during transport. The wire front to the cage needs to be covered on the inside with scrim or hessian to cut down the light and reduce disturbance. It is essential to determine before holding and transporting the birds whether it is possible to handle them as a group, or pairs or as individuals. While guidelines can be established, the operator has to have sufficient flexibility to adapt these for his immediate needs as no two situations are identical.

Following release it is essential that the population be monitored. At a bare minimum all released birds should be banded so that breeding can be assumed if a bird is seen without a band. In other cases more detailed studies involving individual colour banding or radio telemetry may be warranted. The more information that can be gathered without causing unnecessary disturbance, the easier it will be to identify any reasons for the population's failure to establish. What level of disturbance is acceptable is the critical issue.

CAST STUDIES

We can look at the implementation of some of these principles and methods in some practical examples from New Zealand. In 1964 we began our current translocation policy with the transfer of North Island saddleback from Hen Island to Middle Chicken. North Island saddleback, restricted to Hen Island, was considered to be endangered as long as it remained on the one island, an "all eggs in the one basket" situation. The policy was to correct this, and then tackle other species of similar status. Before any move was made studies were carried out to learn the habitat requirements of saddleback. A feeding study was made (Atkinson 1964, 1966) which showed what foods were important at different seasons and where birds were feeding in the habitat. An examination of islands in the Hauraki Gulf showed that several appeared to provide suitable habitat. Transfers from Hen Island were made to Middle Chicken Island in 1964, Red Mercury Island in 1966, and Cuvier and Fanal Islands in 1968. A transfer from Middle Chicken to Big Chicken (Marotiri) Island was made in 1971 (Merton 1975).

The birds were caught in mist nets. J. Kendrick developed the use of play-back tape-recorded song to attract the birds to the nets which proved very effective. Later this technique was improved by using speakers positioned on either side of the net so that the calls could be switched from side to side to draw the bird into the net. It has also been found that far better results can be obtained using the local song dialect rather than one from further away. This often means the local song has to be recorded before trapping can begin. Play back calls can also be used in association with mounted specimens or models which can be made to move by pulling strings.

It was fortunate that this programme had begun, because later in 1964 the Wildlife Service was faced with a crisis when ship rats (*Rattus rattus*) were found to have invaded Big South Cape Island off the south west corner of Stewart Island. This island and two neighbouring islets were the final refuge for three subspecies of birds.

There was no time for detailed studies but several islands were checked for suitability while the recovery team was on its way to Big South Cape. Finally, Big Island and Kaimohu were selected as the most suitable islands immediately available.

Because of the remoteness of the islands and the inclement weather in the region (the transfers were made in winter) it was necessary to build a holding aviary for the birds while awaiting transport. The actual transfers were made in darkened boxes. South Island saddleback (*P. c. carunculatus*) were successfully re-established but Stead's bush wren (*Xenicus australis steadi*), while persisting for four years after transfer, failed to establish. This was probably because only 6 birds could be caught (2 of which died before we learnt how to handle them). This was possibly insufficient to establish a population although other species have been established from a similar number (see below). The demise of the wren was a tragedy as this was the sole surviving race of this endemic species. We were also unable to catch sufficient numbers or maintain alive the Stewart Island snipe (*Coenocorypha aucklandica iredalei*). This also became extinct although other races occur on subantarctic islands.

Since the initial transfers both races of saddleback have been transferred to a number of islands. The North Island race is now very secure as it is firmly established on ten large islands. It has been possible to introduce it to less favourable habitats to (i) make it available to the public, and (ii) to try to adapt it to a wider range of predators. Although this latter attempt appears to have failed, when time and funds are available it may yet prove possible. Although the South Island race has been established on 9 small islands it still needs to be established on a large island to secure its future.

One of the better publicised translocations is that of the black robin (*Petroica traversi*) in the Chatham Islands but much of the detail and planning is not well known. The precarious position of this species was recognised for many years and a census in 1968 showed some 18 birds remained on Little Mangere Island. A scientist was employed in 1972 to study the related South Island robin and to extrapolate these studies to the black robin during limited visits to the island. The studies were mainly biological but failed to produce any real answers apart from one experimental research project to test the ability of South Island robins (*Petroica a. australis*) to establish a population on an island from only 2 pairs. This was achieved on both Motuara and Allports Island (Marlborough Sounds). This gave hope for relocating the black robin.

By 1974 it was recognised that the black robin population was declining and the habitat was deteriorating, partly as a result of climatic changes and partly because of modification by man. By 1975/76 the population had fallen to 9 individuals. A decision was taken to move one of the pairs to neighbouring Mangere Island which was regenerating after years of grazing, although only a small bush remnant remained.

The transfer was planned for September 1976 and the best staff available were assigned to the job. On arrival the party found the position more serious; only seven birds remained and of these only 2 were females. They decided that it was inadvisable to separate the two established pairs so took the brave step of transferring both pairs plus a "spare" male. The male was moved first to try out all procedures - communications, transport, caging, catching and release techniques.

Following this initial transfer the recovery of the species was incredibly slow and as only one female bred successfully the fate of the species hung in the balance. In 1980 a programme of cross-fostering eggs using other species was begun. This increased productivity more than one hundredfold and the species appears now to be on the way to recovery. Cross-fostering and manipulation are other techniques than can assist endangered species and are mentioned here only because there are times when a translocated species may require additional management to become established.

While I have concentrated on the translocation of birds and the two case studies relate to passerines, bird translocations have covered a wide range of families, see Table 1. Most have involved moving wild-bred individuals from one place to another but at times captive-reared populations have been used. The techniques outlined above have been used with various modifications. A new method will be used to re-locate petrels. It has already been shown that petrel eggs can be moved to a burrow in a new location using another species to incubate them and raise the chick (Byrd *et al.*) 1984). The new proposal involves moving a significant number of chicks to a new location after the parents have deserted them just prior to fledgling. They will be placed in either abandoned burrows or artificial ones. There will be a need to encourage the progeny to establish on the new site once they have reached breeding age. This can be done by scenting the area with petrel oil and by playing tape recordings of their calls. Two experiments are planned: (i) to transfer black petrels (*Procellaria parkinsoni*) from Great Barrier to build up depleted numbers on Little Barrier (as a result of cat predation - cats now removed), and (ii) to establish fluttering shearwater (*Puffinus gavia*) on a totally new island although within its breeding range.

Table 1
Bird species translocated in New Zealand by Wildlife Service

Ratites	North Island brown kiwi, little spotted kiwi
Procellariiformes	Black petrel, fluttering shearwater*
Anatidae	Paradise shelduck (Tardorna variegata), brown teal# Anas aucklandica chlorotis), New Zealand scaup# (Aythya novaeseelandiae).
Rallidae	North Island weka (Gallirallus australia grey), takahe (Notornis mantelli)
Charadriformes	[Shore plover], Chatham Islands snipe (Coenocorypha aucklandica pusilla), [Stewart Island snipe]
Columbidae	Chatham Islands pigeon (Hemphaga novaeseelandiae chathamensis).
Psittacidae	Kakapo (Strigops habroptilus), red-crowned (Cyanoramphus n. novaezelandiae) and Antipodes green parakeet.
Passerines	[Stead's bush wren], South Island and Chatham Island black robin, stitchbird (Notiomystis cincta), saddleback (both races), North Island kokako.

*proposed
#ex captivity
[ ]unsuccessful

(Note - the Great Barrier transfer has taken place since the paper was presented)

These programmes while helping the black petrel in particular, are aimed primarily at proving a technique that may be essential for saving a species such as the Chatham Islands taiko (*Pterodroma magentae*).

The Wildlife Service's translocation programme has not been restricted to birds. However, the principles outlined are applicable to all animal groups. To date one transfer, within the same island but to an isolated habitat, has been successfully made with the endemic Hamilton's frog (*Leiopelma hamiltoni*). Plans are in hand to re-establish a rare skink (*Leiolopisma whitakeri*) on an island but this will have to await the removal of Polynesian rats from that island which is planned to begin in 1986. In addition to vertebrates, some work has also been done with invertebrates. The initial work was done in 1934 by Dr W.R.B. Powell who transferred the flax snail (*Placostylus hongii*) to Motuhoropapa Island in the Noises Group, Hauraki Gulf (Powell 1938). Recently, other threatened species of this genus were transferred to islands off northern New Zealand after being bred in captivity. Indications are that most have already bred in their new locations. In 1977 Mr Meads, Ecology Division, DSIR, with the approval of the Wildlife Service, transferred the Cook Strait giant weta (*Deinacrida rugosa*) (wingless cricket) from Mana Island to Maud Island. This population has established and is expanding its range on the island.

Translocation of species is a valuable tool in saving endangered species or making them more secure. It is a technique that has proved to be of outstanding value in New Zealand but it should be used with care and with as much planning and research as possible to avoid pitfalls and to achieve the best results for the effort involved. It may also become a very important tool in maintaining genetic diversity in fragmented populations isolated by habitat destruction or severe modification.

REFERENCES

Anon. 1969. Capture Programmes for Rare Animals. Oryx Vol. 10 : 175.

Atkinson, I.A.E. 1964. Feeding stations and food of North Island saddleback in August. *Notornis* 11 : 93-97.

Atkinson, I.A.E. 1966. Feeding stations and food of North Island saddleback in May. *Notornis* 13 : 7-11.

Atkinson, I.A.E. (1989). The value of New Zealand Islands as Biological resevoirs. This publication.

Bell, B.D. 1978. The Big South Cape Rat Irruption: The Ecology and Control of Rodents in New Zealand Nature Reserves. Department of Lands and Survey, p. 33-37.

Bell, B.D. (1989). The Removal of problem animals from islands. This publication.

Byrd, G.V., Sincock, J.L., Telfer, T.C., Moriarty, D.I. and Brady, B.G. (1984). A Cross-fostering Experiment with Newell's race of Manx Shearwater. Journal of Wildlife Management Vol. 48 : 163-168.

Merton, D.V. 1975. The saddleback : its status and conservation. In Martin, R.D. (ed) "Breeding Endangered Wildlife in Captivity". Academic Press, London.

Powell, W.R. 1938. The Paryphantidae of New Zealand No. IV and the genus Placostylus in New Zealand. Records of the Auckland Institute and Museum Vol. 12 : 133-150.

Williams, G.R. 1956. The Kakapo (*Strigops habroptilus* Gray). A review and reappraisal of a near-extinct species. *Notornis* 7 : 29-56.

Nature Conservation Management of Tropical and Sub-Tropical Island Territories

Neil Hermes, John Hicks, Mike Hinchey and Barry Reville

Australian National Parks and Wildlife Service, PO Box 636, Canberra, ACT, 2601.

Abstract

Within the Island Territories of the Commonwealth, the nature conservation values of Christmas Island, North Keeling Island, the Ashmore Islands, Norfolk and Philip Islands and the Coral Sea Islands of the Coringa Herald and Lihou Reef National Nature Reserves are considered in tabular form. This paper describes their principal terrestrial biological values and the main historical and current impacts upon those values. The conservation management of the islands is described including the establishment of parks and reserves, recent biological surveys, feral animal and noxious weed control, education and law enforcement. The brief case studies of specific island management techniques are presented. Results of the first eighteen months observations from the Abbott's Booby Monitoring Program are assessed in the light of management of the species on Christmas Island. The techniques and results of an extended rabbit program on Philip Island in the South Pacific are described and assessed.

INTRODUCTION

The Australian National Parks and Wildlife Service (ANPWS) is the principal adviser to the Commonwealth Government on national nature conservation and wildlife policies. It works in close co-operation with other Commonwealth Authorities and with relevant State and Territory Agencies. Two of the identified functions of ANPWS, which have particular relevance to oceanic islands, are:

> providing an advisory service to the Department of Territories with respect to the management of wildlife, parks and reserves in external territories;
>
> managing parks and reserves in external territories according to approved guidelines with regard to the local situation.

This paper outlines recent ANPWS involvement in nature conservation management of islands in the tropical or sub-tropical Territories of Christmas Island, Norfolk Island, Ashmore and Cartier Islands, Coral Sea Islands and Cocos (Keeling) Islands (Fig. 1). A description of the islands, their conservation issues and recent conservation management are presented in tabular form. Two island case studies of particular interest are then described. In the first, the Abbott's Booby monitoring program on Christmas Island, the susceptibility of this endangered seabird to habitat disturbance is described along with management implications arising. The second case study on feral species eradication on Philip Island, is a dramatic case study of how severe damage by rabbits on an island ecosystem can be halted.

Case Study - Monitoring

MONITORING AND MANAGEMENT OF ABBOTT'S BOOBY, CHRISTMAS ISLAND, INDIAN OCEAN

Introduction

Abbott's Booby (*Sula abbotti*) is one of the few seabirds unique to Australia or its territories. Though once widely distributed in the Indian Ocean, the species now nests only on Christmas Island (10°14'S, 42'E), probably because of destruction of nesting habitat at previous breeding stations. The current breeding population is estimated at 2 000 pairs of which about half attempt to breed each year.

Clearing of forest on Christmas Island for phosphate mining has raised concern for the survival of the species. It is listed in Appendix 1 to CITES and in the Schedule to the Australia-Japan Migratory Birds Agreement.

The first major study of the bird's breeding biology was by Dr J.B. Nelson in 1967 (Nelson 1971) shortly before extensive forest clearing commenced in the central and western parts of the Island which were preferred Abbott's Booby habitat. Concern over

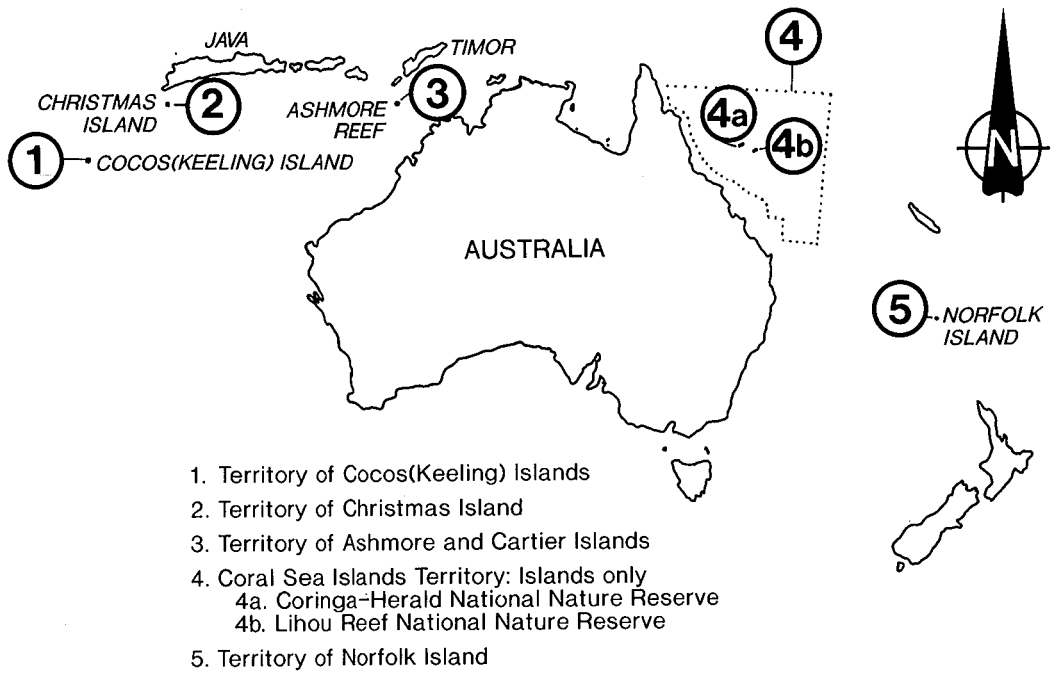


Figure 1. Location of tropical and sub-tropical island territories

Appendix 1

Island territories - summary of natural features, impacts and conservation management

CHRISTMAS ISLAND (10°S, 106°E An elevated atoll of 13 500 ha covered with rainforest that has been cleared in places for phosphate mining.

Significant Natural Features	Main Impacts	Conservation Management
Spectacular coastal and inland cliffs. Unusually structured primary rainforest. Unique stand of mangroves (Bruguiera) perched 30m above sea level. Major colonies of seabirds including the endangered Abbott's Booby Sula abbotti and Christmas Island Frigatebird Fregata andrewsi. Spectacularly high populations of landcrabs. Endemic species and subspecies (21 plants, 5 reptiles, 2 bats, 1 shrew, 10 birds and 2 landcrabs).	(a) Habitat destruction 22% of Island vegetation has been cleared for phosphate mining and associated purposes. (b) Introduced plants False Acacia Leuceana glauca, Sensitive Plant Mimosa invisa and Japanese Cherry Muntingia calabura are major weeds of disturbed areas but have not spread into intact rainforest. (c) Introduced animals Introduction of four cosmopolitan rodent species blamed for the apparent extinction of 2 endemic rats. Domestic cats and dogs disturb ground nesting seabirds near settlement. Some feral cats may affect landbirds. Feral honey bees occur. Giant African Snails Achetina fulica are common in disturbed areas but do not venture into intact rainforest. (d) Hunting Hunting of Robber Crabs Birgus latro and Fruit Bats Pteropus natalis is permitted outside the National Park. Poaching of Blue Crabs Cardisoma hirtipes, Imperial Pigeons Ducula whartoni and seabirds occurs.	(a) Land-use planning/park declaration 12% of Island declared as National Park in 1980 following an environmental study in 1976. A further 5% currently proposed for declaration. A plan for the Park has been prepared (ANPWS, 1985). Conservation priorities for all Island areas have recently been assessed and considered in a land-use study commissioned by Department of Territories. Guidelines to minimise the impact of forest clearing for mining have been adopted and future clearing for mining will be limited to less than 3.3% of the Island. Conservation staff supervise implementation of guidelines. (b) Conservation staff Resident Government Conservator (since 1977) and assistant (since 1984). Three resident scientists working on Abbott's Booby Monitoring Program. (c) Recent biological surveys ANPWS consultants have studied the status of the Island's Imperial Pigeon (Crome, 1978), bats (Tidemann, 1985), terrace seabirds (Woehler, 1984) and landcrabs (George, 1978) and the distribution of plant communities (Mitchell, 1985). A habitat survey of Abbott's Booby (Powell and Tranter 1980) has been followed by a comprehensive monitoring program on Abbott's Booby breeding success (Reville et al., 1984 and 1985). The distribution, abundance and nest site preferences of the Christmas Island Frigatebird have been identified, using three years of comparative data and collection of breeding success data has commenced (Stokes, unpublished data). A comparative breeding study of the White tailed Tropicbird (endemic sub species) and Red-tailed Tropicbird commenced in 1983 (Stokes unpublished. data). (d) Feral animal control Since 1982 stray cats and dogs around the settled areas have been controlled. Robber Crabs Birgus latro have been observed predating African Land Snails. (e) Weed Control Where weeds interfere with regeneration of mined out areas, some control activities are undertaken by the Phosphate Mining Company of Christmas Island. The weeds do not penetrate intact rainforest. (f) Education and enforcement Resident Conservator vets applications for importation of plants and animals. Regular patrols undertaken to control poaching. Since 1980 environmental education program has been underway using publications, displays and ranger guided activities. A vigourous natural history association is present. (g) Other environmental matters The Government Conservator is the administration adviser on all environmental matters affecting the island eg pollution, litter, pests and pesticides, customs/quarantine regulations and activities.

NORFOLK ISLAND AND PHILIP ISLAND (29°S 168°E), Norfolk Island covers 3 500 ha and Philip Island 250 ha. Both are emergent volcanic outcrops. Norfolk Island is mixed farm land, urban and natural and introduced vegetation. Philip Island is heavily eroded and in the process of revegetation with native and introduced species.

Significant Natural Features	Main Impacts	Conservation Management
50 plant species are endemic to Norfolk, 10 of these are endangered or extinct. 13 endemic species or sub-species of landbird of which 5, possibly 6 are extinct. 11 seabird species regular breed on the island.	(a) Habitat destruction. Philip Island vegetation communities have been almost completely destroyed by introduced rabbits. Most of the rainforest on Norfolk has been cleared for settlement and grazing. Habitat destruction contributed to the extinction of the Norfolk Island Starling Aplonis fuscus fuscus and Black and White Sparrow Lalage leucopyga. (b) Introduced plants. Weeds occur throughout most of the remaining rainforest (ANPWS, 1984). The most troublesome are Red Guava Psidium littorale, Hawaiian Holly Hinus terbinthifolius, and African Olive Olea africana. Other weeds important in smaller areas include Lantana comara, William Taylor Eupatorium riparium, Wild Tobacco Solanum mauritianum and Kikuyu grass. (c) Introduced fauna. On Norfolk Island Black Rats Rattus rattus, Kiore Rattus exulans and Feral cats Felis catus seriously affect populations of land and seabirds (ANPWS, 1984). On Norfolk Island domestic cattle have affected the rainforest by browsing on seedlings and trampling. Ten introduced bird species are present including the European blackbird Turdus merula, European starling Sturnus vulgaris, Silvereye Zosterops lateralis and Crimson Rosella Platycercus elegans which have contributed to the extinction /decline of the endemic Grey-headed Blackbird Turdus poliocephalus, Norfolk Island Starling Aplonis fuscus fuscus, White-breasted White Eye Xosterops albogularis and Green Parrot Cyanoramphus novaezelandiae cookii. (d) Hunting. The Norfolk Island Dove Columba sp. and Pigeon Hemiphaga novaeseelandiae argetraea and the Providence Petrel Pterodrama solandri were believed exterminated mainly by hunting (Fullagar, unpublished). Since 1985 attempts at breeding by the Providence Petrel on Philip Island have been observed.	(a) Land use planning declaration. 13% of Norfolk is currently declared as National Park. A plan for the Park has been prepared (ANPWS, 1984). (b) Conservation staff. Resident Conservator (since 1978) with assistant (since 1981) and an administrative assistant (since 1984). (c) Biological surveys. ANPWS consultants have studied the terrestrial invertebrate fauna on Philip Island (Taylor, unpublished), weed species in the National Park (Haseler, 1985), and lichens and mosses (Elix 1985). ANPWS staff have carried out studies of the population of Sooty Terns on Philip Island (Hermes, unpublished), the status of the Norfolk Island Owl and Scarlet Robin and the status of the Norfolk Island Green Parrot Cyanoramphus novaezelandiae cookii (Forshaw 1979). (d) Feral animal control. Major program to eradicate rabbits from Philip Island completed May 1988. (e) Weed control. One small plantation of Hoop Pine Araucaria cunninghamii was removed because fears were expressed that its presence could jeopardise genetic integrity of the closely related endemic Norfolk Island Pine Araucaria heterophylla. Weed control is one of the major management activities in the National Park. (f) Education and enforcement. Since 1979, an environmental education program has been underway using displays, ranger-guided activities and publications including contributions to local newspapers. (g) Captive breeding program. In an endeavour to prevent the extinction of the Norfolk Island Green Parrot, birds are currently held in captivity in an endeavour to captive breed the sub species. Captures indicate a predominance of males in the remaining population.

ASHMORE ISLANDS (12°S 123°E EAST ISLAND 16ha, MIDDLE ISLAND 13ha, WEST ISLAND 32ha. The three islands are herb and grass covered cays with fringing shrubs on Middle and West Islands.

Significant Natural Features	Main Impacts	Conservation Management
Breeding colonies of 15 seabird species including the second largest reported Australian colony of Bridled Terns Sterna anaethetus, the largest reported Australian colony of Noddies Anous stolidus, one of only three known Australian colonies of the White-tailed Tropicbird Phaethon lepturus, a large colony of Sooty terns Sterna fuscata, and the only known breeding colony of what is thought to be a new species of tern. Moderate numbers of Green Turtles Chelonia mydas and some Hawksbill turtles Eretmochelys imbricata nest on West Island and, to a lesser extent, Middle Island. The surrounding lagoon and reef support a rich and diverse marine life with a high degree of endemism and possibly the greatest abundance and diversity of species of sea snakes in the world.	(a) Habitat destruction. Guano extractors reportedly worked the Ashmore Islands in the later part of the 19th century (Woodward, 1917). The depauperate herb and grass growth in the interior of West Island (compared to East and Middle Islands) suggest that mining only occurred on West Island. Recent lopping of fringing shrubs by Indonesian fishermen for firewood and for construction of fish drying racks has been observed. (b) Introduced plants. Although a number of plants such as the Coconut palm Cocos nucifera and maize Zea mays have been introduced, none have spread. (c) Introduced fauna. Rats Rattus rattus have been recorded in large numbers on West Island since 1949 (Serventy, 1952) and mice have more recently been recorded on Middle and East Islands. Rats may be implicated in the absence of attempts at breeding on West Island by smaller seabirds and the limited breeding success of Crested Terns Sterna bergii in 1984. (d) Hunting. Indonesian fishermen have frequently taken seabirds, turtles and both seabird and turtle eggs in contravention of a Memorandum of Understanding with Indonesia concerning permitted activities of Indonesian fishermen in the area. The failure of the larger seabirds Sula leucogaster and Fregata ariel to breed successfully on the Islands till 1988 is attributed to poaching and disturbance. Damage to vegetation by fishermen for firewood, drying racks and camping materials has been substantial.	(a) Park declaration. The Ashmore Reef National Nature Reserve, which encompasses the Islands and 583 km2 of surrounding reefs and waters was declared in 1983. A plan of management is being prepared. (b) Conservation staff. Mainland based ANPWS officers conduct regular patrols of the islands in association with the Civil Coastal Surveillance Program on RAN patrol boats. In 1984/85 there were 17 such patrols. (c) Recent biological surveys. Data on seabirds, vegetation and human use are collected routinely on surface patrols. (d) Feral animal control. A rat eradication program was undertaken in 1984/85 and appears to have been successful. Technique used was Bromadiolone in the form of Bromakil wax blocks; dispensed in PVC spouts imbedded in the soil at 40 m grid square with raised entrances at 45° to deter non target (Hermit Crab Coenobita perlata consumption. Poison stations rebaited at 2-3 week intervals. Warfarin (Ratsak) also employed to treat persistent populations. (e) Weed control. None necessary. (f) Education and enforcement. a program informing and warning Indonesian fishermen using the area is in place. In 1984/85, ANPWS wardens boarded 59 Indonesian fishing vessels under the program. Recently the Department of Territories stationed two personnel on West Island, to inform Indonesian fishermen of constraints in use of the area. Distance from nearest Australian port (450 km) has prevented arrest of offenders due to relative fragility and slow speed of traditional craft. (g) International agreement. The Government proposes to renegotiate the agreement under which Indonesian traditional fishermen have been allowed physical access to the Islands.

CORAL SEA ISLANDS IN CORINGA HERALD AND LIHOU REEF NATIONAL NATURE RESERVES (NNR) between 16 to 18°S and 149 to 152°E. Six islands in Herald Coringa NNR have total area of 125 ha and 16 in Lihou Reef NNR have a total area of 91 ha. The Islands are all cays; vegetation cover varies from nil (13 cays), grassland/herbland (9 cays), fringing shrubland (5 cays) and closed Pisonia forest (3 cays).

Significant Natural Features	Main Impacts	Conservation Management
Nesting areas for 13 seabird species including the most important Australian breeding grounds (after Christmas Island and North Keeling) for the Red-footed Booby Sula sula and Great Frigatebird Fregata minor (Hicks, 1985). The most highly developed vegetation communities on islands in the Coral Sea, including closed Pisonia forest on 3 islands. Green Turtles nest on the cays in large numbers.	(a) Habitat destruction. The vegetation of Chilcott Island may have been affected by guano extraction last century although signs of such damage are not obvious. Otherwise natural habitats intact (Hicks, 1985). (b) Introduced plants. No significant weeds. (c) Introduced fauna. Black rats (Rattus rattus) are present on Coringa Islet and may adversely affect bird populations there (Hicks, 1985). (d) Hunting. No recent hunting pressures.	(a) Park declaration. Reserves declared in 1982. (b) Conservation staff. No resident staff. Regular patrols by ANPWS staff conducted in association with Civil Coastal Surveillance Program on RAN patrol boats. (c) Recent biological surveys. Data on seabirds, vegetation and rats has been obtained during voyages on lighthouse tender vessels (Hill, 1984), during naval patrols and during a month long joint Australian Survey Office. ANPWS survey in 1984 (Hicks, 1985). (d) Feral animal control. Rat control measures on Coringa Islet commenced in 1985. (e) Weed control. None necessary. (f) Education and enforcement. Surface patrols monitor human use of the cays.

NORTH KEELING ISLAND 12°S, 97°E. An atoll of 140 ha covered mostly with *Pamphis* scrub fringing the lagoon.

Significant Natural Features	Main Impacts	Conservation Management
North Keeling is the only island of the Cocos-Keeling group with intact natural vegetation communities. Closed Pisonia forest covers much of the Island (Hicks, 1985). It is one of the few remaining pristine islands in the Indian Ocean (Stokes et al. 1982). Major breeding populations of Red-footed Boobies Sula sula, Least Frigatebird Frigata ariel, Great Frigatebird Fregata minor, White Tern Gygis alba, Common Noddy Anous stolidus and small breeding colonies of 6 other seabirds including two species tropicbird (Stokes, et al. 1982). The only remaining significant breeding colony of the endemic Cocos Buffbanded Rail Rallus philippensis andrewsi. High population of landcrabs Cardisoma hirtipes and a moderate population of the vulnerable Robber Crab Birgus latro.	(a) Habitat destruction. Much original forest remains intact, unlike islands on the main Cocos Atoll where coconut plantations have largely replaced it (Stokes et al., 1982). (b) Introduced plants. Not known to be a problem. (c) Introduced fauna. No rats or cats on North Keeling whereas both are common on islands of the main Cocos Atoll. (d) Hunting. Hunting and other human disturbance drove the majority of seabirds away from the main atoll by 1985 (Forbes, 1885; Fibson-Hill, 1949). Hunting of seabirds on North Keeling, a long established custom by cocos Malays, is thought to have increased in recent years (Stokes et al, 1982). The harvest in 1985 was estimated at 6 000-10 000 birds, mainly immature Red-footed Booby from a population estimated at 17 000 + breeding pairs (Hicks 1985). This is thought to be similar to the hunting pressure taking place since 1982. Prior to that data limited historical data indicates from 3 000-10 000 birds per annum were taken intermittently over the previous 70 years.	(a) Park declaration/Land use. The Island and most of the land on the main atoll were transferred to the Cocos (Keeling) Islands Council in 1984. Transfer of North Keeling was conditional on the acknowledgement of the special need to protect the environment of North Keeling and the early introduction of conservation measures and a management plan for the Island (Anon, 1984). (b) Conservation staff. ANPWS officers, at the request of the Department of Territories, visited the Island three times in 1985 to assist in seabird conservation measures. It is expected that one ANPWS officer will be allocated to work full-time on Cocos conservation matters in the near future. (c) Recent biological surveys. Stokes et al. (1982) described the birds on the Island. Hicks (1985), has collected seabird population and breeding success data for Sula sula and Fregata ariel, the main species harvested. Information has also been collected on historical harvesting levels. The flora has recently been studied by Telford (1985, unpublished). (d) Feral animal and weed control. None necessary at present. (e) Education and enforcement. The Cocos Malays with a population of 376, have had little exposure to wildlife conservation practices and have a long tradition of taking seabirds and other wildlife produce for food. Seabird flesh is particularly favoured for traditional festivities. An environmental education program, which focuses initially on seabird management, has been commenced during visits by ANPWS officers.

the effects of this clearing prompted an island-wide survey of the distribution of nesting sites in 1979/80 conducted by the Conservation Officer for the British Phosphate Commissioners and the Assistant Government Conservator (Powell and Tranter 1981). Following an appraisal of this report and recommendations to the Federal Government a program to monitor the bird's breeding success was established in July 1983, staffed by three ANPWS officers and jointly funded by ANPWS and the Phosphate Mining Company of Christmas Island.

The current Monitoring Program was established with the aim: "to monitor the breeding success of Abbott's Booby to permit continual review of the protection of the bird and the continuation of mining." The results of the program are reviewed annually by an expert panel comprising Dr J.B. Nelson of Aberdeen University, Professor J.M. Cullen of Monash University, the Director, ANPWS, the General Manager PMCI and the head of the monitoring team, Dr B. Reville.

Methodology

The chief technical difficulty in designing a research program to achieve this has been the extreme inaccessibility of the birds: nests are typically placed on thin lateral branches about 30 m above the ground. Also, the nests are scattered over some 10 sq km in different relations to forest clearings and in a wide variety of topographic situations.

The methodology adopted gathers information at two levels, very detailed information at a few sites through time-lapse photography and less detailed information from fortnightly checks on about 600 sites selected at random from the distribution mapped in 1979/80. A wide variety of physical characteristics for each of these sites has been recorded including tree diameter, tree height, position of nest in canopy, branch diameter, branch number, branch angle, slope of ground, topography, distance from clearing, number of adjacent clearings, size of clearing, tree aspects, aspect to clearing and compass bearing of nest in tree.

Monitoring Results

By the end of 1983 it was clear that:

> the birds nested only in tall rainforest trees, especially (70%) in *Planchonella nitida* and *Eugenia grandis*;
>
> nests were restricted to the western half of the island, mostly in rugged topography sheltered from the prevailing South-East Tradewinds;
>
> productivity was extremely low since only one egg was laid per clutch and successful pairs usually laid in only every second year;
>
> typically, the birds were faithful to mate and nesting site from year to year, hence destruction of the nesting tree was likely to be detrimental to subsequent breeding success.

Based on information from two complete seasons, 1983/84 and 1984/85, the results indicate:

1. breeding success (egg to independence) was significantly affected by date of laying, with late laying resulting in lower breeding success;
2. breeding success in 1984/85 (24%) was significantly lower than in 1983/84 (46%), probably due to food shortage;
3. breeding at more frequent intervals than every second year did not contribute significantly to population recruitment;
4. in 1983/84 there was a significant decline in nesting success (independent young/nest) with increasing nest density;
5. in both seasons, nesting success improved with increase in number of branches supporting the nest, suggesting that nest stability is an important factor in breeding success;
6. in 1983/84, the presence of forest clearing to the South-East within 762 m of nest sites significantly diminished their nesting success, especially if the aspect of the tree containing the nest was also South-East; this effect was exacerbated by increase in number and size of clearings;
7. areas within 305 m of clearings have displayed a higher rate of nest site abandonment and have attracted proportionately fewer nests since 1979/80 than areas further away from clearings - these trends appear to be continuing;
8. annual site reoccupation since 1979/80 has been c. 96-98% beyond 762 m of clearings and c. 86% within 305 m of clearings;
9. birds occupying new sites had lower breeding success than birds in familiar sites;
10. in addition, the higher rate of abandonment of nesting sites near clearings suggests that the carrying capacity of habitat within 305 m, and perhaps 762 m of clearings has been significantly reduced. Only about 12% of known nesting habitat of Abbott's Booby remains beyond 762 m of existing clearings;

11. on average, nests which lie within 305 m and to the North-West of areas cleared in the early 1970's are still experiencing diminished nesting success approximately 16% (30 cf. 46%) lower than the rest of the population. Since 37% of nests lie within this zone a substantial proportion of the population has been experiencing reduced nesting success for up to fifteen years.

Discussion

These findings raise serious concern for the survival of Abbott's Booby since it seems that forest clearing may set in train a long-lasting sequence of detrimental effects through increasing exposure of the forest canopy to the prevailing South-East Tradewinds.

Abbott's Booby fulfils the classic recipe for an endangered species - slow breeding, specialised habitat preferences and sensitivity to human disturbance.

The Abbott's Booby Monitoring Program Expert Panel considers that the implications for management of these results are threefold:

> areas of intact forest are likely to have higher long-term carrying capacity than the margins of existing clearings, thus clearing of hitherto intact forest should be avoided;
>
> further clearing of forest within 305 m and to the South-East of significant numbers of Abbott's Boobies should not occur;
>
> existing clearings to the South-East of significant numbers of Abbott's Boobies should have priority in rehabilitation programmes.

The first of these implications has already been acknowledged in decisions regarding further clearing for mining, allowing access to valuable ore bodies beneath habitat now recognised as already deteriorating, while removing areas of intact forest from the current mining schedule.

It is hoped that the remaining implications will be acknowledged in determining future priorities in land-use, particularly in the preservation of suitable areas of intact forest to ensure the survival of Abbott's Booby and determining which existing clearings are to be developed for agricultural and pastoral purposes and which are to be revegetated to ameliorate adverse effects on existing Abbott's habitat.

ACKNOWLEDGEMENTS

The authors wish to acknowledge involvement of Jeff Tranter and Hugh Yorkston, members of the Abbott's Booby Study team.

Case Study - Eradication

RABBIT ERADICATION PROGRAM - PHILIP ISLAND, SOUTH PACIFIC

Introduction

Few places have suffered more than Philip Island from human mismanagement though it has never been permanently inhabited by man (Fullager 1978, Coyne 1981 and 1982). The island of about 240 ha is about 6 km South of Norfolk Island in the south-west Pacific Ocean. When discovered in 1774 it supported a dense subtropical forest. Pigs were released on Philip Island in about 1790 followed by goats and rabbits. These animals rapidly destroyed much of the vegetation and severe soil erosion began. By about 1870 the pigs and goats had gone but the rabbits remained preventing any substantial revegetation and allowing continuous and severe erosion to create a spectacular, barren landscape. Of volcanic origin much of the island appears to have lost approximately one metre of soil. The rabbits by the 1970's were predominantly brown and black in colour unlike the agoutis of Australia and show little tendency to burrow for shelter.

In 1979 the Norfolk Island Council asked the Australian National Parks and Wildlife Service to undertake an experimental program to investigate the damage caused by rabbits and the potential for re-establishing vegetation. Exclosures soon provided spectacular evidence of the effect of rabbit grazing and the ability of the 'soil' to support plant growth. Protection from grazing allowed otherwise unassisted regeneration of both native and introduced species in amazing quantities. Some previously bare sites were quite densely vegetated within six months of fencing, supporting up to 22 plant species, while outside the fences the ground remained bare. By 1980 results of the experimental program has been so spectacular that the Norfolk Island Legislative Assembly asked the Australian National Parks and Wildlife Service to eradicate rabbits from Philip Island.

Methods

Philip Island presented special difficulties for implementing a rabbit eradication program. The extremely rugged terrain, with many colonies on nearly inaccessible slopes, the unreliability of transport to and from the island due to unpredictable seas and the logistical difficulties in having to carry all supplies around the island in backpacks prevented the application of conventional rabbit control techniques. After consultation with CSIRO, it was decided to use

myxomatosis in conjunction with the European rabbit flea.

In March 1981 disease free European rabbit fleas were released on captured rabbits and in burrows in order to establish fleas in the population for future use as vectors for myxoma virus.

Introduction of myxoma began in August 1981 with some rabbits being inoculated subcutaneously or infected ;with eye paste and released but the principle technique was to release rabbit fleas which carried virus particles. To ensure full cover of fleas on the island necessitated staff climbing into some otherwise inaccessible sites and swimming into others. However some populations still remained inaccessible and a rather primitive but effective method of delivering the fleas was developed.

Fleas in a small glass phial were attached to the steel head of an arrow which was shot from a longbow. This method relied upon the momentum of the arrow shattering the phial on impact with the ground thus releasing the fleas.

It was possible to deliver fleas on horizontal ground 90 m away in this manner. In conjunction with a 265 m fall delivery was estimated to extend to 200 m.

By December 1981 all areas of the island had been treated, the rabbit population had declined and vegetation increased remarkably. However the rabbit population stabilised at previous late summer levels. A prefabricated hut was constructed on the island in March 1982 to facilitate the program and improve living conditions for personnel isolated by sea conditions.

In July 1982 a stepped-up myxoma release program was successful in again reducing the rabbit population. In this program greater emphasis was placed on inoculating live rabbits caught in wire funnel traps planted with rye corn or baited with carrot, pigface *Carpobrotus* or oats.

The attraction of exclosure plots containing regenerating vegetation was exploited by either setting perimeter traps or converting some partially or wholly to funnel traps to capture animals for inoculation or flea release. By December 1982 the supply of rabbit fleas all but stopped. Rabbit numbers had not by that stage been reduced sufficiently to enable isolation of small groups which could be treated separately. Curtailment of supplies of rabbit fleas necessitated a change of technique before rabbit numbers again built up. During the winter and spring of 1983 a major build up of supplies on the island was conducted in preparation for poisoning with 1080 'one shot oats'. Oats were used as free-feed in 320 dispensers for several months and in November 1983 poisoning began. The first poisoning reduced the population dramatically, perhaps as much as 90%. A month later the bulk of the island was poisoned again and after this about 12 discrete areas of known rabbit activity remained. Oats continued to be used as the principal bait with carrot and pigface used to a lesser extent. To treat cliff ledges and slopes disposable plastic food containers of 1080 treated chopped carrots were hurled from above and exploded on impact spreading the baits.

After initial poisoning to dramatically reduce numbers other techniques were introduced as appropriate to each population's special conditions. Techniques used included trapping, gassing, shooting, habitat removal by burning, hand ripping and barrier fencing. No one technique was 100% effective in any one area and depending on conditions different techniques were more or less useful. Funnel traps were in some instances built into barrier fences to intercept animals attempting to enter clean areas. Shooting was only useful once the population had been otherwise reduced. A .22 rifle equipped with silencer was used for sniping animals at close range; a .222 high powered rifle equipped with a 8 power x 56 scope was used for long distance shooting on the cliffs where wind turbulence was a consideration.

From January 1984 to November 1985 work concentrated on removing each of the discrete groups. On occasion reinfestations of previously cleared areas were detected. By June 1985 all populations capable of colonising other areas had been eliminated and at that time 6 discrete groups remained on ledges and slopes isolated by cliffs and barrier fences. By November 1985 only 2 groups remained.

For staff to land on these last two sites required vertical rock climbs/descents of at least 180 m or landings from the sea on dangerous rocky shores. Destruction of these last rabbits was planned when sea and weather conditions allow access by zodiac inflatable craft during the summer of 1985/86.

Discussion

As normal field strains of the myxoma virus are of moderate virulence, they could not be expected to kill all rabbits infected, although in a previously unexposed population such as Philip Island, mortality could be expected to be as high as 99.5% of infected rabbits. A highly virulent artificially bred strain (Lausanne Strain) was chosen for use on Philip Island because no rabbits were likely to recover and hence become resistant. However rabbits infected with this strain die faster than would be the case with a less

virulent strain and the Lausanne Strain was therefore expected to be less transmissible than field strains. In the event progress using a combination of methods had not proved successful an option remaining would have been to introduce a persistent field strain to achieve a high degree of control.

The lack of total success with the myxoma release program was due to inadequate numbers of vector insects and the failure of the fleas to successfully breed. This led to poor transmissibility and repeated extinction of the virus. Rabbit numbers were never reduced sufficiently by myxomatosis to enable isolation of small groups of rabbits which could be treated separately.

The apparent lessons learnt by this program were that reliance should not be placed on any single control mechanism. Myxoma virus was effective in reducing rabbit numbers to the extent that the subsequent use of oats and 1080 was logistically feasible. Techniques were applied sequentially so as to ensure that the survivors of one technique were naive to the next eradication method.

The last rabbit killed on the accessible main body of the island was observed evading two types of trap before being shot. A large black male, it was found to be carrying an eartag indicating it had previously been live trapped and inoculated with Lausanne Myxoma virus indicating recovery or ineffective inoculation.

Predatory animals were not employed because of the significant populations of breeding seabirds on the island. Staff were required to develop a keen eye for rabbit signs in order to detect active areas as well as develop hitherto unknown climbing abilities. Unconventional climbing techniques developed included the use of star pickets as belay points on the crumbling volcanic soils.

The significant removal of the rabbits by January 1983 and effective eradication from the bulk of the island by June 1985 has allowed vigourous plant growth. The changes are being monitored by photo points, vegetation surveys and aerial photography.

A species of plant *Abutilon julianae* endemic to the Norfolk Island group and presumed extinct since the beginning of this century was recently found on Philip Island.

POSTSCRIPT

The last two sites received one poisoning each followed up by shooting and trapping. By May 1986 both areas and the remainder of Philip Island were believed clear. Periodic monitoring continued however and in January 1988 a rabbit was sighted on a cliff ledge in an area believed cleared in February 1986. A descent was made in February 1988 but the inaccessibility of the ledge prevented the use of direct methods. What is believed to have been the last rabbit on Philip Island was eventually shot from the adjacent cliffs on 25 February 1988.

In the course of this program a small population of Providence Petrel *Pterodroma solandri* were discovered breeding on the higher parts of Philip Island. Once numerous on Norfolk Island this species was considered locally absent for almost 200 years. Its only other known breeding site is Lord Howe Island.

ACKNOWLEDGEMENTS

The authors wish to acknowledge Dr Peter Coyne who conducted the experimental revegetation trials and led the program till the end of myxoma introduction and Derek Greenwood of ANPWS Norfolk Island staff who has assisted throughout the program. ANPWS has received considerable assistance from residents of Norfolk Island engaged in a casual or volunteer capacity and also from volunteer climbers from Australia. Rabbit fleas and myxoma virus were initially supplied by CSIRO Division of Wildlife and Rangelands Research and subsequently by the Keith Turnbull Research Institute.

REFERENCES

Anon (1984). Cocos (Keeling) Islands Annual Report 1983-84, Department of Territories, AGPS.

ANPWS (1984). Plan of Management Norfolk Island National Park and Norfolk Island Botanic Garden. Australian National Parks and Wildlife Service.

ANPWS (1985). Christmas Island National Park Plan of Management. Australian National Parks and Wildlife Service, Canberra.

Coyne, P. (1981). An extreme example of the effects of feral animals. *Australian Ranger Bulletin* Vol 1(2): 28-29.

Coyne, P. (1982). The Day of the Rabbit, *GEO* 4(2): 30-39.

Coyne, P. (1982). Rabbit Control Techniques on Philip Island. *Australian Ranger Bulletin* 2(1): 14-15.

Crome, F.H.J. (1978). Report on the Christmas Island Imperial Pigeon unpublished report. Australian National Parks and Wildlife Service, Canberra.

Elix, J.A. and Streimann, H. (1985). Lichens and Bryophytes of Norfolk Island. ANPWS, Canberra (unpublished).

Fobres, H.O. (1985). A Naturalist's Wandering in the Eastern Archipelago. London, Sampson, Low, Marston, Searle and Rivington.

Forshaw, J.M. (1979). The Norfolk Island Parakeet *Cyanoramphus novaezelandiae cookii* - a threatened population: status and management options. ANPWS, Canberra (unpublished).

Fullagar, P.J. (1978). Report on the Rabbits of Philip Island, Norfolk Island. Unpublished CSIRO report to ANPWS.

George, R.W. (1978). The Land and Freshwater Crabs of Christmas Island unpublished report. Australian National Parks and Wildlife Service, Canberra.

Gibson-Hill, C.A. (1949). The Birds of Cocos-Keeling Islands, *Ibis* 91: 221-243.

Haseler, W.H., Diatloff, G. and Wells, C.H. (1984). Report on Survey of Weed Species in Mount Pitt Reserve Norfolk Island and Recommendations for Weed Control. ANPWS, Canberra (unpublished).

Hermes, N., Greenwood, G. & Hinchey, M. (1986). eradication of rabbits from Philip Island. *Australian Ranger Bulletin* Vol 4, No. 1.

Hicks, J. (1985). The Breeding Behaviour and Migrations of the Terrestrial Crab *Gecarcoidea natalis* (Decapoda : Brachyura) *Australian Journal Zoo*logy, 33: 127-42.

Hicks, J. (1985). Lihou Reef and Coringa-Herald National Nature Reserves Field Trip October 1984, Report on Cay Studies. ANPWS, Canberra (unpublished).

Hicks, J. (1985). Field Observations North Keeling 16-23 April 1984. ANPWS, Canberra (unpublished).

Hicks, J. (1985). North Keeling Red-footed Booby and Least Frigatebird Nest Data July/August 1985. ANPWS, Canberra (unpublished).

Hill, L. (1984). Report on Coral Sea Nature Conservation Program. ANPWS, Canberra (unpublished).

Mitchell, B.A. (1985). A Vegetation Survey of Christmas Island. ANPWS, Canberra (unpublished).

Stokes, T., Sheils, W., and Dunn, K. (1984). Birds of the Cocos (Keeling) Islands, Indian Ocean, *Emu* 84: 23-28.

Tidemann, C. (1985). A Study of the Status, Habitat Requirements and Management of the Two Species of Bats on Christmas Island (Indian Ocean). ANPWS, Canberra (unpublished).

Woehler, E.J. (1984). Breeding Seabirds on the Shore Terraces Christmas Island, Indian Ocean. Royal Australian Ornithologists Union Report, Number 12, Moonee Ponds. Vic.

Management of New Zealand's Outlying Island Reserves

Wayne T. Devine

Department of Lands and Survey, Wellington, New Zealand

Abstract

Six of New Zealand's outlying island groups are set apart as nature reserves which are administered by the Department of Lands and Survey with the help of an advisory committee. The role of this committee is outlined, particularly in policy formulation. The paper gives examples of how a range of policies have been applied to management of these islands and/or the background to their formulation. The administrative structure has allowed special emphasis to be placed on the conservation of these protected areas.

INTRODUCTION

Where man has set foot on smaller islands to settle or harvest, others must often follow to heal and restore. This is part of the challenge of nature conservation in managing New Zealand's outlying islands today.

New Zealand territory extends from the Kermadec Islands in the north (at 29 degrees south latitude) and Campbell Islands in the south (at 53 degrees). The equivalent spread of Australian territory would be from Geraldton north of Perth almost to the latitude of Macquarie Island. The outlying islands are the principal reason why New Zealand has an EEZ fourteen times the size of its total land area (see Fig. 1).

In total New Zealand has over 500 offshore islands or island groups ranging from small rock stacks to areas of several thousand hectares. Fig. 2 shows the control of island natural protected areas by total number (of islands and/or groups) and areas. Offshore and outlying islands are separately grouped and compared. There are 137 offshore islands included in Fiordland National Park alone. About half the remainder are reserves in the three Maritime Parks and are controlled by park boards. The park areas are managed by the Department of Lands and Survey along with the island reserves for which they have a direct control and management responsibility. The Wildlife Service of the Department of Internal Affairs is the other main management and controlling body. (All these protected areas came under the jurisdiction of a new Department of Conservation in 1987 along with the Outlying Islands.)

This paper deals primarily with management necessary for the conservation of New Zealand's Outlying Islands (excluding the Chathams). It describes the administrative organisation and gives examples of how some management problems have been resolved.

NEW ZEALAND OUTLYING ISLAND RESERVES

The Kermadec Islands are the most northerly of New Zealand's Ecological Regions; they lie about half way between Auckland City and Tonga. Raoul, the principal island, has an area of about 3 000 ha. The climate is subtropical with rainfall distributed fairly evenly throughout the year. Forest covers the greater part of Raoul which is the only island in the group to have more than a purely coastal forest association. All the islands are volcanic and Raoul and Curtis are still active. The most significant point about their flora and fauna is that natural colonisation has been by chance resulting in the number of indigenous species being small; the few endemics have evolved only to a minor degree from their nearest relatives elsewhere.

The Subantarctic Islands consist of five groups south and south east of Stewart Island and have a total area in excess of 85 000 ha. They include some of the world's last remaining areas of vegetation unmodified by man or his introduced animals. They are a habitat and breeding area for birds and sea mammals peculiar to the subantarctic regions. Auckland Island at 45 397 ha, is the largest of all the New Zealand subantarctic islands. As a group the Aucklands are the fifth largest of the 22 in the Southern Ocean (Insulantarctica) (Clark and Dingwall, 1984).

The New Zealand Islands are all classed as uninhabited although meteorological stations are

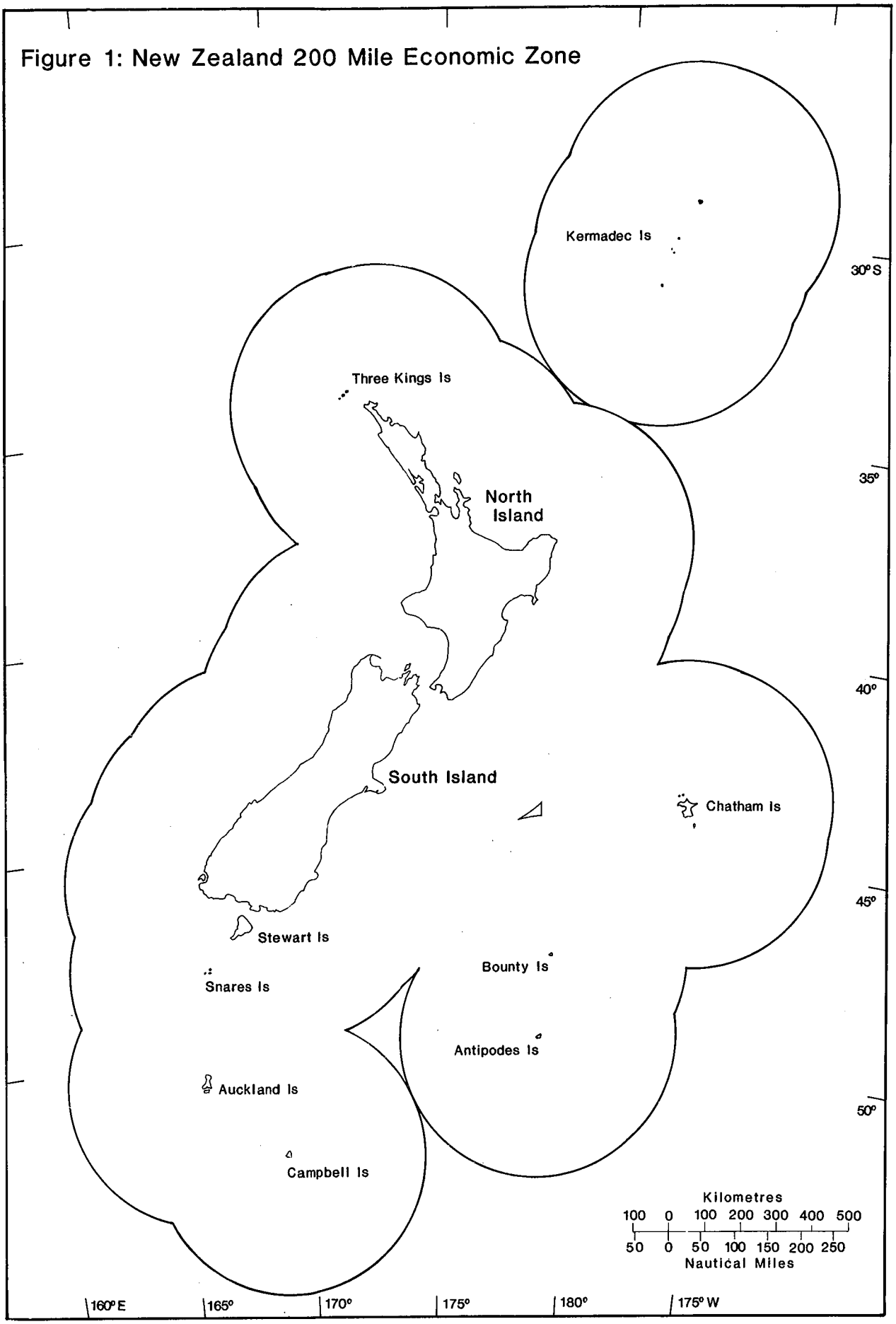


Figure 1: New Zealand 200 Mile Economic Zone
Kermadec Is
30° S
Three Kings Is
North Island
35°
South Island
Chatham Is
40°
45°
Stewart Is
Snares Is
Bounty Is
Antipodes Is
Auckland Is
50°
Campbell Is
Kilometres
100 0 100 200 300 400 500
50 0 50 100 150 200 250
Nautical Miles
160° E
165°
170°
175°
180°
175° W

maintained by the New Zealand Government (Ministry of Transport) on Raoul and Campbell Islands.

All the islands briefly described above are set apart as nature reserves, having been given statutory protection over a period from 1910 to 1961. With the exception of Raoul, these islands have never been held in private fee simple titles. Pastoral leases were offered over the subantarctic islands in the 1800's under their then Crown land status but the only significant grazing took place on Campbell Island over a short period.

Purpose of Nature Reserves

The goal of setting aside nature reserves in New Zealand is to protect and preserve in perpetuity indigenous plants and animals that are "of such rarity, scientific interest or importance or so unique that their protection and preservation are in the public interest."

Statutory management prescriptions require that in nature reserves:

(a) Indigenous plants and animals, ecological associations and the natural environment are preserved as far as possible.

(b) (With prescribed exceptions) exotic plants and animals are as far as possible exterminated.

(c) Any scenic, historic, archaeological, biological or other scientific feature is managed and protected to the extent compatible with the principal purpose.

(d) Their value as soil, water and forest conservation areas are maintained to the extent compatible with the principal purpose.

(e) Entry is prohibited except under the authority of a permit.

"Exotic" is taken as referring to any organism which has established in New Zealand as a result of man's activities. The relevant statutory provisions allow for only indigenous plants and animals to be introduced into a nature reserve. This may be done for the purpose of restoring ecological communities or promoting the survival of species if it is compatible with the principal purpose and conserves the indigenous plants and animals already in the reserve. Thus a species which occurs naturally in an entirely different ecological region of New Zealand is able to be translocated into a nature reserve.

The Outlying Island Reserves Committee

In 1967 the control and administration of the subantarctic islands was shifted to Wellington to allow full advantage to be taken of centralised professional services and expertise in the Department of Lands and Survey and other agencies. A Subantarctic Reserves Committee was set up initially to give scientific advice and later to also coordinate various agency roles. In 1970 the Kermadec Islands were brought into the system under the Committee's jurisdiction and it was renamed the Outlying Island Reserves Committee.

Members of the committee are drawn from the:

Department of Internal Affairs - Wildlife Service, Department of Scientific and Industrial Research

- Botany Division

- Ecology Division

- Oceanographic Institute,

National Museum,

Ministry of Agriculture and Fisheries - Fisheries Research Division,

NZ Forest Service - Environmental Forestry Division

Ministry of Transport, and

Ministry of Defence.

The member of the Department of Lands and Survey, Head Office, staff with management responsibility for these reserves is ex officio Chairman of the Committee. The Department's Senior Scientist and Supervising Ranger are officers of the committee.

Originally the committee had a purely advisory role with no delegated powers and the department maintained the right to disregard any of its recommendations. However, this was seldom done and the committee exerted considerable influence over the managerial and administrative activities associated with these islands. The advisory role evolved to include making recommendations on aspects such as tourist visits, the issue of permits for scientific expeditions, wild animal and rodent quarantine requirements and the effect and desirability of commercial activities.

In 1980 the Government brought in new legislation which reorganised the main QUANGOs associated with the department's administration of national parks and reserves. This meant that in general ex officio government members were no longer

Figure 2

NZ Offshore and outlying island reserves (area and control) (excludes islands where there are significant non protected areas)

Other		Maritime Park Board		Dept Lands & Survey		Wildlife Service		Total	
No	Ha	No	Ha	No	Ha	No	Ha	No	Ha
Offshore Islands									
3	250	73	8 959	172	43 170	32	457	280	52 836
Outlying Island Groups									
-	-	-	-	6	78 306	-	-	6	78 306
								286	131 142

Compiled from Register of Protected Natural Areas in New Zealand (Department of Lands and Survey, 1984).

appointed and greater management responsibility was given to the department's staff. QUANGO members lost broad ranging executive powers but, in a partnership with managers, retained responsibility for policy and management plans in addition to an advisory and priority setting role. The Outlying Islands Reserves Committee was left with the same membership structure, a lesser role in day to day management, but gained increased powers. For example, entry permits are now granted by the department without reference to the committee but in accordance with their general policies. Where there is disagreement between the committee and the department an issue is referred to the National Parks and Reserves Authority.

Surveillance

In starting an active management role for the outlying islands in the 1970's the department's first hurdle was to obtain sea transport. (It's largest vessel is able to travel to the nearest reserve, the Snares, but not further and is fully employed in other duties on the mainland coast.) As funding could not be spared for suitable ship purchase or private charter on the necessary scale an approach was made to the Defence Department and initially rebuffed. However, cooperation was obtained at a Ministerial level and has developed to a stage where the department can rely almost totally on Royal NZ Navy transport when it can fit in with Defence operations. Without this support, management programs such as the ones referred to later in this paper may never have started or been sustained. The willing commitment has largely arisen from the representation of Defence Department on the Committee and full participation by its two members in the committee's business. Also, the Royal New Zealand Airforce (RNZAF) has taken on island surveillance responsibilities as part of its EEZ fisheries patrols.

Policy Formulation

The National Parks and Reserves Authority has an overview role for all protected natural areas covered by legislation which the department administers. The existing general and operational policies of the Outlying Island Reserves Committee and the department are providing the foundation for formulating Authority policy on nature reserve management.

Management plans are prepared for each of the reserves in accordance with statutory processes. They apply the common general policies which give management of the far flung outlying islands their cohesive style.

General and operational policies are drafted by the department and put before the committee for approval in principle or for its advice. They are then circulated for invited comment from outside groups, including other affected government agencies, the Royal Society of NZ, the Royal Forest and Bird Protection Society of NZ and similar bodies. Interest in management of the outlying islands tends to be at the organisational level rather than that of individual members of the public. This is hardly surprising since the reserves are so remote from areas of habitation

and scheduled transport routes. Occasionally, because of the complexity of a problem, issues papers have been released before policy is formulated (eg on quarantine precautions against the introduction of rodents). Because there are no staff involved full time with the outlying islands, and there are so many peripherally involved but interested agencies, the process of policy formulation can be a very slow one, often spread over two or three years for each general or operational policy. Such written statements are therefore embarked on only for topics of some consequence to reserve management.

In the remainder of this paper a range of examples of how these policies have been applied and or the background to their formulation will be covered.

Rodent Quarantine

None of the outlying islands have populations of all four exotic species of rodent found in New Zealand. In two of the groups only mice have established. The Snares, Bounties, and some significant larger islands of the Auckland group are among those entirely free of rodents.

The committee has always had a concern about the risk of rodents being carried to these reserves or their accidental transfer between islands under its jurisdiction. It has played a leading role in promoting public and departmental awareness of the consequences of such invasions. This was instrumental in the foreshores of the outlying islands being added to the reserves in 1975 and in new statutory provisions affecting all New Zealand's island nature reserves coming into effect in 1978. These measures were essentially aimed at controlling the mooring of vessels to the shore. It is now an offence for any person without authority to bring a boat in physical contact with the shore (by rope or otherwise) or with a wharf constructed on or partly on the reserve. While the department is empowered to grant permits giving this authority, the general policy is to prohibit shore mooring. A consequence is that at some islands or some anchorages smaller vessels have to remain under power if they are to obey the law.

In 1981 it was discovered as a result of RNZAF surveillance that rock lobster fishermen were mooring their boats to the shore of the main island of the Snares group. This practice, it was later learnt, had started before the 1977 legislation making it an offence, although the associated landings were illegal even then. It was established that shore mooring was essential to safe harvesting of the fishery as offshore mooring or anchorage was not feasible and no other shelter was available. The department favoured a policy exception for existing use and the committee was initially opposed. The Authority ruled in favour of the department after careful deliberation. Originally this endorsement was given for one year.

Reasons for the Department's Stance

(a) The cooperation of the fishermen is essential for protection of the reserve since fishing could not be prohibited;

(b) It is a principle of law that anchorage should not be restricted if it is necessary to avoid loss or damage of property or loss of human life or injury;

(c) The grant of conditional shore mooring permits would result in less risk of rodent introduction than prohibition;

(d) While by refusing to grant permits the department could absolve itself from blame this was less important than a mechanism for imposing rodent quarantine precautions on fishing boats.

Reasons for the Committee's Stance

(a) The degree of risk is unacceptable;

(b) The Snares fishing ground has little significance in the overall Southern Rock Lobster Fishery;

(c) The onus is on the fishermen to comply with the policy of mooring prohibition, not on the department to make an exception.

The Fishermen's Stance

(a) The risk of rats being carried on their boats is negligible;

(b) They are prepared to take voluntary precautions;

(c) Catches are declining in the wider fishery and access to the Snares is necessary to sustain the industry, especially for Stewart Island where fishing dominates the economy of the small community.

(d) The Snares has a sustainable fishery and there are no valid fisheries reason for closing it.

The last factor is a significant one as the legislation dealing with fisheries does not allow for the protection of adjoining terrestrial reserves (or their avifauna) as a reason for restricting fishing.

Several shore mooring permits have been issued annually since 1982. They are restricted to the fishermen who were using the anchorage when the use was first detected. Renewal is granted only if the mooring was used in the previous season, with the intention that shore mooring will be phased out. This was agreed to by the committee after a hearing of

submissions on the management plan. There are currently 3 eligible permeates of the original six. However, at least one other fisherman has found a way round the controls by installing a mooring just below mean low water mark. A total of 13 boats are licensed for the fishing ground. While catches are declining, and the problem may resolve itself temporarily, there is still increasing concern from conservationists who believe that as long as fishing boats visit the Snares, the risk of rats swimming ashore remains, no matter how stringent the conditions, or how careful the fishermen.

The problem of reducing to a minimum the risk of rats gaining access to the Snares has been discussed widely among scientists, fishermen, conservationists and managers. Several organisations and individuals consider that the only logical way to achieve the conservation objective in the long term is to close this section of the fishery. Adequate compensation for the fishermen involved would be needed. This view was conveyed to the Minister of Fisheries of the previous National Government in 1983 but no action was taken. The Authority believes that the international significance of the reserve is so high that the matter needs to be raised again with the present government.

Exotic Plants

The present check list of Kermadec Islands flora has 152 taxa of adventive plants of which 81 have been recorded since 1910. Most of these are found on Raoul and result mainly from unsuccessful attempts at settlement before it was reserved in 1934. The amount of modification caused by individual species varies enormously; some turned up once and subsequently died out, while other have persisted and have spread over the island and to some of its offshore islets. Some are probably occupying a larger area than when they were cultivated but have not increased or spread much further. Only a few adventive species are inhibiting the regeneration of indigenous plants or are actually recolonising areas already occupied by indigenous plants. The most significant ecologically are mainly woody dicotyledous or perennial herbaceous monocotyledons and dicotyledons in the tropical and humid sub-tropical element of the adventive flora (Sykes, 1977).

The bulk of the department's budget for outlying island field operations is spent on controlling these latter plants on Raoul, with the long term goal of eradication. Action was promoted largely as a result of 1966-67 Ornithological Society of New Zealand's scientific expedition to the Kermadecs.

A program using herbicides, fire and manual measures was begun in 1973 (Devine, 1977) and is continuing, with the committee giving advice as required. To ensure this is efficient, the principal exotic species have been categorised under one or other of the following groupings on the advice of the committee and as a result of environmental impact assessment:

(a) Widespread adventives which it is desirable and feasible to eventually exterminate (10 species).

(b) Adventives which it is desirable to exterminate but which are too abundant (2 species).

(c) Adventives which are not spreading but need to be monitored (5 species).

(d) Persistent relics of cultivation either of historical interest, a landscape feature or used to provide edible fruit (although wild these plants have not become properly adventive).

(e) Casual adventives which are only present as a few plants, often in one place or which have recently arrived and not yet become common; extermination is desirable.

These groupings provide the basis for determining work program priorities, with the greatest attention being given to aggressive adventives in Category A. These are likely to spread further if not controlled.

No control of category B or D plants is currently carried out. The main historical interest is in old cultivars which could shed light on the origins of early Polynesian visitors to Raoul (eg ti, *Cordyline terminalis*) and in Norfolk Pines reputed to have been planted by the original European settlers.

The department has one employee on the island all year round with the Meteorological Station team and a further two work there for 6 months of the year. Appointments are made annually and lack of staff continuity poses some hindrance to effective operations.

Control methods have been determined on the basis of scientific premise, tried and satisfactorily proven in the field. The Category A plants do not occur elsewhere in New Zealand and there was no prior experience to build on and no record was found in a search of overseas literature. Scientific monitoring has been casual but the department has been fortunate in having the same expert advisor (now a member of the committee) since the inception of the program. He has been able to make brief visits every 2-3 years.

A comprehensive review of operations was carried out in 1984 after an appraisal by an experienced

protected area field manager. A number of improvements are being made to organisation, work methods, and recording.

Shipwreck Salvage

The sailing ship *General Grant* struck the western cliffs of Auckland Island on the night of 14 May 1866 and finally sank inside one of the many sea caves along that coast. The ship's manifest showed that she carried two boxes of gold (2 576 ounces) though there may have been more; a number of passengers were goldminers returning to England and reputed to be carrying large quantities of gold. Attempts to recover the gold (some with loss of life) began in 1868 and continue to the present day, with the latest expedition planned for late 1985.

The committee's policy is based on consideration of an application made in 1969 which was referred to it for advice. Neither the department nor the committee has jurisdiction over salvage rights, and any wreck of this vintage is protected by legislation administered by the New Zealand Historic Places Trust, not by the department. Although some shore-based salvage attempts have been mooted all those carried through have been made from the sea, which again has put them outside the jurisdiction of the department.

Because of the natural attractions of the Islands and because salvage attempts are so rigorous in such a location inevitably salvors wish to land for sightseeing and might do so illegally if not authorised. Since there is little prospect of the gold being recoverable (even assuming the right wreck can be found) the department attempts to discourage them from proceeding with their plans and prohibits any land based operations. If the salvor is determined to proceed, however, he is usually permitted restricted landing privileges on a similar basis to tourist visitors.

Tourist and Related Visits

The department and the committee began to develop a policy for tourist and related non scientific visits to the outlying islands in 1967 when overseas Antarctic cruising expeditions started showing an interest in making visits. The circuit included Macquarie Island until 1982 when the Australian Commonwealth Government, for quarantine reasons, required boats visiting the Island to first be cleared at an Australian Port.

The department consulted with the Australian Department of Science, Antarctic Division to find out about Macquarie tourist policies during a 1977 review. A further review was carried out in 1983 at the request of the committee.

In terms of New Zealand tourism the number of people wishing to visit these reserves would be very small and little growth is likely. However, the department is currently considering the first application by a New Zealand adventure tourism promoter. The opportunity of gaining world-wide public support and sympathy for conservation of the outlying islands is considered to be the greatest benefit to this country rather than any economic one. Under IUCN criteria, strict nature reserves are generally expected to be closed to tourism, but New Zealand legislation is silent on the subject. However, unlike other classes of reserve, the public is not given freedom of entry and access.

The committee has decided on a compromise whereby entry permits are granted for a few islands. Landings elsewhere are prohibited for any one or more of the following reasons:

(a) highly sensitive habitats present (eg petrel burrows).

(b) extremely valuable habitats (eg absolutely pristine islands),

(c) rodent free islands (especially free of mice),

(d) only dangerous or extremely difficult landings are possible,

(e) features can be viewed or appreciated without the necessity of landings.

With the exception of Raoul, only daylight visits are generally allowed to the "open" islands. On Raoul visits are limited to no more than 2 days as a joint policy with the Ministry of Transport. No special facilities or on-site interpretation is provided on any of the Islands. Except for visits to Raoul and Campbell, where there are resident honorary rangers, a person who has the confidence of the department is required to travel on the vessel to watch out for the interests of the reserves. This person also takes part in shipboard education and interpretation programs.

Exotic Animals

Feral sheep on New Zealand's southernmost reserve are taken as an example under this topic. The main Campbell Island (11 000 ha approx) was offered as a pastoral leasehold run in 1895. It was stocked with Lincolns, Romneys, Lincoln/Merino, Romney/Merino and Merinos. Probably around 8 000 animals were run at the peak of farming activity. As the grazing became eaten out sheep numbers declined, farming was abandoned in 1931, and only 2 000 animals remained 10 years later. The population halved again over the next 20 years and it was expected it would become extinct.

However, in 1969, when counted again, the sheep population was found to have increased to 3 000. This raised concern over their presence in a reserve dedicated to the preservation of the indigenous biota. At the time, there was no law requiring that consideration be given to their extermination. The strategy of taking sheep off half the island at a time was decided on to help determine how best to manage the reserve's seral vegetation and its wildlife and to lessen the risk of creating new and unexpected conservation problems. (For example it was thought that the grazed vegetation might favour albatross nesting.) A post and netting fence was erected across the "waist" of the Island in 1970 and the sheep on the northern side were shot.

A monitoring program was set up, and research into the biology, population ecology and agricultural value of the sheep was intensified. However, because of a number of factors, but mainly the isolation of the reserve, it was not possible to tightly co-ordinate research, and study objectives were not therefore fully satisfied in the first 10 years of the experiment.

Apart from containment, and the taking of an occasional animal by meteorological staff for food and by scientists for autopsy, the sheep on the Island were not disturbed (McKerchar and Devine 1982).

The publication of a draft management plan for the reserve in 1981 revealed differences of opinion in the scientific community about what should happen to the remaining sheep, since it was estimated that the population left south of the fence was increasing. From the point of view the manager, a decision had to be made under a new statutory obligation to far as possible exterminate introduced animals. At the same time there was an onus to protect scientific features to the extent compatible with preserving the important indigenous biota.

As to the original experiment, removing the sheep showed clear advantages and no apparent disadvantages to the natural vegetation and birds, although it was considered too early to anticipate with confidence the final repercussions of complete removal (Taylor, 1977).

The Outlying Islands Reserves Committee held hearings of interested parties about the future of the sheep and made a recommendation on policy to be included in the final management plan. This policy was, in view of the scientific interest of the sheep but concern by some botanists:

> *"To preserve for at least 5 years a minimum population including about 400 ewes, confined in their range in such a way that they (a) do not threaten the survival of any indigenous taxa of plants and animals, or (b) do not diminish natural scientific features of the reserve, and (c) are maintained in a wild state."*

As a result of further consultation and environmental impact assessment it was decided to fence of approximately 1 000 ha on the south-western end of the island. This work was undertaken in 1984 and the sheep (found to be in excess of 4 000) in between the two fences are being eradicated. A population of about 800 animals in the new enclosure will be protected and remain unmanaged. Scientifically randomised culling may however be undertaken if numbers increase to levels likely to induce severe wind erosion. The situation will be reviewed in 1989.

CONCLUSIONS

The paper illustrates how a particular administrative structure involving scientists and managers from within the department and other agencies has placed special emphasis on conservation of New Zealand's outlying islands. It has facilitated policy formulation, management and funding. The same degree of co-ordination and co-operation could not otherwise have been achieved.

The management tasks faced are common to protected island management world-wide, being concerned with protection; the strict control of access; the restoration of conditions prior to disturbance by man where necessary; encouraging public awareness and support for management policies; and trying to bring about compatible use of adjacent marine areas for ecological and management reasons.

ACKNOWLEDGEMENTS

Additional information for Fig 2 was provided by the Chief Surveyor, Department of Lands and Survey, Invercargill.

REFERENCES

Clark, M.R. and Dingwall, P.R. Conservation of Islands in the Southern Ocean. IUCN (1984).

Devine, W.T. A Program to Exterminate Introduced Plants on Raoul Island. *Biological Conservation* (11) (1977).

McKerchar, N.D.R. and Devine, W.T. *The Campbell Island Story: The Management Challenge of Subantarctic Islands* in National Parks, Conservation and Development. Jeffrey A. McNeely and Kenton R. Miller, Ed. IUCN (1982).

Sykes, W.R. Kermadec Islands Flora : An Annotated Checklist. NZ DSIR Bulletin 219. (1977).

Taylor, R.H. Feral Sheep on Campbell Island : Review of Research and Management Program and the Recommendations of the 1975/76 Expedition. Unpublished DSIR report, 7 pages (1977).

Reservation and Management of Seabird Breeding Islands in New South

Peter J. Smith* and Michael J. Dodkin

New South Wales National Parks and Wildlife Service, P.O. Box 1967, Hurstville, NSW 2220.
*Present address: 44 Hawkins Parade, Blaxland N.S.W. Abstract

Abstract

Thirty-nine islands along the New South Wales coast are used as breeding sites by a total of 12 seabird species. Twenty-eight of the islands are current or impending conservation reserves. Because of the small size and confined nature of these island reserves, preservation of their seabird colonies will depend on careful management. Introduced animals and plants, fire, and direct human disturbance are obvious, though often complex, problems. There are also less direct effects of human activities. The basis for management should be regular monitoring of the seabird colonies, so that major problems and long-term trends can be identified.

INTRODUCTION

The coastline of New South Wales is dotted with numerous offshore islands, the majority of which are used as breeding sites by seabirds. A total of 39 islands are used by a total of 12 seabird species (Appendix 1.). These seabird colonies have long been a subject of scientific and general interest (e.g. Hull 1911, 1912, 1916; Hindwood 1958; Lane 1979a). In this paper we review the progress made in reservation of these breeding sites, and consider the problems posed in management of such small and vulnerable reserves. The protection of breeding sites is seen as the major role of the N.S.W. National Parks and Wildlife Service in seabird conservation (Smith 1985).

Seabird Species

The 12 species of seabirds that breed on the islands along the New South Wales coast are listed in Table 1. Four of these species also breed on the mainland - the Little Penguin and Eastern Reef Egret on rocky sea-coasts, and the Silver Gull and Australian Pelican on estuaries and inland lakes. The other species breed only on islands.

None of the species is endemic to New South Wales, nor even to Australia. However, Cabbage Tree Island is the only known breeding site for the nominate subspecies of Gould's Petrel (another subspecies, *caledonica*, breeds in New Caledonia). Six species are true seabirds, spending most of their time and obtaining most of their food at sea - Little Penguin, Gould's Petrel, Wedge-tailed Shearwater, Sooty Shearwater, Short-tailed Shearwater and White-faced Storm-Petrel. The remainder are coastal species - Australian Pelican, Eastern Reef Egret, Sooty Oystercatcher, Silver Gull, Kelp Gull and Crested Tern, with the Australian Pelican and Silver Gull also found along inland rivers and lakes.

Historical changes in the breeding seabirds of New South Wales are apparent from a series of surveys during this century (Hull 1911, 1912, 1916; Hindwood 1958; Lane 1979a). It is noteworthy that in spite of considerable disturbance on many of the islands, no species appears to have ceased nesting in the State during this period. In fact, three species are recent colonists. The Short-tailed Shearwater and Kelp Gull were first recorded breeding in New South Wales in 1958 (Davies 1959; Gwynne and Gray 1959) and have been steadily increasing in numbers since then (Lane 1979a). The Australian Pelican was first recorded breeding on offshore islands of the State only in 1983 (Battam *et al.* 1986).

Reservation of Breeding Islands

The 39 islands along the New South Wales coast that are used by breeding seabirds are listed in the Appendix. The most important is Cabbage Tree Island, which contains the only known breeding colony of the nominate subspecies of Gould's Petrel. The islands with the largest populations of breeding seabirds are Montagu Island (33 650 pairs, 7 species), Big Island (20 900 pairs, 5 species), Tollgate Islands (19 709 pairs, 7 species), Broughton Island (13 160 pairs, 6 species), Muttonbird Island (12 400 pairs, 1 species) and North Solitary Island (10 516 pairs, 4 species).

In the mid 1950s, at the instigation of Dr R. Carrick of the CSIRO Division of Wildlife Research,

Table 1.

Seabirds known to breed on offshore islands in New South Wales (from Lane 1979a, Floyd & Swanson 1983, Battam *et al.* 1986).

	Species	Breeding population (pairs)	Comments
1.	Little Penguin *Eudyptula minor*	16 800	c.74% of this population is found on Brush, Tollgates and Montagu Islands off the south coast. Some birds breed on rocky sea-coasts on the mainland.
2.	Gould's Petrel *Pterodroma leucoptera*	250-300	Confined to Cabbage Tree Island.
3.	Wedge-tailed Shearwater *Puffinus pacificus*	52 000	c.77% of this population is found on Solitary group, Muttonbird, Broughton group, Cabbage Tree and Boondelbah Islands off the north coast.
4.	Sooty Shearwater *P. griseus*	250	c.60% of this population is found on Montagu Island.
5.	Short-tailed Shearwater *P. tenuirostris*	25 700	c.84% of this population is found on Tollgates and Montagu Islands off the south coast.
6.	White-faced Storm-Petrel *Pelagodroma marina*	10 700	c.65% of this population is found on the Tollgates Islands.
7.	Australian Pelican *Pelecanus conspicillatus*	9	Big and Martin Islands. Most breeding in NSW occurs on inland lakes.
8.	Eastern Reef Egret *Egretta sacra*	5	Also breeds on rocky sea-coasts on the mainland.
9.	Sooty Oystercatcher *Haematopus fuliginosus*	20-25	Breeds only on islands.
10.	Silver Gull *Larus novaehollandiae*	30 000	c.70% of this population is found on Big, Bass and Martin Islands off the central coast. Also breeds on estuaries and inland lakes.
11.	Kelp Gull *L. dominicanus*	13	Restricted to islands off the central coast.
12.	Crested Tern *Sterna bergii*	13 000	c.62% of this population is found on North Solitary Island.

Appendix 1.

Offshore islands used by breeding seabirds in New South Wales.

Islands are listed in geographical order, north to south. Figures in parentheses are the estimated numbers of breeding pairs. Question-marks indicate that breeding is unconfirmed, at least in recent years.

1. Cook Island

Location:	28°12'S 153°35'E.	Area: 4.7 ha.
Status:	Cook Island Nature Reserve.	
Breeding seabirds:	Wedge-tailed Shearwater (2000), Crested Tern (?).	
Sources:	Lane (1973c, 1979a).	

2. Julian Rocks

Location:	28°37'S, 153°36'E.	Area: 1.3 ha.
Status:	Julian Rocks Nature Reserve.	
Breeding seabirds:	Wedge-tailed Shearwater (?), Crested Tern (300).	
Sources:	Lane (1976a, 1979a).	

3. North Solitary Island

Location:	29°55'S, 153°23'E.	Area: 17.4 ha.
Status:	North Solitary Island Nature Reserve.	
Breeding seabirds:	Wedge-tailed Shearwater (2500), Sooty Oystercatcher (1), Silver Gull (15), Crested Tern (8000).	
Sources:	Lane (1974a, 1979a).	

4. North Rock, Solitary Islands

Location:	29°59'S, 153°15'E.	Area: 4 ha.
Status:	North Rock Nature Reserve.	
Breeding seabirds:	Wedge-tailed Shearwater (100), Sooty Oystercatcher (?), Silver Gull (?).	
Sources:	Morris (1975b), Lane (1979a).	

5. North-west Solitary Island

Location:	30°02'S, 153°16'E.	Area: 1.9 ha.
Status:	North-west Solitary Island Nature Reserve.	
Breeding seabirds:	Wedge-tailed Shearwater (100), Sooty Oystercatcher (1).	
Sources:	Morris (1975a), Lane (1979a).	

6. South-west Solitary Island

Location:	30°09'S, 153°14'E.	Area: 6.8 ha.
Status:	South-west Solitary Island Nature Reserve.	
Breeding seabirds:	Wedge-tailed Shearwater (1500).	
Sources:	Lane (1975a, 1979a).	

7. South Solitary Island

Location:	30°12'S, 153°16'E.	Area: 17.4 ha.
Status:	Commonwealth land - lighthouse site.	
Breeding seabirds:	Little Penguin (20), Wedge-tailed Shearwater (100), Sooty Shearwater (?), Silver Gull (300), Crested Tern (300).	
Sources:	Lane (1975c,d, 1979a).	

8. Split Solitary Island

Location:	30°14'S, 153°11'E.	Area: 5.2 ha.
Status:	Split Solitary Island Nature Reserve.	
Breeding seabirds:	Wedge-tailed Shearwater (100).	
Sources:	Lane (1974b, 1979a).	

9. Little Muttonbird Island

Location:	30°18'S, 153°08'E.	Area: 1.1 ha.
Status:	Vacant Crown land.	
Breeding seabirds:	Wedge-tailed Shearwater (20), Silver Gull ?).	
Sources:	Roberts (1976), Lane (1979a).	

10. Muttonbird Island

Location:	30°18'S, 153°09'E.	Area: 8 ha.
Status:	Muttonbird Island Nature Reserve.	
Breeding seabirds:	Black-winged Petrel *Pterodroma nigripennis* (?), Wedge-tailed Shearwater (12 400), Sooty Shearwater (?), Short-tailed Shearwater (?), White-faced Storm-Petrel (?).	
Sources:	Swanson (1976), Floyd & Swanson (1983), Lane (1970, 1979a), Lane & White (1983), Holmes (1975).	

11. Korff's Islet

Location:	30°19'S, 153°09'E.	Area: 0.9 ha.
Status:	Vacant Crown land.	
Breeding seabirds:	Silver Gull (100), Crested Tern (100).	
Sources:	Lane (1976j, 1979a).	

12. Sawtell Islet

Location:	30°23'S, 153°06'E.	Area: 3 ha.
Status:	Vacant Crown land.	
Breeding seabirds:	Wedge-tailed Shearwater (10), Sooty Oystercatcher (1), Silver Gull (100).	
Sources:	Holmes (1976b), Lane (1979a).	

13. Green Islet

Location:	30°55'S, 153°05'E.	Area: 2.3 ha.

Status:	Vacant Crown land.	
Breeding seabirds:	Wedge-tailed Shearwater (80).	
Sources:	Holmes (1976a), Lane (1979a).	

14. Delicate Nobby

Location:	31°16'S, 152°58'E.	Area: 4.5 ha.
Status:	Vacant Crown land.	
Breeding seabirds:	Little Penguin (20), Wedge-tailed Shearwater (500).	
Sources:	Lane (1976i, 1979a).	

15. Statis Rock

Location:	32°26'S, 152°32'E.	Area: 2.2 ha.
Status:	Vacant Crown Land.	
Breeding seabirds:	Little Penguin (5), Silver Gull (100), Crested Tern (10).	
Sources:	Holmes (1979), Lane (1979a).	

16. North Rock, Broughton Group

Location:	32°36'S, 152°19'E.	Area: 4.7 ha.
Status:	Forms part of Stormpetrel Nature Reserve.	
Breeding seabirds:	Wedge-tailed Shearwater (1000), White-faced Storm-Petrel (1000), Silver Gull (20).	
Sources:	Lane (1976d, 1979a).	

17. Inner Rock, Broughton Group

Location:	32°36'S, 152°18'E.	Area: 1.2 ha.
Status:	Forms part of Stormpetrel Nature Reserve.	
Breeding seabirds:	Wedge-tailed Shearwater (100), White-faced Storm-Petrel (100).	
Sources:	Lane (1976e, 1979a).	

18. Broughton Island

Location:	32°37'S, 152°19'E.	Area: 138 ha.
Status:	Forms part of Myall Lakes National Park.	
Breeding seabirds:	Little Penguin (20), Wedge-tailed Shearwater (12 000), Sooty Shearwater (10), Short-tailed Shearwater (1000), White-faced Storm-Petrel (?), Silver Gull (80), Crested Tern (50).	
Sources:	Lane (1976b, 1979a,b), van Gessel (1978).	

19. Little Broughton Island

Location:	32°37'S, 152°20'E.	Area: 36 ha.
Status:	Little Broughton Island Nature Reserve.	
Breeding seabirds:	Wedge-tailed Shearwater (4500), Sooty Shearwater (5), Short-tailed Shearwater (1000)	

Sources:	Lane (1976c, 1979a).	

20. Cabbage Tree Island

Location:	32°42'S, 152°14'E.	Area: 26 ha.
Status:	John Gould Nature Reserve.	
Breeding seabirds:	Little Penguin (300), Gould's Petrel (300 - only known breeding site of the nominate subspecies), Wedge-tailed Shearwater (2500), Sooty Shearwater (50), Short-tailed Shearwater (20).	
Sources:	Fullagar (1976), Lane (1979a).	

21. Little Island

Location:	32°42'S, 152°15'E.	Area: 1.2 ha.
Status:	Vacant Crown Land.	
Breeding seabirds:	Silver Gull (50), Crested Tern (40).	
Sources:	Lane (1976k, 1979a).	

22. Boondelbah Island

Location:	32°42'S, 152°14'E.	Area: 9.3 ha.
Status:	Boondelbah Nature Reserve.	
Breeding seabirds:	Little Penguin (1000), Gould's Petrel (?), Wedge-tailed Shearwater (3500), Sooty Shearwater (10), Short-tailed Shearwater (500), White-faced Storm Petrel (100).	
Sources:	Morris (1976), Lane (1979a).	

23. Shark Island

Location:	32°45'S, 152°12'E.	Area: 1.5 ha.
Status:	Vacant Crown land.	
Breeding seabirds:	Wedge-tailed Shearwater (10), Eastern Reef Egret (1).	
Sources:	Lane (1976l, 1979a).	

24. Moon Island

Location:	33°05'S, 151°41'E.	Area: 2.3 ha.
Status:	Moon Island Nature Reserve.	
Breeding seabirds:	Little Penguin (15), Wedge-tailed Shearwater (?), Sooty Oystercatcher (1), Silver Gull (1000), Kelp Gull (2), Crested Tern (700).	
Sources:	Gray & Gwynne (1974), Lane (1979a).	

25. Bird Island

Location:	33°14'S, 151°36'E.	Area: 12 ha.
Status:	Bird Island Nature Reserve.	
Breeding seabirds:	Little Penguin (5), Wedge-tailed Shearwater (1000), Sooty Shearwater (5), Short-tailed	

	Shearwater (25), White-faced Storm-Petrel (500), Eastern Reef Egret (1).	
Sources:	Lane (1973a, 1979a).	

26. Lion Island

Location:	33°33'S, 151°20'E.	Area: 8 ha.
Status:	Lion Island Nature Reserve.	
Breeding seabirds:	Little Penguin (300), Wedge-tailed Shearwater (300), Sooty Shearwater (7), Short-tailed Shearwater (?).	
Sources:	Lane (1975b, 1979a).	

27. Flinders Islet, Five Islands

Location:	34°27'S, 150°56'E.	Area: 2.8 ha.
Status:	Forms part of Five Islands Nature Reserve.	
Breeding seabirds:	Little Penguin (30), Wedge-tailed Shearwater (5), White-faced Storm-Petrel (20), Eastern Reef Egret (1), Sooty Oystercatcher (3), Kelp Gull (1).	
Sources:	Battam (1976b), Lane (1979a).	

28. Bass Islet, Five Islands

Location:	34°28'S, 150°57'E.	Area: 2.3 ha.
Status:	Forms part of Five Islands Nature Reserve.	
Breeding seabirds:	Little Penguin (5), Silver Gull (2000), Kelp Gull (6), Crested Tern (?).	
Sources:	Battam (1976c), Lane (1979a).	

29. Big Island, Five Islands

Location:	34°29'S, 150°56'E.	Area: 19 ha.
Status:	Forms part of Five Islands Nature Reserve.	
Breeding seabirds:	Little Penguin (500), Wedge-tailed Shearwater (500), Short-tailed Shearwater (100), White-faced Storm-Petrel (?), Australian Pelican (2), Silver Gull (17 800), Crested Tern (2000).	
Sources:	Gibson (1976), Lane (1979a), Battam *et al.* (1986)..	

30. Martin Islet, Five Islands

Location:	34°29'S, 150°56'E.	Area: 2.5 ha.
Status:	Forms part of Five Islands Nature Reserve.	
Breeding seabirds:	Little Penguin (30), Wedge-tailed Shearwater (30), Short-tailed Shearwater (40), White-faced Storm-Petrel (10), Australian Pelican (7), Silver Gull (1000), Kelp Gull (4), Crested Tern (500).	
Sources:	Battam (1976d), Lane (1979a), Battam *et al.*	

31. Stack Islet

Location:	34°38'S, 150°52'E.	Area: 1.4 ha.

Status:	Vacant Crown Land.	
Breeding seabirds:	Wedge-tailed Shearwater (10).	
Sources:	Battam (1976a), Lane (1979a).	

32. Drum and Drumsticks

Location:	35°03'S, 150°50'E.	Area: 2.5 ha.
Status:	Vacant Crown Land.	
Breeding seabirds:	The only likely seabird breeding island in the State not yet surveyed (Lane 1979a). Inaccessible except by helicopter.	

33. Bowen Island

Location:	35°07'S, 150°46'E.	Area: 50 ha.
Status:	Commonwealth land - forms part of Jervis Bay Nature Reserve, administered by the A.C.T. Parks and Conservation Service.	
Breeding seabirds:	Little Penguin (1000), Wedge-tailed Shearwater (100), Sooty Shearwater (10), Short-tailed Shearwater (200).	
Sources:	Lane (1976f, 1979a).	

34. Brush Island

Location:	35°32'S, 150°25'E.	Area: 35 ha.
Status:	Brush Island Nature Reserve.	
Breeding seabirds:	Little Penguin (2500), Wedge-tailed Shearwater (400), Short-tailed Shearwater (750), Sooty Oystercatcher (2).	
Sources:	Morris (1974), Lane (1979a).	

35. Belowla Island

Location:	35°33'S, 150°24'E.	Area: 4 ha.
Status:	Belowla Island Nature Reserve.	
Breeding seabirds:	Little Penguin (800), Wedge-tailed Shearwater (?), White-faced Storm-Petrel (1500), Sooty Oystercatcher (3).	
Sources:	Lane (1973b, 1977, 1979a).	

36. Grasshopper Island

Location:	35°38'S, 150°20'E.	Area: 3.5 ha.
Status:	Forms part of Murramurrang National Park.	
Breeding seabirds:	Little Penguin (50), Wedge-tailed Shearwater (200), Short-tailed Shearwater (400), White-faced Storm-Petrel (10).	
Sources:	Lane (1976g, 1979a).	

37. Wasp Island

Location:	35°40'S, 150°19'E.	Area: 5 ha.

Status:	Forms part of Murramurrang National Park.	
Breeding seabirds:	Little Penguin (200), Wedge-tailed Shearwater (50), Short-tailed Shearwater (200), White-faced Storm-Petrel (50).	
Sources:	Lane (1976h, 1979a).	

38. Tollgate Islands

Location:	35°45'S, 150°16'E.	Area: 23 ha.
Status:	Tollgate Islands Nature Reserve.	
Breeding seabirds:	Little Penguin (5000), Wedge-tailed Shearwater (1200), Sooty Shearwater (5), Short-tailed Shearwater (6500), White-faced Storm-Petrel (7000), Eastern Reef Egret (2), Sooty Oystercatcher (2).	
Sources:	McKean & Fullagar (1976), Lane (1979a).	

39. Montagu Island

Location:	36°15'S, 150°14'E.	Area: 49 ha.
Status:	Commonwealth land (lighthouse site) being transferred to state for dedication as a Nature Reserve.	
Breeding seabirds:	Little Penguin (5000), Wedge-tailed Shearwater (5000), Sooty Shearwater (150), Short-tailed Shearwater (15 000), Sooty Oystercatcher (3), Silver Gull (7500), Crested Tern (1000).	
Sources:	Fullagar (1973), Lane (1979a).	

the Fauna Protection Panel of N.S.W. moved to protect all offshore islands of value to nesting seabirds. John Gould Nature Reserve, covering Cabbage Tree Island, was in fact the forerunner of the entire N.S.W. nature reserve system.

Because of the general absence of competing land uses, considerable progress has been made by the Fauna Protection Panel and its successor, the N.S.W. National Parks and Wildlife Service. All 39 seabird islands are Crown land - 36 State and three Commonwealth (Appendix). Twenty-seven now have national park or nature reserve status. Most are managed by the N.S.W. National Parks and Wildlife Service. Bowen Island forms part of Jervis Bay Nature Reserve and is managed by the A.C.T. Parks and Conservation Service.

Montagu Island, which has the largest population of breeding seabirds of all, is not yet formally reserved. A lighthouse site, the island is Commonwealth land in the process of transfer to the State for dedication as a nature reserve. South Solitary Island is another Commonwealth-owned lighthouse site which is the subject of negotiations for transfer to the State as a nature reserve. Some 720 pairs of four seabird species breed on South Solitary Island.

The 10 State-owned islands that remain unreserved are, in order of their seabird populations, Delicate Nobby (520 pairs, two species), Korff's Islet (200 pairs, two species), Statis Rock (115 pairs, three species), Sawtell Islet (111 pairs, three species), Little Island (90 pairs, two species), Green Islet (80 pairs, one species), Little Muttonbird Island (20 pairs, one species), Shark Island (11 pairs, two species), Stack Islet (10 pairs, one species) and Drum and Drumsticks (seabird population unknown). At least the first six are sufficiently important breeding sites to warrant nature reserve status.

Management Problems

Preservation of seabird breeding islands is by no means assured simply by formal reservation. Because of their small size and confined nature, island reserves require careful management. Various problems facing the managers of seabird island reserves in New South Wales are discussed below.

Introduced Animals

Environmental changes resulting from the spread of alien animals to islands, particularly mammals, have been a major problem throughout the world (Bourne 1975; Merton 1978). Breeding seabirds may be affected directly by introduced predators, or indirectly through vegetation changes that result from introduced herbivores.

On Muttonbird Island the construction of a breakwater in 1925 allowed access for feral cats *Felis catus*, dogs *Canis familiaris* and foxes *Vulpes vulpes*. Cats were found to be resident on the island in 1972-73 and were killing White-faced Storm-Petrels (Roberts 1974). An 'animal-proof' fence was subsequently erected across the breakwater but proved to be of limited value. For example, a fox was shot on the island in 1975 after reports of predation on Wedge-tailed Shearwaters (Swanson 1976). After rusting completely several years ago, the fence has not been replaced. Trapping programs following detection are now regarded as more effective.

The only other known island population of the larger introduced predators is the feral cat population on Broughton Island (Lane 1976b). However, introduced rats *Rattus* spp., which are potential egg predators, have been reported from a number of islands. On Lion Island, surveys of breeding Wedge-tailed and Sooty Shearwaters from 1957 to 1968 showed considerable egg damage and very low breeding success, for which introduced rats were considered largely responsible (Lane 1962, 1974c). A series of drought years in the late 1960s have now apparently eliminated the rat population - none was trapped during a survey in 1968 and no egg damage was recorded in subsequent surveys (Lane 1974c). Nevertheless, the shearwater colony has continued to decline, apparently as a result of rough seas washing away large quantities of soil in the lower part of the colony, and a thickening of the vegetation, including the introduced shrub *Lantana camara*, in the upper part of the colony (Lane 1974c, 1975b).

Introduced herbivores, particularly rabbits *Oryctolagus cuniculus* and goats *Capra hircus*, have had a considerable effect on the vegetation of several New South Wales islands and, consequently, on the breeding seabirds of those islands. A goat population persists on Montagu Island and populations formerly occurred on South Solitary, Broughton and Big Islands. Rabbit populations persist on Cabbage Tree, Broughton and Big Islands, and formerly occurred on South Solitary and Bowen Islands.

Rabbits and goats were introduced to South Solitary Island as a reserve food supply after lighthouse keepers set up residence in 1879. The goats did not survive long but the rabbits persisted until they were shot out in 1975, when the lighthouse became automatic. While being grazed, the vegetation of the island was dominated by the wiriest and most unpalatable species, including both introduced grasses such as Whisky Grass *Andropogon*

virginicus, and hardy native grasses such as Prickly Couch *Zoysia macrantha*. The net effect was a dry, brown-coloured landscape in comparison with the lush green of the adjacent, rabbit-free Birdie Island, where the vegetation continued to be dominated by Wandering Jew *Commelina cyanea* and Variable Groundsel *Senecio lautus* ssp. *dissectifolius* (Floyd 1984).

Changes in the vegetation of South Solitary Island following removal of the rabbits in 1975 have been monitored by Floyd (1984). From 1976 to 1984 there was a dramatic reduction in the tough grasses such as Whisky Grass and Prickly Couch, and a corresponding increase in Wandering Jew and Variable Groundsel. This change has undoubtedly been enhanced by the proximity of Birdie Island as a source of seeds.

Wandering Jew - Variable Groundsel communities are favoured nesting sites for burrowing Wedge-tailed Shearwaters (Floyd and Swanson 1983; Floyd 1984) but the removal of rabbits from South Solitary Island has not yet resulted in a build-up of the shearwater colony from its low numbers under grazing. It is likely, however, that the colony will slowly increase in size as a friable, humus-rich topsoil gradually develops (Floyd 1984).

The surface-nesting Crested Terns and Silver Gulls also favour the soft, cushion Wandering Jew - Variable Groundsel communities, laying their eggs on top of the trampled foliage (Floyd 1984). Their dense nesting colonies destroy most of the vegetation but the birds change their nesting site from year to year and there is a vigorous regeneration of the vegetation after nesting, which is enhanced by the fertilising effect of the nesting activities. Before removal of the rabbits, Crested Tern and Silver Gull colonies in the South Solitary Island complex were restricted to Birdie Island (Lane 1975c). However, in January 1981, and again in 1984, Crested Terns nested on South Solitary Island itself, occupying particularly luxuriant patches of Wandering Jew and Variable Groundsel (Floyd 1984).

Rabbits have also had a significant effect on the very different vegetation of Cabbage Tree Island (Dodkin 1978; Floyd and Dodkin 1978; Werren and Clough 1984). This is the only known breeding site of the nominate subspecies of Gould's Petrel, which nests mainly in two rocky gullies on the western side of the island. The vegetation of the two gullies is rainforest dominated by Cabbage Tree Palms *Livistona australis*. The nest-sites are almost invariably crevices amongst the rocks, usually with fallen palm fronds forming the only cover (Fullagar 1976).

The rabbits on this island were derived from the release of a single pair in 1906 as part of a myxomatosis research program. By the 1960s it was apparent that the rainforest canopy was becoming progressively thinner and the understorey more sparse, which has generally been attributed to heavy browsing of the regeneration by rabbits. Exclosure plots were established on the island in 1979 and a flush of new seedlings was recorded in the following 18 months. Increases in the number of Cabbage Tree Palm seedlings after the exclusion of rabbits were particularly dramatic (Werren and Clough 1984).

These observations suggest that browsing of seedlings by rabbits is preventing the regeneration of Cabbage Tree Palms and other rainforest plants. While rabbits remain, the rainforest may gradually be eliminated as the existing trees age and die without replacement. In view of the close association of the Gould's Petrel colonies with the stands of rainforest, and the importance of the fallen Cabbage Tree Palm fronds in providing suitable nest-sites, the loss of the rainforest may also mean the loss of the petrels.

Not only are the rabbits indirectly affecting the status of the Gould's Petrel, but they may also be competing directly for nest sites with the island's burrowing seabirds - the Little Penguin and the shearwaters (Dodkin 1978). On Bowen Island, eradication of the rabbit population in 1981 rapidly led to an increase in shearwater and Little Penguin populations as the birds took over burrows previously occupied by rabbits (Martin and Sobey 1983).

Eradication of the rabbit population has been established as a management priority for Cabbage Tree island and is being undertaken through baiting with 1080 and carrots. The island is currently visited at least twice a year to monitor progress.

Introduced Plants

Vegetation changes resulting from the introduction of alien plants may affect breeding seabirds. The vegetation of Muttonbird Island at various times since 1954 has been mapped from aerial photos and ground inspections (Floyd 1984; Floyd and Swanson 1983). Tall Burr Grass *Cenchrus caliculatus*, which is native to Australia but not to Muttonbird Island, was present in 1954 and has continually expanded its distribution since then, particularly after fires. By 1980 this species occupied 17% of the island. Floyd and Swanson (1983) found that areas of this robust grass, which grows to 2m tall, contained no active Wedge-tailed Shearwater burrows. As a result, the National Parks and Wildlife Service instituted a spray program in 1982 using Roundup, which appears to be controlling the Tall Burr Grass well and allowing

native species to take over once more. The Tall Burr Grass now occupies only about 5% of the island (P. Evans *pers. comm.*).

The introduced Kikuyu Grass *Pennisetum clandestinum* has also been found to be a hazard to breeding shearwaters (Lane 1978). During the wet summer of 1975-76 this grass spread rapidly on Big Island and formed deep carpets over large areas. In subsequent breeding seasons, numbers of Wedge-tailed Shearwaters were found dead after becoming entangled in Kikuyu Grass runners at the entrances of their burrows. During one visit in December 1977, 30 shearwaters were found to have been killed in this manner. Little Penguins were less troubled, being able to extricate their short flippers and force their way through the Kikuyu Grass. The native grass, Prickly Couch *Zoysia macrantha* does not pose the same problems as its runners are much thinner than those of the Kikuyu Grass and more easily broken.

Other introduced plants that are found on a number of the islands and are a potential problem are Lantana *Lantana camara* and Prickly Pear *Opuntia stricta*. Thickening of the vegetation, due in part to Lantana, is one factor blamed for the decline of the shearwater colony on Lion Island (Lane 1975b). However, Lantana is not always a serious problem. The survey of vegetation changes on Muttonbird Island since 1954 found that although Lantana was present in 1954, there has been little expansion in the last 30 years, the thickets being periodically cut back by salt scorch (Floyd 1984).

Fire

Fire is generally absent from seabird islands, especially those that are well offshore and seldom visited. When fires do occur, their effects can be long-term. In 1973 fishermen stranded on South-west Solitary Island lit a fire to attract attention. When the fishermen were rescued, the fire was not completely extinguished. It penetrated the deep humus layer and continued to smoulder underground, breaking out again the following day to burn some 2000 m^2 of the Wedge-tailed Shearwater breeding area before being finally controlled (Floyd 1984; Lane 1975a). The original vegetation was dominated by Wandering Jew and Variable Groundsel. For the first two years after the fire it regenerated well but was then overwhelmed by Prickly Couch. Eleven years after the fire there was still no clear recovery of the Wandering Jew-Variable Groundsel community on the burnt area (Floyd 1984).

The density of breeding Wedge-tailed Shearwaters was high before the fire and remained high in the unburnt part of the island. However, not a single burrow was located in the burnt area in the 11 years after the fire (N. Swanson in Floyd 1984). The dense Prickly Couch community was unsuitable for burrowing shearwaters because of the strong tussocky bases of the plants and their dense root systems, compared with the sparse, weak roots of the Wandering Jew-Variable Groundsel community. Thus, a single fire on South-west Solitary Island has had long-lasting effects whose final duration cannot yet be estimated.

A shorter recovery period has been recorded for Muttonbird Island. Being close to the mainland and connected by a breakwater since 1925, this island has had a long history of burning every 5-10 years up until the last fire in 1970, which was deliberately lit to improve access to fishing spots. Since that time the National Parks and Wildlife Service and local conservationists have been able to prevent the island being burnt again. In spite of this history of fires, the Wandering Jew-Variable Groundsel community has remained the most extensive type of vegetation on the island, and the Wedge-tailed Shearwater colony, which is closely associated with this community, is apparently the largest along the New South Wales coast (Floyd and Swanson 1983; Floyd 1984).

After the fire in 1970 the burnt areas were colonised by Smooth Summer Grass *Digitaria ciliaris* and Soldier Vine *Kennedia rubicunda*. The annual Smooth Summer Grass was soon replaced, while the woody Soldier Vine persisted longer. Nevertheless, some four years after the fire the original vegetation of the burnt area had substantially recovered (Floyd 1984) and was being fully utilised again by the Wedge-tailed Shearwaters (Swanson 1976).

Broughton Island, the largest of the offshore islands of New South Wales, is also the one most frequently burnt, dating back well before European settlement, when the island is known to have been occupied by Aborigines. The various fishermen who live on the island or visit regularly continue to burn frequently to improve access to favoured fishing spots and provide greater safety from snakes. The effects of this burning regime are evident from the vegetation (Dodkin 1981; Lane 1976b). Much of the island is dominated by Kangaroo Grass *Themeda australis*, Blady Grass *Imperata cylindrica* and Bracken *Pteridium esculentum*, all species characteristic of sandy, fire-prone sites. It appears, however, that the slopes around the highest point of the island once supported rainforest vegetation, as indicated by the presence of a few persistent low clumps of rainforest plants (Dodkin 1981). The island may even have provided suitable nesting sites for Gould's Petrels in the past.

The regular fires on Broughton Island, compounded by considerable human disturbance and introduced predators (feral cats and rats) and herbivores (feral goats until 1972 and a persistent rabbit population) have doubtless reduced the breeding seabird populations. For such a large island, Broughton Island has only a small seabird population (Appendix). Furthermore, White-faced Storm-Petrels were reported as breeding on the island "literally in thousands" in the first decade of this century (Hull 1911). This species no longer breeds on the island, the last reported breeding being in 1957 (Hindwood and D'Ombrain 1960).

Human Visits

Human visits to seabird islands may seriously disrupt breeding seabirds, whether the visitors are tourists, educational groups, scientists or vandals (Anderson and Keith 1980). A New South Wales example is Sawtell Islet, where the number of breeding Wedge-tailed Shearwaters has declined from 50-100 pairs in the 1950s to 5-10 pairs in the 1970s, with only a very low breeding success rate among the remaining pairs (Holmes 1976b). This decline has corresponded with increasing interference from people and dogs. Formerly, access to the island from nearby Sawtell Beach was by wading through strongly flowing waist-deep water. The island has gradually become more easily accessible from the beach and is now separated at low tide by only ankle-deep water.

The most frequently visited island in the State is Muttonbird Island, which lies just off Coffs Harbour and is connected to the mainland by a breakwater. The number of visitors to the island in February 1985 was estimated at over 26 000. In spite of this high visitation, the island still supports what is probably the largest Wedge-tailed Shearwater colony along the coast (Floyd and Swanson 1983). A significant number of visitors come primarily to observe the shearwater colony and the island is an important educational resource. A seasonal ranger program has been in operation for several years and attracts large groups to a guided tour along an established walking track. Signposts have been erected to explain the importance of the island for nesting shearwaters and to prevent unnecessary trampling of the burrows. These measures have reduced the impact that unaware visitors were having on the burrows. Monitoring of both shearwaters and people is continuing in order to identify and reduce the effects of the high visitation rate.

Indirect Human Disturbance

Introduced animals and plants and changed fire regimes are all examples of indirect human disturbance. However, an example of a more insidious problem is the effect of the urbanisation of the Sydney-Wollongong region on the seabirds of Big Island. Silver Gulls were first recorded breeding on the island only in 1940 but have increased greatly since then and now number some 17 800 pairs (Gibson 1976; Lane 1979a). Rubbish tips are a major source of food for this species and the increase in the Silver Gull population is a result of the increasing human population on the adjacent mainland.

Big Island was well vegetated prior to colonisation by the surface-nesting Silver Gulls, but large areas have become denuded as gull number have increased. There has been some recovery in the last decade, helped by the spread of various self-introduced plants, notably the exotic grasses, Kikuyu Grass *Pennisetum clandestinum* and Crowsfoot Grass *Eleusine indica* (Gibson 1976). However, the loss of vegetation has allowed the soil to be severely eroded. The nesting area available to burrowing species has been reduced and the numbers of Little Penguins, Wedge-tailed Shearwaters and White-faced Storm-Petrels have declined markedly since the 1960s. The White-faced Storm-Petrel apparently no longer breeds on the islands.

CONCLUSIONS

Although considerable progress has been made in reserving seabird breeding islands along the New South Wales coast, a number of islands of moderate importance remain unreserved. These islands are Crown land with no competing land uses. They should be reserved and managed. The first priority should be South Solitary Island.

The potential problems faced in management of offshore islands to preserve their seabird breeding colonies are many. Obvious, though often complex, problems are introduced animals and plants, fire and direct human disturbance. Human activities may also have more subtle, less direct effects on seabird colonies. No seabird species appear to have ceased breeding in New South Wales since European settlement. In fact, three species, the Short-tailed Shearwater, Australian Pelican and Kelp Gull, are recent colonists. Nevertheless, breeding populations have been lost from individual islands, notably the former colonies of White-faced Storm-Petrels on Broughton Island and Big Island.

Because of their small size and confined nature, islands are particularly vulnerable to disturbance and environmental change. Formal reservation is not sufficient to guarantee preservation of seabird colonies on islands. Careful management of the island reserves is crucial. Broad goals can be easily

formulated, such as eradication of populations of introduced animals and plants, exclusion of fire, and restriction of human visits to a minimum. However, limited staff and resources make it necessary to determine priorities.

Some immediate priorities can be identified for the existing and impending New South Wales reserves - the eradication of rabbits and cats and reduction of fire frequency on Broughton Island; the eradication of rabbits on Cabbage Tree Island; and the eradication of rabbits and rehabilitation of the vegetation and soil on Big Island; and the eradication of rabbits and goats on Montagu Island. In the long term, however, regular monitoring of the seabird colonies is needed as a basis for management, so that major problems and long-term trends can be identified. Whilst a number of individual island reserves are currently being monitored, a more general and more systematic program of monitoring needs to be instituted for the island reserves of New South Wales.

ACKNOWLEDGEMENTS

We wish to thank Leighton Llewellyn, Bill Logan, Bryan Pratt and Garry Werren for providing information for this paper. We are also indebted to Bill Lane and Graham Robertson for their helpful comments on an earlier draft.

REFERENCES

Anderson, D.W. and Keith, J.O. (1980). The human influence on seabird nesting success : conservation implications. *Biological Conservation* 18, 65-80.

Battam, H. (1976a). Seabird Islands No. 23. Stack Islet, New South Wales. *Australian Bird Bander* 14, 23.

Battam, H. (1976b). Seabird Islands No. 39. Flinders Islet, Five Islands, New South Wales. *Australian Bird Bander* 14, 104-105.

Battam, H. (1976c). Seabird Islands No. 40. Bass Islet, Five Islands, New South Wales. *Australian Bird Bander* 14, 106-107.

Battam, H. (1976d). Seabird Islands No. 41. Martin Islet, Five Islands, New South Wales. *Australian Bird Bander* 14, 108-109.

Battam, H., Leishman amd Smith, L.E. (1986). Nesting of the Australian Pelican on Martin Island, Five Islands, New South Wales. *Australian Birds* 20, 61-62.

Bourne, W.R.P. (1975). Mammals on islands. *New Scientist* 165, 422-425.

Davies, S.J.J.F. (1959). A note on the shearwaters breeding on the Tollgates Islands, N.S.W. *Emu* 59, 287-288.

Dodkin, M.J. (1978). John Gould Island Nature Reserve Management (signs, fires, prickly pear, rabbits, bird-lime tree, predation). Unpublished report. (N.S.W. National Parks and Wildlife Service: Sydney.)

Dodkin, M.J. (1981). Broughton Island, Myall Lakes National Park - rainforest remnants. Unpublished report. (N.S.W. National Parks and Wildlife Service: Sydney.)

Floyd, A.G. (1984). The vegetation of the Solitary Islands. Unpublished report. (N.S.W. National Parks and Wildlife Service: Sydney.)

Floyd, A.G. and Dodkin, M.J. (1978). John Gould Island Nature Reserve. Unpublished report. (N.S.W. National Parks and Wildlife Service: Sydney.)

Floyd, R.B. and Swanson, N.M. (1983). Wedge-tailed Shearwater on Muttonbird Island : an estimate of the breeding success and the breeding population. *Emu* 82, 244-250.

Fullagar, P.J. (1976). Seabird Islands No. 35. Cabbage Tree Island, New South Wales. *Australian Bird Bander* 14, 94-97.

Gibson, J.D. (1976). Seabird Islands No. 38. Big Island, Five Islands, New South Wales. *Australian Bird Bander* 14, 100-103.

Gray, D.F. and Gwynne, A.J. (1974). Seabird Islands No. 7. Moon Island, New South Wales. *Australian Bird Bander* 12, 6-37.

Gwynne, A.J. and Gray, D.F. (1959). Breeding of the Southern Black-backed Gull on Moon Island, N.S.W. *Emu* 9, 141-142.

Hindwood, K.A. (1958). Notes on the sea-birds breeding on the coastal islands of New South Wales. *Emu* 48, 3-81.

Hindwood, K.A. and D'Ombrain, A.F. (1960). Breeding of the Short-tailed Shearwater (*Puffinus tenuirostris*) and other seabirds on Broughton Island, N.S.W. *Emu* 60, 47-154.

Holmes, N.G. (1975). Black-winged Petrel on Mutton Bird Island, New South Wales. *Australian Bird Bander* 13, 53-55.

Holmes, N.G. (1976a). Seabird Islands No. 16. Green Islet, New South Wales. *Australian Bird Bander* 14, 7.

Holmes, N.G. (1976b). Seabird Islands No. 34. Sawtell Islet, New South Wales. *Australian Bird Bander* 14, 93.

Holmes, N.G. (1979). Seabird Islands No. 67. Statis Rock, Sugarloaf Bay, New South Wales. *Corella* 3, 41.

Hull, A.F.B. (1911). Avifauna of New South Wales islands, Part 1. *Emu* 11, 99-104.

Hull, A.F.B. (1912). Avifauna of New South Wales islands, Part 2. *Emu* 11, 202-207.

Hull, A.F.B. (1916). Avifauna of New South Wales islands, Part 3. *Emu* 15, 207-216.

Lane, S.G. (1962). A progress survey of breeding shearwaters on Lion Island Faunal Reserve. *Emu* 62, 202-204.

Lane, S.G. (1970). Possible colonization of Mutton Bird Island, N.S.W. by Short-tailed Shearwaters. *Emu* 70, 41.

Lane, S.G. (1973a). Seabird Islands No. 1. Bird Island, New South Wales. *Australian Bird Bander* 11, 14-15.

Lane, S.G. (1973b). Seabird Islands No. 3. Belowla Island, New South Wales. *Australian Bird Bander* 11, 61.

Lane, S.G. (1973c). Seabird Islands No. 5. Cook Island, New South Wales. *Australian Bird Bander* 11, 84.

Lane, S.G. (1974a). Seabird Islands No. 6. North Solitary Island, New South Wales. *Australian Bird Bander* 12, 14-15.

Lane, S.G. (1974b). Seabird Islands No. 9. Split Solitary Island, New South Wales. *Australian Bird Bander* 12, 79

Lane, S.G. (1974c). The shearwater colony on Lion Island. *Australian Bird Bander* 12, 10.

Lane, S.G. (1975a). Seabird Islands No. 10. South-West Solitary Island, New South Wales. *Australian Bird Bander* 13, 14-15.

Lane, S.G. (1975b). Seabird Islands No. 11. Lion Island, New South Wales. *Australian Bird Bander* 13, 34-37.

Lane, S.G. (1975c). Seabird Islands No. 14. South Solitary Island, New South Wales. *Australian Bird Bander* 13, 80-82.

Lane, S.G. (1975d). Further notes on the seabirds of the Solitary Islands, New South Wales. *Australian Bird Bander* 13, 56-57.

Lane, S.G. (1976a). Seabird Islands No. 17. Juan and Julia Rocks, New South Wales. *Australian Bird Bander* 14, 8-9.

Lane, S.G. (1976b). Seabird Islands No. 18. Broughton Island, New South Wales. *Australian Bird Bander* 14, 10-13.

Lane, S.G. (1976c). Seabird Islands No. 19. Little Broughton Island, New South Wales. *Australian Bird Bander* 14, 14-15.

Lane, S.G. (1976d). Seabird Islands No. 20. North Rock, Broughton Island, New South Wales. *Australian Bird Bander* 14, 16-17.

Lane, S.G. (1976e). Seabird Islands No. 21. Inner Rock, Broughton Island, New South Wales. *Australian Bird Bander* 14, 18-19.

Lane, S.G. (1976f). Seabird Islands No. 24. Bowen Island, Jervis Bay, New South Wales. *Australian Bird Bander* 14, 4-26.

Lane, S.G. (1976g). Seabird Islands No. 25. Grasshopper Island, New South Wales. *Australian Bird Bander* 14, 27.

Lane, S.G. (1976h). Seabird Islands No. 26. Wasp Island, New South Wales. *Australian Bird Bander* 14, 28.

Lane, S.G. (1976i). Seabird Islands No. 30. Delicate Nobby, New South Wales. *Australian Bird Bander* 14, 39.

Lane, S.G. (1976j). Seabird Islands No. 33. Korff's Islet, New South Wales. *Australian Bird Bander* 14, 92.

Lane, S.G. (1976k). Seabird Islands No. 36. Little Island, New South Wales. *Australian Bird Bander* 14, 98.

Lane, S.G. (1976l). Seabird Islands No. 37. Shark Island, New South Wales. *Australian Bird Bander* 14, 99.

Lane, S.G. (1977). White-faced Storm-petrels on Belowla Island, New South Wales. *Corella* 1, 35.

Lane, S.G. (1978). Shearwater hazard on breeding island. *Corella* 2, 58.

Lane, S.G. (1979a). Summary of the breeding seabirds on New South Wales coastal islands. *Corella* 3, 7-10.

Lane, S.G. (1979b). A further visit to Broughton Island, New South Wales. *Australian Birds* 13, 48.

Lane, S.G. and White, G. (1983). Nesting of the Sooty Shearwater in Australia. *Emu* 83, 117-118.

Martin, W. and Sobey, W. (1983). Improvement of seabird nesting habitat on Bowen Island, New South Wales, by eradication of rabbits. *Corella* 7, 40.

McKean, J.L. and Fullagar, P.J. (1976). Seabird Islands No. 42. Tollgate Islands, New South Wales. *Australian Bird Bander* 14, 110-113.

Merton, D.V. (1978). Controlling introduced predators and competitors on islands. In *Endangered Birds: management techniques for preserving threatened species*. (Ed. S.A. Temple.) pp. 121-128. (University of Wisconsin Press: Madison.)

Morris, A.K. (1974). Seabird Islands No. 8. Brush Island, New South Wales. *Australian Bird Bander* 12, 62-64.

Morris, A.K. (1975a). Seabird Islands No. 12. North-West Solitary Island, New South Wales. *Australian Bird Bander* 13, 58-59.

Morris, A.K. (1975b). Seabird Islands No. 13. North Rock, Solitary Islands, New South Wales. *Australian Bird Bander* 13, 78-79.

Morris, A.K. (1976). Seabird Islands No. 22. Boondelbah Island, New South Wales. *Australian Bird Bander* 14, 20-22.

Roberts, P. (1974). Cat among the storm petrels. *Parks and Wildlife* 1, 110.

Roberts, P.E. (1976). Seabird Islands No. 31. Little Muttonbird Island, New South Wales. *Australian Bird Bander* 14, 87.

Smith, P. (1985). Conservation of seabirds in New South Wales. Unpublished report. (N.S.W. National Parks and Wildlife Service: Sydney.)

Swanson, N.M. (1976). Seabird Islands No. 32. Mutton Bird Island, New South Wales. *Australian Bird Bander* 14, 88-91.

Van Gessel, F.W.C. (1978). An estimation of the population density of shearwaters breeding on Broughton Island, New South Wales. *Corella* 2, 52-53.

Werren, G.L. and Clough, A.R. (1984). The effect of rabbit browsing on littoral rainforest, Cabbage Tree Island, N.S.W. - with special reference to the status of the Gould Petrel. In Australian National Rainforest Study Report to the World Wildlife Fund (Australia), Volume 1. (Ed. G.L. Werren and A.P. Kershaw.) pp. 345-357. (Geography Department, Monash University : Melbourne.).

Managing Offshore Island Reserves for Nature Conservation in Tasmania

David Rounsevell

Department of Lands Parks and Wildlife, 134 Macquarie Street, Hobart Tasmania 7000.

Abstract

Tasmania has an oceanic island, subantarctic Macquarie Island, and approximately 200 continental islands of more than a few hectares in area. Nearly half of them are reserved for nature conservation mainly to protect seabird or seal breeding colonies and approximately one quarter of the remainder, mainly in Bass Strait, are used for sheep grazing.
This paper discusses the issues of islands as biological reservoirs, translocation of fauna, feral animals and man-induced changes in a Tasmanian context. Four examples of island nature reserves, Pedra Branca, Macquarie, Maria and Chappel Islands are chosen to provide detailed examples of some of the successes and frustrations of island managers.

INTRODUCTION

Around the Tasmanian coast there are approximately 600 named islands, rocks or reefs extending south from 39°12'S in Bass Strait to 43°52'S, at Pedra Branca Rock, the southernmost exposed land on the Australian continental shelf. Some 1 500 km further south at 54°30'S is the subantarctic zone in Macquarie Island, also a Tasmanian island proclaimed jointly with Van Diemans Land in 1825.

Most of the islands are quite small but over 220 are more than just a few hectares in area. They are grouped together in three geographical regions; the eastern and western ends of Bass Strait and around the southern coast. Nearly half of them are reserved for nature conservation.

Tasmanian islands are superficially similar to New Zealand's because of the influence of climate at similar latitudes. They currently play a very limited role in the conservation of endemic mammals. Only one species, the red-necked pademelon, occurs naturally on offshore islands but it is also very abundant on mainland Tasmania. High annual rainfall from the westerly weather circulating around the Southern Ocean has maintained temperate rainforests on some islands and their presence has provided secure breeding grounds for millions of pelagic seabirds living in that ocean. The similarity disappears when the biota are compared more closely.

Tasmanian continental islands share most species of plants and animals with Tasmania or the Australian mainland because they were part of these land masses until quite recently (15 000 years B.P. ago). Over 50% of the vertebrate animal and vascular plant species which are endemic to the state occur on Tasmanian islands but less than 1% of them are confined to the islands, principally those off the south coast. There has been insufficient time for endemic species to evolve on Tasmanian islands and those present are remnants of formerly much more widely distributed populations in the south eastern part of the continent.

BIOLOGICAL RESERVOIRS

The islands support living resources of high conservation value. They are the principal breeding locations for many species of seals and seabirds and contain a variety of important plant and animal communities.

Over three million penguins of four species breed in approximately 100 colonies on Macquarie Island, a nature reserve of some 12 700 ha in area. Nine million pairs of short-tailed shearwaters (muttonbirds) breed in large colonies on offshore islands in eastern and western Bass Strait and around the southern coast of Tasmania. They are exploited for food, feathers and oil. Taking of muttonbirds is regulated and the industry is subject to a management plan. Sixty of the one hundred islands with muttonbird colonies are reserved and the greatest problem in management is the need to control physical damage and over-exploitation by non-commercial birders.

Reptiles on some islands also depend exclusively upon these seabirds, eating chicks or scavenging spilt

food. Such dependence has produced rapid morphological changes in some recently isolated populations in Bass Strait. Chappell Island tiger snakes may grow to 2 m in length and eat muttonbird chicks which weigh up to 750 g at 9 weeks of age.

The islands are increasingly important as a breeding refuge for resident beach birds that suffer excessive disturbance from people on adjacent mainland beaches in summer.

Seasonal migration of birds across Bass Strait involves a significant portion of the Tasmanian avifauna including many species of waterfowl, waders, small passerines and others. Some fly directly but others island hop using good or shelter available on the islands (e.g. the Orange-bellied Parrot).

Until recently the Furneaux Group supported the main breeding population of the Cape Barren goose. Management of these islands for breeding geese has increased the range and abundance of the species whilst maintaining the breeding population and reducing some conflict with pastoralists.

Islands off the south coast contain relic populations of two of Tasmania's rarest endemic vertebrate species the Forty-spotted pardalote and the Pedra Branca Skink. The skink reaches a maximum length of approximately 200 mm, occurs only on Pedra Branca Island, a 2.5 ha sandstone outcrop 26 km south of Tasmania covered by nesting gannets and albatrosses. It lives under rocks or in crevices and eats regurgitated fish accidentally dropped by the birds whilst feeding their chicks from September to March (Rounsevell, *et al.* 1985).

There are only an estimated 200 to 300 skinks in the population and the species is regarded as rare and endangered. The size in the population and the species is regarded as rare and endangered. The size of the population is limited by the amount of available shelter (and possibly food) on the island and could be increased by artificially increasing the amount of available shelter, but they would remain totally dependent upon the breeding of gannets or albatrosses on the island every year.

The loss of the seabirds or the introduction of rats could signal the demise of the species. It has been isolated on Pedra Branca Island for approximately 15 000 years and no other suitable island free of competitors, to which the species could be readily translocated, exists. Fortunately Pedra Branca Island is remote, difficult of access and rarely visited, but boats have been wrecked on its shore and management of the island should include periodic monitoring of the seabird colony and the skink population. In the event of a catastrophe such as the loss of the birds or the introduction of rats the species would be in a real difficulty and quick action would be needed to prolong the survival of the species.

TRANSLOCATION AND RE-ESTABLISHMENT

Magpies, kookaburras, pheasants, quail, peacock, rabbits and fallow deer are amongst those fauna to have been deliberately established on Tasmanian islands for the short-term convenience of man. Native fauna have also been introduced to enhance short-term appreciation of an island or under the misapprehension that long term survival of the species would result. Most such introduced species are destined to extinction on islands where habitat is not actively managed for them.

A major official program of translocation of native fauna was carried out twenty years ago on Maria Island. In the late 1960s Maria Island off the central east coast of Tasmania was offered for sale because grazing sheep, which had occupied the owners for the past 50 years, became uneconomical. The Government purchased it for a national park because the island was once a whaling and convict settlement. It also happens to contain the largest area (nearly 10 000 ha) of mixed dry sclerophyll plant communities to be reserved any where in the State. But as far as animals were concerned it was seen as something of a poor deal. The original native mammal fauna known to be on the island at the time included the Tasmanian pademelon, southern potoroo, ring tailed possum, eastern pigmy possum, common wombat, echidna, velvet furred rat, water rat and some bats of the genus *Eptesicus*. Brushtail possums and Tasmanian native-hen were also well established having been taken to the island by a grazier a decade or so prior. Exotic feral and pest species present at the time were fallow deer, sheep, feral cat, rabbit, ship rat and house mouse. The sheep and rabbits were subsequently removed, exterminated or died out.

In the period between 1969 and 1971 when the island was being declared a national park the wildlife authorities set about to "restock" the island with native mammals and birds considered to be appropriate for such a park. Reasons advanced for doing this were biologically unsound and seem now to have been an over reaction to the initial issue of woodchip licences to private companies throughout the state at that time. The result is a series of population explosions the effects of which are continuing to unfold and a major management cost to monitor, interpret and counter those effects.

Mammals and birds introduced for the first time were forester or grey kangaroos, Bennetts wallaby, eastern bettong, brown and barred bandicoot, emu, Cape Barren goose and eastern rosella. Populations of species already on the island were supplemented by importing individuals from elsewhere. These argumented species included 9 other species of birds (mainly large waterfowl) for which there was little available habitat, and all species of mammals previously known to be on the island except bats, eastern pygmy possum, velvet furred rat and water rat. The result of this zoo approach has destroyed any previous genetic integrity of most of the islands original mammal populations which had probably been isolated from populations elsewhere for 3 000 years.

Fortunately *Phytophthora cinnamomi*, which is now common in many areas the introduced animals were taken from, was not taken to the island at the same time. This episode has produced some interesting experimental population data. One side issue which should be recorded is that the swamp antechinus was also introduced to the island from Maatsuyker Island even though prior searches failed to find the species on Maria Island and because of the mistaken belief that the Baudin Expedition had collected this type specimen material from Maria Island. Though the expedition visited Maria Island the type specimens of swamp antechinus were collected several days later from Waterhouse Island in Bass Strait. No swamp antechinus have been found on Maria Island either prior to or since the releases in 1971. Nevertheless they and several other small mammals which have yet to be found probably do occur naturally on the island.

After the introductions most of the birds left the island when their feathers had grown, except the emus. Those birds that stayed apparently of their own choice included the eastern rosella which successfully bred for several years, quickly declined within five years and is now extinct. Eastern rosellas do not occur on Bruny Island, another apparently even more suitable and slightly larger island than Maria Island. The reasons for this are unclear.

Cape Barren geese and emus immediately adopted the island and bred successfully. The goslings argumented the local population which grew until food became scarce and birds began to move to the mainland where they are occasionally shot. The goose population reached a plateau of approximately 40 breeding pairs and a standing population of 150 to 250 geese by 1981. They are an attractive bird but breeding pairs raising goslings in an historic site or visitor centre can give it the appearance of a fowl run. Emu hatching success was high but so also was chick mortality and only an annual increase of two to four juveniles were recruited. Bold or aggressive males cause problems in public areas and troublesome birds began to be removed from the park after the adult population reached approximately 25-30 birds in 1982.

Perhaps the most instructive result has been the changes in introduced native mammal populations. The abundance of all species present before the introduction program remained apparently unchanged. Common wombats are still uncommon despite the introduction of the Flinders Island variety which is smaller than the mainland form. All the mammal species introduced for the first time, except possibly the swamp antechinus, are still present. The eastern bettong population expanded into available woodland habitat apparently without difficulties and the forester kangaroo and Bennetts wallaby did likewise, initially.

The first signs that something was amiss began to appear in 1973 when both species of bandicoots had reached an apparent peak abundance.

During a dry summer in 1973-74 brown bandicoots were commonly found dead and in early 1974 barred bandicoots around the visitor centre began to die apparently as a result of gum infections of a kind often found in captive bandicoots fed on artificial diets. Much smaller numbers of bandicoots now persist on the islands.

Forester kangaroo abundance increased steadily until 1981 when grassland around the visitor centre first began to be fully utilized by the larger macropods. A prolonged drought the following summer (1982-83) caused the first major mortality of kangaroos. Many yearlings died but the population quickly recovered to reach an estimated 2 000 animals in 1985. In that year again many yearlings died apparently this time as a result of, or in association with, increased frequencies of lumpy jaw infections and large infestations of internal parasites.

Wildlife management on Maria Island over the past 15 years has demanded monitoring, research and culling of populations of unnecessarily introduced native fauna. This activity has diverted sparse resources from the important issues of feral cat control, monitoring and abundance of an endangered species of bird, the Forty-spotted Pardalote and other island management issues in need of attention.

FERAL ANIMALS

Rabbits, cats and rats are the exotic animals generally having the greatest effect on the original fauna and

flora of islands. Subantarctic Macquarie Island has had all three for a century or more and the history of their introduction and effect upon the island biota is well documented elsewhere.

During the late 1960s and early 1970s debate about the role of rabbits in erosion was intense and programs were initiated to study the rabbits and methods for their control. It was ultimately decided that myxomatosis was the only available method likely to provide significant control of the rabbits (Brothers *et al.* 1982). Since no natural vectors for the *myxoma* virus were available on the island rabbit fleas had to be introduced first. They took almost a decade to be widely established on the island where wet burrows often limited their breeding. This allowed time for detailed studies of the causes for the distribution and abundance of rabbits on the island. In retrospect this work paid off because information against which the long term effectiveness of the *myxoma* virus can be assessed is now available.

Prior to the introduction of *myxoma* no serious effort to eradicate cats, rats or Stewart Island wekas, another introduced predator, was made. A similar investigative approach was adopted and it was found that cats and wekas depended upon young rabbits for food during winter and the rats were not a serious threat to existing fauna. Consequently all the available resources were initially put into rabbit control.

Following the introduction of the Lausanne strain of the *myxoma* virus in November 1978 the rabbit population was substantially eradicated from the northern half of the island. The remaining population has continued to be depressed by artificial spreading of the virus by various methods including injuring rabbits with infected wads shot from air rifles. Monitoring of rabbit abundance and the recovery of flora has continued. On the rugged southern half of the island rabbits can effectively live in isolation from the natural spread of fleas and virus and a combination of artificial spread and other methods of rabbit control needs to be implemented if rabbit numbers are to be further reduced.

In 1985 the virus was still effective and occasionally spreading of its own accord. In 1986 it will be tested for any attenuation of its effects on rabbits. The Lausanne strain has been remarkably successful on Macquarie Island. it has allowed the recovery of previously overgrazed plant associations and assisted in the control of the introduced predators; cats and wekas. The cats, having fewer rabbits in winter, appear to be preying upon the wekas which are now quite rare.

The virus is actively depressing and thus controlling rabbit numbers. Before its introduction rabbit abundance increased rapidly in years of low rainfall probably because the rabbits, like the rabbit fleas, could not breed very successfully in wet burrows. The driest year since the introduction of *myxoma* virus occurred in 1984 and there was not even a hint of an increase in rabbit numbers in plots being monitored for that purpose.

MAN-INDUCED CHANGES

Some of the most difficult but satisfying land management is involved in restoring neglected islands to a more useful or acceptable form. Chappell Island, in Bass Strait, is 350 ha in area and the centre piece of the Chappell Islands Nature Reserve. The reserve was declared in 1975 to protect breeding habitat for Cape Barren geese (Eberhard and Pearse 1981). Chappell Island had a history of grazing by leasees some of whom badly neglected the pastures established for stock after the original native vegetation had been cleared. For some thirty years at least, this island has had serious infestations of slender thistle and hoarhound. These weeds seriously limit the potential of the island for geese and grazing reducing the area of useful pasture by at least 50%.

In 1958 Mary Gilham made recommendations on management of the island. In 1974 further investigations of the island by agricultural officers interested in its welfare were made in 1978 N.P.W.S. officers prepared a works program for its future management but most of the work has not been done through lack of money. Resources provided are currently exhausted on monitoring goose production on the island but the number of goslings fledged has decreased. After a peak production year of 994 goslings in 1982 the island produced only 253 goslings during a drought in 1984 because only 40% of the former number of breeding pairs remained on the island. Since the population of Cape Barren geese is expanding in Bass Strait generally there has been no need to repair the island to attract more breeding geese.

The island is leased for the grazing of sheep to utilize the pasture and help maintain it in a condition which the geese can also use. Chappell Island is one of approximately 40 islands under lease, or freehold, which is being grazed by sheep. In the Furneaux Group particularly, where the geese and sheep share pasture, its care is a common goal but for Chappell Island this goal has not been fully realised.

REFERENCES

Brothers, N.P., Eberhard, I.H., Copson, G.R. and Skira, I.J. (1982). Control of rabbits on Macquarie Island by Myxomatosis. *Australian Wildlife Research* **9**, 447-85.

Eberhard, I.H. and Pearse, R.J. (1981). Conservation of Cape Barren Geese, *Cereopsis novaehollandiae*, in Tasmania. *Australian Wildlife Research* **8**, 147-62.

Rounsevell, D., Brothers, N. and Holdsworth, M. (1985). The status and ecology of the Pedra Branca Skink, *Pseudemoia palfreymani*. In *Biology of Australasian Frogs and Reptiles* (G. Grigg, R. Shine and H. Ehmann Eds.) Surrey Beatty and Sons. pp. 447-480.

Island Management in South Australia

A.C. Robinson

South Australian National Parks and Wildlife Service, GPO Box 1782 Adelaide 5001

Abstract

The varying conservation value of South Australia's 150 offshore islands means that a variety of management strategies must be employed. Kangaroo Island has problems which are specific to an island of this size both in relation to the increasing impact of tourist developments and in general wildlife management on the island. The conservation value and management problems of the eight islands over 800 ha are discussed individually and then some aspects of management of important wildlife populations on the remaining islands is considered. Reintroduction programs for Brush-tailed Bettongs and Stick-nest Rats to islands are considered followed by a summary of the large number of deliberate introductions of native vertebrates both to Kangaroo Island and other smaller islands which have taken place in the past. Finally the specific management needs of the islands of the Sir Joseph Banks Group are presented as a case study to show the range of management strategies which need to be employed.

INTRODUCTION

South Australia has approximately 150 offshore islands around its coastline (depending on distinctions made between reefs, islets and islands). Details of these islands are shown in Table 1, and the location of the main island groups and of places mentioned in the text of this paper are shown in Figs 1-3. All are continental islands and were thus connected to the South Australian mainland during the last Pleistocene glaciation. Using the present water depth between the islands and today's mainland shore and a curve of Pleistocene sea level change (Thom and Campbell 1975) it can be estimated that the oldest South Australian island was isolated 12 600 years ago (South Rocky Island). South and North Neptune Islands were isolated 11 900 years ago, Hart Island 10 850 years ago and Pearson and Greenly Islands 10 500 years ago. The majority of the remaining islands were isolated between 7 000 to 9 500 years ago. Biological surveys have now been completed on most of the South Australian offshore islands (excluding Kangaroo Island) and the preliminary results and methods used have been reported (Robinson and Canty 1984). The detailed results of these surveys are currently being prepared for publication (Robinson *et al.* in prep).

Kangaroo Island with an area of 4 350 km^2 is by far the largest South Australian offshore island and the third largest in Australia. The next largest island is St Peter at only 40 km^2. Kangaroo Island therefore has special management problems and requirements not shared by the other South Australian islands and so will be treated separately first. This will be followed by accounts of some of the management problems of the smaller islands and a general conclusion on future directions for offshore island management in this state.

CONSERVATION MANAGEMENT ON KANGAROO ISLAND

Kangaroo Island had an Aboriginal population which survived the isolation of the island 9 500 years ago by the rising seas, but which appears to have become extinct between 2 250 and 4 300 years ago (Lampert 1981). Following Flinders and Baudins voyages of 1802 and their reports of the numerous seal colonies around Australia's southern coastline bands of sealers worked the island fur-seal and later sea-lion colonies. A permanent European settlement was established at Reeves Point near the present town of Kingscote in July 1836 by the South Australian Company before the formal settlement of Adelaide in December 1836. The Reeves Point site was abandoned in 1839 but over the succeeding years the island was re-settled and a farming and fishing economy developed with much of the island being cleared for livestock production and cereal growing. The present population is approximately 3 500 and in 1981 the most recent figures from the Australian Bureau of Statistics Census showed that 1 652 people were employed as shown in Table 2 (S.A. Department of Tourism 1984). this Table also shows the changes in employment in the various industry categories between 1976 and 1981.

TABLE 1: A LIST OF SOUTH AUSTRALIAN OFFSHORE ISLANDS SHOWING AREA, DISTANCE FROM THE MAINLAND, LATITUDE AND LONGITUDE AND FORM OF LAND MANAGEMENT.

Group	Island	Area (ha)	Distance From Main-	Latitude/ Longitude	Management Land (km)
	Nuyts Reef	5	12	32° 7'30" 132° 8'00"	Conservation Pk
	Sinclair	2	4	32° 8' 0" 132° 8' 0"	Conservation Pk
Nuyts	Lounds	24	8	32°16'30" 133°22'00"	Conservation Pk
Archipelago	Purdie	40	8	32°16'00" 133°13'30"	Conservation Pk
	St Francis	809	35	32°30'30" 133°17'30"	Conservation Pk (Lighthouse Res.)
	Smooth	12	33	32°39'00" 133°18'30"	Conservation Pk
	Egg	60	32	32°28'30" 133°19'00"	Conservation Pk
	Dog	60	32	32°29'30" 133°20'00"	Conservation Pk
	Freeling	16	32	32°29'00" 133°20'30"	Conservation Pk
	West	60	35	32°30'30" 133°17'30"	Conservation Pk
	Masillon	202	40	32°33'30" 133°17'30"	Conservation Pk
	Fenelon	81	43	32°35'00" 133°17'00"	Conservation Pk
	Hart	12	43	32°39'00" 133°14'00"	Conservation Pk
	Lacy	121	21	32°24'00" 133°22'30"	Conservation Pk
	Evans	141	21	32° 0'30" 133° 3'30"	Lighthouse Res
	Franklin	405	19	32°27'00" 133°39'00" Prohibited Area)	Conservation Pk
	St Peter	4 028	5	32°17'00" 133°34'30"	Conservation Pk
	Goat	303	13	33°58'30" 133°29'00"	Conservation Pk
	Eyre	1 012	5	32°22'00" 133°49'00"	Conservation Pk
	Olives	12	8	32°43'30" 133°59'00"	Conservation Pk
	Eba	121	1	32°41'00" 134°16'00"	Conservation Pk
	Pigface	2	0.5	32°42'00" 134°16'30"	Conservation Pk
Baird Bay	Unnamed	13	1	33° 4'00" 134°17'00"	Conservation Pk
Islands	Jones	8	1	33°11'30" 134°54'00"	Conservation Pk
Venus Bay	A	20	2	33°10'30" 134°36'00"	Conservation Pk
Islands	B	2	1	33°11'00" 134°37'30"	Conservation Pk
	C	6	1	33°11'00" 134°36'30"	Conservation Pk
	Germein	202	2	33°12'30" 134°40'30"	Conservation Pk
	Unnamed	1	0.5		Conservation Pk
	Garden	2	1	33°12'30" 134°42'00"	Conservation Pk
	Tank	0.5	0.5	33°13'00" 134°42'00"	Conservation Pk
Investigator	Waldegrave	292	3	33°36'00" 134°47'30"	Conservation Pk
Group	Little Waldegrave	32	5	35°34'30" 138°38'30"	Conservation Pk
	Flinders	3 642	29	33°44'00" 134°31'00"	(Perpetual Lease Agric and Lighthouse Res.

Group	Island	Area (ha)	Distance From Main-	Latitude/ Longitude	Management Land (km)
	Topgallant	20	24	33°43'30" 134°37'30"	Conservation Pk
	Ward	20	53	33°45'00" 134°19'30"	Conservation Pk
	Pearson	213	62	33°58'00" 134°18'30"	Lighthouse Res.
	The Veteran Isles	14	65	33°59'30" 134°18'30"	Conservation Pk
	Dorothee	56	68	34° 0'30" 134°17'00"	Conservation Pk
	Cap	8	8	33°57'00" 135° 7'00"	Conservation Pk
	Rocky (North)	16	5	34°15'30" 135°15'30"	Conservation Pk
	Greenly	202	30	34°39'30" 134°48'00"	Conservation Pk
Mount Dutton &	Mt Dutton (Nth)	1	0.5	34°32'00" 135°25'30"	Conservation Pk
Coffin Bay	Mt Dutton (Sth)	1.5	0.5	34°35'30" 135°24'30"	Conservation Pk
	The Brothers	8	1	34°36'00" 135°22'30"	Conservation Pk
	Rabbit	4	1	34°37'30" 135°26'00"	Conservation Pk
	Goat	2	1	34°37'00" 135°28'00"	Conservation Pk
	Yangie Bay	45	0.5	34°38'00" 135°23'00"	National Park
Whidbey Group	Avoid	6	0.5	34°34'00" 135°12'30"	Conservation Pk
	Black Rocks	7	1.5	34°37'00" 135°17'00"	Conservation Pk
	Golden	23	1.5	34°42'00" 135°20'00"	Conservation Pk
	Price	58	2	34°42'30" 135°17'00"	Conservation Pk
	Perforated	121	16	34°43'30" 135°09'30"	Conservation Pk
	Four Hummocks (Nth)	8	24	34°45'30" 135°02'30"	Conservation Pk
	Four Hummocks (Cent)	32	24	34°46'30" 135°01'30"	Conservation Pk
	Four Hummocks (Sth)	27	24	34°47'00" 135°02'00"	Lighthouse Res.
	Rocky (South)	8	45	34°49'00" 134°42'30"	Conservation Pk
Port Lincoln	Liguanea	202	5	34°58'30" 136°43'00"	National Park
Islands	Curta Rocks	44	1	34°56'30" 135°52'00"	National Park
	Wanna	8	0.5	34°54'00" 135°51'00"	Crown Land
	Williams	141	3	35°02'00" 135°58'30"	Lighthouse Res.
	North Neptune	243	42	35°14'00" 136°04'00"	Conservation Pk
	South Neptune	104		35°19'30" 136°07'00"	Conservation Pk
	South Neptune (Lighthouse)	98	49	28°08'00" 136°02'00"	Lighthouse Res.
	Wedge	947	38	34°28'04" 136°27'30"	Freehold, Agric. /Tourism
	Peaked Rocks	3	38	35°11'03" 136°29'00"	Conservation Pk
	South-west Rock	1	41	35°10'30" 136°25'30"	Conservation Pk
	North Islet	64	39	35°07'30" 136°28'00"	Conservation Pk
	Thistle	3 925	9	34°59'00" 136°12'00"	Perpetual lease, Agric./Tourism
	Albatross	6	19	35°04'00" 136°11'00"	National Park
	Hopkins	162	5	34°57'00" 137°10'00"	National Park
	Smith	4	3	34°59'00" 136°01'30:	National Park
	Lewis	30	3	33°19'30" 136°00'30"	National Park
	Little Islet	20	3	34°57'00" 136°01'30"	National Park
	Taylor	243	3	34°52'30" 136°00'30"	Perpetual Lease, Agric
	Owen	8	5	34°51'30" 136°00'30"	National Park
	Grindal	81	3	36°39'30" 136°31'30"	Perpetual Lease, Agric

Group	Island	Area (ha)	Distance From Main-	Latitude/ Longitude	Management Land (km)
	Bickers	13	1	34°45'00" 135°57'00"	National Park
	Donnington	1	1	34°43'30" 136°00'00"	National Park
	Grantham	40	1	34°46'30" 135°52'30"	Recreation Res
	Boston	809	3	34°42'00" 135°55'30"	Freehold Agric
	Rabbit	20	5	34°36'30" 135°59'00"	Conservation Pk
	Louth	182	3	34°34'30" 135°57'00"	Freehold & Crown, Agric
	Tumby	30	1.5	34°24'30" 136°08'30"	Conservation Pk
	Lipson	1	0.5	34°15'00" 136°16'00"	Conservation Pk
Sir Joseph	Kirkby	27	11	25°31'30" 136°06'30"	Conservation Pk
Banks Group	Sibsey	30	16	34°38'30" 136°11'00"	Conservation Pk (Lighthouse Res.)
	English	3	19	34°38'00"136°11'00"	Conservation Pk
	Stickney	70	22	34°41'00" 136°16'00"	Conservation Pk
	Spilsby	468	27	34°40'00" 136°20'30"	Perpetual Lease, Agric./Tourism
	Boucaut	16	27	34°39'00" 136°22'00"	Conservation Pk
	Duffield	7.5	29	34°39'30" 136°19'00"	Conservation Pk
	Hareby	53	19	34°35'00" 136°17'30"	Conservation Pk
	Roxby	92	21	34°35'30" 136°19'00"	Conservation Pk
	Langton	26	16	34°36'00" 136°16'30"	Conservation Pk
	Blythe	5	19	34°34'00" 136°17'30"	Conservation Pk
	Dalby	5.5	13	34°34'00" 136°14'00"	Conservation Pk
	Reevesby	344	16	34°31'30" 136°16'30"	Conservation Pk
	Lusby	14	14	34°32'30" 136°15'30"	Conservation Pk
	Marum	10	13	34°39'00" 136°15'00"	Conservation Pk
	Partney	40	13	34°31'30" 136°15'30"	Conservation Pk
	Winceby	30	16	34°29'30" 136°17'00"	Conservation Pk (Lighthouse Res.)
	Dangerous Reef	12	17	34°49'00" 136°12'30"	Lighthouse Res.
Yorke Peninsula					
Islands	Bird	8	0.5	33°58'30" 137°31'30"	Conservation Pk
	Goose	2	5	34°27'30" 137°22'00"	Conservation Pk
	Cormorant	0.5	5	34°27'30"137°22'00"	Conservation
	White Rocks	0.5	5.5	3°27'30" 137°21'30"	Conservation Pk
	Green	0.5	1	34°28'00" 137°24'00"	Annual Licence
	Island Point	1	1	34°26'30" 137°24'30"	Conservation Pk
	Rocky	0.5	0.5	34°29'00" 137°25'30"	Conservation Pk
	Wardang	2 023	5	34°30'00" 137°22'00"	Aboriginal Res.
	Royston	5	0.5	35°12'00" 136°50'30"	National Park
	Middle Islet	45	1	35°13'00" 136°50'00"	National Park
	South Islet	5	0.5	35°14'00" 136°50'00"	National Park
	Chinaman's Hat	0.5	0.5	35°17'30" 136°55'00"	National Park
	Seal	8	6	35°20'30" 136°55'00"	National Park
	Haystack	5	4	35°19'30" 136°54'30"	National Park
	Althorpe	96	8	35°22'30" 136°51'30"	Lighthouse Res. and Conservation Pk
	Troubridge	2	6	35°07'00" 137°49'30"	Conservation Pk (Lighthouse Res.)
	Kangaroo	435,000	25	36°00'00"137°30'00"	Freehold, National Park Conservation Park

Group	Island	Area (ha)	Distance From Main-	Latitude/ Longitude	Management Land (km)
Kangaroo Island	West Bay Islet	2	0.5	35°54'00" 136°32'00"	National Park
Coast	Casuarina (Nth)	2	0.5	36°04'00" 136°42'00"	National Park
	Casuarina (Sth)	2	2.5	36°05'00" 136°41'30"	National Park
	Nobby Islet	12	0.5	36°00'30" 136°10'30"	Conservation Pk
	Pelorus Islet	20	8	36°07'30" 137°31'30"	Crown Land
	Busby Islet	0.5	4	35°37'30" 137°38'30"	Conservation Pk
	Beatrice Islet	10	2	35°39'00" 137°41'00"	Conservation Pk
Encounter Bay	North Page	10	13	35°45'30" 132°18'00"	Conservation Pk
Islands	South Page	10	15	35°47'00" 132°17'30"	Conservation Pk (Lighthouse Res)
	West	10	1.5	35°36'30" 138°35'30"	Conservation Pk
	Wright	2	1	35°35'00" 138°36'30"	Pub. Pleasure Res.
	Granite	32	1	35°34'00" 138°38'00"	Recreation Res. and Harbours Bd. Res.
	Seal	1	3	35°34'30" 138°38'30"	Conservation Pk
	Pullen	1	1	35°32'30" 138°41'30"	Conservation Pk
South-East Coast Islands	Baudin Rocks	40	3	37°05'30" 139°43'00"	Conservation Pk
	PenguinIslet	2	0.5	35°30'00"140°01'00"	Conservation Pk

TABLE 2: INDUSTRY OF THE EMPLOYED POPULATION OF KANGAROO ISLAND IN 1976 AND 1981, FIGURES FROM AUSTRALIAN BUREAU OF STATISTICS CENSUS DATA (SOURCE S.A. DEPARTMENT OF TOURISM 1984)

Industry Category	1976 Nos. Employed	1976 % of Workforce	1981 Nos. Employed	1981 % of Workforce	% Growth
Agriculture, etc.	784	(48.1)	652	(39.5)	-16.8
Mining	12	(0.7)	15	(0.9)	25.0
Manufacturing	49	(3.0)	39	(2.4)	-20.9
Electricity, Gas, Water	14	(0.9)	14	(0.8)	0.0
Construction	72	(4.4)	67	(4.1)	-6.0
Wholesale, Retail Trade	181	(11.1)	183	(11.1)	1.1
Transport and Storage	106	(6.5)	94	(5.7)	-11.3
Communications	24	(1.5)	24	(1.4)	0.0
Finance, Business Services	35	(2.1)	39	(2.4)	11.4
Public Administration	22	(1.3)	53	(3.2)	9.5.
Community Services	130	(8.0)	173	(10.5)	33.1
Entertainment, Motels, Restaurants, Recreation	114	(7.0)	135	(8.2)	18.4
Other, not classified not stated	86	(5.3)	164	(9.9)	90.7
TOTAL	1629		1652		1.4

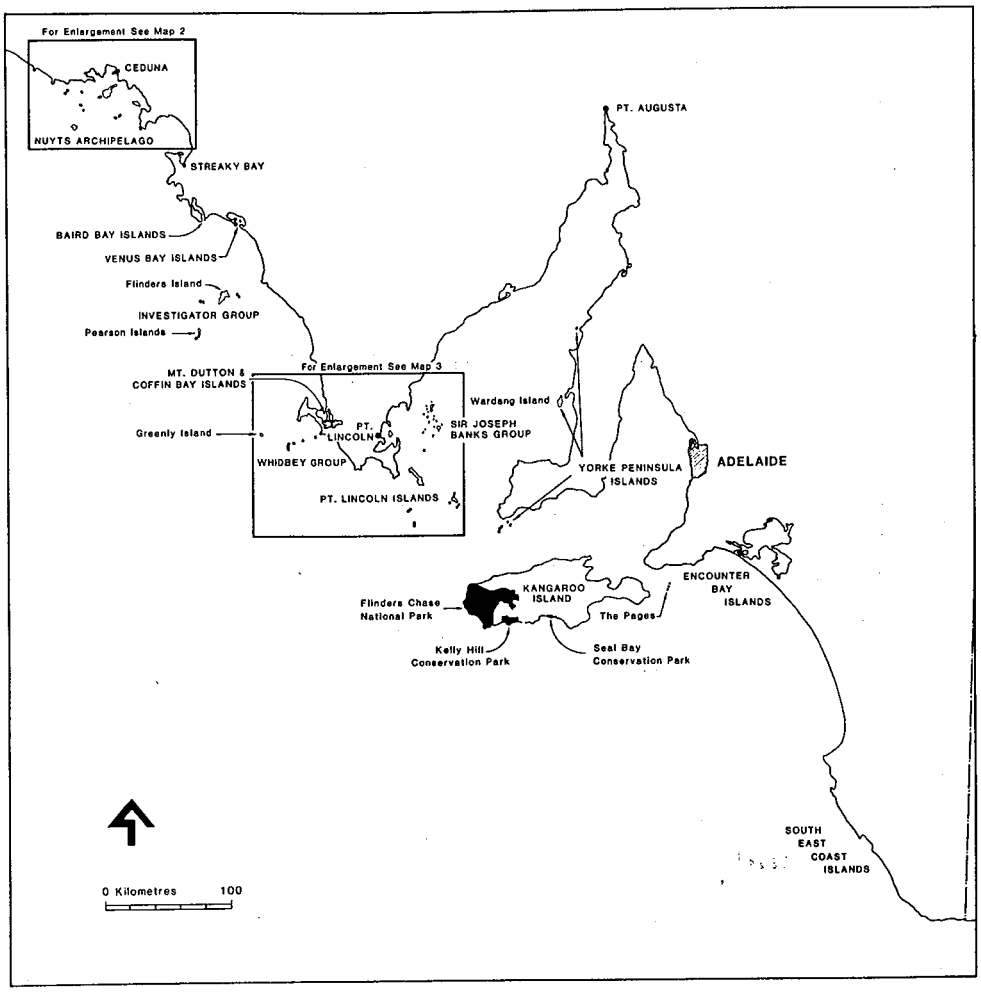


Figure 1.
The major island groups off the South Australian coast and the three conservation areas on Kangaroo Island mentioned in the text.

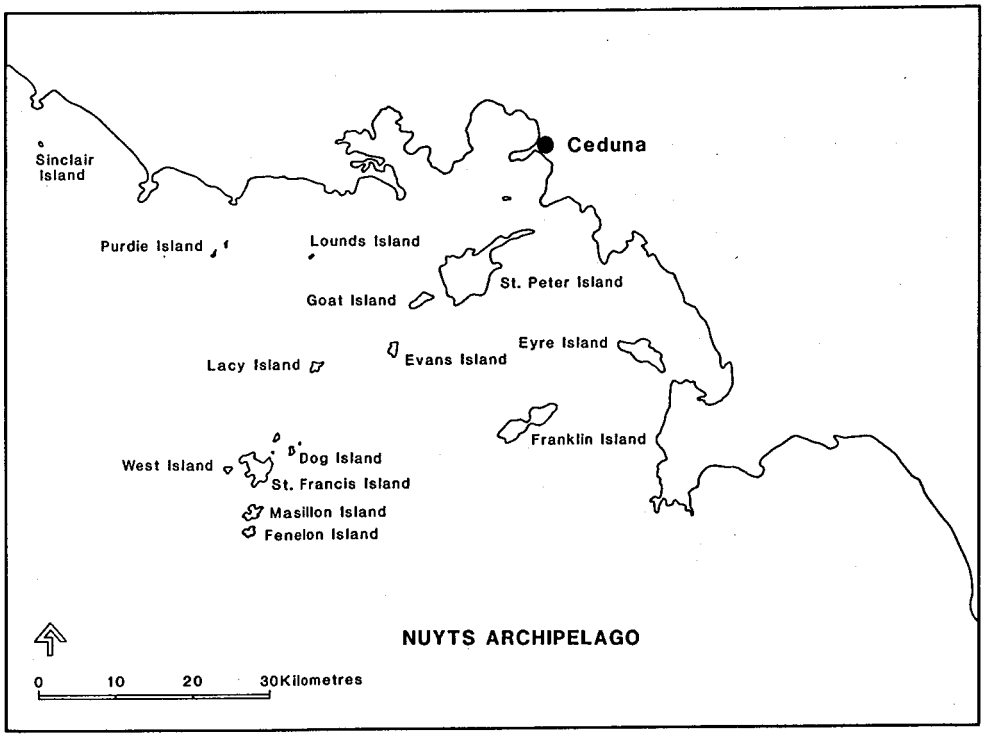


Figure 2.
Nuyts Archipelago and the Isles of St Francis.

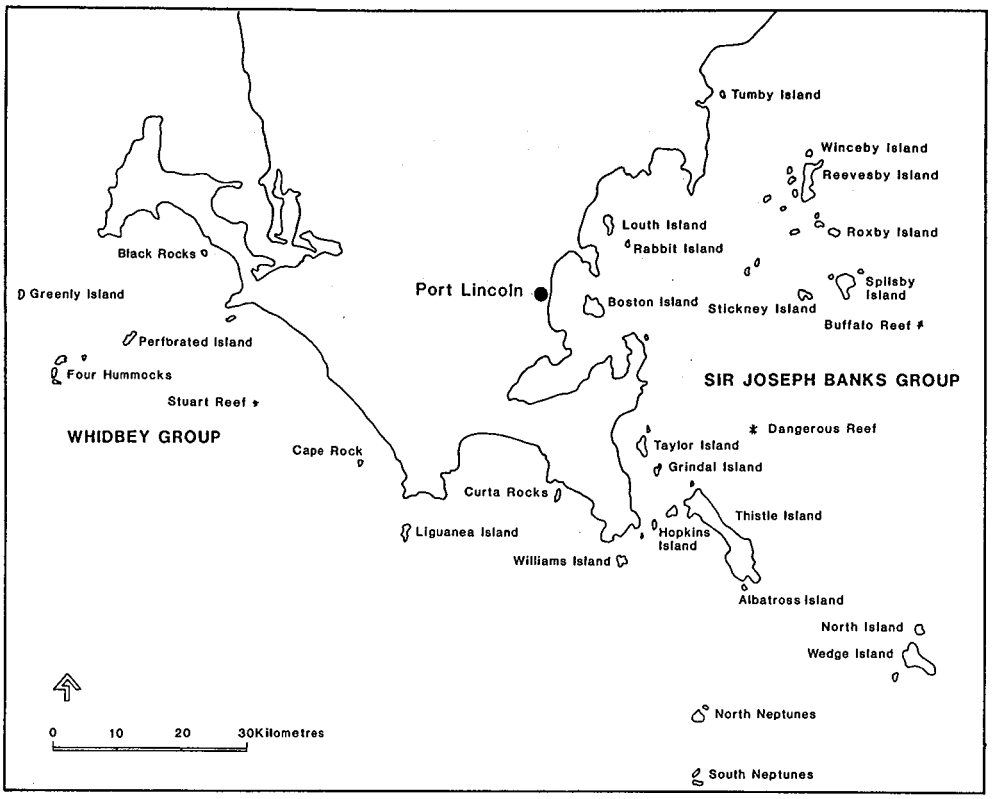


Figure 3.
The Whidbey and Sir Joseph Banks Groups.

The things to note in the context of conservation management on Kangaroo Island are the decline in employment in agriculture and manufacturing and the increase in community service and other industries related to tourism. A detailed report on future management of Kangaroo Island for tourism has been prepared (South Australian Department of Tourism 1984) while Table 4 shows the origin of visitors to Flinders Chase National Park on the western end of the island in 1982/83 (NPWS 1986).

It can be seen that the majority of visitors to Kangaroo Island and its major National Park are from South Australia with only between 3% and 4% from outside Australia.

Details of tourist use of Kangaroo Island have been provided because although up until relatively recent times, development for agriculture has been the main impact on wildlife conservation, the tourist industry will have a much more significant impact in the future. Up top 30 June 1985 there was one National Park and 15 Conservation parks on Kangaroo Island covering 107 762 ha or 26.6% of the island. It is now estimated (Vegetation Management Branch, S.A. Department of Environment and Planning) that only 13% of Kangaroo Islands remaining natural vegetation in on private land. In 1974 when these figures were last calculated 43% of the island was covered with natural vegetation and this has now been reduced to 39% of which 64% is now within the park system. This is by far the highest percentage (and area) of natural vegetation remaining in the agricultural districts of South Australia and its occurrence on an offshore island with no rabbits of foxes (although feral cats are present) makes the remaining natural areas of Kangaroo Island among the most significant for conservation in the higher rainfall areas of the State.

The move towards acquisition of areas for conservation on Kangaroo Island has a long history which is documented, in some detail in NPWS (1986). Flinders Chase Fauna and Flora Reserve (now Flinders Chase National Park) was the second area set aside in South Australia for conservation in 1919. The actual battle for this magnificent park however begin 1892 (Dixon 1920). It was managed by a Fauna and Flora Board from 1920-1972 comprising two representatives from each of the Government, the University of Adelaide and the Royal Society of South Australia. In 1972 with the passing of the National Parks and Wildlife Act, management of the re-named Flinders Chase National Park was transferred to the newly established National Parks and Wildlife Service. As with most major National Parks the predominant

TABLE 3: THE ORIGIN OF VISITORS TO KANGAROO ISLAND FROM THE DOMESTIC TOURISM MONITOR, INTERNATIONAL VISITOR SURVEY (SOURCE S.A. DEPT OF TOURISM 1984)

Place of Residence	% of Total visitors
South Australia	86.1
Interstate	11.1
Overseas	2.8
TOTAL	100.0

TABLE 4:THE ORIGIN OF OVERNIGHT VISITORS TO FLINDERS CHASE NATIONAL PARK, KANGAROO ISLAND, JULY 1982 TO JUNE 1983 FROM RECORDS OF CAMPING PERMITS ISSUED AT THE PARK. (SOURCE NPWS (in prep))

Place of Residence	Number of Permits	% of Total Visitors
SA Mainland	389	57.6
Kangaroo Island	84	12.4
VIC.	95	14.0
NSW	54	30.
ACT	10	1.5
WA	8	1.2
QLD	2	0.3
TAS.	1	1.2
NT	3	0.4
Overseas	29	4.3

management activity is the provision of facilities for visitors in such a way as to minimise the impact of visitation on the parks conservation value. Approximately 40 000 people now visit Flinders Chase National Park annually and together with the caves at Kelly Hill Conservation Park and the Australian Sea-lions at Seal Bay Conservation Park it is by far the major "tourist attraction" on Kangaroo Island. Wildlife management on Flinders Chase National Park has been largely devoted to fire control measures to try and ensure that in the inevitable event of a major wildfire some large parts of the total park area can hopefully remain unburnt. The legacy of native Australian animals introduced to Flinders Chase in its early days form the other major conservation management problem but these are discussed in detail later in this paper.

The two other parks on Kangaroo Island with major visitor use are Kelly Hill Conservation Park with 18 500 visitors per annum and Seal Bay Conservation Park with approximately 70 000 visitors per annum (Robinson and Dennis 1988). At Kelly Hill Conservation Park the vast majority are day visitors who come to tour the caves and then either return to Kingscote to stay or continue on to camp in nearby Flinders Chase National Park. The portions of this extensive cave system accessible to tourists have recently been extensively upgraded by the National Parks and Wildlife Service with installation of a safer entrance and modern lighting system. The interpretation provided for visitors by both the resident ranger and casually employed cave guides has been significantly modified and now concentrates on the geological and biological aspects of caves and the element of fantasy using the shapes of cave formation has been reduced.

Only day visitation is allowed to Seal Bay Conservation Park and although provision of a picnic area in recent years has given people some incentive to spend more time in the park the majority of visits are of quite short duration (1-2 hours). The beach at Seal Bay provides visitors with very close access to a wild population of Australian Sea-lions (*Neophoca cinerea*) and an experience of contact with seals which is generally available in very few other parts of the world outside the Arctic and Antarctic regions. The sea-lions breed in rocky coves at either end of the beach which is accessible to visitors and these areas have been prohibited to the public since 1967. Fairly regular counts of the sea-lion at Seal Bay have been maintained since 1967 and it appears that numbers increased from peaks of about 200 in 1967 to 400 in 1974. Since that time numbers have generally peaked at around 400 with considerable variation in counts within a year mostly relating to events in the reproductive cycle. Complete counts to 1987 are given in Robinson and Dennis (1988). Seal Bay Conservation Park was the first park in South Australia to have a plan of management prepared for it when the provision of park management plans became a statutory requirement under the National Parks and Wildlife Act 1972. The draft plan was released for public comment in 1976 (NPWS 1976) and the final plan was released in 1977 (NPWS 1977). Since then a major redevelopment of visitor access to the beach at Seal Bay has been completed. It provides a single boardwalk, a raised bridge over the dunefield and a well constructed graded track from an enlarged and formalised car park. In addition there is a walking track to a lookout over the beach for those who do not wish to actually see the seals at close quarters on the beach. Interpretive signs and pamphlets are now available to visitors giving information on sea lion biology and warning visitors to respect these quite formidable wild animals. Perhaps surprisingly, there have been very few people actually bitten by the sea-lions, just a slight lunge and a roar from a full-grown bull sea-lion is usually enough to deter even the most enthusiastic seal toucher! It appears that to date the number and distribution of visitation to Seal Bay has not affected the sea-lion population at the gross level of total numbers counted on the beach. In September 1987 the National Park and Wildlife Service established a guiding system on Seal Bay beach for which all visitors to the park pay a fee. Future monitoring will address issues such as retreat of seals into the water when large numbers of people are on the beach and the possible need to further regulate in some way both the timing and total numbers of people on the beach in the future. The details of present management at Seal Bay are discussed in Robinson and Dennis (1988).

The thirteen other Conservation Parks on Kangaroo Island are largely accessible only to walkers on a day visit basis and were acquired to obtain as representative as possible range of the islands ecosystems. The management of 65% of the remaining natural vegetation on Kangaroo Island that is reserved under the National Parks and Wildlife Act is the responsibility of 5 rangers, based at Kingscote, Murrays Lagoon (Cape Gantheaume and Seal Bay Conservation Parks) Kelly Hill Conservation Park and Flinders Chase National Park (2 rangers). Within the context of the approximately 80 ranger staff in the whole of South Australia this represents a significant commitment to reserve management on Kangaroo Island.

Responsibility for wildlife management in broader terms on Kangaroo Island as a whole however, is not nearly so clear cut. The mosaic of natural vegetation and agricultural land has created ideal habitat for the two native macropod species the Tammar (*Macropus eugenii*) and the Western Grey Kangaroo (*Macropus fuliginosus*). Both these species are biologically important, the Kangaroo Island population of *Macropus fuliginosus* is the nominate race and differs significantly from Australian mainland populations (Poole, 1976). The large Tammar population on Kangaroo Island is probably the last South Australian population although there was a small population which persisted on Eyre Peninsula into the 1970s (Smith 1983). Its present status however is unknown. Both Tammars and Kangaroos are regarded as agricultural pests on Kangaroo Island where they compete with domestic stock for food on the improved pastures of the island farms. The conflict is particularly pronounced on the western half of the island with its complex mosaic of natural vegetation patches and farmland providing very large areas of the scrub - pasture transitions favoured by these macropods. Management of the problem to date has been the issue of limited numbers of destruction permits to farmers and one individual farmer has developed something of a business in the capture of Tammars alive for sale to Australian Universities as a research animal under the system of Permits to Take Protected Animals from the Wild operated by the South Australian National Parks and Wildlife Service. In addition to their impact on the farming community both these species are frequent road kills on the island road network (together with goannas, brush-tailed possums and echidnas) and the impact of increased tourist traffic and proposals to seal some of the main island roads may increase the impact of road kills on these populations.

The clearance of native vegetation for agriculture on Kangaroo Island which has, until very recently, been the most significant conservation management problem on Kangaroo Island has now virtually ceased and a good network of conservation reserves has been established which only require relatively minor additions to be as representative as it is now possible to obtain. The potential problem for the future is posed by a significant increase in tourist use of the island. The importance of the three natural "attractions" managed by the National Parks and Wildlife Service for tourism, namely the sea-lions at Seal Bay, caves at Kelly Hill and the Flinders Chase National Park has already been highlighted. While the sea-lions are perhaps most vulnerable to increased tourist pressure all natural areas will undoubtedly be adversely affected. Because Kangaroo Island is an island it should be relatively easy to assign to it a "carrying capacity" which retains for visitors the quality of holiday they now experience. The latest plan for increased tourist development (S.A. Department of Tourism 1984) does not really adequately address the problem of a finite limit to potential tourist development, although it does at least go part of the way by defining areas of the island which are inappropriate for particular types of tourist development. Clearly conservation managers in South Australia have some way to go in educating the public and the tourist industry about the potentially large impact of increased tourism on natural areas and the very special biological problems of mans impact on offshore islands.

Island over 800 ha

St Peter (4 028 ha), Thistle (3 925 ha), Flinders (3 642 ha), Wardang (2 023 ha), Eyre (1 012 ha), Wedge (947 ha), Boston (809 ha) and St Francis (809 ha) Islands make up this group of large islands. All of them with the exception of Eyre Island have been extensively modified by nearly a hundred years of agricultural development. The land tenure of these large islands is given in Table 1 and it can be seen that only Eyre, St Francis and St Peter Islands are Conservation Parks. Management of the remaining islands is therefore the responsibility of the lessee or owner and a fair diversity of management approaches are apparent.

St Peter Island was held as a pastoral lease until 1987 when it was purchased by the National Parks and Wildlife Service and proclaimed a Conservation Park and the sheep removed. Approximately one third of the island has been cleared and fenced and the natural vegetation on the remainder of the island was grazed and regularly burnt, normally in early summer when a steady northerly wind is blowing resulting in quite hot fires. In spite of this type of management history St Peter Island has considerable conservation value. The extensive mangroves and tidal mud flats provide very important habitat for migratory waders while the remaining natural vegetation is quite diverse and, in spite of the fire and grazing history, it is probably still in much better condition than any of the adjacent mainland where rabbits have caused severe degradation.

Thistle Island off the southern tip of Eyre Peninsula has a higher rainfall than St Peter Island and therefore supports quite different vegetation. Again roughly half the island has been cleared for agriculture, sheep are still grazed and occasional oats and barley crops are grown. Summer burning has been extensively practiced and much of the remaining

natural vegetation has dense thickets of the fire tolerant species *Acacia paradoxa*. This extremely thorny shrub effectively discourages sheep from grazing much of the vegetation and a wide diversity of heath and mallee understorey plants grows in the shelter of these bushes. The tenure of this island has been converted from leasehold to freehold with the provision that most of the remaining natural vegetation be fenced to exclude sheep and that future burns are excluded from the natural vegetation. Thistle Island (together with nearby Taylor Island) supports a large population of Brush-tailed Possums, (*Trichosurus vulpecula*), possibly the last remaining on Eyre Peninsula. Together with Kangaroo, Taylor and Boston Islands, Thistle Island is the last breeding stronghold of the Stone Curlew (*Burhinus magnirostris*) in the State. It also has a natural population of goannas (*Varanus rosenbergi*) which will be discussed later when island introductions are considered. Thistle Island is permanently occupied by a caretaker who maintains the water supply and manages the sheep. Approximately 50 holiday house blocks have been sold in a single consolidated subdivision and houses will be progressively built on these blocks. The airstrip on the island enables easy access for holiday house owners.

Flinders Island must originally have been a magnificent natural area but most of the natural vegetation has now been cleared and the distinctive sub-species of the Tammar (*Macropus eugenii*) it once supported now appears to be extinct (Delroy, 1974, Robinson *et al.* in prep). The largest remaining area of natural vegetation has been fenced to exclude sheep since 1968, in an effort to provide some undisturbed habitat for the last remnant of the wallaby population, but this appears to have failed. None-the-less, this and a few other smaller areas of natural vegetation and its magnificent coastline still make Flinders Island a valuable natural area. Breeding Ospreys and Sea Eagles add to its conservation value.

Wardang Island is vested with the Aboriginal Lands Trust of South Australia and is currently under investigation as to the feasibility of a Commonwealth Government funded long-term programme to re-vegetate and ultimately re-establish some of its original native fauna. Virtually the entire island has been cleared and grazed and a large lime sand mine has only recently ceased operation. It supports a large population of rabbits and is generally in an extremely degraded condition. With the exception of its coastline and an area of saltmarsh its present conservation value is minimal.

Eyre Island, although only isolated from the mainland for about 6 000 years is a magnificent coastal wilderness of mangrove channels, samphire flats and well vegetated sand dunes. The surrounding tidal mud and sand flats support a wide variety of shorebirds and migratory waders. It supports a large population of Southern Bush Rats (*Rattus fuscipes*) and an important Death Adder (*Acanthophus antarcticus*) population. It's series of stranded dune lines are beginning to be examined to help document past sea-level changes and it is undoubtedly one of the more important and undisturbed island Conservation Parks in South Australia.

Wedge Island is held in freehold title and although grazed and farmed for many years is now like Thistle Island, in the process of trying to sell several hundred holiday house subdivisions. Access to and from the island is by light aircraft. Wedge Island has some small areas of natural vegetation but the removal of sheep should allow considerable regeneration. Negotiations are currently underway to proclaim that portion of the island outside the holiday house subdivisions and associated facilities as a Conservation Park.

Boston Island has been held in freehold title for many years and is virtually completely cleared. It is still primarily used for agriculture but tourist use is increasing. Efforts are being made to replant some areas of the island, mainly with Drooping Sheoaks (*Allocasuarina verticillata*) which were originally widespread on the island.

St Francis Island is part of the Isles of St Francis Conservation Park, and, although a large part of the island was cleared and the whole island was grazed by sheep, it is beginning to recover. It supports an extremely important population of Carpet Pythons (*Morelia spilotes*) and is one of only two islands which has a Short-nosed Bandicoot (*Isoodon obesulus nauticus*) population. The Brush-tailed Bettong re-introduction programme will be discussed later in this paper.

In summary then the eight large islands in South Australia have varying conservation value but in general, the current management practices on all of them are at least not accelerating the long decline in their conservation value due to their history of agricultural development. In some cases current management practices are actually increasing their conservation value. Their future undoubtedly lies not in farming but in tourism and any increase in their natural values will also increase their value for visitors.

Important wildlife on the remaining islands

As can be seen from Table 1, most of the remaining islands less than 800 ha in area are National or Conservation Parks managed by the National Parks and Wildlife Service. The following section outlines the conservation value of some of these island parks.

The islands of the Sir Joseph Banks Group Conservation Park support most of the winter breeding population of Cape Barren Geese (*Cercopsis novaehollandiae*) in South Australia. The natural history and management of this species is discussed in detail in Robinson *et al.* (1982). The only important development since this was published has been the establishment of a breeding population on Reevesby Island first noted in the winter of 1985 (Robinson and Delroy 1986). If these geese are able to raise clutches in the face of the small feral cat population on Reevesby Island this large island (344 ha), which has not had Cape Barren Geese breeding on it in living memory, has the potential to significantly expand the total summer population of this species in South Australia, currently estimated at approximately 3 000 birds (Robinson *et al.* 1982).

Franklin Island in Nuyts Archipelago Conservation Park supports the last known population of the Greater Stick-nest Rat (*Leporillus conditor*). A three-year ecological study of this population has been completed (Read 1984, Copley 1988). It is too early yet to formulate detailed management recommendations for this species but the establishment of another population, possibly on Reevesby Island is being seriously investigated.

The Australian Sea-lion (*Neophoca cinerea*) is one of the rarest seals in the world (Ling 1978). It is restricted to the southern coast of Australia from Eclipse Island in Western Australia to The Pages Islands in South Australia. With a total estimated population of approximately 5 000, 3 000 are found in South Australia together with the major breeding populations. The three main breeding areas in order of size are Seal Bay (discussed earlier), Dangerous Reef and The Pages. Smaller breeding colonies are found on 14 other south Australian islands (Robinson and Dennis 1988). Virtually all the islands however are used as hauling out sites and are a vital part of the sea-lions habitat even though they only actually breed on relatively few. Sea-lions take fish from nets tearing the nets to get them and, although totally protected, a small number are illegally shot. These tend to be lone animals, often large males and the shooting of a single animal often solves the problem. There have also been reports of people moored in boats off sea lion colonies shooting the animals "for sport". These incidents are quite rare and hopefully, with increasing public concern for marine mammals will cease altogether. A biologically interesting but virtually unknown potential management problem relates to the removal of the major predator of sea lions the White Pointer (*Carcharodon carcharias*) by game fishermen. The waters off the sea lion breeding colony at Dangerous Reef are one of the major white pointer fishing sites in the world with about 3-4 very large sharks being taken each year. At present this game fishing is totally unregulated in South Australia.

The Pearson Island Rock Wallaby (*Petrogale lateralis*) occurs naturally only on Pearson Island, isolated for 10 500 years. This spectacular granite island is one of the most unspoiled of all South Australian islands. It has a population of approximately 500 wallabies on the main section (Robinson 1980) but visitors to the island in 1923 and the 1960's noted that there were no wallabies or signs of wallabies on the central and southern sections. These sections, although containing apparently suitable habitat, are separated from the main island by a rocky point and sand spit which can be crossed at low tide. In 1960 five wallabies were captured on the main part of the island for transport back to Adelaide to establish a captive colony. They were kept penned on the central section and four females, a male and one of unknown sex escaped. These have now established and there were between 50 and 150 animals in 1969 (Thomas & Delroy 1971) on the central and southern sections. The most recent estimate in 1976 (Robinson 1980) was of 150 individuals and they have caused a measurable reduction in the cover of the chenopod shrublands on these parts of the island (Fatchen 1982). In 1974,75, 16 animals were transported to Thistle and in 1975 10 to Wedge to establish additional colonies in case of a disaster on Pearson Island. Neither of these islands are known to have supported rock wallabies, and they have quite different habitat from Pearson Island. Both however are much larger than Pearson Island and have been significantly degraded by past agriculture. These introduced populations are both still present and breeding has been recorded. The 200 m cliffs that the wallabies inhabit makes it virtually impossible to carry out any systematic population monitoring.

Tammer wallabies occurred naturally on kangaroo, St Peter, Flinders, St Francis, Thistle and possibly Reevesby Islands as well as on the South Australian mainland at the time of European settlement. As mentioned previously the only population still definitely remaining is that on Kangaroo Island

although the Flinders Island population only became extinct in the late 1960s. In 1907 Tammars were introduced to Greenly Island from Kangaroo Island as food for shipwrecked mariners. With an area of only 200 ha, Greenly Island is very much smaller than any of the islands that supported natural Tammar populations. The results over the subsequent 74 years were disastrous and the wallabies have converted much of the island from a quite diverse shrubland to a virtually single species *Poa poiformis* grassland. In addition there is no evidence of seedling regeneration of either the Sheoaks or the *Melaleuca lanceolata* scrubs which cloth the top of the island. Tammars did not reach the NE section of the island which is separated from the main island by a 3-5 m sea-way which humans can jump across in calm weather. The dramatic difference in both vegetation structure and floristic composition between the main island and this ungrazed section has been documented by Fatchen (1982).

Black Tiger snakes occur on a number of South Australian offshore islands and there are mainland populations on the southern tip of Eyre and Yorke Peninsulas and in the southern Flinders Ranges. The taxonomy and ecology of South Australian tiger snakes has been examined by T.D. Schwaner by studying populations from Kangaroo, Franklin, Goat, Roxby, Hareby and Hopkins Islands. There are a large number of both morphometric and biochemical differences between these populations with the extremes being the very large snakes on Franklin Island and the small animals, on Roxby Island, two populations which have diverged to the point when they will not now interbreed. Preliminary results of these studies have been published by Schwaner (1985a)

Reintroduction Programs

The South Australian National Parks and Wildlife Service has carried out a major program to reintroduce Brush-tailed Bettongs (*Bettongia penicillata*) to St Francis Island. The original population on this island became extinct in the early 1900s when the lessees the island, experiencing problems with the bettongs in their vegetable garden, imported cats to the island. These cats, coupled with the habitat distruction brought about by clearing a large part of the island for cereal growing, caused the Bettongs extinction. The population of Nuyts Archipelago Bandicoots however managed to survive and are still present. In 1975 five Bettongs were obtained from Western Australia and a captive colony was established at Para Wirra Recreation Park just north of the city of Adelaide. Animals from the captive colony were released on three small islands to test the ability of captive-bred animals to survive in the wild and to provide additional stock for ultimate re-introduction to St Francis Island. Forty captive-bred animals were released on St Francis Island in 1980 and an additional 20 "wild" animals from the introduced population of Island A in Venus Bay were introduced in 1983. On the 1983 trip to St Francis Island trapping established that although some of the 1980 release had died, one female with a pouch young conceived on the island was still present. The most recent trip, in 1988, again resulted in the capture of a single female and it appears that this re-establishment has not been successful. Further details of this program are in Delroy *et al.* (1986). A group of bettongs were also released on Wedge Island in 1983 where they are still present and a follow up monitoring in 1988 resulted in the capture of 38 individuals and evidence was seen of a large population now present.

The Greater Stick-nest Rat (*Leporillus conditor*) which was widespread across southern Australia at the time of European settlement is now only found on the Franklin Islands in Nuyts Archipelago Conservation Park. It has now been the subject of a three year ecological study (Read, 1983; Copley, 1988). A captive colony has now been established in specially designed facilities in Adelaide and, further down the line, it is proposed to release some of these captive-bred animals onto Reevesby Island in the Sir Joseph Banks group, the only other off shore island known to have supported the Greater Sticknest Rat in the past. This is based on the discovery of skeletal material in sandhill blowouts on Reevesby Island together with Tammar Wallaby remains. None of the living former lessees of Reevesby Island whose periods of residence on the island go back to the 1920s can remember either of these mammals being present there. The major impediment to the establishment (or re-establishment) of Sticknest Rats on Reevesby Island is the presence of a small (we think) population of feral cats and these will have to be eradicated before any release can be contemplated.

Introductions of Australian native animals to South Australian islands

There are a number of introductions of native animals to South Australian islands which have already been discussed, Pearson Island Rock Wallabies to Wedge and Thistle Islands, Tammar Wallabies to Greenly Island and Brush-tailed Bettongs to islands in Venus and Baird Bay, and Wedge Island. There was no evidence that these species had occurred on these

TABLE 5: DETAILS OF INTRODUCTIONS OF NATIVE VERTEBRATES TO SOUTH AUSTRALIAN ISLANDS OTHER THAN KANGAROO ISLAND

Species	Island	Source of Animals	Number of Animals	Date of Introduction	Comments
Varanus gouldi?	St. Peter	Adjacent mainland	?	?	
Varanus rosenbergi	Spilsby	? Thistle Is			
" "	Reevesby	Spilsby & Thistle Is	? & 6	pre 1937 & 1952	
" "	Taylor	?	?	pre 1960	
" "	Louth	?	?	?	
Dromaius novaehollandiae	Wedge	Adjacent mainland	?	1975	Still Present
Lasiorhinus latifrons	Wedge	Blanchtown region	6	1971	Still present, no Breeding noted
Macropus fuliginosus	Granite	Kangaroo Island	?	1971	All removed in 1984
Macropus eugenii	Greenly	Kangaroo Island	?	1907	Caused major vegetation change
" "	Granite	Kangaroo Is. (Captive Stock)	?	1970	Present & Breeding, now a "problem"
" "	Boston	Kangaroo Is. (Captive Stock)	?	?	Present & Breeding, now a "problem"

Species	Island	Source of Animals	Number of Animals	Date of Introduction	Comments
Petrogale lateralis	Thistle	Peason Island	11	1974	Still present & Breeding
" "	Wedge	Peason Island	10	1975	Still present & Breeding
" "	Central & Sth Peason	Main Peason Is.	6	1960	Accidental release now established & degrading habitat
" "	West	Peason Island (Captive Stock)	6 & 7	1973, 1975	Survived to 1980 - no breeding now? extinct.
Bettongia penicillata	Bird Club	W. Aust. (Captive Stock)	2 & 4	1979	No longer present
" "	Island A	" "	7	1980	Present & Breeding
" "	Bairds Bay	Island A "	10	1982	Present & Breeding
" "	Wedge	W. Aust. "	11	1983	Present

islands since their isolation from the mainland and so they were true introductions rather than re-introductions of a population that had become extinct since European settlement such as the St Francis Island Bettong re-introduction program. Kangaroo Island also has a number of deliberate introductions of native animals and these will be discussed separately. The known introductions of native vertebrate species to South Australia's islands (excluding Kangaroo Island) are shown on Table 5.

These introductions have been carried out for a variety of reasons by people with various motivations. Goannas for example were introduced by island farmers to get rid of venomous snakes on the islands and the acedotal evidence now available on these introductions is discussed in detail in Schwaner (1985b) and Robinson *et al.* (1985). As would be expected the introductions of herbivorous mammals to islands which had never supported natural populations of these species since their isolation have resulted in significant degradation of the natural vegetation. the effects of introduced predators such as goannas is much more difficult to assess but there are quite low density snake populations (or no snakes at all) on islands with introduced goanna populations. Other forms of environmental degradation is addition to goanna predation however have undoubtedly also affected these snake populations. Although future proposals for introducing native vertebrate species to offshore islands must be assessed on their individual merits, the environmental damage from many of the South Australian introductions to date, would argue against supporting future island introductions.

On Kangaroo Island, Flinders Chase National Park has a long history of introductions and these are listed in Table 6.

Between 1911 and 1957 fourteen species of birds were introduced but of these only three emus, a few Gang Gang Cockatoos and a breeding population of Brush Turkeys remain in the park today. The Cape Barren Goose introduction was undoubtedly the one that has had the most impact on the islands biology. The expansion and subsequent management problems of the Kangaroo Island Cape Barren Goose population are discussed in Robinson *et al.* (1982).

The mammal introductions were more successful. A small breeding population of the Platypus now appears to be well established along Rocky River and recently a small number have been released into nearby Breakneck River (NPWS 1986). The introduced Koala population has unfortunately, become only too well established, and as is happening with introduced koala populations elsewhere in eastern Australia, is now causing severe defoliation of Manna Gums and to a lesser extent Swamp Gums. The origins and spread of this koala population are discussed in Robinson (1978). It is not known (and details of its impact on Kangaroo Island are in Robinson *et al.* [1989]) if Common Ringtail Possums occurred on Kangaroo Island naturally prior to the 1926 release but they are now widely distributed on the western end of the island. Hairy-nosed Wombats and Wallaroos apparently failed to become established but there are continuing reports of the possible persistence of a population of Burrowing Bettongs in Flinders Chase National Park at least into the 1960s but there have unfortunately been no recent sightings. Of the reptile introductions, shinglebacks are still present but the tortoises did not survive.

Small Island management problems in South Australia. The Sir Joseph Banks Group, a case study.

The Sir Joseph Banks Group consists of 14 islands and two outlying reefs at the head of Spencer Gulf 40 km east of the town of Port Lincoln. They are relatively easily accessible, contain a variety of safe anchorages and they are becoming increasingly popular with cruising yachts and diving groups. Their conservation value is high, and as mentioned previously, they are the major breeding area for Cape Barren Geese in South Australia and in addition support large and important sea-bird breeding colonies. The following species are present: White-faced Storm Petrels, Black-faced Cormorants, Pacific, and Silver Gulls, Crested and Fairy Terns and Little Penguins. Important shoreline breeding birds include Pied and Sooty Oyster-catchers, Hooded Plovers, Ospreys and Sea Eagles, while major breeding populations of Rock Parrots and a variety of other passerine birds are also found. Dangerous Reef has the second largest breeding colony of Australian Sea lions in the region while Hareby, Roxby, Reevesby and Winceby Islands support the important populations of Black Riger snakes already mentioned. The two main islands, Reevesby and Spilsby, were farmed for nearly one hundred years and most of the outlying islands were grazed by sheep during the winter months. Extensive guano mining operations were carried out on some islands. The whole group, with the exception of Spilsby Island and Dangerous Reef, have been part of the Sir Joseph Banks Group Conservation Park since 1972. There is no resident ranger staff and the islands are managed from Port Lincoln. The National Parks and Wildlife Service has only had its own Port Lincoln based boat for the last nine years. Dangerous Reef is managed by the Commonwealth as an automatic lighthouse reserve

TABLE 6: NATIVE VERTEBRATES RELEASED ON KANGAROO ISLAND BETWEEN 1911 AND 1957 (SOURCE NPWS, (1986)

DATE	NUMBER	COMMON NAME	SCIENTIFIC NAME
1911	17	Malleefowl	Leipoa ocellata
1923	2	Malleefowl	Leipoa ocellata
	6	Koalas	Phascolarctos cinereus
	2	Cape Barren Geese	Cereopsis novaehollandiae
1924	2	Malleefowl	Leipoa ocellata
	2	Burrowing Bettong	Bettongia lesueur
1925	12+ young	Koala	Phascolarctos cinereus
1926	4	Laughing Kookaburra	Dacelo gigas
	2	Burrowing Bettong	Bettongia lesueur
	1	Hairy-nosed Wombat	Lasiorhinus latifrons
	15	Common Ringtail Possum	Pseudocheirus peregrinus
	50	Shingle-backs	Trachydosaurus rugosus
	2	Emu	Dromaius novaehollandiae
1928	2	Emu	Dromaius novaehollandiae
	3	Platypus	Ornithorhynchus anatinus
1929	2	Emu	Dromaius novaehollandiae
1932	2	Cape Barren Goose	Cereopsis novaehollandiae
1936	3	Cape Barren Goose	Cereopsis novaehollandiae
	1	Wombat	Probably Lasiorhinus latifrons
	2	Brush Turkey	Alectura lathami
	6	Mallee Fowl	Leipoa ocellata
1937	12	Crested Pigeon	Ocyphaps lophotes
	12	Peaceful Dove	Geopelia placida
	2	Common Wallaroo	Macropus robustus
	4	Common Bronzewing	Phaps chalcoptera
	12	Zebra Finch	Poephila guttata
	4	Diamond Dove	Geopelia cuneata
1940	4	Bar-shouldered Dove	Geopelia humeralis
	2	Magpie Goose	Anseranas semipalmata
	2	Spinifex Pigeon	Geopelia plumifera
	10	Peaceful Dove	Geopelia placida
	8	Gang-gang Cockatoo	Callocephalon fimbriatum
1941	6	Platypus	Ornithorhynchus anatinus
	2	Northern Rosella	Platycercus venustus
1946	6	Platypus	Ornithorhynchus anatinus
	4	Wonga Pigeon	Leucosarcia melaoleuca
	2	Tortoise	Species unknown
1948	3	Malleefowl	Leipoa ocellata
1956	16	Gang-gang Cockatoo	Callocephalon fimbriatum
1957	3	Emu	Dromaius novaehollandiae

but, with the exception of the light tower and a small shed, this development has not disturbed the sea lions and breeding seabirds at all (negotiations to include Dangerous Reef within Sir Joseph Banks Group Conservation Park will be included by the end of 1989). Spilsby Island is not longer an economic farm although some sheep are still run on it. It now supports a small holiday house subdivision similar to those on Wedge and Thistle Islands.

The grazing history of the Group has left a legacy of disturbance particularly in the form of introduced plants. All islands support extensive winter growing pastures of Medic and introduced grasses between the native *Atriplex paludosa* shrubland and the larger islands, where the native vegetation was actually cleared and large areas cultivated for barley and oats, have a wide variety of weed species. The most severe weed problem from a conservation management point of view is African Boxthorn. It grows extremely well on islands eventually choking out much of the native shrub vegetation. Its red berries are consumed by a variety of birds including starlings, gulls and rock parrots and the seeds spread from island to island in their droppings. the only way to begin to control it is to start on the smaller patches cutting, poisoning and burning by hand and then gradually working in towards the major infestations which will have to be tackled with machinery.

Reevesby Island currently supports introduced populations of cats, goannas and house mice with Spilsby, Stickney and several of the small islands still support (or have supported in the recent past) populations of chinchilla rabbits originally introduced to provide a rabbit fur industry which never eventuated. Eradication of the feral cats on Reevesby Island is of critical importance both in efforts to preserve the large White-faced Storm Petrel populations nesting there and in the longer term, in relation to the possible re-introduction of Stick-nest Rats.

The control of access to and visitor use of these islands is extremely difficult without resident ranger staff and can really only be achieved by an education program among the groups who are likely to visit such as yachtsman, fisherman and scuba-diving groups. Consideration is being given to extending the Conservation Park boundaried to low-water-mark to achieve management control over the island beaches and to the possibility of establishing a large Aquatic Reserve in association with these islands. Visitor access to sea lion, seabird and Cape Barren Goose breeding areas during the breeding season needs some form of voluntary control by visitors rather than complete prohibition which could not be enforced.

The development of a successful management strategy for the Sir Joseph Banks Group for conservation, should enable the development of management guidelines for the State's other island Conservation Parks where the pressures are currently nowhere near as great as in this group of islands with its wide array of management problems.

REFERENCES

Copley, P. (1988). The Stick-nest Rats of Australia. A final report to World Wildlife Fund (Australia) (National Parks and Wildlife Service, S.A. Dept. Env. Plan, Adelaide).

Delroy, L.B. (1974). Flinders island Wallaby *S. Aust. Nat.* 49, 15.

Delroy, L.B., Earl, K., Radbone, I., Robinson, A.C. and Hewett, N. (1986). The breeding and Re-establishment of the Brush-Tailed Bettong, *Aust. Wildl. Res.* 13, 387-396.

Dixon, S. (1920). The full story of Flinders Chase Kangaroo Island. (Adelaide Field Naturalists Society, S.A.)

Falchen, T.J. (1982). Vegetation distribution and change on offshore islands of the Investigator Group and Whidbey Isles, Great Australian Bight. *Trans. R. Soc. S. Aust.* 106 39-60.

Lampert R. (1982). The Great Kartan Mystery. *Terra Australis*, 5.

Ling, J.K. (1981). The status of endangered Australian marine mammals In The Status of Endangered Australasian Wildlife M.J. Tyler Ed. pp 67-75 (Royal Zoological Society of South Australia, South Australia, Adelaide)

N.P.W.S. (1976). Draft Management Plan Seal Bay and Cape Gantheaume Conservation Parks, Kangaroo Island, South Australia. (Government Printer, Adelaide).

N.P.W.S. (1977). Management Plan Seal Bay and Cape Gantheaume Conservation Parks, Kangaroo Island, South Australia. (Government Printer, Adelaide).

N.P.W.S. (1984). Draft Management Plan - Conservation Parks of Kangaroo Island, Beatrice Islet, Busby Islet, Cape Hart, Cape Torrens, Dudley, Mount Taylor, Nepean Bay, Parndana, Pelican Lagoon, Seddon, Vivonne Bay, Western River. (Government Printer, Adelaide).

N.P.W.S. (1986). Draft Management Plan, Flinders Chase National Park, Kangaroo Island, South Australia. (Government Printer, Adelaide).

Poole, W.E. (1976). Breeding biology and current status of the Grey Kangaroo *Macropus fuliginosus*, of Kangaroo Island, South Australia *Aust. J. Zool.* 24, 169-187.

Read, V.T. (1984). The Stick-nest Rats of Australia, A Preliminary Report. (S.A. Dept. Env. Plan, Adelaide).

Robinson, A.C. (1978). The Koala in South Australia. In The Koala : Proceedings of the Taronga Symposium of Koala biology, management and medicine, Sydney 11-12 March 1976. Bergin, T.J. ed., pp 132-143 (Royal Zoological Society of NSW.)

Robinson, A.C. (1980). Notes on the mammals and reptiles of Pearson, Dorothee and Greenly Islands, South Australia. Trans R. Soc. S. Aust. 104, 93-99.

Robinson, A.C. and Canty, P.D. (1984). Biological survey of South Australia's offshore islands. In Survey methods for Nature Conservation. Proceedings of a workshop held at Adelaide University, 31 August - 2 September 1983. Myers, K., Margules, C.R. & Musto, I., eds. pp298-318 (CSIRO Division of Land & Water Resources.)

Robinson, A.C., Canty, P.D., Mooney, P.A. and Rudduck, P.M. (in prep). South Australia's offshore Islands. (Government Printer, Adelaide).

Robinson, A.C., Spark, R. and Halstead, C. (1989). The distribution and management of the Koala (*Phascolarctos cinereus*) in South Australia *S. Aust. Nat* (in press).

Robinson, A.C., Delroy, L.B. and Jenkins, R.B. (1982). the conservation and management of the Cape Barren Goose *(Cereopsis novaehollandiae)* Latham in South Australia. *Dept. Env. Plan. S. Aust. Spec Publ* 1, 1-54.

Robinson, A.C. and Delroy, L.B. (1986). Monitoring of Cape Barren Geese Populations in South Australia *S. Aust. Orn.* 30, 45-51.

Robinson, A.C. and Dennis, T.E. (1988). The status and management of Seal Populations in South Australia. In marine Mammals of Australasia, Angee M.L. ed., pp87-109 (Surrey Beatty Pty Ltd, Sydney).

Robinson, A.C., Mirtschin, P.J., Copley, P.B., Canty, P.D. and Jenkins, R.B. (1985). The Reevesby Island Goanna - a problem in conservation management *S. Aust. Nat* 59, 56-62.

Schwaner, T.D. (1985a). Population structure of black tiger snakes, *Notechis ater niger)*, on offshore islands of South Australia; in Biology of Australasian Frogs and Reptiles. Eds. G. Grigg, R. Shine and H. Ehmann pp 35-46. (Royal Zoological Society of New South Wales.)

Schwaner, T.D. (1985b). The eradication of a native animal from an island reserve. A critical assessment of the Reevesby Island Goanna case history. *S. Aust. Nat.* 59, 52-55.

Smith, M.J. (1983). Tammar Wallaby *Macropus eugenii* In The Australian Museum Complete Book of Australian Mammals Strahan R. ed., pp 232-233. (Angus and Robertson, Sydney. Thom, B.G. and Chappell, J. (1975). Holocene sea levels relative to Australia. *Search* 6, 90-93.

Thomas I.M. and Delroy, L.B. (1971). Pearson Island Expedition (1969) 4. The Pearson Island Wallaby *Trans R. Soc. S. Aust.* 95, 143-145.

The Dampier Archipelago - Managing People in a Nature Reserve

K.D. Morris

Department of Conservation and Land Management, Karratha, W.A. 6714

Abstract

The nature reserves in the Dampier Archipelago have significant conservation values which include providing nesting beaches for four species of marine turtle, nesting sites for 14 species of sea bird, feral animal free habitat for native fauna and undisturbed vegetation associations. The islands are also a popular recreational destination for the public of Dampier, Karratha, Wickham and Roebourne, and this use is likely to increase as the iron-ore and petroleum industries develop in the Pilbara. A management plan is being prepared to ensure the conservation values of the nature reserves are preserved. This will be achieved through the recognition of Conservation Zones, with restricted public access, and Recreation Zones where camping and day trips will be permitted. Public awareness of the islands values will be promoted through access to visitor tolerant sites such as Osprey nests and historic sites. Implementation of the management plan will require the full time attention of an Operations Officer.

INTRODUCTION

Since 1980, the Wildlife Research Centre, Department of Conservation and Land Management (formerly part of Department of Fisheries and Wildlife), has been actively involved in the management of people in nature reserves, through the production of management plans and the development of communication techniques that promote public awareness of conservation values.

The Dampier Archipelago has major conservation and recreation values and since October 1982 biological, physical, historical and cultural information of the area has been collected for a management plan. The draft management plan has now been prepared. This plan will be the primary means of managing the public in this important conservation area. This paper presents the conservation and recreation values of the Dampier Archipelago and discusses the management objectives and how those that relate to public use, will be achieved.

THE DAMPIER ARCHIPELAGO RESOURCE

The Dampier Archipelago is a group of approximately 40 islands within a 45 km radius of the port of Dampier (20°40' S, 116°42' E) off the Pilbara coast, Western Australia (Figure 1). The islands range in size from rocks and islets of less than 1 ha to large islands of over 3000 ha, and were formed approximately 8 000 years ago when rising sea levels flooded coastal valleys leaving hills and ridges exposed (Merrilees 1979, Semeniuk *et al.* 1982).

Unlike most of the other nature reserves off the north west coast which are composed of Quaternary and Tertiary limestone, many of the islands of the Dampier Archipelago are composed of igenous rock of Precambrian age and have a rugged appearance similar to the adjacent Burrup Peninsula and mainland. A few islands in the north of the archipelago are composed of Quaternary limestone and have a flatter appearance. Beaches and sandplains of Holocene origin have formed between rocky headlands on many of the islands (Department of Mines 1979).

The Dampier Archipelago was known to Dutch navigators in 1628 as it appeared along with Barrow Island the the Monte Bello Islands (then unnamed on a chart drawn by the cartographer for the Dutch East India Company (de la Rue 1979).

In 1699 William Dampier visited the islands naming one Rosemary Island after a plant, *Olearia axillaris* he collected which reminded him of the herb rosemary. Some doubt exists whether the island he actually landed on is the island presently known as Rosemary Island (Tuckfield 1955, George 1971). Nicholas Baudin passed by the islands in 1801 and named several of the northern islands. A more detailed inspection of the archipelago was undertaken by Phillip King and botanist Allan Cunningham in 1919 (Lee 1925) and several plant specimens were

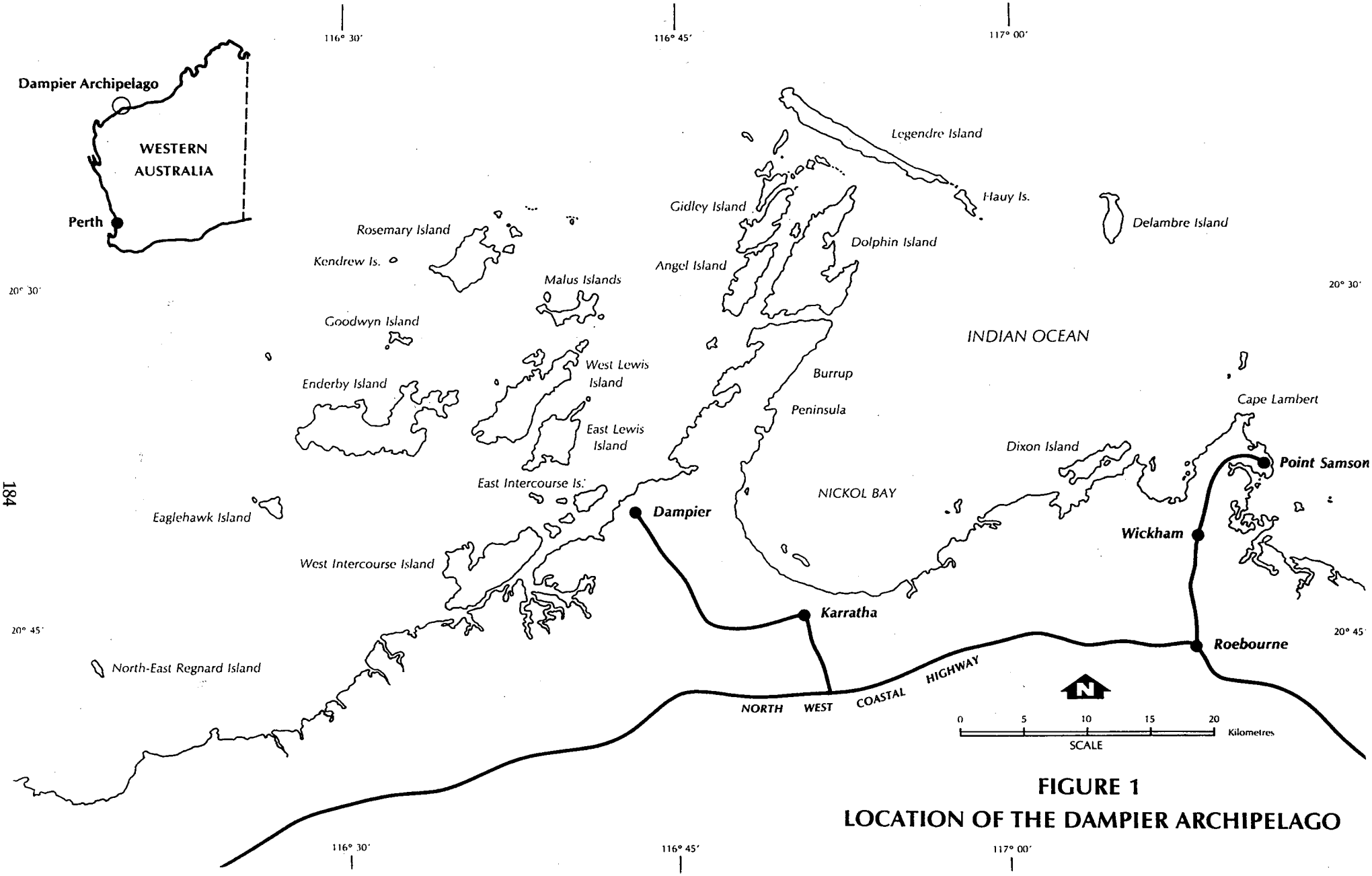


FIGURE 1
LOCATION OF THE DAMPIER ARCHIPELAGO

collected. King named the group of islands Dampier's Archipelago as well as many of the individual islands.

Following Gregory's reports of good grazing land in the Pilbara in 1861 (Gregory and Gregory 1884) settlers journeyed from the south to establish the pastoral industry. With the establishment of the towns of Roebourne (1866) and its port Cossack (1872) the islands became bases for fishing, pearling and whaling operations. The remains of these and other historic sites in the Dampier Archipelago have been surveyed (MacIlroy 1979).

At the time of European settlement an estimated 100-120 Aboriginal people of the Yapurarra tribe occupied the Burrup Peninsula and islands of the Dampier Archipelago (Rhoads and Gara 1984). However introduced diseases, exploitation and violent confrontation with the settlers reduced their numbers and they are now believed to be extinct. Many of the aboriginal sites on the Burrup Peninsula have been extensively surveyed (Rhoads and Gara 1984) however, those on the islands have not. Aboriginal sites on the islands include rock etchings, middens, fish traps and hunting hides.

The first recorded collection of fauna from the Dampier Archipelago was by John Tunney in 1901, when he collected the rock wallaby *Petrogale rothschildi* from Enderby Island and the native rat *Rattus tunneyi* from West Lewis Island (correspondence of J.T. Tunney, W.A. Museum library). More recent collecting visits include a party from the W.A. Museum in 1961 and a joint W.A. Museum/W.A. Herbarium party in 1962. A detailed biological survey of many of the islands was undertaken in 1970 (Burbidge and Prince 1972). These trips, together with the biological survey undertaken between 1982-1985 have enabled the major conservation values of the nature reserves in the Dampier Archipelago, to be identified. These are:

1. Providing suitable nesting beaches for four species of marine turtle, the Green, Hawksbill, Flatback and Loggerhead turtle.

Some information on beach utilization by the turtle has been obtained since October 1982. The nesting season in this area extends from September to April, with a peak in activity during December and January (Figure 2), and this is related to suitable incubation temperatures on the beaches. Bustard and Greenham (1968) suggested that a range of 25C to 35C spanned the normal incubation temperature for the Green turtle, and that this probably applied to all marine turtles. Nesting activity in the Dampier Archipelago also appears to be greater during neap tides than spring tides (Figure 2).

Not all islands in the Dampier Archipelago are used to the same extent by turtles for nesting (Table 1). Over 50 percent of turtle nesting activity occurs on Rosemary Island, even though this island only has 20 percent of the total beach available for nesting. Legendre and Delambre Islands are also important in terms of nesting activity. From a conservation viewpoint, the distribution of nesting species is also important, and ground surveys have shown that the Loggerhead and Flatback turtle prefer to nest on the limestone based islands to the north of the archipelago and closer to deep water. The Green turtle is the most common and nests on most beaches. The Hawksbill turtle is also widespread in the archipelago but in lower numbers than the Green turtle.

2. Providing breeding sites for at least 14 species of sea bird, including 4 species of tern (Caspian, Crested, Bridled and Fairy Tern), Wedgetailed Shearwater, Pelican, Osprey and White-breasted Sea Eagle. Most species breed in the winter and spring, however, throughout the year at least one species is breeding (Table 2). Some of these nesting species are more vulnerable to disturbance than others. For example, Fairy and Caspian Terns nest on beaches with well camouflaged eggs and young, and the burrows of Wedgetailed Shearwaters are readily collapsed if walked over. The small breeding colony of Pelicans on Keast Island is only the seventh to be recorded in Western Australia. Other species, such as the Osprey and White-breasted Sea Eagle are more visitor tolerant. Another 78 species of land bird are known, and some of these such as Signing Honeyeater, Corella, Richards Pipit, Bar-shouldered Dove and Welcome Swallow also breed on the islands.

3. Supporting the only feral animal free populations of the rock wallaby *Petrogale rothschildi*, a species restricted to the Pilbara region. This is one of the "critical weight range" mammals that has been adversely affected by the introduction of the fox. Another 8 species of native mammal have also been recorded on the islands. One of these the Sandy Inland Mouse *Pseudomys hermannsburgensis*, although common and widespread on the mainland is known from only two other islands (Kitchener and Vicker 1981).

4. Supporting undisturbed vegetation association which to some extent reflect the vegetation of the adjacent mainland prior to pastoral and mining activities. The sandplain areas in particular warrant

Fig. 2. Seasonal turtle activity on islands in the Dampier Archipelago during neap (————) and spring (----------) tides, October 1982-October 1985. (mid values and range shown)

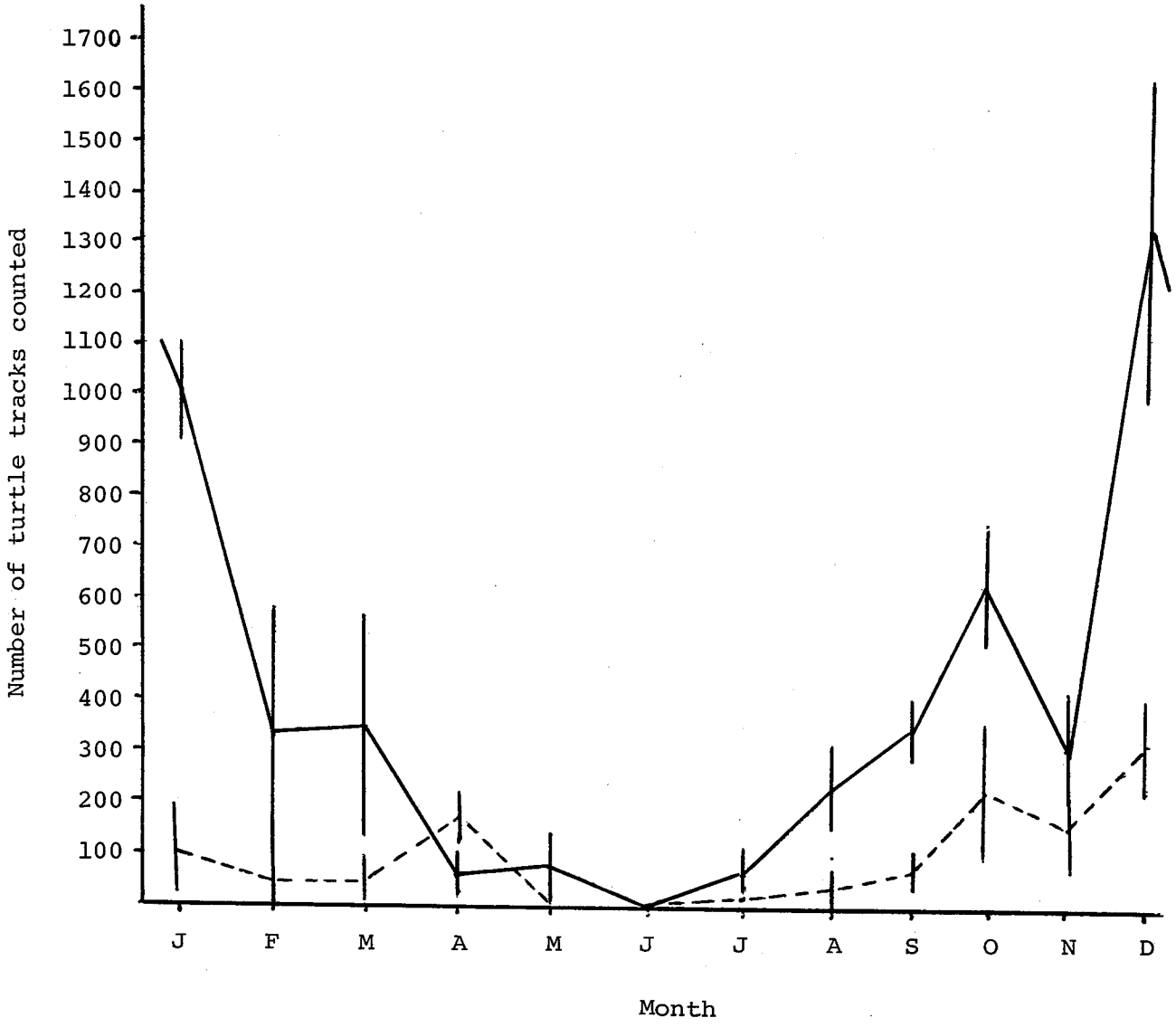
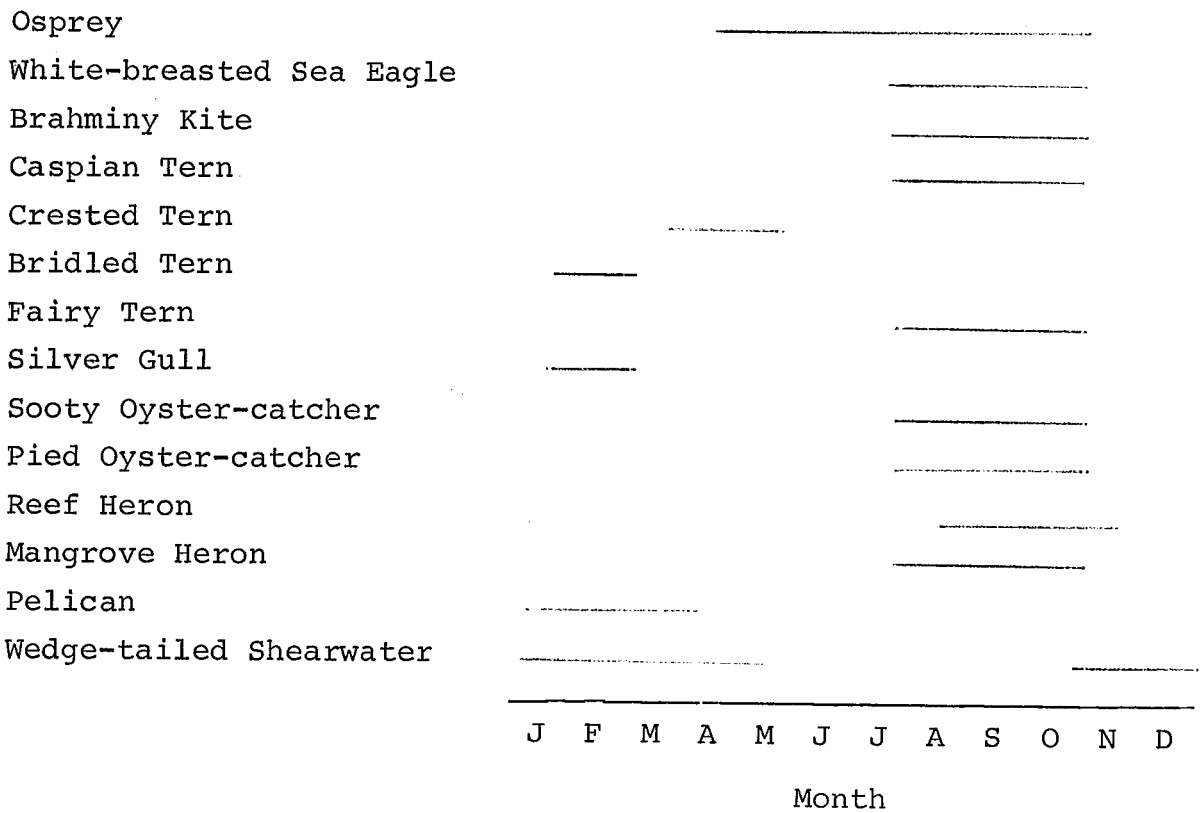


Table 1. Proportion of turtle activity on individual islands in the Dampier Archipelago

	Proportion of total turtle activity %	Beach available for nesting as a proportion of total archipelago beach distance %
Eaglehawk Island	2.5	3.4
Enderby Island	4.8	15.8
Goodwyn Island	0.7	3.4
Rosemary island	55.9	20.2
Malus Island	2.2	7.9
Angel Island	0.9	7.9
Gidley island	1.1	7.9
Collier Rocks	1.4	4.4
Keast Island	3.0	4.4
Legendre Island	14.6	9.0
Hauy Island	3.6	3.4
Delambre Island	8.9	5.6
Dolphin Island	0.6	6.7
		100% = 44.5 km

Table 2. Seasonal distribution of sea bird breeding in the Dampier Archipelago



special protection as they support the most diverse flora and fauna, and have been shown to be critical to the continued survival of *Petrogale rothschildi* on Enderby and Rosemary Islands (Kinnear *et al.* 1984). They are also adjacent to beaches some of which are used by the public.

In addition to their conservation values, the nature reserves of the Dampier Archipelago have other values which must be considered with respect to managing people in the area. These include aesthetic values, historic values, and aboriginal sites. These can be broadly categorized as recreational values as awareness of them by the public can contribute to their overall enjoyment of the islands. Public awareness of the native flora and fauna can also be seen as contributing to their enjoyment of the islands.

With the development of the iron ore industry in the Pilbara and associated increase in population in the 1960s, it was recommended that the Dampier Archipelago be managed in a way that recognized both the recreation and conservation values of the islands (Australian Academy of Science 1962, Conservation Through Reserves Committee 1974, Environmental Protection Authority 1975). In 1977 State Cabinet agreed that a system of nature and recreation reserves be established and in October Dolphin Island was gazetted a nature reserve. Many of the other islands followed in 1980, with recreation areas set aside for day trips, camping and shack development. Twenty six of the islands are now nature reserves managed by the Department of Conservation and Land Management (CALM).

PUBLIC UTILIZATION OF THE DAMPIER ARCHIPELAGO

Between 1900-1965 the islands in the Dampier Archipelago were used by fishermen mainly from Point Samson and Onslow for shelter and campsites. Very little recreational activity was undertaken as the islands were relatively inaccessible at this stage. In 1963 the North West Game Fishing Club obtained a special lease of 7.3 ha from the Lands Department to cater for a shack and facilities which had been erected in Norbill Bay, Rosemary Island. An airstrip was also constructed and a well sunk and these were connected to the lease area by a track.

When the Commonwealth government eased restrictions on iron ore exports in 1960, exploration and development of iron ore deposits in the Pilbara proceeded rapidly and by 1965 Hamersley Iron Pty Ltd began constructing the town and port of Dampier to house 2 500 employees involved in the companies' export of iron ore. The Dampier Archipelago, at this stage vacant Crown land, immediately became a focus for recreational activities and this use increased from 1970 with the construction of Karratha and Wickham to cater for another 8 000 people. By 1981 the combined population of Karratha, Dampier, Wickham and Roebourne was 14 800. By 1992 this is predicted to increase to 18 000 (Department of Industrial Development 1983). These towns are all with a 50 km radius of the Dampier Archipelago (Figure 1).

When the majority of the islands were gazetted as nature reserves in 1980, areas of recreation reserve were set aside to cater primarily for camping and shack development. This situation was revised in 1984 when all East and West Lewis Islands became recreation reserve and that part of Malus Island containing shacks remained recreation reserve. All the other recreation reserves on Rosemary, Angel and Delambre Islands were incorporated into the adjacent nature reserve. Overnight camping and day trips were permitted to continue on nature reserve beaches, however, all shack development was restricted to the recreation reserves and is managed by the Department of Conservation and Environment.

Since 1982, data on public utilization of nature reserves has been obtained mainly through regular aerial surveys and liaison with the public on site. The following points characterise the present public use:

1. The beaches and other scenic qualities of the islands are seen by the public as the major values of the islands.

2. Because of the climate and topography of the islands, camping and day trips are restricted almost exclusively to the beaches.

3. With the exception of Norbill Bay on Rosemary Island and Delambre Island campers and day trippers prefer to use beaches on their own and avoid other forms of occupation. They tend to stay away from shack beaches and invariably use nature reserves beaches "to get away from it all".

4. Most camping occurs during long weekends or holidays in the cooler months (April-September) however because mainly of the "rostered day off" system operated by Hamersley Iron and Woodside outside of public holidays, some camping also occurs over standard weekends. The maximum number of camps counted to date on nature reserves is 32, which equates to approximately 120 people (Table 3).

5. Camping is short term and rarely exceeds the permitted 5 nights.

Table 3. Estimates of the maximum public use of islands in the Dampier Archipelago from October 1982 - October 1985.
[(-) = no observation]

		Long weekend/ holidays		Standard weekend	
Month	Number of Public Holidays	Max. No. of boats	Max. No. of camps	Max. No. of boats	Max. No. of camps
JAN	2	106	15	76	0
FEB	0	0	0	5	0
MAR	1	68	8	-	0
APR	2	151	32	53	0
MAY	1	23	0	53	0
JUN	1	25	11	8	1
JUL	1	79	4	72	0
AUG	1	117	7	-	0
SEP	1	43	12	37	3
OCT	1	86	4	12	3
NOV	0	0	0	-	0
DEC	2	-	0	-	0

6. The extent of day trips to nature reserves is more difficult to estimate, however up to 17 boats at a time have been observed moored at beaches but not associated with a camp. This equates to approximately 70 people. Up to 150 boats have been counted around the islands at any one time.

Even with the present, relatively low level of recreational use of the nature reserves, management problems are apparent for example disturbance of turtle nesting and seabird nesting colonies, excessive use of foredune areas, potential for wildfire on sandplains, litter, and presence of dogs. With restrictions placed on the number of shacks that can be erected on the recreation reserves, it is likely that camping and day trip activities on nature reserves will increased significantly in the next ten years as the population increases.

PLAN FOR MANAGEMENT

After evaluating the conservation and recreation values of the nature reserves of the Dampier Archipelago, and taking into account the Department of Conservation and Land Management's responsibilities under the Conservation and Land Management Act (1984), the following management objectives were developed:

1. To maintain and restore the natural environment and protect it from any disturbance that would reduce its value to nature conservation.

2. To promote public appreciation and enjoyment of the natural, historical and archaeological values of the islands, consistent with the first objective.

3. To eradicate or control exotic plants and animals.

4. To promote scientific study of the islands ecosystem.

With respect to management for recreational use it is predominantly the first two of these objectives that must be addressed, and the key to achieving these objectives is through effective communication with the public.

a. To maintain and restore the natural environment and protect it from any disturbance that would reduce its value to nature conservation

To achieve this objective the nature reserves will be divided into Conservation Zones and Recreation Zones.

The Conservation Zones will be areas of restricted public access and will include four categories:

a. no access at any time - this zone will apply to most of the Wedge-tailed Shearwater breeding sites in the nature reserves. Some sites are conducive to public viewing.

b. no access during the breeding season - this will apply to seabird nesting sites and as many species, especially terns are not loyal to nesting sites, this zoning will need to be flexible and implemented as the need arises.

c. daylight access only from September to April - this will apply only to the important turtle nesting beaches and is to prevent disturbance to adult and hatchling turtles caused by lights and crowds of people. Some controlled night access during September-April will be possible. Other turtle nesting beaches occur outside this zoning.

d. daylight access only all year round - this applies to all inland areas other than (a), and to some beaches where, because of insufficient space for camping, vegetation cover may be affected by this activity.

Recreation Zones will be beach areas where unrestricted day access and camping for up to 5 nights will be permitted. Effectively this applies to most beaches on the nature reserves, except those occupied by sea birds or turtles during their nesting season. In both the Conservation Zones and Recreation Zones, Wildlife Conservation Regulations (Wildlife Conservation Act 1980) will apply, and nature reserve signs of modular pine log construction will inform the users, using symbols, that the island is a nature reserve and that no dogs, open fires, or camping (in the Conservation Zones) are permitted.

The above zonings will be delineated by appropriately worded signs that identify the zone and provide reasons for the restriction. If necessary post and rail fencing will be used to mark off areas. Information post and rail fencing will be used to mark off areas. Information boards showing a map of the Dampier Archipelago will be erected at the two boat ramps in Dampier and one in Wickham to inform the public of the status of the islands and the zonings that apply. A brochure containing this information will also be prepared and distributed from the Karratha office of Department of Conservation and Land Management. It may also be possible to arrange distribution of this brochure through the Department of Marine and Harbours, through whom private boats must be licensed.

The other part of the objective, to restore the natural environment, will be achieved through rehabilitation works to the areas so far affected by public use of the nature reserves. The airstrip surface on Rosemary Island has been broken up to allow revegetation, and tracks not approved by CALM for use by the North West Game fishing Club on Rosemary Island will be fenced off. The foredune areas of popular camping sites such as Norbill Bay, Rosemary Island, and Delambre Island will possibly require fencing with pine logs and access to the inland areas restricted to a few points. Areas that have previously been used for camping and have subsequently been affected, through a loss of vegetation, by this activity, will have future access restricted to daylight only through Conservation Zone (d). Other rehabilitation works will be undertaken as the need arises.

b. To promote public appreciation and enjoyment of the natural, historic and archaeological values of the islands, consistent with the first objective

Several, natural, historic and archaeological features have been identified as visitor tolerant on the nature reserves and these will be used to promote public appreciation and enjoyment of the islands.

(a) Natural features include Osprey nests, turtle nesting and Wedge-railed Shearwater breeding sites.

Osprey nests even when containing eggs or young can be readily approached and photographed without any long term disturbance.

Visits by the public to turtle beaches designated under Conservation Priority Area Zone (c) could only be undertaken if supervised by

CALM staff and restricted to six persons per visit. The public would be educated as to how to observe nesting turtles without disturbing them.

Wedge-tailed Shearwater breeding sites could be observed from suitably positioned lookouts on the edges of the sites. Night time excursions to these areas would be supervised by CALM staff.

(b) the many historic sites on the nature reserves could be viewed by the public without supervision from CALM staff.

(c) many of the archaeological sites are close to beach areas and readily accessible by the public. Aboriginal sites are subject to special protection under the aboriginal Heritage Act (1972-1980) and the W.A. Museum would be involved in any management of these sites.

Information boards would be erected at all these sites, and brochures with details on the sites would be available from the CALM office in Karratha. The location of these visitor tolerant sites would also be included on the information boards located at the boat launching ramps at Dampier and Wickham.

Other means of promoting public appreciation and enjoyment of the nature reserves include articles in the local newspaper on points of interest, talks to interested groups such as naturalist clubs and schools, and personal liaison with the public on the islands.

Obviously, the important aspect of a management plan is its implementation and the management of the nature reserves in the Dampier Archipelago will require the full-time attention of an Operations Officer based in Karratha. However, before it is implemented, the management plan will have to be "sold" to the public and their support obtained. Some of the island users are transient and don't have a long term interest in their surroundings. They believe that because of the islands rugged topography and hot, dry climate, they have no value. Many of the longer term residents used the islands without control prior to them becoming nature reserves in 1980, and even since then, no access restrictions have been placed on the islands. All users need to be reminded that the islands have long term conservation and recreation values which need careful management now, and the management plan is the means of achieving this.

Once the draft management plan has been subject to public review, amended and accepted in its final form, the Operations Officer will be responsible for such activities as erection of nature reserve signs and information boards, monitoring public use of the islands, assessing sea-bird nesting sites so that appropriate protective zonings can be implemented, supervising access to turtle beaches and Wedge-tailed Shearwater breeding sites, and disseminating information to the public. Close liaison with the Wildlife Officer is also essential to ensure that Wildlife Conservation Regulations and the guidelines set out in the management plan are adhered to.

The Operations Officer will also be responsible for implementing management procedures to achieve the other two objectives mentioned above that is to eradicate existing plants and animals, and to promote scientific study of the island's ecosystem.

Finally it should be emphasized that the management plan will be under continuous review during its currency and CALM will undertake any action necessary to achieve the stated objectives of management for the nature reserves of the Dampier Archipelago.

REFERENCES

Australian Academy of Science (1962). Report of the Western Australian Sub-Committee of the Australian Academy of Science Committee on National Parks. Unpublished report.

Burbidge, A.A., and Prince, R.I.T. (1972). The Fauna, Flora and Planned Useage of the Dampier Archipelago. Report No. 11. Dept. of Fisheries and Fauna, W.A.

Bustard, H.R., and Greenham, P. (1968). Physical and chemical factors affecting hatching in the green sea turtle, *Chelonia mydas* (l.) *Ecology* 49 (2) 269-276.

Conservation Through Reserves Committee (1974). Conservation Reserves in Western Australia. Report of the Conservation Through Reserves Committee to the Environmental Protection Authority.

de la Rue, K. (1979). Pearl Shell and Pastures. Cossack Project Committee (Inc.).

Department of Industrial Development (1983). The Pilbara : a regional profile, unpublished report.

Department of Mines (1979). Urban Geology Series (1 : 50 000). 2256 I, IV; 2 257 II-III; 2 356 IV and 2 357. Geological Survey of W.A.

Environmental Protection Authority (1975). A report to Hon. Minister for Conservation and Environment on Conservation Reserves for Western Australia as recommended by the Environmental Protection Authority system 4, 8, 9, 10, 11 and 12.

George, A.S. (1971). The plants seen and collected in north-western Australia by William Dampier. *W.A. Naturalist* 11 (8) 173-178.

Gregory, A.C. and Gregory, F.T. (1984). Journals of Australian Exploration. James C. Beal Govt. Printer Brisbane. (Facsimile edition 1981 Hesperian Press).

Kinnear, J., Onus, M., and Bromilow, B. (1984). Foxes, Feral Cats, and Rock Wallabys. *Swans*. 14 (1) 3-8.

Kitchener, D.J. and Vicker, E. (1981). Catalogue of Modern Mammals in the Western Australian Museum 1895 to 1981. Western Australian Museum Publication.

Lee, I. (1925). Early Explorers in Australia. Methuen & Co. Ltd., London.

MacIlroy, J. (1979). Dampier Archipelago Historic Sites Survey. A report prepared for the Australian Heritage Commission.

Merrilees, D. (1979). The prehistoric environment in Western Australia. *Journal of the Royal Society of W.A.* 62 (1-4) 109-128.

Rhoads, J.W. and Gara, T.J. (1984). Introduction, Dampier Archeological Project. Aboriginal Sites Dept. W.A. Museum.

Semeniuk, V., Chalmer, P.N., and Le Provost, I. (1982). The marine environments of the Dampier Archipelago. *Journal of the Royal Society of W.A.* 65 (3) 97-114.

Management of Barrow Island

W.H. Butler

Dinara Pty Ltd, 233 Adelaide Terrace, Perth.

Abstract

Barrow Island, the second largest of Western Australia's offshore islands, is a Class A Reserve vested in Department of CALM., and a producing oil field under the control of West Australian Petroleum (WAPET). Because of government agreements the preservation of the island's wildlife values has become the responsibility of WAPET.

A Plan of Management supportive of the compatibility of conservation and development in accordance with the World Conservation Strategy and the National Conservation Strategy for Australia, was developed to implement the preservation of Barrow Island conservation values. A wide range of problems was identified and recognised to interact and thus be compounded or synergistic. The main themes of the Island Management Program were:

workforce education; quarantine, which has effectively prevented any exotic invasions; rehabilitation of all finalised work areas; fire control; disturbance reduction; planned waste disposal in an environmentally acceptable manner; Rattus rattus eradication on adjacent areas; banning of all terrestrial hunting and unnecessary fauna disturbance; strict regulation of marine disturbance and fishing, plus amelioration of the effects of barriers, ecosystem changes, dust, spills and flares.

The success of the program is indicated by the presence of all known vertebrate species being maintained; no introduced species breeding; restoration to original condition of large tracts, and general environmental concern expressed by all workforce.

Special advantages have been workforce training extending into other oil field development areas of Australia; significant inputs deriving from disciplines other than ecological, biological, or conservation, and considerable scientific research and investigation from external bodies carried out under the auspices of WAPET Research Grants.

Regular inspections from concerned government agencies have been carried out and all recommendations deriving from these have been implemented into the Plan of Management.

Lessons learned on Barrow Island may have application in other island management situations but it must be recognised that the special significance of islands is reflected in the special requirements of individualised management.

Unlike the majority of delegates to this workshop, I am a private Consultant who works in the area of conservation management including islands. Thus I work with development and conservation requirements in accordance with the principles of the World and National Conservation Strategies. In addition, as an Honorary Wildlife Officer I have some responsibility to the Department of Conservation and Land Management.

In order to understand why Barrow Island is not directly managed by government authorities a brief history of Barrow Island is required.

Although Barrow was sighted by the French in 1803 it was named in honour of a recently retired Secretary of the British Admiralty, John Barrow, by Philip Parker King in 1818.

Minor biological collections were made until 1900 when John Tunney extensively studied the area.

The biological work of Tunney and his predecessors, plus the record of large numbers of Green Turtles breeding on the island, caused the Western Australian Government to declare Barrow Island a Nature Reserve in 1908. This declaration was subsequently raised to Class A in 1910.

Despite various attempts to have this overthrown for developmental reasons no change to that status occurred. Very few people, including scientists, visited the island until 1964 when West Australian Petroleum Pty Ltd (WAPET) was given permission to carry out exploration for oil. This followed its recognition in 1954 by company geologists of an anticline with oil potential.

In June 1964 the Barrow No. 1 well produced oil and led to an intensive exploration and development program which has been continuous up to and including the current time. By June 1985 over 700 wells have been drilled for the purposes of producing oil or gas, water injection, water disposal or water source.

The development following the original discovery was made possible by a special Act of Parliament (Act No. 85 of 1966). This gave the entire development of the oil leases to WAPET on the environmental proviso that there was no unnecessary damage or molesting of fauna and no unnecessary destruction of flora. The leases covered the entire island which effectively made its management during development and operations a WAPET responsibility.

Contrary to what many people believe, developers are not automatically destroyers of alternate resources. Also nonsense is the constant reiteration that environmental and engineering disciplines are not compatible. Modern engineers and environmentalists are involved in communication which is complementary and compatible. Any conflict between engineering and environment derives from individuals who make it so.

Because of an earlier involvement with the company, I was able to provide WAPET with a fundamental outline of procedures to be followed. These were very simple things: no pets, no firearms, no traps, no poisons, no introduced plants, no jetties, etc. These simple principles became an inherent part of the ongoing Barrow Island development. At the same time, using my relationship with the company, coupled with the work of other investigators, I was able to identify that the 23 400 hectare desert island was representative of the almost vanished Pilbara vegetation complex on the adjacent mainland.

Because there were no introduced animals or plants, Barrow still appeared to have its full suite of original wildlife. The entire island is limestone, vegetated with 300+ identified plant species which combine into nine important ecosystems. These are:

- *Triodia wiseana* hummock grassland on limestone uplands
- *Triodia angusta* hummock grassland on water courses and lowland loam
- *Triodia pungens* hummock grassland on red or white sand
- *Spinifex longifolius* and *Acacia coriacea* on coastal dune complexes
- A short Forb community on flood out flats
- Salty flats
- Mangrove
- Coastal rock assemblages
- Disturbed areas

A total of 29 subtypes are recognised in the ecosystems of the island as described by Buckley (1983). This combination of ecosystems and habitats supports 13 native mammal species including 8 marsupials; 105 bird species, mostly nomad or waders; 49 reptile species and 1 frog species (Butler 1970, 1975). In addition, it has an incompletely catalogued but rich invertebrate fauna.

Despite the adversary approach of the sixties and seventies which asked "Should wildlife or oil be protected?" "Should conservation or development come first?" it was, and still is my belief, that conservation and development are compatible if properly planned and managed. This is supported by the principles of the World Conservation Strategy which are inherent and basic to the National Conservation Strategy for Australia.

Based on this understanding and assisted by concerned government departments, a philosophy of conservation and development was established from which arose a functional Plan of Management for Barrow Island. Although never completely formalised, this is nevertheless inherent in all Barrow Island development.

The Plant of Management is based on apparently simple factors:

1. To recognise and preserve irreplaceable segments of the natural environment which are key to island wildlife survival.
2. To recognise and preserve representative areas of all recognised habitats and plant associations.
3. To exclude unnecessary impact of the development on the natural environment.
4. To reduce to a minimum those impacts which cannot be avoided.
5. To systematically rehabilitate all utilised areas once completed.

Recognising that problems involved in achieving this may be compounded and synergistic, each had to be isolated and identified and answers formulated to reduce effects. The following were identified as needing specific answers to ensure the validation of the Plan of Management.

(a) Fauna disturbance through the presence of man and his works.

(b) Soil and habitat disturbance through active development.

(c) The loss of cover through fire protection and other developments.

(d) The possibility of introduced species of plants and animals.

(e) The possibility of road casualties.

(f) The effect of gas flares, particularly on phototrophic species.

(g) The potential for toxic or noxious spills.

(h) Dust and associated problems.

(i) Surface runoff dangers through the construction of road, pipelines and other facilities.

(j) Human predation on wildlife.

(k) Food availability changes due to the differential in water and nitrogen contents of regrowth and the availability of waste foods.

(l) Ecosystem balances changed due to selective development of particular areas.

(m) Barrier effects caused by roads, pipelines and other services.

(n) Fire and control.

Management methods to overcome these problems are multiple and involve a wide range of disciplines and people. Of particular importance is the necessity to ensure that such a management plan does not become so prescriptive and solidified that there is no room for improvement and no opportunity for individuals to contribute.

Any individual who wishes to draw the company's attention to apparent errors or omissions does so through a supervisor. No such submissions are overlooked and many have significant long term effects on the implementation of future plans of management.

The basic philosophy that conservation is compatible with development is propounded and detailed in clearly understood terms to all decision makers. By all, I mean senior management in Perth office and individual operators on the island, including all contractors. Most employees and contractors routinely make decisions affecting the environment so decision making is everybody's business, not just senior management's. All decision makers are therefore advised of basic philosophies in environmental care.

A comprehensive program of workforce education is carried out, ensuring that everybody in the company, particularly those on the island, know what they are conserving and why they are conserving it. The 'how' of conservation applies to individual units and sections with particular responsibilities.

Specifically dealing with the problems already outlined, the following were invoked:

(a) Fauna disturbance through the presence of man and vehicle was reduced by alternative areas of development so that no one area has a constant impact. Newly disturbed faunas may move into adjacent areas and repopulate once disturbance is completed.

One side issue of this is that naturally less successful individuals, in particular sub-adult or past-prime, have been forced into areas of constant impact and have acclimatised themselves to regular activity on the island. This is verified by a regular examination of road casualties for comparison with non-road casualties.

All areas not involved in island development are closed to vehicles excepting for necessary access roads.

Each physical disturbance area was reduced to as small a site as possible.

(b) Soil disturbance through active development was primarily to extract gravels for the numerous well sites, roads, and other use areas plus the gravel pits themselves. Such developments were limited to single areas at any one time with restoration as part of the ongoing pattern of utilisation. Restoration included vegetation and topsoil stripping, compaction relief, erosion control, flood and water runoff control, and final replacement of topsoil and stripped vegetation on the proper horizon.

Rehabilitation is staggered in such a way that at no time does rehabilitation present too much of one age regrowth material.

(c) The loss of cover through fire protection and development relates to firebreaks and the pre-stripping of vegetation prior to working. Initially artificial shelters of drums with mesh and cleared vegetation piled over it, plus some old huts, were utilised. However, once the rehabilitation and regrowth program were established, artificial covers were abandoned as no longer necessary.

In this respect, it was noted that the solid shade and shelter of oil field fixtures replaced cover for some species.

(d) The possibility of introduced species of plants and animals was very high on our list of potential problems. A rigorous quarantine control program was instigated which checked cargoes on aircraft and barges, created washdown points for machinery, and carried out consistent warehouse and store area

checking for introductions. Everything comes on to Barrow Island via landing barges or aircraft and total control is applied.

Pets were totally barred, both introduced and island species.

Oil discharge is operated through a submarine pipeline and no jetty has been built.

Early investigations established that *Rattus rattus* occurred on Double Island, Middle Island, Boodie Island and Pasco Island.

During a Western Australian Wildlife Authority visit in 1983 *Rattus rattus* was located on Boomerang Island, which is connected to Barrow at low water. An immediate eradication program was undertaken accompanied by a live trapping program on the adjacent areas of Barrow Island. No trace of *Rattus rattus* was found in any adjacent areas but only on Boomerang. Further eradication programs have been carried out on Double, Pasco and Boodie Islands while Middle Island will be undertaken in the near future (Morris, this publication).

Following recognition of the need for Barrow Island workforce amenity, government permission was given for eucalypts (excepting *E. patellaris* not of Barrow Island genotype) to be used for landscaping as required on Barrow Island. The trees around the camp site and workshop areas are a result of this.

There have been repeated requests from workforce and island management to include coconut palms, mango, banana and the like. These were refused by the Western Australian Wildlife Authority on the grounds that they may upset food supplies on the island, create dependent species, introduce new faunas supported by the new plants, or run wild. Occasional outbreaks of introduced plants have occurred on the island, mostly during very good seasons, and following contractors coming ashore from the adjacent mainland. In all cases successful eradication programs have been carried out to remove cape weed, blackberry nightshade and the other species which have been involved.

(e) The possibility of road casualties was recognised prior to construction of service and access roads on Barrow Island. On a space basis of the distribution of fauna populations, road casualties would be completely unavoidable among mammals, birds and reptiles.

Larger species mammal casualties examinations indicate that pre- and post-prime animals are almost invariably involved. The suggestion is that prime animals occupy territories away from the disturbance sites and force the less successful animals into contact areas.

The main controls on this aspect were to enforce a speed limit on the island and to reduce night driving. There is essential night driving required for safe field operation, and some night driving because of recreational use of the island. All driving and road use is under constant review and supervision for both safety and environmental protection reasons.

(f) The effect of flares was very difficult to deal with, because flares are a necessary part of the safety requirements of an oil field. The physical size of flares was reduced to limit the effect as far as possible and the flares were turned horizontal instead of vertical, partly for safety, partly to create evaporation of ponded liquid, and partly to reduce phototrophic effects.

(g) The potential for toxic or noxious spills, such as oils, chemicals and salt water, are prevented by good oil field design and maintenance plus contingency plans and specific treatment applied in any affected areas. For example, oil spills are ripped to break up ground compaction and allow oils to volatilise. If oil contamination persists, yeast materials are applied to reduce oil by increasing bacterial ingestion.

In the ballast pond where some entrained oil comes through ballast water, oil ingesting algae were introduced.

Of far greater concern are salt water spills which can only be ripped and left alone to allow natural flushing to take place in due course.

Part of the ongoing management program is water retention across the island drainage system. The small earthen dams and banks will pond and contain accidental runoff so that downstream effects are reduced. At the same time the program ensures aquifer recharge while reducing environmental damage from violent storms. All toxic or noxious materials used in the oil field are bulk handled as far as possible, with resultant lessened risk. A toxic chemical inventory is available at all times to ensure that all toxins are accounted for.

(h) Dust and associated problems are handled to some degree by the ongoing program of sealing roads. Dust also offers considerable problems to some areas of the field, such as workshops, as well as creating a safety hazard to users. Examinations of dust effects caused by Barrow Island traffic led to the conclusion that dust enhances roadside plant growth. Among the reasons for this enhancement is that dusted vegetation is less palatable to grazing fauna and that dust helps

to increase nutrient build up and lessen water loss in road verges.

(i) Surface runoff changes are basically handled by engineering culverts and diffusion drains to ensure continuation of original runoff patterns.

As previously mentioned a deliberate program of runoff recharge was instigated on all waterways. Since most gravel comes from stream beds, the clearing of vegetation prior to gravel extraction led to areas where water velocity could build up with no inhibition. By creating ponds, this velocity was checked and the area became a silt trap as well as an aquifer recharge.

Another result is a greatly lessened storm silt load running into the sea which has extra positive value in marine environmental preservation. An examination of the adjacent mainland, where pastoral extremes have caused desertification to a considerable degree, shows rivers discharge significant silt load which causes marine organisms to be inundated and stifled.

(j) Human predation on wildlife was effectively prohibited by the banning of any taking of fauna or flora on the island. Stringent fishing rules for offshore areas were enforced, in many cases the Barrow Island laws being more severe than the State laws. Fishing rules control the taking of specimens, such as molluscs and corals, limit the catch number and size, and declare areas where fishing is totally prohibited.

(k) Food availability changes due to the differential in water and content of regrowth, plus waste disposals, were controlled. Ecosystem change was through a systematic pattern of restoration, so that at no time would there be a greater amount of regrowth than could be found periodically in an undisturbed ecosystem following a natural disaster such as a fire or cyclone.

This became a major principle in dealing with environmental issues on Barrow Island. It is recognised that each ecosystem and its components has both genetic and individual survival capacity evolved over a period of time to survive local extremes of natural catastrophe.

In the case of Barrow Island, natural catastrophe includes cyclones, floods, drought, fire and periodic heat and cold levels. Species that could not cope with these became extinct long before the oil field existed.

The prime target of environmental management was to restrict the effects of oil field development so that island species resilience would allow repopulation from stable unaffected stocks.

Natural catastrophe records include a 1962 photographic record of a wildfire which affected approximately 90% of the island, numerous cyclones, and the variable weather records of the past century.

Waste disposal food availability was reduced by incinerating all waste with a food potential. Inert wastes are disposed of by earth fill in borrow pit areas.

Toxic wastes are disposed according to authority requirements, that is back to the mainland, as are toxic waste containers.

(l) Ecosystem balance changes due to selective development of particular areas particularly applied to creek beds which were used for gravel extraction. By alternating rock crushing as a gravel source, and by determining the sensitivity of proposed gravel sites, material can be obtained from least sensitive areas. A rigid control program over development of gravel pits and fill areas ensures that no new development takes place until rehabilitation is complete on a similar area of a similar ecosystem.

(m) Barrier effects caused by roads, pipelines and other services are of significance. It was decided that to bury pipelines on Barrow Island would create more environmental damage than to lay them on the surface, thus all flow and product lines on Barrow, with very few exceptions, are surface lines.

All flow lines are pre-welded into suitable lengths, and hydrostatically tested. Line lengths are dragged by a rubber typed machine across existing vegetation without clearing. Field welding is done over fire mats, thus reducing fire risk or necessity of clearing at welding points.

Road crossings and culverts established for drainage flow also reduce the road barriers.

Large lay-down areas and other impervious areas are rehabilitated as soon as possible within the framework of the overall program.

(n) Fire and Fire Control are critical in establishing safety factors in hydrocarbon fields which seek the complete prevention of fire. On the evidence that Aboriginal people did not occupy or utilise Barrow Island plus the evidence of stumps and burned ground material, it appears that fires on Barrow were infrequent and catastrophic, normally arising from lightning strikes. Photographic evidence of a 1962 fire which affected approximately 90% of the island's surface is available. Prior to that in December 1864 a Captain Jarman explored Barrow Island and recorded it as "the most unpromising looking spot we have seen in the north west country ... we fired it from end to

end making a splendid sight in the strong breeze blowing at the time, which caused a perfect sea of flame to traverse the island at a most astonishing pace."

From these two experiences it is apparent that significant wild fires occurred on Barrow and that the fauna and flora were capable of recovering from such fires.

Thus the no-fire oilfield policy was reinforced by the evidence of the fire history of the island before the oilfield.

Despite the most rigorous care occasional fires can and do break out accidentally and a number of such have occurred in the twenty one years of WAPET occupation. These have derived variously from burning rubbish, vehicle accidents, welding sparks and other industrial naked flames. In all cases the policy was total containment. Current investigation into alternate methods of fire control is underway to seek a cost effective, environmentally sound system.

Needless to say, a complete fire training program exists on the island and all necessary equipment including a fire engine is available at all times.

Because of fire rarity, careful monitoring of burned areas has been carried out to determine speed of regrowth and extent of change in vegetation that may persist. Following a fire adjacent to a main road,exclosures were established to keep out large grazers. It was found that there was no difference within or without the exclosure. Later work, using finer mesh which excluded rodents, showed significant difference and it is my belief that more grazing pressure on Barrow Island is applied by rodents than by large herbivores.

Through the application of these techniques implementing the policies of the Plan of Management, Barrow Island has become an area where, although individual animals and plants may be temporarily disturbed of destroyed, sufficient stock of all species in sufficient representative habitats of all ecosystems have been preserved. As a result, regeneration and repopulation are automatic from the resources. Approximately half of the island not directly involved in the oilfield development is totally closed to operations apart from the necessary service access roads passing through. As stated, these undisturbed areas are essential in maintaining a major re-population source and we ensure that they contain representation of all the habitats on the island.

As Consultant to WAPET, I am responsible for overall environmental management planning of the total oilfield program, including abandonment procedures. By deliberately not having an environmental department, all workforce on the island regard environment as their personal responsibility at all times. Thus environmental care and protection is both individual and collective workers' responsibility - and it works remarkably well!

A major asset of the overall program has been the education of ten thousand men in the twenty one year period of the field. These have learned the fundamental philosophies of conservation working in harmony with development. They have carried the pragmatic observation of those philosophies to other projects in other parts of Australia. Feedback is beginning to emerge as the principles are being applied in other parts of Australia and the world.

A word of warning, however! Although the basic concepts developed on Barrow Island have been applied successfully to other projects, there are no absolute answers to environmental preservation. Each project needs specific input to meet its specific need in its particular environment.

Philosophies may be constant, but technologies and methods must vary from place to place and time to time. The basis of conservation on Barrow Island is the preservation of habitat, i.e. air, water, soil and vegetation. Species protection in this instance is seen to be less important than ecosystem protection. We are very little concerned with aesthetic appreciation and protection because we do not believe that wildlife has an aesthetic appreciation. The evidence on Barrow is that fauna will occupy places that humans regard as unaesthetic areas as well as those which are regarded as highly pleasing.

By preserving the habitat in all its forms, the survivors of thousands of generations of natural selection adapt to the short term intrusion of man and his works provided that intrusion is not of a greater or more diversified impact than has been imposed on the area by nature. In addition, such intrusion must be actively and professionally managed. Without such management, even minor man-made perturbations could be a major catastrophe in the fragile ecosystems of Barrow Island.

REFERENCES

Buckley, R.C. (1982). The flora and vegetation of Barrow Island, Western Australia. *Journal of the Royal Society of Western Australia*, Vol. 66, Part 3, 1983 : 91-105.

Butler, W.H. 1970). A summary of the vertebrate fauna of Barrow Island, W.A. *The Western*

Australian Naturalist, Vol. 11, No. 7, August 7, 1979: 149-160.

Butler, W.A. (1975). Additions to the fauna of Barrow Island, W.A. *The Western Australian Naturalist*, Vol. 13, No. 4, 1975 : 78-80.

Management of Queensland's Great Sandy Islands

John Sinclair

Fraser Island Defenders Organisation Limited, Australian Conservation Foundation, PO Box 226, Red Hill, Queensland, 4059.

Abstract

The increased demand for outdoor recreation combined with a heavy and rapid increase in the public use of off road vehicles has led to a rapidly growing use of three major offshore sandmasses in south-eastern Queensland - Stradbroke Island, Moreton Island and Fraser Island - as well as providing stronger pressure for their conservation and better management. The controversies over land use and management of the Queensland sandmasses since the early 1970s, mainly associated with sandmining, and the many subsequent studies and inquiries have resulted in comprehensive understanding of the sandmasses and how they should be managed. The political sensitivity of the Queensland Government to land use issues on the sandmasses and its predisposition towards exploitation have so far frustrated the implementation of any management plans for any of the sand islands. There are many unresolved conflicts over the best methods of land management for the sand islands. The difficulty of reconciling the divergent interests and the lack of consultation have hindered the implementation of any effective plans of management. The major problem for management is the acceptance by the Queensland Government that conservation should be the major objective for such management plans.

INTRODUCTION

There are three major offshore sandmasses in south-eastern Queensland - Stradbroke Island, Moreton Island and the world's largest sand island and largest single sandmass, Fraser Island. They are still in a relatively natural state. Fraser Island along with Cooloola and the rest of the Great Sandy Region has been proposed for World Heritage listing.

These three offshore sandmasses are the three principle offshore sand islands in Australia. They are well vegetated with tall forests, and have high dunes of aeolian sand. Because of the similarity of their geomorphological features and biological characteristics and the similarity of the threats and management problems the three islands are collectively grouped as Queensland's Great Sandy Islands.

Their most startling feature though, is their geomorphology. Their claims include world's largest sand island and largest single aeolian (laid down by wind) sandmass, and the highest permanent sandhill in the world (Mount Tempest, 300 metres, on Moreton Island). They also contain some of the most active and dramatic wind erosion processes occurring in vegetated dunes to be witnessed anywhere in the world.

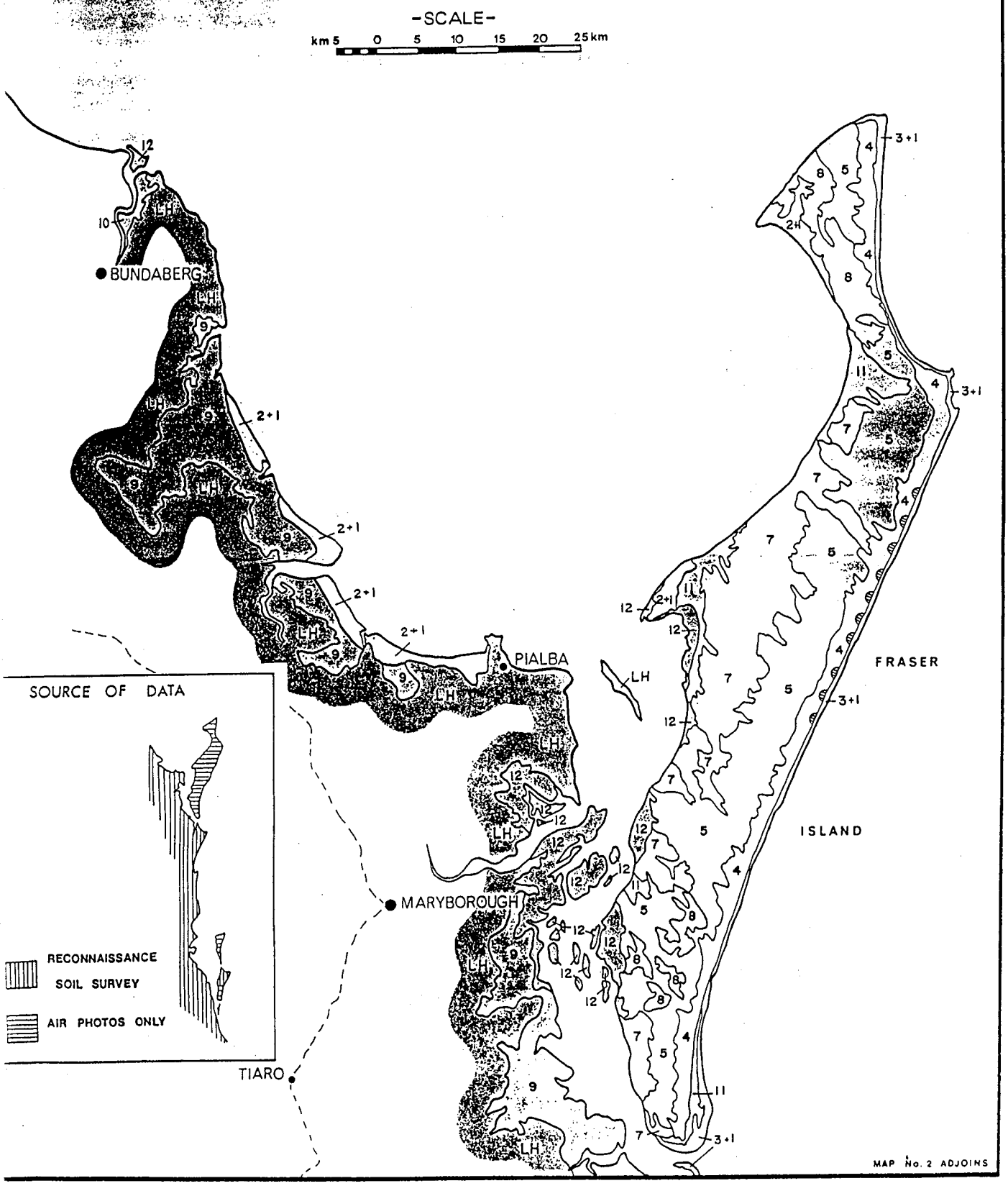
The outstanding aesthetic features of sand islands include the numerous scenic perched dune and window lakes, streams flowing through spectacular and unique tall rainforest growing on dones with clear water coloured either port wine or crystal, the startling coloured sands, scenic rugged rocky headlands, a vast, expansive surfing beaches, varied heathlands and open forests, and the impressive cultural legacy of former Aboriginal populations. They also have a rich and unusual biota, including several endemic species, which occupies the mosaic of diverse vegetation from mangroves and tidal meadows to the terrestrial vegetation.

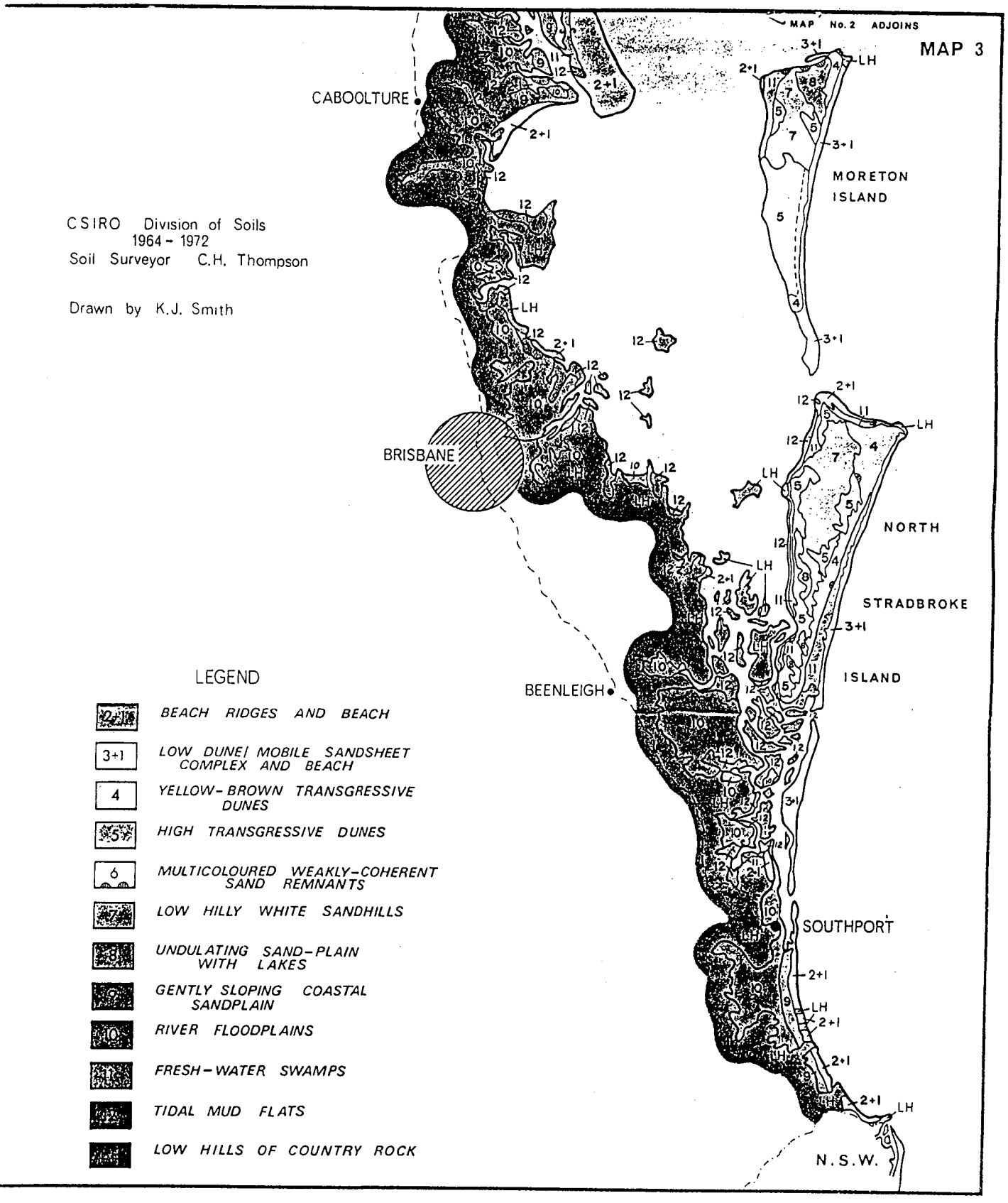
The outstanding geomorphological, biological, cultural and aesthetic properties have led to proposals that Fraser Island, the world's greatest coastal sandmass, be placed on the World Heritage List along with Cooloola and other parts of the Great Sandy Region.

As natural wonders each now attracts hundreds of thousands of visits annually. Each has a rapidly growing tourist traffic. Whereas less than a decade ago the major appeal of these islands was to beach anglers who enjoyed its legendary fishing, they are now increasing attracting those with a sensitivity and feeling for beautiful natural places and an appreciation for the awesome processes of nature.

MAP 1

COASTAL LANDFORMS OF SOUTHERN QUEENSLAND





Map from "Stradbroke Island Symposium" by Stevens

Collectively North Stradbroke Island, Moreton Island and Fraser Island are barrier islands. They lie roughly parallel to the coast for about 200 kilometres and protect about half the South Queensland coast between the New South Wales border and Bundaberg. Moreton Island and North Stradbroke Island combine to form the eastern side of Moreton Bay. Fraser Island forms the eastern side of Hervey Bay and Great Sandy Strait.

Of the three islands, Fraser Island is by far the largest. Its 160 000 hectares exceeds the combined areas of almost all of the the remaining sandmasses in central and southern Queensland. It dwarfs North Stradbroke Island (27 520 ha) and Moreton Island (18 500 ha) in area but the significance of these two islands in strategic geographical and management terms is emphasized because of their close proximity to Brisbane.

Fraser Island, located 190 kilometres north of Brisbane, is the largest sand island in the world with an average width of 15 kilometres and a length of over 120 kilometres. The dunes reach up to 240 metres.

Moreton Island and North Stradbroke Island are similar in shape and size with only shallow South Passage, about 2 kilometres wide, separating them. Both are about 40 kilometres in length with an average width of 11 kilometres. Moreton Island is slightly narrower and more tapered. Both have quite attractive and rugged rocky headlands at their north east corner and both are widest at their northern end. Both islands are approximately 40 kilometres from the mainland suburbs of Brisbane. Both are also now within an hour of Brisbane by launch. The main difference between the two is that Moreton Island has largely escaped the exploitive land use and urbanisation that has heavily impacted North Stradbroke Island. There is strong public pressure to preserve and to protect both islands.

The three islands enjoy a subtropical climate with an annual average rainfall of between 1250 and 1800 mm.

The isolation of these islands and their infertile soil let them escape major European development and exploitation until the latter part of the twentieth century.

The significant lode of heavy mineral sands led to major land use conflicts involving each of the islands during the last two decades. Some sandmining has occurred on all three islands; only a relatively minor area was disturbed on Fraser Island, before it ceased in 1976. A limited amount of beach scalping was carried out on Moreton Island in 1957-58. Sandmining has had a very heavy environmental impact on Stradbroke Island, where operations are currently being expanded. There are constant threats to resume sandmining on Fraser Island and Moreton Island. This impasse has not been resolved.

The three islands are not the only sand islands in Queensland. Bribie Island is also a sand island. It is an inshore island and because no part of its 14 400 ha are above 10 metres in elevation it has not been dealt with in this paper. South Stradbroke Island broke away from North Stradbroke Island only in 1986. Apart from its closer proximity to the mainland, South Stradbroke Island's small area doesn't justify separate discussion.

VALUES

The three sand islands have innumerable examples of large parabolic dunes, unique in the world. Hundreds of wind-driven sand dunes are part of a complex cycle eroding and restructuring the sand mass. This process is more developed than anywhere else in the world. It is this complexity and the active, dynamic nature of the dune system which excited one scientist to exclaim, "*Fraser Island is for sandmasses of the World what the Great Barrier Reef is to coral reefs of the world*". Fraser Island is the world's greatest sand mass and the oldest age sequence of giant coastal sand dune systems yet recorded; some dunes may be 400 000 years old.

The complex interaction of the windblown sand, the flora and decomposing organic material, results in impervious layers being developed which support lakes high above the water table. These lakes, resting on impervious organically bound sand in wind-formed dune depressions, are unparalleled in the world. There are many perched dune lakes. These contain some of the freshest, purest water in the world.

Botanists have identified hundreds of species of flowering plants and ferns, including a number of rare and endemic plants. More than 150 listed plants are found in the rainforests of Fraser Island. The islands contain a compact, outstanding example of "wallum", the vegetation of coastal lowlands, along with important examples of heathland communities. It contains a wide diversity of marine, terrestrial and avian fauna, some of which is rare of endemic. surprisingly, despite the dense biomass. The terrestrial part of the islands are relatively poor as far as mammals are concerned. However, what they lack in the volume of fauna is compensated for by the great rarity of species.

As recently as 1980, in a previously logged area, the measured biomass at one site on Fraser Island was the second highest yet recorded in the world. It was exceeded only by the giant Sequoia forests of California. Almost as remarkable as the prodigious bulk of biomass is the incredible age of some of the trees and the evidence of the changes to their environment as they stood there. On Fraser Island are ancient Paperbarks *Melaleuca quinquinervia*, estimated to be 2 000 years old.

More than 250 species of birds have been listed from the three islands. Most are common to all islands but the largest list comes from Stradbroke Island where there has been more intensive observations. These range from the dull brown migratory waders to the more colourful honeyeaters, lorikeets and parrots. Many of the birds are uncommon elsewhere. Fraser Island contains important habitat for the Ground Parrot. The estuaries in the lee of the islands are recognized as most important summer stopovers for migratory wading birds.

There is a great diversity of reptiles on the islands. Although there is a diversity of land mammals, the populations are very small and often isolated. There are no macropods on Moreton Island. Only Stradbroke Island has population of koalas, and a residual population of *Macropus agilis*. The dingoes of Fraser Island are regarded as one of the purest strains of dingoes in Australia. There are many small rodents.

The absence of feral cats and dogs has helped to avoid decimation of many wildlife populations. More recently though, feral fish, cane toads, cats, dogs and foxes have begun to make a heavy impact on Stradbroke Island. Feral horses, cattle, goats and pigs have competed with the wallabies and kangaroos to their detriment. There is increasing concern that feral predators may become more of a threat to fauna. Domestic dogs have passed on diseases such as Parvo virus to the dingoes, with devastating impact.

Apart from their aesthetic appeal the islands are regarded by many as having wilderness values even though these have been seriously compromised through intensive networks of tracks and easier access.

The cultural, biological, aesthetic and geomorphological values of the three islands have been well identified and are widely recognized as the bibliography indicates.

HISTORY

The sandmasses have always been important for humans. Prior to European civilization the sandmasses were a haven for rich Aboriginal cultures.

The first recorded Europeans to reside in what is now Queensland, were three escaped convicts who took up residence with the Aborigines of Stradbroke Island. They were found by Oxley when he arrived to establish the Moreton Bay settlement in 1824. A settlement was established at Amity Point on Stradbroke Island about 1829, to serve as a pilot station to guide ships through South Passage. In 1847, after a marine disaster on the South Passage Bar, the pilot station was moved to Bulwer on Moreton Island, and a large area of land there was alienated. In 1849 Dunwich was established as a quarantine station. Despite the early colonization the mainland, the offshore sand islands escaped heavy impact of European settlement until the late 1940s and exploitation was limited.

Since European settlement of southern Queensland, the island's Aboriginal cultures have been decimated. The only island where some of the once very significant Aboriginal population still resides is Stradbroke Island. Fraser Island and Moreton Island have been depopulated of Aborigines in a very sordid and abrupt way.

There has been an historic tendency to accept the existing European Australian practices to predicate how the land should be used subsequently. This had unfortunate effects. It reinforces the rights of established management regimes and provides precedents for their continuation.

In 1893 the Australia Association for the Advancement of Science proposed that the whole of Fraser Island should be made a National Park, however due to the fact that a National Park would be incompatible with the existing logging operations, the proposal was shelved for over eightly years. Even now the Great Sandy National Park only embraces those parts of Fraser Island which the sandminers, land exploiters or timber interests are prepared to concede. Such exploiters have a virtual *defacto* power of veto over any National Park proposal in Queensland.

Although the character of the islands changed very little in the first century of European settlement, after World War Two the pressure for increased exploitation grew rapidly. North Stradbroke Island was the most accessible and suffered the heaviest impact mainly from sandmining. A whaling station was established at Tangalooma on Moreton Island in

1952. While the whaling station was in operation fertilizer trials were conducted using whale meat fertilizer in a futile bid to render the infertile sand more arable. When whaling ceased in 1962. Tangalooma became a resort.

During the 1960s there were a number of coincidental claims made for land on Fraser Island. A new resort proposal at Orchid Beach, applications for residential allotments by many individuals and the mining leases caused the Forestry Department to opt out of the total authority over Fraser Island. To accommodate this demand,and the Lands Administration Commission was given control over more than 80 kilometres of seaboard of Fraser Island between Eurong and Sandy Cape in 1963. During the 1960s there was a great deal of expansion of interests in resorts and residential areas. Land at the site of two villages, Eurong and Happy Valley, was subdivided and sold in 1966. Orchid Beach was established in 1966.

It was during the 1960s and 1970s that the European settlement of the islands made the biggest impact. The villages of Cowan Cowan and Kooringal on Moreton Island were also expanded and the subdivisions were sold off about this time.

The sandmasses have continued to attract a lot of public interest and attention. Since 1970 the recreational use of these areas has shown exponential increase. Increased vehicular ferry access has made the sandmasses much more accessible to four wheel drive recreational vehicles. The increase has been generally of the order of 12 to 20 per cent annually since the growth in popularity of off road vehicles. In the case of Fraser Island there has been an aggregate increase of about 1 000% in 15 years.

In 1970 there was a major move to expand the area of sandmining already established on both Fraser Island and Moreton Island. This led to a bitter land-use controversy which saw the establishment of such voluntary conservation groups as the Fraser Island Defenders Organisation and Moreton Island Protection Committee. The disputes simmered for years until 1975 when the Commonwealth Government established the Fraser Island Environmental Inquiry. This inquiry generated a great deal of information about Fraser Island. It also led to the banning of mineral sands from there for export which effectively has ended sandmining there since 1976.

Subsequently the Queensland Government, in an attempt to forestall Commonwealth Government intervention on Moreton Island commissioned an Environmental Impact Study from A.A. Heath and Partners. This was followed up by the Cook Inquiry into the land-use questions on Moreton Island in 1977.

In 1975 the Royal Society of Queensland held its first Symposium on Stradbroke Island. It held a second Symposium in 1984. The Queensland Government commissioned a management plan for Fraser Island in 1978, although it subsequently declined to implement its recommendations. The CSIRO about this time began their studies of dune dynamics on Cooloola which had relevance to the island sandmasses.

These various inquiries and studies have led to Queensland's sandmasses being amongst the best studied and most understood natural areas of Australia. The studies indicate the optimum management policies for these areas.

ACCESS AND LAND USE

Access to Stradbroke Island has been quite open for many years. Since sandmining began in the 1950s, there have been regular ferry services and roads to carry conventional vehicles.

Two of the islands, Moreton and Fraser, are untrafficable to any but off-road vehicles because there is no network of hardened roads. Until the late 1970s neither of these islands had even any sort of hotel and there was very limited permanent accommodation. There was no vehicular ferry service and it was difficult for any vehicle to be landed on the islands. There were no shops and all supplies had to be carried in. Self sufficiency was necessary. There were no schools, shops, police, casualty centres or public services. There is still no mains electricity supply on either of these two islands although there are moves in that direction. This has meant that until now many visitors have been deterred from going unless they had access to special vehicles and equipment or they were quite intrepid adventurers.

Each island is now served with three different vehicle services and a variety of other fast passenger services for day trippers. Although there are now hotels and resorts, the majority of visitors who stay over on Fraser Island and Moreton Island are campers. There is little in the way of support facilities and services.

There are three major means of travel on the islands: on foot, in a four wheel drive, or else in a conducted tour or safari. Four wheel drivers and their parties usually drive to one of the three embarkation points to the island and take one of the vehicular ferries. Regular daily tourist services

operate from Hervey Bay City, Rainbow Beach and Noosa to Fraser Island and from Brisbane, Redcliffe and the Redlands District to Moreton Island and Stradbroke Island.

Fraser Island has a permanent resident population of only about 100 people, who reside in one of the four main tourist villages of Orchid Beach, Happy Valley, Eurong or Dilli Village, the Ungowa Forestry camp or the Sandy Cape lighthouse station. Because of its mild climate and idyllic settings the campers far outnumber those who seek sturdier accommodation at one of the resorts. The resident population of Moreton Island is less than 50 and it is similarly based on the lighthouses and the tourist industry.

The permanent population of Stradbroke Island is about 1 667 due to the employment generated by the sandmining tourist, and fishing industries. It includes a significant Aboriginal population. The network of roads and power supply installed to serve the sandmining industry encouraged a larger infrastructure such as a school, shops and services with their associated employment. In turn this attracted a significant retired population.

Fraser Island annually attract more than 500 000 visits. Visitors are well catered, for even though not all tourist and travel agencies are as well informed about available services as they should be. Moreton Island attracts a similar number of visits.

The number of visits to Stradbroke Island is probably much larger but probably involves fewer persons such as residents and relatives making more frequent visits. The traffic to Stradbroke Island is oriented towards domestic purposes and recreation, whereas recreation is the dominant reason for the visitors to both Fraser Island and Moreton Island.

Fraser Island is divided between National Park and State Forest with some private tenure in places. Most of the southern two thirds of Fraser Island are State Forest and most of the northern third is National Park. There are fewer than 500 ha in private ownership but subdivision is causing a proliferation of landholders which makes implementation of management policies more difficult.

There is only one small national park on Stradbroke Island (512 ha). The bulk of Stradbroke Island is Vacant Crown Land. There is dispute over that land. Much of it covered by mining leases. Conservationists and the bulk of residents want this area committed to become national parks. The Queensland Government is determined to have it subdivided and to achieve that objective is planning a bridge across Moreton Bay.

Moreton Island has now more than 90 percent of its area covered by the Moreton Island National Park. The Queensland Government is pledged to convert another 6.4 percent to national park after it has been mined.

MANAGEMENT

It is proposed to focus on Fraser Island to illustrate the problems of management of all three islands.

Until 1963, the whole of Fraser Island was in the hands of the Forestry Department. The management of the island under a State Forest regime (other than its impact on the forests) was fairly benign. There had been no great impact on the island's eastern exposed coast. The number of visitors was well within its carrying capacity. It was only with the increasing fragmentation of management which took place from 1963 onwards that the degradation accelerated.

In 1963, the applications for extensive sandmining leases meant that the Forestry Department had to begin sharing management with the Mines Department. At the same time, a number of applications for permanent leases and other land tenure along the island's east coast prompted the Forestry Department to cede a strip about 80 kilometres along and one kilometre wide to the Lands Department. This enabled the Forestry Department to avoid the contentious problems of administering subdivision and resort development. However, the more that responsibility for this island was shared the weaker the overall management became. Management to most of this coastal strip from Eurong to Sandy Cape, could only be advanced if the mining companies, the Mines Department and the Lands Departments all agreed. All had some jurisdiction over it. No such agreements were forthcoming.

The added tourist interest added the dimensions of the control by both the Tourist Department and Fisheries Department to be added to the burgeoning bureaucracy. To that was added a Beach Erosion Control District administered by the Beach Protection Authority which extended 400 metres inland from the high water mark.

In 1971, the Queensland Government sought to appease public support for the conservation of the island by declaring a large section of the most remote northern end as a National Park. This has subsequently been enlarged to now embrace almost all of the northern third of the island. A new set of managers was installed - the Queensland National Parks and Wildlife Service.

Then in 1976, the Queensland Government resolved the squabble over which local authority, Maryborough or Hervey Bay should have the control over the island with the wisdom of Solomon. They changed the administration of Fraser Island from just one Council to being administered by two rival councils. This made the implementation of any effective by-law to control vehicular traffic or collection of a management fee almost impossible unless there was total unanimity between the two councils. This wasn't forthcoming. Splitting management between two authorities also meant that some private subdivision proposals, which would not have been previously countenanced, were allowed to proceed. The opportunity to prepare a strategic planning scheme for the whole island was frustrated.

All to this add the interest of other departments. The Department of Aboriginal Affairs and its concern for preserving Aboriginal artifacts and relics. The Water Resources Commission also became involved in attempting to preserve the quality of the great body of groundwater. The bureaucratic snare became even more entangled.

The impact of this continued proliferation of agencies with management responsibilities is best demonstrated by the frustrations experienced by the Maryborough City Council. In trying to establish a designated camping ground, the council, after six years was unable to proceed. It was frustrated in turn by the more than seven different Queensland Government departments. Similar frustrations prevented the Council establishing public toilet facilities and urgently needed public rubbish tips.

In a little over a decade, from 1963 to 1975, the Queensland Government has presided over the sharing of management decisions from just one government department, Forestry, to a proliferation of departments and a proliferation of private landholders. At the same time it rendered the local authorities impotent to address the problems. The level of management was reduced to the lowest common denominator.

In 1985 the Queensland Government responded to the public demands of the previous decade for better management. Management of Fraser Island is being coalesced again. A similar authority on Moreton Island has been foreshadowed.

Following special legislation passed by the Queensland Parliament, from 1st December, 1985 Fraser Island falls under the control of the Fraser Island Recreation Authority (FIRA). FIRA is a body which will divide management responsibilities between just two departments; the National Parks and Wildlife Service and the Forestry Department. Fees will be charged to all island visitors other than residents and people working there. Permits are needed prior to visiting the island from either of the Authority if it is intended to traverse or to camp there. The problem is to reduce the number of authorities with jurisdiction on the island. The Queensland Government has declared that the Authority is not going to address land-use, it is just going to "control the visitors to the island". At least this is seen as beginning to address some of the more critical management problems.

In 1984, there was some attempt to regulate the land-use on Moreton Island and Fraser Island in an extraordinary land deal. Mining companies surrendered some mining lease titles there in return for millions of dollars worth of real estate on Inskip Point immediately to the south of Fraser Island. Whilst the reduction of mining leases is welcomed by the conservation movement, there is still major alarm at the prospect that mining could occur on the remaining leases.

OBJECTIVES OF THE SAND ISLAND MANAGEMENT POLICIES

There is a major dilemma over the management of the sand islands. The principle management decisions can only be made by the Queensland Government or its agencies. The Queensland Government's political prescriptions for the objectives of management of the Great Sandy islands are oriented towards exploitation. The option for sandmining is retained on all three islands. Logging operations on Fraser Island are to be continued.

Such policies bring the Queensland Government into conflict with very large sections of the community represented by the voluntary conservation movement, which opposes exploitation. The conservation movement believes that there are most important aesthetic, cultural, biological and geomorphological values which deserve greater protection. They would prefer to see the bulk of islands' area dedicated as National Parks. They want exploitation limited.

The State government's attitude to maximization of tourism and its reluctance to obstruct free enterprise adds to the conflict over both land use and management. It has totally shunned this option of having National Parks taking precedence over other land-uses. This is also a source of continuing friction with the advocates of conservation who regard the sand islands as being very fragile and requiring sensitive management.

The Queensland Government has no environmental impact legislation at all. This has meant that many works on the islands are needlessly adding to the accelerating degradation. Roads are being widened, and urban expansion and building and construction projects proceed without any consideration for the environment. Environmental Impact Statements are not even required for the most destructive land use practices and proposals such as logging and sandmining. On the few occasions when EISs have been prepared they have had questionable validity and conclusions and/or the recommendations in them to minimize any adverse impact have been ignored.

There is also a difference between the Queensland Government and the Commonwealth Government over what should be the objectives of management. This reached its climax with the banning of mineral sand exports from Fraser Island from 31st December 1976. This action effectively stopped sandmining on Fraser Island. A similar restriction for mineral sands from Moreton Island is now Commonwealth Government policy. In addition, the proposal that the Commonwealth Government should nominate the whole of the Great Sandy Region for World Heritage listing has added to the strained intergovernmental relations on this issue. The Queensland Government, which reluctantly agreed to nominate the Great Barrier Reef for World Heritage listing in 1981, has now declared that "not one more inch of Queensland" will be added to that list.

In this tense political situation of quite contradictory objectives for management there has been little progress towards resolution. A Queensland Government commissioned management plan was prepared for Fraser Island in 1978 but it was immediately shelved. In 1983, the State government foreshadowed that it would respond to a critical management problem on Fraser Island by establishing a new management authority. On 1st December, 1985, two and a half years later the Fraser Island Recreation Authority is due to come into operation but without any degree of public involvement in the Authority, either as advisors or consultants in the process of development of the planning.

The Queensland Government has stated that its support for logging of Fraser Island is not negotiable. This is a further problem. However, the impasse over both logging and sandmining are not now seen as critical as the cumulative effects of general environmental degradation resulting from the present *laissez-faire* management. There is no control over the number of visitors, where they can camp, what becomes of the garbage that they generate, how they travel over the dunes, the creation of new roads and the widening of existing roads, the spreading influence of embroyonic urban areas and resorts, behaviour or hygiene. As well the Queensland Government has shown itself relatively impotent or weak in the control of squatters. The absence of environmental controls and the multiplicity of agencies dealing with these issues has prevented any resolution of the issues. The fact that there is almost a paranoia on the part of the Government to engage in any meaningful process of public consultation has impeded resolution of the issues.

Part of the problems may be resolved by the creation of one authority to control Fraser Island instead of the multiplicity of agencies which have shared and vied for control until now. The model of the Fraser Island Recreation Authority is being considered also for Moreton Island.

Many people believe that the degradation on Stradbroke Island is too far advanced to be able to easily resolve. There are still advocates of conservation and a majority of island residents who do not want this island degraded any further. They see the chance to resolve the management dilemma best served by including the bulk of Stradbroke Island in a national park.

Obviously there needs to be a mechanism to resolve the differences of opinion and the competing land use interests in Queensland. This is examplified by the impasse over the management of the sand islands. Unfortunately there is little opportunity for open consultation and public participation in the planning process in Queensland.

THREATS POSED TO THE SAND ISLANDS

The major threat to the sand islands comes from the failure to have any management plan which has public acceptance and endorsement. There are three major threats:

1. Sandmining

This is really only an issue which is at best stalemated by the position taken by the Commonwealth Government. The Queensland Government has a policy of encouraging the mining of about 6.4 percent of Moreton Island and a similar proportion of Fraser island. Sandmining is destructive of the environment in many ways. It has a heavy impact on the vegetation, the hydrology and the long term stability of the sandmasses. It is the most fiercely contested land-use issue involving the sandmasses as it is regarded by the majority of the

people as an unacceptable environmental cost for such highly regarded recreation areas.

The presence and even expansion of sandmining on Stradbroke Island results from three factors; firstly it is on the island which is regarded as the most degraded of the three; secondly, it is the basis of employment for a very significant proportion of the Stradbroke Island residents including the Aboriginal community; and thirdly because there is a very strong "squatter principle" in Queensland, which gives rights to any previous landuser.

2. Logging

This is only an issue on Fraser Island but here it is fought with the same passion and dedication as the sandmining issue or the campaign to prevent the continued logging of the tropical rainforest in North Queensland. Moreton Island and Stradbroke Island do not have commercial forests. It is the presence of the commercial forest which is effectively preventing the declaration of the most attractive and significant parts of Fraser Island as National Park.

3. Subdivisions and creeping urbanisation

This is really an issue which is most ominous on Stradbroke Island where the public auction of Crown land a few years ago yielded an unexpected bonanza which has spurred on a rapid release of Crown land and encouraged the Queensland Government to move to construct a new bridge across Moreton Bay. The Lands Administration Commission does not appear to have any clear policy on the release of land other than to maximize its cash return from land sales or to satisfy political requests.

It is this desire to realize the cash values of land that appears to underlie the Queensland Government's determination to build a bridge to Stradbroke Island and to destroy its remaining isolation. Stradbroke Island, already the most seriously degraded island of the three, will suffer irrepairable damage if the bridge is built, as currently seems most likely.

Squatting has occurred with seeming immunity on both Moreton Island and Fraser Island. The Lands Administration Commission seems unable to remove any determined squatter who calls its bluff. Worse, there is now an established practice of rewarding squatters with either cash or legal tenure elsewhere in bids to coerce them to move voluntarily.

Tourist resorts such as Orchid Beach and Eurong on Fraser Island and Tangalooma on Moreton Island are expanding rapidly. What began as isolated hotels catering for those seeking seclusion in remoteness have now become identified with creating enlarged urban complexes around them with consequential environmental degradation. For example to cater for the demands of the Eurong Resort following dramatic increases in the cost of diesel fuel, the local electricity authority is proposing to establish a swathe of destruction along the foredunes of more than 80 kilometres.

The establishment of properly organized camping areas is vital to the long term management of the islands but there is no coherent policy which could achieve that. Instead there is a catering to private developers who can sell plausible stories of what they will do if given title to a bit of land which they have "selected".

Added to these three major issues which many regard as incompatible with the long term use of the sandmasses are a number of lesser but still significant issues. These include:

a. Prevention of introduction of injurious agencies. The impact of Cane toads (*Bufo marinus*) on all islands, feral goats, horses and pigs on Moreton Island, the impact of brumbies and to a much lesser extent feral cattle on Fraser Island and the effect of feral cats and dogs needs to be addressed. Attempts to remove the feral cattle on Fraser Island as part of the tuberculosis-brucellosis campaign early in 1985, were not successful and some "scrubbers" remain. There was such a public outrage when it was suggested that the brumbies be removed from Fraser Island in 1974 that the authorities backed off. A similar controversy occurred when authorities attempted to eliminate feral animals from Moreton Island. Pigs were eliminated but some brumbies and goats remain.

   The largest problem exists on Stradbroke Island where there is no control of public access and there is a busy roll-on/roll-off ferry service and a network of sealed roads for conventional vehicles. This makes the dispersal of feral animals and ominous menace. There are feral cats, dogs foxes and fish (*Gambusia*) all having an adverse impact. It is believed that feral dogs may have eliminated the Agile wallaby population.

   On Fraser Island, dingoes have kept domestic dogs under control and there is virtually no evidence of feral cats. The Fraser Island Recreation Authority has indicated that it will now prevent any domestic cats from being taken to the island under any circumstances. However the Authority refuses to address the more vexed

issue of dogs, which are still allowed to go to Fraser Island and do so in great numbers.

The larger more sinister problem in the introduction of weeds, disease and pathogens such as *Phytophthora cinnamomi*. There appears to be no attempt to practice quarantine on islands such as these to insulate them from diseases which have ravaged much of the mainland in disturbed areas.

Already two noxious weeds, grounsel and lantana, have gained a strong foothold on all three islands. A more potent weed threat is Bitou Bush or Boneseed, which although not reported on any of the islands, is now well established at Inskip Point, just two kilometres across the water from Fraser Island.

b. Fire is a problem on the sandmasses where the surface of the soil can dry out very quickly. This, combined with the dense biomass allows uncontrollable fires to develop easily. There have been several major fires which have damaged the crowns of the forests on the northern part of Fraser Island during the last 20 years. All were results of deliberately lit fires which got out of control very quickly. Wider public usage has not increased the frequency of fires. The need for a fire management policy is vital for the whole of each island in any future management plan.

c. Control of traffic across the foredunes and limiting the number of vehicular access points to the beach and even the closing of beaches to vehicular traffic should be an important consideration for any managers. So far political considerations have prevented these options from being fully addressed.

d. Control over rubbish and garbage disposal. The preferred option of "carry in - carry out" is being practiced by more and more people. Unfortunately resorts are great creators of garbage and in the pursuit of profits shun this option. The result is that the resorts tend to create dumps convenient to themselves which are used with quiet abandon by the less environmentally conscious in ugly displays of laziness. This very visible symptom of management is one which has served to focus wider attention on the environmental sensitivity of the sandmasses

e. Sewage and human waste disposal. The perched lakes on the islands are a result of the sealing of the sand with organic colloids. The use of septic tanks tends to rapidly reproduce those conditions and cause the sand surrounding soakage drains to become impervious. This is a problem already experienced in every heavily used septic block. The alternatives of evaporation ponds are expensive and are shunned by the resorts. This is a problem yet to be properly addressed.

The safest method of human waste disposal is by the earth closet methods. These are used extensively by campers. Unfortunately, the indiscriminate location of these pits are unknown and apart from fouling the water quality they present a potential health hazard particularly as many campers do not observe all of the recommended practices in sealing them afterwards.

There is now a well recognized problem in trying to avoid enrichment and eutrification of the lakes by avoiding the use of soap and any other additions to the water. The awareness has not prevented one popular dune lake suffering considerable enrichment and loss of water quality through the added urine.

f. Foredune camping is now at a premium. The demand for sites is so great that on the better sites as soon as one lot of campers vacate the next campers move in. This has a devastating impact on the ground cover and access to the site. It usually means that the sites are progressively expanded. The impacts result from the destruction of the ground cover, the stripping and removal of trees, the fouling of the ground with litter and human waste and the proliferation of access tracks across the foredunes to the sites.

As firewood along the foredune is at a premium, it also usually results in the surrounding trees being stripped of any easily removable limbs. Because almost every camp uses open fires, and a very large percentage of four wheel drive vehicles carry chainsaws, the environmental impact that campers can be very severe. The constant use of the limited number of attractive sites does not allow sufficient time for the vegetation to recover. As well, the constant proliferation of both vehicle and pedestrian tracks across the foredune increases the problem.

The devastation of the vegetation in this fragile and sensitive foredune area plus the health hazards have made this type of camping one of the most urgent management problems to be addressed on both Fraser Island and Moreton

Island. The complexities of proliferation of authority described above, has so far prevented establishment of any adequate alternative to the present uncontrolled foredune camping practices.

g. The need for better environmental impact assessment of any new project on the sand islands must be recognized and practised. Too frequently shortcuts are taken deliberately by persons who work on the premise that "It is easier to beg forgiveness than obtain prior approval". Under this practise roads are widened, gravel is introduced to the sandmass with the impact on the water quality and the risk of pathogens, and clearing occurs indiscriminately. The process is assisted by the lack of clear authority and responsibility for control and the predjudice in Queensland against any form of mandatory environmental assessment. It is made worse by the lack of mechanisms for public involvement in the planning processes. As a result even statuatory authorities such as Telecom are negligent in applying proper environmental evaluations.

h. The management of people and traffic has become an increasing role for the police. Petty larceny, drunkeness and, most of all, loutish recklessness in vehicles, has increased alarmingly during the past five years on the sand islands. There has been a longstanding police presence on Stradbroke Island but Moreton Island and Fraser Island, where any police presence was until recently regarded as superflous, are now regarded as needing police during busy times. The Police Department is now planning to establish a Police Station on Fraser Island.

i. Expansion of National Parks. The most urgent issue in management policies for all three islands is the expansion of the existing National Parks. This is seen as a more or less permanent resolution to many of the land use problems.

This would also bring management under the control of one authority.

j. Restriction of access. The factor which has most aided the retention of the naturalness of the islands has been their relative isolation. The management problems have dramatically accelerated with the greater vehicle access by more ferries. The provision of bridges as proposed for Stradbroke Island would create the heaviest impact yet on these fragile ecosystems.

CONCLUSION

The three major offshore islands of south east Queensland are very important. They are important to the community as largely natural areas of great attraction which are ideally suited and conveniently located for recreation. They are very important biologically. They are extremely significant in geomorphic terms. Two islands, Moreton Island and Fraser Island, have retained their essential natural character and are being sought almost in their entirety as National Parks. Stradbroke Island is more degraded as a result of heavier settlement and more extensive sandmining but there is still a strong pressure for much greater areas to be dedicated as National Park rather than being opened up to more subdivision.

The attitude of the Queensland Government has been the largest single obstacle to the management of these sand islands. It has been unsympathetic to conservation. Therefore conservationists and others have increasingly turned to the Commonwealth Government to implement policies which would guarantee less exploitive management and preserve the natural character of these islands. The main objective is to ensure that future generations can enjoy the enormous recreational potential of these islands in a relatively undisturbed state.

REFERENCES

Cameron, McNamara and Partners, 1983. North Stradbroke Island Development Strategy, Queensland Government. (The Cameron McNamara Report)

Coleman, R.J., Covacavich, J. and Davie, P., eds., 1984. Focus on Stradbroke Boolarong and Stradbroke Island Management Organization, Brisbane.

Cook, N.J. *et al.* 1977. The Committee of Enquiry - Future Land Use Moreton Island Queensland Government. (The Cook Report).

Durbidge, E. and Covacevich, J., 1981. North Stradbroke Island, Stradbroke Island Management Organisation, Brisbane.

Fraser Island Defenders Organisation, 1978. Fraser Island Management Strategy 1978-2000.

Heath, A.A. and Partners. Moreton Island Environmental Impact Study and Strategic Plan.

Hicks, A.B. and Hookey, J., 1976. Fraser Island Environmental Inquiry - Final Report of the Commission of Inquiry. AGPS Canberra.

Hemmings, L. and Sinclair, J. 1984. Nomination of the Great Sandy Region for inclusion on the World Heritage List, Australian Conservation Foundation.

Horton, Helen, 1983. Islands of Moreton Bay Boolarong Publications, Brisbane.

Inter-Departmental Committee Report, 1978. Fraser Island Management Plan Queensland Coordinator General's Department.

Inter-Departmental Committee Report, 1972. Survey of Major Moreton Bay Islands, Queensland Coordinator General's Department.

Oceanic Islands - Differences in values and management when compared to continental islands

Mike Hinchey

Australian National Parks and Wildlife Service, GPO Box 636, Canberra ACT, 2601.

Oceanic Islands were considered to:

- be isolated from large land mass;
- usually possess plants and animals descended from forms capable of surviving the long distance from continental land masses. It can be presumed they started off with no species;
- possess a relatively small number of plants and animals when compared with continental islands of equivalent size. In the case of oceanic islands that lie on important migratory routes, this difference may not be quite so apparent for birds;
- evidence a high degree of speciation and sub-speciation. This one-off nature of oceanic island ecosystems can generally result in their being individually more biologically valuable than their continental counterparts;
- often support populations of animals extremely tolerant of humans in the first instance. As a result of this tolerance such species are highly vulnerable to disturbance and predation by man and domesticated animals. This vulnerability may be exacerbated by the absence of previous exposure to predators and competition;
- usually receive a low number of vagrants few of which successfully colonise. This is also a factor in the development of species and sub-species. The example of Christmas Island was cited where endemism among plants and land crabs is low at 10% and 8% respectively, whereas for vertebrates it is high - reptiles 68% and birds 50%;
- sometimes result in certain species evolving to fulfil different roles to their continental counterparts. Using Christmas Island again as an example, *Macaranga* there is a tall rainforest tree whereas elsewhere it is a successional or low shoreline species. Within that island's rainforest land crabs undertake the role of primary digester of forest floor litter, a role elsewhere undertaken by earthworms or leaf-eating insects;
- have generally been free of humans until late in the development of their faunas and floras. In the case of areas like Polynesia it is apparent that humans reached oceanic islands over a wide period of time.

Continental Islands on the other hand were considered to:

- support populations of species common to the adjacent mainland, the number depending on the size of the island;
- only support a degree of endemism or sub-speciation depending on the mobility of the species. Such development is more likely in the case of wingless animals and plants with small non-floating seeds or seed cases;
- be more likely to have had human pressure or visitation but not necessarily all types of such pressures. For example, native peoples may have visited continental islands but not been resident on them for significant periods.
- not be less or more prone to colonisation by species due to prevailing winds or ocean currents. This was asserted in view of experience at Macquarie Island and an artificial "island" created 180 km off the Western Australian coast where no pattern has emerged in over two years;
- be more likely to have replicates which to some extent may reduce their separate biological value;
- are more vulnerable to the introduction of feral animals and exotic plants indirectly through the auspices of man. For example, animals and plants may swim or float to continental islands or be carried there inadvertently by man.

It can be generally be concluded that the above differences are a combination of distance, replication, size and interference factors.

When considering **management** of both broad types of islands it is apparent that different parameters apply to both depending on whether they are developed/occupied by man or not.

When considering unoccupied islands management difficulties and expenses are generally higher for oceanic islands than continental islands. Western Australia's vast estate of continental islands however poses logistical problems in some cases just as significant as oceanic islands in view of that State's vast coastline.

Though uninhabited, continental islands, because of their proximity to continental land masses and populations, are more vulnerable to change by humans or domesticated organisms because of ease of access in a distance sense. In general, oceanic islands require larger and more expensive ships to successfully negotiate oceanic waters.

The unique nature of many oceanic islands may demand more enlightened management because the resources to be conserved may respond differently to their continental equivalents.

In Australia it is notable that some nature conservation reserves have been established over continental islands by States for many years whereas the Commonwealth has only recently moved to establish nature conservation reserves on Australia's oceanic islands.

Both Australian and New Zealand delegates recognised the immensely valuable logistical support provided in the past by the navies of both countries and by Government vessels of non nature conservation authorities ranging from fisheries to lighthouse supply vessels. Without such support the effectiveness of Australasian nature conservation authorities in administering the important values of oceanic and continental islands would have been much less.

This Workshop **recommends** to CONCOM Standing Committee that defence force and other Government vessels continue to be made available to support nature conservation authorities for island management as an integral part of their sovereign duties in the overseeing of Australian and New Zealand resources. This Workshop also **recommends** active liaison with defence forces to facilitate island management and notes that defence support has not and should not necessarily be confined to supporting such activities in its own country, as a gesture of goodwill and in recognition of the internationality of nature as set out in the World Conservation Strategy.

Management Planning for Islands

P.R. Dingwall

Department of Lands and Survey, Wellington New Zealand[1]

From papers presented on the subject and from ensuing discussion, several points of consensus emerged on the role of management planning for islands, as follows:

1. Management planning is widely accepted as an important component of management practice for islands, especially those which are legally protected. Indeed, one can argue that because of the greater management constraints on islands planning is more important for them than for mainland situations.

2. Approaches to management planning throughout Australia and New Zealand, though differing in some procedural details, are essentially similar in practice. Key common elements include a statutory basis for planning; the importance attached to research and monitoring in planning; the value of planning for involving the public in management decision-making; and the dynamic nature of the planning process which incorporates review procedures. A conspicuous exception occurs in Queensland where there is no legal provision for management planning or for public involvement in decision making.

3. Management planning is recognised as providing many benefits including; improving public awareness and education; facilitating assessment of manpower and financial requirements; and contributing to management training and co-ordination needs.

Some important considerations arose for guiding future planning efforts, as follows:

1. Management planning for islands is revealed as being still in its infancy and often neglected by comparison with other management activities.

2. Although greater priority is required for management planning, the constraints imposed by limited specialist capacity are also obvious. In most agencies, staff responsible for management planning of existing protected areas are also those required to investigate opportunities for adding new areas to the protected area system. Which of these two tasks should have priority? The ranking of islands according to their priority for management was highlighted as one solution.

3. Management planning for islands should not be conducted in isolation, but should take account of the place and role which islands have in their regional, national and international setting.

4. Some regard management planning as having become too detailed, involved and time-consuming. There is also concern that plans are often written with more regard to pedantic planning principles than to ensuring that plans are straightforward, realistic, attainable and readily assimilated by managers.

5. There are several options for improving the efficiency of plan preparation, such as:

   (a)

   Where comprehensive policy statements are prepared as a guide for management, with public consultation (eg, New Zealand's general policy for reserves), there may not be a need for detailed management plans. Implementation plans can be prepared for specific management programs.

   (b)

   Broad management strategies may be prepared for assemblages of islands, thus avoiding the need for a series of detailed plans for individual islands. This is easier where all protected islands in a group are managed under one authority (eg, New Zealand's maritime

---

1 Current address: Conservation Sciences Centre, Department of Conservation, PO Box 10-420 Wellington, New Zealand.

parks) than where there is divided authority (eg, Dampier Archipelago). There is also a danger that this approach might neglect the real differences in management requirements among islands. However, a major advantage is gained where co-ordinated planning of islands enables a wide range of protection and use options to be provided.

6. While the legal requirements for preparing management plans appear to be being satisfied, there is much less evidence that there is sufficient commitment of resources for effective implementation of plans. There are examples in Western Australia where funding has been guided by policies established in management plans. However, implementation doesn't just involve finance. A real test of planning is the role it plays in problem-solving. In New Zealand, wildlife management on islands is strictly governed by objectives established in management plans. Plans have also been used effectively in New Zealand to resolve conflicts over human access to island reserves, eg, Kapiti Island Nature Reserve where access is limited to a maximum of 50 persons per day. The Australian National Parks and Wildlife Service uses management plans as a fundamental guide to setting research priorities and implementing operational procedures.

7. The question was raised of what happened to policies when major new developments are proposed, such as oil recovery. It was noted that planning must be able to respond to such situations; as occurred a few years ago in New Zealand when contingency plans were prepared for accommodating the potential needs of offshore oil recovery operations in the vicinity of subantarctic island nature reserves - an operation which has not eventuated. The model provided by Barrow Island reveals that co-ordinated planning between private enterprise and a government land administration can allow potentially destructive developments to co-exist successfully with the requirements for nature conservation.

Feral Animals on islands - Effect and Control

K.D. Morris

Department of Conservation and Land Management, Karratha, W.A. 6714.

Earlier papers in these proceedings have discussed the effects and control of feral animals on Australia and New Zealand islands and it is clear that feral animals, both vertebrate and invertebrate, can significantly degrade conservation values of islands through predation, overgrazing, competition for food and nesting sites etc. It is also clear that eradication and control programs will only be successful if undertaken by personnel determined to succeed and if supported by appropriate resources. It should be noted that in this workshop no distinction is made between control and eradication and the term control is subsequently applied in the general sense.

Because of the large number of feral animals introduced to New Zealand, and the early realisation of the conservation values of New Zealand islands, control programs have been underway in New Zealand for many years and Australia has been able to learn a great deal from the New Zealand experience, particularly in control and post control techniques such as relocation of species. However, because of the physical differences between many Australian and New Zealand islands, and because instances control on Australian islands is undertaken to preserve population of native mammals (many of which are in the critical weight range referred to by Burbidge in these proceedings), Australian workers have in some cases developed their own technique for feral animal control.

Feral animal control is an important aspect of island management in both Australia and New Zealand, and consideration was given during this workshop to how priorities for control should be established. Consideration was also given to responsibility for control of feral animals and the public relations aspect of feral animal control.

Resources for feral animal control including funding, personnel and equipment have always been, and will probably continue to be limited and it is important for any organisation involved in this to determine their own priorities. Some of the factors influencing these priorities could be:

a. Is the feral animal actually a problem animal and causing damage to an ecosystem?

b. Does its continued presence threaten the survival of a species? (Islands with the last population of a species should receive high priority for control.)

c. What other values does the island have, and will eradication of the feral species make it available for other purposes?

d. Is there a good chance of successful eradication, and is there a possibility of further works being required.

e. How many feral species need controlling? If more than one species, it should be determined which be eradicated first and what the consequences of this on the other feral species will be.

Presently feral animal control is conducted by government agencies on land for which they have responsibility, or against declared pest species. There are problems on freehold and leased islands where the owner/lessee does not control feral animals and in some cases may even encourage them.

It was suggested that feral animal control should be a coordinated undertaking between all responsible government agencies and land owners, and that a single species, such as the fox in Australia, should be tackled on a national scale. Invertebrate pest species should also be considered for coordinated control where they affect wildlife conservation. Techniques for control such as genetic engineering, sterilization and chemosterilants were discussed. This type of response to feral animal control could possibly be co-ordinated by the CONCOM Feral Animal Committee. As part of this co-ordinated approach, a register of personnel and institutions involved in feral animal control in New Zealand and Australia would be kept.

Public scrutiny of feral animal control programs is increasing and the public relations aspect is an important consideration when planning such a program. The public should be informed accurately about why control is necessary and how it will be undertaken. The positive aspects of the program should be emphasized. There is a Code of Practice for feral animal control and control should be undertaken in the most humane way possible. The emotive value of target species is also important to consider, especially when undertaking control programs close to population centres.

Translocation of Endangered Species to Islands

Brian D. Bell

Department of Internal Affairs, Wellington, New Zealand

Brian Bell introduced the discussion by explaining that translocation was one of many techniques available as a management tool for conservation of rare species. However, it should not be treated as an end in itself but should have specific objectives. We must be aware of the consequences of any translocation undertaken. Although we are discussing island transfers it could be extended to include mainland islands, where habitats have been isolated by land management and populations within them have no contact e.g. N.I. Kokako. While considering the limitations of transfers we could perhaps consider international translocations, for example the echo parakeet from Mauritius to Christmas Island. Zoogeographic regions might be the limits for such translocations.

The role of captive breeding was raised. Brian said there was a place for captive breeding in translocation. It has a number of problems which are not involved in wild species transfers. These include the problem of the species settling into captivity and when there they are move vulnerable to disease, getting them to breed, imprinting etc. Then there is the problem of releasing them back into the wild so that they are equipped to deal with predation, finding natural foods etc. There are few examples of success at present but the method should not be abandoned as it does provide another method of helping species in trouble, and in some cases may be the only practical solution.

Harry Butler raised the question of the legal ownership of captive animals as they are no longer wild. Andrew Burbidge considered it was essential that ownership of the animals should be maintained by the nature conservation authorities. This could perhaps be achieved by lending the animals to the zoos. Harry also raised the question of what do you do with animals bred up in captivity. He saw releasing them back into the wild as having some problems with the possibility of transmitting disease back into the field. Many diseases (not all) are present in the wild and only become problems under additional stress.

Andrew asked if there was a need for guidelines to be established for the geographic range of releases. Brian said no guidelines had been set up but it clearly needed considerable thought before any action was taken. Some releases could jeopardise later options.

Brian pointed out that zoos which have a multipurpose approach have a high disease risk. The New Zealand Wildlife Service had established a special station for breeding only takahe so that the disease risk factor could be kept to a minimum. Only eggs were taken into the station. The cost factor in captive rearing is also a disadvantage. Islands are really open-air aviaries and birds can be cropped from these from time to time very economically.

John Sinclair said there was an over-abundance of koala on Philip Island which could be placed elsewhere. This was also the case on Kangaroo and Magnetic Islands. They had originally been translocated to these islands. Several people questioned whether transfers should be made at all. Harry considered it important to boost numbers of endangered species as there was safety in numbers. Brian said priorities for translocation needed to be set and this could be on taxonomic as well as other grounds.

John raised the question of whether the transfer of kokako to Little Barrier was really in that species' interest. Once the birds were put on an island timber interests could say the birds were safe and their habitat was no longer critical. Ian Atkinson pointed out that we cannot guarantee the kokako will survive on Little Barrier in the long-term. Brian said that the birds had come from areas already being clearfelled. The main habitats (on the mainland) still required maximum protection to maintain the real core of the kokako population and

that had priority. The Little Barrier move was only additional security.

Brian continued by explaining that some translocations are not as successful as others. Recent stitchbirds transfers have been disappointing since, after initial establishment, numbers have declined. This may be due to a shortage of food at certain times during the year under unusual weather patterns, etc. The question is being studied. He also suggested that 30 birds is the minimum figure for transfers if this is possible. In the case of endangered species it is often necessary to transfer considerably less than this number. Harry inquired whether a "stud book" was kept for our translocated species. This was not done but in some cases where small populations are involved this virtually occurs, e.g. black robin. However, the main aim is to increase numbers as quickly as possible.

The question of re-introducing plants was discussed and it was suggested that tissue cultures may be a suitable way of avoiding the introduction of undesirable pathogens. Tony Robinson suggested that there were some problems in that the species you clone may have no resemblance to the wild population.

David Rounsevell asked whether translocation was anything more than buying time. Harry saw it as something one may be forced to do or a way of insuring future security. He did question the possibility of shifting animals from one region to another. However, some species have been saved by this method. There are New Zealand examples and others from the Pacific.

Harry also inquired whether we should examine the genetics of endangered species before doing further translocations. The development of new technology is increasing the scope of work that can be undertaken in this field. Brian pointed out that restrictions have been made in relation to moving kiwis because genetic studies involving blood protein analysis by electrophoresis have shown that there may be three distinct types of North Island brown kiwi. Insufficient genetic heterozygosity could also be a factor but if the individuals transferred are genetically diverse and the population grows quickly, there should be no long-term problems. Many island populations undoubtedly established naturally from a very small number of individuals and this seems to indicate that few problems will arise.

Tony pointed out that, despite the large number of islands, few options were available for transfer of mainland animals. Brian agreed that islands are a limited resource, particularly islands that are large enough to ensure long-term survival. While translocation is a management tool applicable in some circumstances, it is not the primary objective. This must be to preserve existing habitats and the species within them.

Managing Public Use of Islands

Susan A. Moore

Planning Branch, W.A. Department of Conservation and Land Management, Murdoch House, 5 The Esplanade, Mt. Pleasant W.A. 6153.

This workshop was based on the general acceptance that the public use and are attracted to islands. This use may be recreational or educational, or both. In all instances the managing agency should attempt to guide use of an island, or group of islands, so that the public gain an appreciation and understanding of the island's natural values and features.

The following discussion points were used:

1. Conservation as a primary objective;
2. The importance of interpretation;
3. Managing traditional use;
4. Social research and monitoring; and
5. The regional setting and planning in a regional context.

CONSERVATION AS A PRIMARY OBJECTIVE

The workshop agreed that conservation should be the primary objective in the management of most of our offshore islands. This objective should determine the acceptable level of public use.

THE IMPORTANCE OF INTERPRETATION

It was agreed that all use of islands by the public should be guided by interpretive facilities (e.g. signs) and, if possible, interpretive programs (e.g. pamphlets, guided tours). Discussions on ways of guiding public use, and informing and educating the public, occupied most of the workshop session.

The main limiting factors, in the provision of interpretive facilities and material, are staff and resources. In addition, interpretation is recognised as a skill and, therefore, staff with expertise in this area are fundamental to the success of any interpretive program. Thus, given limited resources, effort should be concentrated on more heavily used islands or more heavily used site(s) on a given island. A major problem in informing and educating island users is the nature of the user, as many are 'individuals' seeking areas little used by the general public. One solution is placing signs at launching sites or conspicuous sites, and then reinforcing the message with signs on the islands. However, with an area like the Great Barrier Reef, with thousands of islands and hundreds of kilometres of coastline from which boats can be launched, the manager may find it difficult to anticipate where people come from and where they go.

The workshop felt that the wording on signs should be as brief as possible, and the number of signs should be kept to a minimum. It may be appropriate in some areas to have signs in several languages (e.g. Ashmore Reef).

Another solution is providing guides. In New Zealand, on Kapiti Island, the ranger (or his wife) meets the boat-loads of visitors as they arrive, and provides a 15 minute briefing on where to go, what to see and how to act. Good training for these guides is essential, and it was suggested that guides should be issued with a licence once they have successfully completed a training course. People in organised parties were recognised as being generally easier to control than 'unsupervised' individuals or groups.

Another solution is self-guided walks and unmanned interpretive facilities. In general, rangers are the preferred resource, then guides, then pamphlets, then signs, all of which were considered better than nothing at all.

Licencing was advocated as a solution to both educational and enforcement/management problems. It was suggested that when a licence for use of a particular island is issued, it is accompanied by information on the values of the island. This technique has been successfully used in both Australia and New Zealand. In Western Australia, ecological information on the value of local offshore islands has recently been added to the boat user's guidebook for the Barrow Island region. In Queensland, the tide book includes information on conservation.

Not only does licencing provide a way of informing the public, it also provides a means of managing

potential damaging forms of use, such as the construction and use of shacks. This approach has achieved some success on islands off the Western Australian coastline, with squatters occupying shacks gradually leaving once their licence or lease has expired.

All workshop members agreed that the surveillance necessary to achieve a satisfactory level of control and guidance of public use was not currently available.

MANAGING TRADITIONAL USE

The problems of managing traditional use and informing traditional users of the conservation values of an island, or group of islands, was identified by all workshop members. Although traditional use is difficult to define, it must be recognised as a valid form of public use. As such, total protection is an unrealistic goal. Management plans identifying an acceptable range and level of uses provide a solution.

Joint management and formulation of management plans is one of the best ways of informing traditional users of the conservation values of an area as well as rationalising the level of use. In Australia joint management plans have been developed for several national parks in the Northern Territory. The development of these plans has been based on the use of a planning matrix to compare conservation needs with the aspirations/perceptions of the traditional users. In this way areas of conflict can be identified and moves instigated to resolve them.

SOCIAL RESEARCH AND MONITORING

Social research is necessary to firstly, investigate the capability of a site to support various levels of use without unacceptable levels of damage to the environment, and secondly, to determine the demand for particular forms of use. Once information is available on these two aspects, the suitability of a site for a particular form of use can be determined.

The need for monitoring is now widely accepted. However, the importance of monitoring the success, or otherwise, of management practices, particularly those related to public use, deserves special emphasis. This could involve, for example, monitoring the effectiveness of interpretive facilities. Social monitoring may range from regular counts of visitor numbers to more detailed data collection to determine the impact of a particular form of recreational use.

THE REGIONAL SETTING AND PLANNING IN A REGIONAL CONTEXT

Planning in a regional context (i.e. local, state, national and international) is essential if the conservation values of islands are to be protected, whilst at the same time meeting recreational demand. Planning must be based on a recognition of regional demands, as well as the suitability of parts of an island, or of an island in a group, for particular forms of public use. In this way more sensitive areas or islands can be protected by directing use to less sensitive sites.

This serves to emphasise the importance of regional planning independent of tenure. In this way, for example on multiple-use islands, private enterprise could be encouraged to absorb the majority of use, thus keeping areas of high conservation value relatively free of disturbance.

Zoning was suggested as a successful technique for optimising resource use and management. Zoning should be based on a stratification of uses and areas. The workshop agreed on the importance of zoning, although it may necessitate some sacrifice of conservation values in certain areas.

The workshop concluded that planned management of public use, particularly in regard to the optimisation of resources at the regional level, was essential for the conservation of island values. An integral part of this planning is the provision of interpretive facilities and material.

Developing Priorities for the Use of Scarce Resources

Keiran J. McNamara

Department of Conservation and Land Management, PO Box 104 Como WA 6152.

INTRODUCTION

Resources were regarded as consisting essentially of personnel and financial allocations, with the latter governing the availability of equipment and access to islands. The workshop accepted, as a basis for discussion, that:

1) Islands are of crucial importance for nature conservation;

2) Resource requirements are high, particularly because of the costs of access to and surveillance of islands using boats and aircraft, and the correspondingly high costs associated with any resident staff and operational bases;

3) Resources are inadequate to carry out the range of activities on islands which would be desirable, or even essential, for nature conservation purposes, and are likely to remain so;

4) It is therefore necessary to develop priorities for the use of those scarce resources.

The situation is also changing rapidly, for example in terms of increasing visitation to islands by people with more leisure time and boats, an increasing focus on islands by tourism and extractive industries, and changing ownership of some islands.

The workshop then addressed its topic under four headings as follows.

Priorities Between The Mainland And Islands

It was recognised that while nature conservation problems and responsibilities on islands are significant, so are those on the mainland. It is therefore impossible to consider islands entirely separately from the remainder of the nature conservation estate. The roles of government agencies and the political process in ultimately setting priorities for the allocation of resources were noted.

The proposition was put that nature conservation authorities are aware of the importance of islands and their resource allocation to islands has been reasonable, with some notable exceptions, in relation to known problems and threats and the total resources available. Responses to this varied. In some cases the statement was considered accurate, even to the extent that in New Zealand there has been criticism that too little attention is being paid to mainland problems. On the other hand it was pointed out that in other places islands have been totally ignored, or almost so. A "rule of thumb" that a set percentage of resources be allocated to islands was suggested, but the figure would have to vary according to the circumstances of each nature conservation agency.

Priorities Between One Island And Another

The workshop then turned to priorities between one island and another, although much of the discussion was equally pertinent to the issue of priorities between the mainland and islands. It was noted that resource allocation has varied widely between islands, from very high in a few instances (eg. several New Zealand examples, Lord Howe Island, Christmas Island) to nil in many cases.

Reference was made to Western Australia where priorities for management have been developed using stated criteria, resulting in the most critical islands, out of a total of 3 400, being identified (Burbidge, this publication). Those criteria were based on mammals in the critical weight range, endemic species, important seabirds, seals, turtles, current or impending disturbance, need for rehabilitation (including eradication of exotic plants and animals), and potential for the reintroduction or introduction of endangered species. There was some discussion of the apparent emphasis on vertebrates in these criteria. This reflects the fact that comparable information on other biota is generally lacking and it was also said that many vertebrates, because of their appeal to people, can help attract public support for island conservation priorities.

It was generally agreed that agencies with responsibility for nature conservation on islands

should identify priorities based on a systematic examination of available information and using criteria relevant to their own regions and circumstances. Some factors other than those used for Western Australia which might need to be taken into account are island size, access, political and socio-economic factors (eg. relating to the tourism, fishing and the oil and mining industries), proximity to population centres, and the traditional and/or legal rights of island residents, owners and visitors. It was also noted that a priority-setting process of this type might be more applicable to relatively similar continental islands, the values of which are more likely to be replicated, than to oceanic islands, each of which is likely to be of very high value. Priorities should remain flexible, as they may need to be changed as more information becomes available.

In summary it was noted that the greater problem is the total allocation of resources for nature conservation, rather than allocations between the mainland and islands or between one island and another. It was also suggested that each agency with responsibility for nature conservation on islands should establish a specialist islands unit, recognising that islands present different problems to the mainland and that they require significant resource allocation. One task of such units would be to develop and review priorities.

What Purposes Should Resources Be Used For?

The purposes for which resources could be used were listed as:

- survey/inventory of island resources;
- research;
- management planning;
- management (including the options of no intervention, minimal intervention and active manipulation);
- monitoring;
- surveillance and enforcement;
- public education, information and interpretation;
- lobbying for public, agency and political support for increased resources.

Some emphasis was put on the need for priority to be given to the allocation of resources to management and monitoring, particularly for those islands where good inventory and research information is already available. However the workshop took the view that there is no universal answer to this question, as circumstances vary widely from one case to another. There was recognition of the need for an integrated approach to island nature conservation responsibilities, with all of the listed activities being carried out simultaneously to the greatest extent practicable. Opportunistic visits to islands, for example with defence force or lighthouse maintenance vessels, often assist in the carrying out of these activities at relatively little cost.

Several participants pointed out that public demands and expectations will have a significant influence on the use to which resources are put. This is likely to be particularly evident in relation to recreational and interpretive needs. The view was put that most resources in the future will be allocated to management of environments which have been, are being or are about to be used or disturbed by human activity. The need for planning, for example to avoid the mistakes made on many islands, was also emphasised.

Most importantly, it was noted that there needs to be an ongoing commitment to the provision of resources for management.

How Do We Get Increased Resources?

The workshop briefly discussed some means of increasing the resources available for island work, noting that islands have to compete with other demands on limited resources. As well as the usual means of educating and informing the general public about the values and importance of islands so that there is community support for their conservation, and the lobbying of government agencies and politicians, some time was spent discussing:

- the use of volunteers, honorary wardens or wildlife officers, amateur naturalists and lighthouse-keepers, with proper direction;
- the valuable information which can be obtained from Aboriginals where they inhabit or visit islands;
- the need to make more use of corporate and private sources of funds.

Clearly there is a need for increased resources to be allocated to nature conservation on islands, and consequently there is a need to put more effort into achieving that objective.

REFERENCE

Burbidge, A.A. This publication.

Summary Report of CONCOM Technical Workshop on Island Management

Keiran J McNamara

Department of Conservation and Land Management, PO Box 104 Como WA 6152.

INTRODUCTION

The thousands of islands in the Australia-New Zealand region traverse a range of climates from subantarctic to tropical. They include examples of oceanic, continental and coralline origin, and range in size from small rock stacks to many thousand hectares. Islands are of crucial importance to nature conservation, but they present special problems for management and are increasingly being used for purposes other than conservation.

At its thirteenth meeting in July 1984, the Council of Nature Conservation Ministers (CONCOM) supported a proposal for a workshop on the management of islands. The Western Australian Department of Conservation and Land Management convened the workshop which was held on 8-13 November, 1985 at Barrow Island with the generous assistance of West Australian Petroleum Pty Ltd (WAPET) and Mr W.H. Butler of WAPET's conservation consultant Dinara Pty Ltd.

The objective of the workshop was to review island survey, ecology and management in the AustraliaNew Zealand context and to publish a series of comprehensive review papers as an up-to-date statement of island biological conservation.

The workshop was attended by representatives from a number of State, Territory, Commonwealth and New Zealand nature conservation agencies and by other specialists involved in island research and conservation, including the consultant to a private company engaged in the management of Barrow Island. The Queensland, New South Wales and Victorian nature conservation authorities were not represented, resulting in an incomplete coverage of Australian islands. A list of participants is given at the front of this publication.

In addition to the presentation of review papers and formal discussion sessions, field excursions were an important part of the workshop. Barrow Island is one of the most important islands for nature conservation in Australia, particularly because of its faunal richness which includes several rare mammals and large turtle populations. The island has been developed as a commercial oilfield since 1964. Participants examined the environmental controls that have governed this development, including measures to prevent the introduction of exotic plants and animals, waste disposal, rehabilitation and fire suppression. The workshop noted that while there have been inevitable impacts as a result of the development, the high nature conservation value of the island has been maintained through the management techniques followed by WAPET. The introduction of exotic plants and animals has been prevented and the island's full suite of indigenous species remains intact.

This summary report is intended to draw together the workshop's conclusions and recommendations for consideration by CONCOM and for use by interested individuals, organisations and government agencies. As far as possible this summary report represents the consensus reached at the workshop, but this does not imply that all of the conclusions and recommendations are necessarily supported by all of the workshop participants or by the agencies, organisations and companies they represent.

Values of Islands

Islands have a range of values which make them crucially important for nature conservation. Islands and their surrounding marine environments have intrinsic values as functioning ecosystems supporting a variety of wildlife. Their features range from habitats and species unique to islands, especially in the case of oceanic islands, to being examples of adjacent mainland ecosystems.

The importance of islands for biological conservation would be difficult to overstate. They provide the major breeding grounds for seabirds, turtles and seals, with many species breeding only on islands. As well as supporting more common wildlife, islands are also refuges for many rare and endangered species which either occur only on islands or have

their most secure populations on islands. Another feature is that because of the isolation of islands, various life forms have evolved quite differently from related forms elsewhere, resulting in a high degree of endemism among many island biotas. The biological significance of islands is illustrated by the following:

- without offshore islands, 10 species of terrestrial mammals which formerly occurred on the Australian mainland would have become extinct (see Table 1), while some other mammals which have suffered serious declines on the Australian mainland now have their most secure populations on islands (e.g. tammar wallaby, eastern barred bandicoot);
- eight birds occurring in Australia's external island territories are on the CONCOM list of endangered vertebrates (including Abbott's booby, Norfolk Island parrot), as are three birds from Lord Howe Island (including the Lord Howe Island woodhen) and a number of other species occurring on various islands (e.g. six of the mammals listed in Table 1, rufous hare-wallaby, Gould's petrel, lesser noddy, forty-spotted pardalote, Lancelin Island skink, Pedra Branca skink);
- of 39 species or subspecies of terrestrial mammal declared rare under the Western Australian Wildlife Conservation Act, 13 occur on islands in the State, and six of those occur in the State only on islands;
- about 25% of New Zealand's native frog and reptile species are confined to its offshore and outlying islands, as are about 50% of its species and subspecies of breeding birds, 6% of its vascular plant species and some groups of invertebrates (e.g. stitchbird, saddleback, Chatham Island black robin, little spotted kiwi, Antipodes Island parakeet, tuatara, Stephens Island gecko, Hamilton's frog and the giant weta *Deinacrida heteracantha*), and without offshore islands six species of birds from the North and South Islands of New Zealand would have become extinct;
- the islands of Bass Strait support an estimated 18 million short-tailed shearwaters, while New Zealand's Snares Islands are breeding grounds for an estimated 5 million sooty shearwaters and thousands of other seabirds, including the endemic Snares crested penguin;
- New Zealand's Auckland Islands are the main breeding grounds for the rare Hooker's sea-lion as well as being a breeding site for at least 52 species of birds including 3 penguins and 17 albatrosses, mollymawks and petrels.

Mainland and island ecosystems have suffered from the deleterious impacts of human activity, such as introduction of non-indigenous animals (predators and herbivores, including domestic stock) and plants, habitat destruction, increased use of fire, disease, mining, industrialisation, pollution, exploitation of wildlife, human habitation and general human use including tourism and recreation. While European people have been responsible for massive changes, indigenous peoples have also used and affected many islands.

The extent to which islands have been affected by human activity varies widely, ranging from islands which have been almost totally devastated (e.g. Philip Island (near Norfold Island) through introduced herbivores), through islands which are used for various purposes but are well managed, to those which are relatively free of human influence. There are still many islands which have escaped some or all of the deleterious impacts of human activity. Depending on their degree of modification, islands can be reference areas which provide an insight into the pre-European (and even pre-Aboriginal or pre-Maori) environment, as well as opportunities to study the effects of various human influences.

Islands have other scientific values as living laboratories where plant and animal communities can be studied. In particular, islands provide:

- opportunities to study intact biotas and genetic resources, relatively undisturbed ecosystems, and evolutionary and geomorphic processes;
- opportunities to study island biogeography and issues of critical importance to conservation such as reserve size and design, minimum viable population size and genetic bottlenecks;
- benchmarks against which to measure the effects of human activity on mainland and other island ecosystems (e.g. reference areas for fire studies);
- opportunities to study and experiment with management techniques;
- the possibility of monitoring the health of marine ecosystems using indicator species (e.g. key seabirds).

One of the most important features of islands is that, because of their isolation and size, they often present the opportunity to correct past mistakes in a way not possible on the mainland. For example, eradication rather than control of problem species on islands can be achieved, whereas constant reinvasion would occur

Table 1

Mammals which have become extinct on the Australian mainland but survive on islands (compiled from Strahan 1983; Burbidge and Jenkins 1984).

Extinct on mainland	Occurs only on islands other than Tasmania (number of islands shown in brackets)	Occurs only in Tasmania	Listed as endangered by CONCOM
Thylacine *Thylacinus cynocephalus*	Xa		X
Eastern quoll *Dasyurus viverrinus*		X	
Tasmanian devil *Sarcophilus harrisii*		X	
Western barred bandicoot *Perameles bougainville*	X (2)		X
Burrowing bettong *Bettongia lesueur*	X (4)b		X
Tasmanian bettong *Bettongia gaimardi*		Xc	
Banded hare-wallaby *Lagostrophus fasciatus*	X (2)b		X
Tasmanian pademelon *Thylogale billardierii*		Xd	
Greater stick-nest rat *Leporillus conditor*	X (1)		X
Shark Bay mouse *Pseudomys praeconis*	X (1)		X

a. The thylacine is considered to be extremely rare, and possibly extinct, in Tasmania.

b. Not including Dirk Hartog Island, where it is now extinct.

c. Including Bruny Island.

d. Including a number of islands in Bass Strait.

on a mainland reserve. Isolation also means that many deleterious impacts can be prevented from occurring in the first place.

Finally, islands are important because of their past and present use by people, as they:

- may be home to or have special significance for Aboriginal communities;
- may be sites of past human use and exploitation of historical or archaeological significance, thereby comprising an important part of our cultural heritage;
- may be places where people live and work;
- provide a range of recreational and tourism opportunities which are attractive to many people;
- provide a range of scientific and educational opportunities, because of their many features and values;
- provide a range of opportunities for commercial development and resource exploitation.

It is important to conserve islands for all of these reasons and as representative samples of island communities.

ISLAND CONSERVATION PROBLEMS

"Island ecosystems are extremely vulnerable to disturbance, and such factors as fire, introduced animals and plants, pollution of the surrounding seas or even too many people coming ashore could trigger off changes that would eliminate whole species" (Crisp 1985).

Management agencies and others involved with island management face a range of problems which threaten the nature conservation values of islands.

General

There is an overriding need for increased awareness of the importance and vulnerability of islands and for a greater commitment to their protection.

Some particular problems of a political nature are:

- remote islands are of high national significance because of extensions they provide to national sovereignty but the provision of adequate protection and surveillance is very costly;
- legislation relating to the management of islands is often inconsistent or overlapping, and inadequate;
- attention is drawn to inhabited islands rather than uninhabited islands for electoral reasons.

Failure to recognize the threats to the values of islands for nature conservation and to deal with them effectively could result in further serious degradation of islands and extinction of many Australasian species.

Protected Area Status

Conservation problems may arise as a result of the status of islands and their surrounding marine environments. Problems include:

- some islands with significant nature conservation values do not have protected area status;
- in some cases existing island reserves have insufficient security, as they may be revoked without parliamentary approval;
- there are no management plans for most existing island reserves;
- island reserves which do not extend to low water mark or include the entire island give rise to inadequate control of public access and foreshore and littoral communities;
- the existence of multiple management authorities for islands or groups of islands can result in uncoordinated development and often expensive conflict between authorities;
- misuse of surrounding marine environments can have an impact on islands.

Human Use

Islands have intrinsic attractions for residents and visitors but misuse may lead to degradation and destruction of the island values which people want to enjoy. Problems include:

- disturbance of breeding areas and animals, particularly on beaches where the majority of visitor impact is centred;
- transport and introduction of exotic plants and animals (e.g. weed seeds, pets, rats and mice);
- accumulation of litter and human waste;
- erection of buildings, campsites and facilities which may be inappropriate, cause erosion, increase the risk of introductions, and become a focus for people thus concentrating disturbance;
- increased trampling and use of off-road vehicles and machines, particularly on foredunes and other fragile areas, can lead to blowouts and soil disturbance which are extremely difficult to control;
- indiscriminate collection of specimens by both visitors and scientists can deplete or even exterminate vulnerable island populations;
- cutting of island vegetation for fuel;
- significant health problems and physical injury for visitors can result from inadequate sewage and litter control and cause bacterial infection of wildlife;
- island residents and visitors with legal or traditional rights may exercise those rights in a way which adversely affects conservation values.

All developments for tourism, recreation, extractive industries, agriculture, grazing or fishing have potential for significant impact on island values. Particular problems include:

- island developments often need to be more self-contained than equivalent mainland developments, leading to utilisation of island resources and disposal of wastes which may create a serious effect on island conservation values (e.g. uncontrolled extraction of water from small island aquifers can cause destruction of the water resources to the detriment of the island's flora and fauna and the development; it is often not economically viable to return rubbish and wastes to the mainland);
- often there are no clear environmental guidelines available before developments take place;
- where there is ignorance of the need for quarantine and lack of compliance with existing procedures, the possibility of accidental introductions is greatly increased;
- sufficient attention has not always been paid to rehabilitation of degraded and disturbed areas;
- the presence of an island development may increase casual visitation.

Another problem which has been evident is a lack of respect for the conservation values of islands by people from other nations visiting islands while exploiting marine resources.

Introduced Species

Islands are particularly susceptible to introduced plants and animals such as predators, herbivores, weeds and diseases, including the dieback fungus *Phytophthora cinnamomi*. History shows conclusively that introductions can cause rapid extinctions of island species.

Problem species often threaten the last populations of endangered species, including some animals which have become extinct on adjacent mainland areas where eradication of the problem species is not possible.

While eradication is often possible on islands, it is generally expensive and requires considerable commitment, and ingenuity, over a long period. Where introduced rats are involved, eradication is usually not possible except on the smallest islands.

There are a few examples where it has been argued that feral species on islands should not be eradicated because they have, or may have, special scientific values (e.g. in genetic terms).

Fire

Many islands have been burnt very infrequently in historical times, and some not at all. The species on these islands may not be adapted to frequent fire. Particular problems associated with fire are:

- access to fight island fires is extremely difficult and fires often burn virtually all vegetation;
- lack of adequate surveillance networks means that fires are often not detected until it is too late to effect control;
- there is often little or no logistical support and equipment (boats, helicopters etc.) available on or near islands to allow a quick response;
- increasing visitor usage, if unmanaged, will inevitably increase fire frequency;
- on islands with a variety of land uses the absence of coordinated fire control programs and strategies may lead to loss of conservation values;
- polarity of scientific and management opinion on island fire management has resulted in non uniform fire regimes on islands.

Resources for Management

Management of islands is often more expensive than management of mainland reserves for a number of reasons:

- there can be difficulties of access and transport costs are high;
- island structures are particularly vulnerable to deterioration and destruction and require regular maintenance and security;
- island management staff need special skills and training;
- there is often a lack of resident staff and support facilities;
- island isolation can cause a high turnover of management staff;
- social problems and cultural differences may be exacerbated in isolated island communities.

Resources allocated to island conservation are inadequate to carry out the range of activities which would be desirable for nature conservation purposes.

RECOMMENDATIONS

The problems facing island managers are not uniform around Australia and New Zealand, nor has island management progressed to the same level in all areas. Consequently, the following recommendations are not necessarily equally applicable in all areas and to all CONCOM agencies and others involved with island management.

In recognition of the special nature conservation values of islands and of the problems that have occurred and may occur in the future, the workshop made the following recommendations:

General Policy and Directions

1. In view of the special significance of islands for nature conservation and other values of community interest, governments should give high priority to legislative and policy provisions to enable their management without degradation of their biological and other resources.

2. Governments and their nature conservation agencies should give high priority to the allocation of adequate resources for islands, including resources for:

   (a) survey and inventory;

   (b) research;

   (c) management planning;

   (d) management;

   (e) monitoring;

   (f) surveillance and enforcement;

   (g) public education, information and interpretation.

3. Agencies should identify priorities for island conservation and management based on a systematic examination of existing knowledge, island values and management resources, using criteria relevant to their own regions and circumstances.

Protected Area Status

4. High priority should be given to the reservation of islands for nature conservation purposes, and reserve status should be such that revocation can only occur after parliamentary approval.

5. Existing systems of island reserves should be examined to ensure their adequacy in terms of protecting conservation values and new reserves should be declared as necessary.

6. Wherever possible, whole islands or groups of islands should be reserved.

7. In the reservation and management of islands for nature conservation, the relationship of the island to intertidal areas, the surrounding marine environment and nearby islands should be recognised.

8. Island reservation should extend at least to low water mark to enable management of public access and of foreshore and littoral communities.

9. Consideration should be given to declaration of marine protected areas adjacent to island conservation areas.

10. Wherever possible there should be a single management authority for islands or groups of islands. Where this is not practical, there needs to be effective cooperation and coordination between the authorities involved.

11. For each island or group of island reserves, a plan of management should be prepared. The planning process should include public participation and plans should be subject to periodic review.

Human Use

12. Human use of islands which are important for nature conservation should be subject to appropriate control and management.

13. To encourage government and community support for and cooperation in the protection of islands, public education, information and interpretation programs should be initiated outlining the important conservation, scientific and other values of islands and the necessity for protection and careful management.

14. Human use and development of islands should be carried out in a planned manner and in accordance with comprehensive guidelines or controls that include rehabilitation requirements where appropriate. Developments should be preceded by evaluation of their environmental impacts and, wherever possible, should be sited on adjacent mainlands.

15. Where traditional or established prior uses of islands conflict with important conservation values, there should be consultation aimed towards phasing out those uses. Where phasing out is not possible, such uses should only be allowed on a sustainable basis and monitored, so as to maximise conservation values.

16. Island residents, owners, visitors and users with traditional and/or legal rights should be involved in management planning and, where appropriate, management. The legal basis for any such rights must be clearly established.

17. There should be an integrated approach to the use of islands so that proliferation of particular uses and facilities is avoided, i.e. planning and use of one island should take into account other islands and the adjacent mainland.

Introduced Species

18. High priority should be given to preventing the introduction of species not native to an island, and to monitoring and surveillance aimed at detecting any introductions. Exceptions should be considered only in special circumstances (e.g. introduction of an endangered species in order to establish an additional population; planting of suitable shade trees for residents or tourist developments).

19. High priority should be given to the eradication of introduced species from islands, taking into account the values of the islands concerned, management priorities, the impact which the introduced species is having and the likelihood of success. Support for continuing research into and development of eradication techniques is essential. Where eradication is not achievable, control may be necessary.

20. The nature conservation values of islands should override any perceived scientific (e.g. genetic) values of their introduced populations. If it is desired to preserve the latter on an island where an introduced species is damaging important nature conservation values, then the introduced population should be re-established elsewhere.

Fire

21. Agencies should develop a planned approach to fire management on islands, including improved surveillance and reporting of fires as well as fire management guidelines indicating, for each island, the

type of action that should be taken in response to a reported fire.

22. As a general principle, no deliberate burning should be carried out except for the purposes of research, protection of property values and to meet particular management requirements, and any such burning should be properly monitored.

Other Management Requirements

23. For each island, consideration should be given to the range of available management options, from no intervention to active manipulation and from prohibiting visitation to allowing unrestricted access.

24. Appropriate attention and priority should be given, as necessary, to management actions such as rehabilitation and restoration programs, soil conservation measures and waste disposal, and to research into and development of the required techniques.

Resources for Management

25. Recognition should be given to the high cost of managing islands to conserve their nature conservation values and to the need to allocate resources accordingly. Priorities for the allocation of resources should be set according to stated criteria and should be reviewed regularly.

26. Management agencies need to be innovative in getting resources, and should make use of opportunistic visits by other agencies, amateur assistance, island inhabitants, and corporate and private sources of funds. Defence force and other government (e.g. fisheries, lighthouse tender) vessels have an important role to play in this regard, and should be made available to support nature conservation agencies on island management as an integral part of their sovereign duties in the overseeing of Australia's and New Zealand's resources.

27. To maximise the efficient use of resources, there is a need for an integrated approach to island nature conservation responsibilities, with all of the activities listed in Recommendation 2 being carried out simultaneously to the greatest extent practicable.

Other

28. Agencies should consider establishing:

(a) advisory groups to consider and develop island policies and priorities;

b) specialist units, with appropriate training, responsible for management activities including fire control, rehabilitation and control/eradication of introduced species;

(c) specialist research and planning capability with respect to islands.

29. There should be continuing informal liaison among CONCOM agencies and with others interested in island conservation and management, with a view to another technical workshop after a suitable period (say 5 to 10 years).

30. Recognising the internationality of nature conservation and the proximity of Australia and New Zealand to numerous island nations in the Pacific and Indian Oceans, governments and agencies should assist where possible in the island nature conservation activities of other countries.

31. CONCOM Standing Committee should consider the desirability of a public information booklet on island conservation and management being produced as a CONCOM initiative. As an alternative, individual agencies should consider producing booklets and/or pamphlets suited to their own needs.

32. CONCOM Standing Committee should consider conveying this Summary Report to other appropriate Ministerial Councils (e.g. Councils dealing with tourism, vertebrate pests and fisheries) and Commonwealth agencies (defence forces, coastal surveillance authorities and lighthouse authorities), drawing their attention to recommendations relevant to their interests and responsibilities. Consideration should also be given to conveying this Summary Report to appropriate international organisations (e.g. World Wildlife Fund and the International Union for the Conservation of Nature and Natural Resources).

REFERENCES

Burbidge, A.A. and Jenkins, R.W.G. (Eds.) (1984). Endangered Vertebrates of Australia and its Island Territories. Report of the Working Group on Endangered Fauna of the Standing Committee of the Council of Nature Conservation Ministers. (Australian National Parks and Wildlife Service : Canberra).

Crisp, P. (1985). New Zealand's Offshore and Outlying Islands. Nature Conservation Council Information Booklet No. 24. (Nature Conservation Council : Wellington).

Strahan, R. (Ed.) (1983). *The Australian Museum Complete Book of Australian Mammals*. (Angus and Robertson :Sydney).

0763-0190-750