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ECOLOGICAL RESTORATION OF NEW ZEALAND ISLANDS - INTRODUCTION

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A very significant part of New Zealand's biological heritage depends for its future on our offshore and outlying islands. No area on the mainland can provide the same opportunities for protecting lowland and coastal communities from the major modifying influences of humans and their introduced animals. Furthermore, islands provide the most cost-effective method for protecting many species of endangered or potentially endangered animals and plants. The intelligent management of islands and their biotas must therefore be seen as a major component of a comprehensive policy for nature conservation in New Zealand.

A comprehensive conservation policy must go beyond passive protection of biological resources. The Conservation Act (1987) for the first time made one department, the Department of Conservation, responsible for managing the nation's biological, historic and prehistoric heritage. The Act also gave three new areas of responsibility to the Department of Conservation that were not previously included in the conservation statutes. First, protection was interpreted in the context of enhancement, thereby providing for active intervention in management. Second, a mandate for advocacy was included. Third, the Act required that management must take account of the rights of the *tangata whenua* (people of the land) as provided for by the Treaty of Waitangi. Although these new responsibilities have wide ramifications, they came with few national guidelines on how they should be applied to islands. Effectively applied, they will involve the public through education, facilitate partnerships between conservation organisations and Maori tribal authorities, and increase the options for conserving rare species, communities and other resources both natural and historic. Inappropriately applied there is potential to create some expensive mistakes (Diamond 1990).

The Conference on Ecological Restoration of New Zealand Islands was held between 21 and 24 November 1989 at the University of Auckland. The theme of ecological restoration was envisaged as a catalyst that would raise, and possibly crystallise, many issues facing those interested in island management. It generated wide interest (240 participants), 55% of whom were either private individuals or from agencies other than the Department of Conservation. The 31 papers and 6 workshop summaries included in the following volume examine almost all facets of island management in New Zealand and provide a wealth of ideas and information that will have practical application in the future as well as a basis for much Department of Conservation policy.

The 1989 conference was not the first to concentrate on New Zealand islands. The largest previous one, however, focused on the northeastern islands (Wright and Beever 1986), whereas this conference covered the entire resource and also drew on lessons from Hawaii (Carlquist) and Australia (Rosier). Unlike the preceding conference, the present one aimed to raise issues of direct application to resource managers including issues of public participation and tourism.

The volume is divided into four sections. In Section 1 an international perspective on the New Zealand biota is given by Diamond, while the review by Daugherty *et al.* underlines the significance of islands in maintaining the diversity of this biota. Several contributions address gaps in the current approach to island restoration: Ballantine (marine systems), Davidson (archaeological sites) and Gibbs (invertebrates); while others discuss particular techniques relevant to restoration (Chester, Saunders, Veitch and Bell). Atkinson examines ways of achieving success with restoration programmes, and Simberloff's contributions analyse the theoretical and practical constraints inherent in restoration with suggestions for overcoming some of them. Meurk and Blaschke look at the restoration potential of islands from a climo-edaphic viewpoint while Towns *et al.*'s contribution outlines the potential for restoration within a specific island group. Innovative ways of involving the public are emphasised by Craig and by Bellingham, while the experience of public volunteers is described by Galbraith. O'Connor and Simmons discuss the potential threats to islands from an increasingly mobile public, McLean and Sharp approach this problem from an economic viewpoint, and the prospect of World Heritage status for at least some of the islands is raised by Molloy and Dingwall.

The results of these presentations were debated in six workshops, each introduced by one or two position papers that acted both as reviews and sources of questions for debate. Three topics, eradication of pest species, translocation of organisms and revegetation, are elements in restoration programmes, and were treated separately. There were potential areas of either conflict or support for these activities and these formed the basis for the other three workshops: recreation and tourism, cultural perspectives, and advocacy (public participation). These position papers with recommendations of the workshops are presented in Sections 2 and 3.

More papers were presented than could be published in this one volume. Abstracts for those not published in full are provided in Section 4. A number of additional papers are being published by the *Journal of the Royal Society of New Zealand.*

We have set a tight schedule for publication of this volume, and could only aspire to it because of the able assistance provided by the Science Publications Manager, Jane Napper, and Science Editor, Mary Cresswell. The level of their effort and commitment can be seen from the quality of this production. Thanks should also be expressed to Leigh Moore for drafting, to Hugh Best for assistance with photographic work, to all those who reviewed papers and to those few contributors who had to withstand constant badgering for being unable to produce their papers when we asked for them. Our special thanks are due to Professor John Wells of Victoria University for coordinating funding and itineraries for Jared Diamond and Dan Simberloff; to Rod Morris of the Natural History Unit of Television New Zealand for making Shelwin Carlquist's presence possible; and to other members of the Conference Organising Committee, particularly Dick Veitch, for organising the conference facilities and venue. Finally, our thanks to Professors Carlquist, Diamond and Simberloff for their thought-provokingcontributions and discussions.

August, 1990

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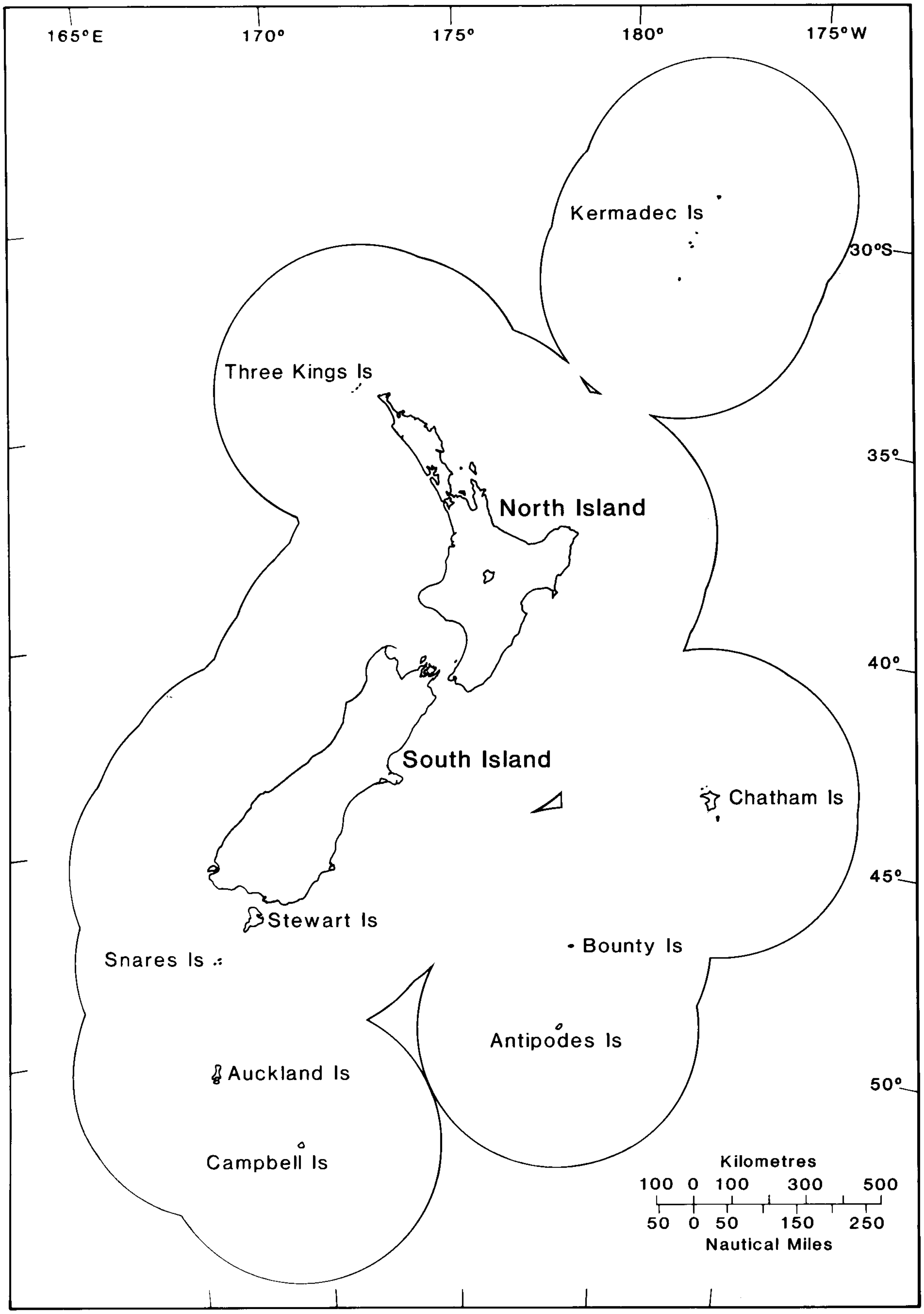
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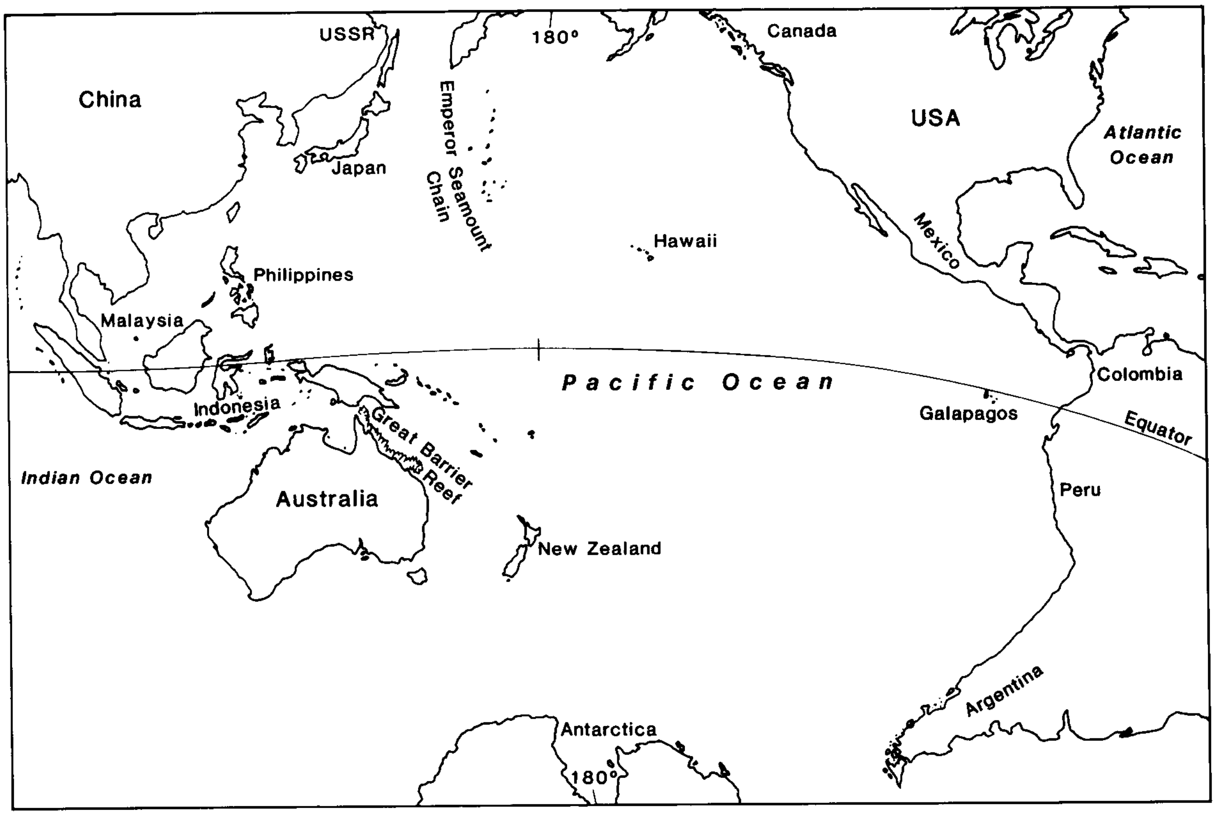
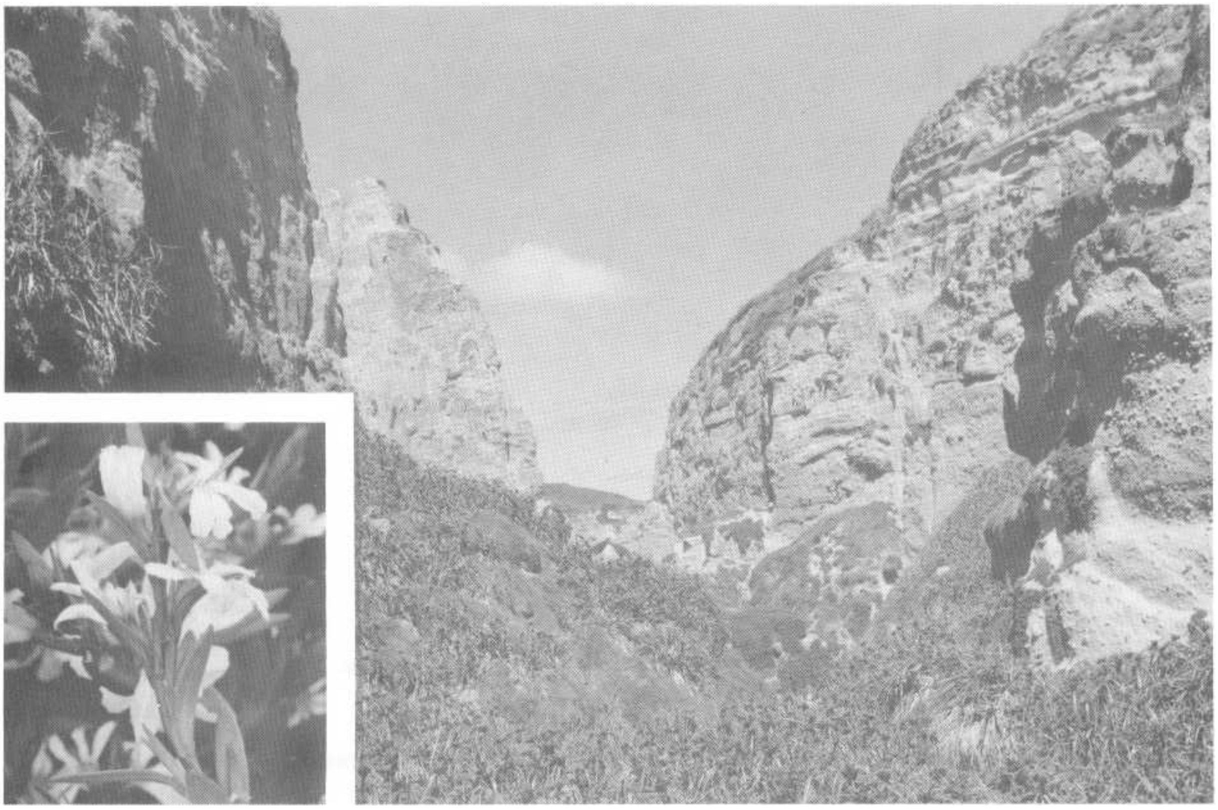
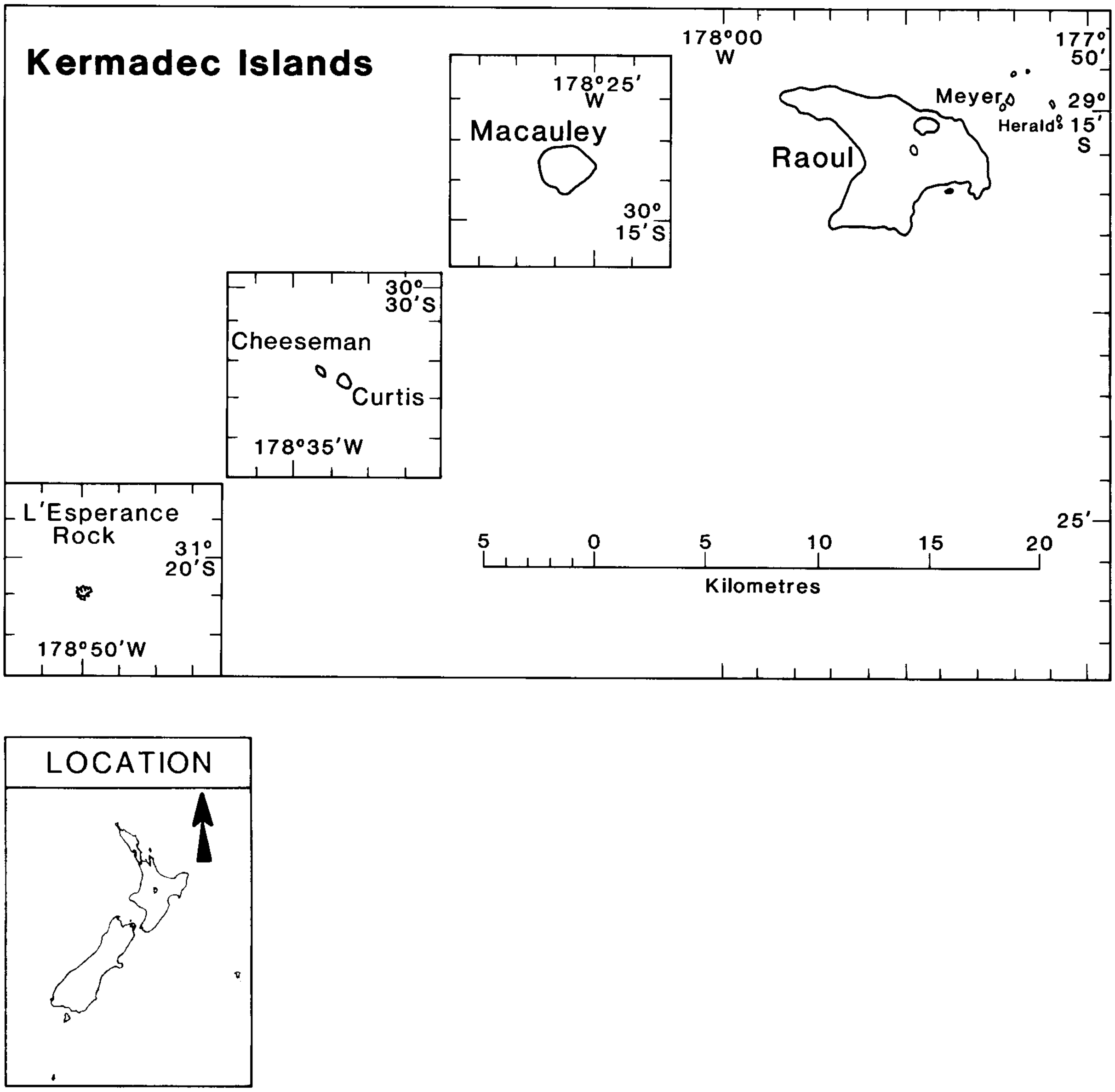


Overleaf: New Zealand, its outlying islands, and Exclusive Economic Zone.

Above: The Pacific Basin, showing the position of New Zealand relative to other landmasses.

SECTION 1: RESOURCES AND MANAGEMENT





Above: Kermadec Islands.

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NEW ZEALAND AS AN ARCHIPELAGO: AN INTERNATIONAL PERSPECTIVE

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ABSTRACT

New Zealand's biota is interesting on an international scale for many reasons. For example, though one usually thinks of New Zealand as an island or archipelago, it is also one of the world's smallest continents, defined biogeographically as a land mass within which birds and mammals can achieve completed speciation not dependent on water gaps. Its biota arrived both over water during a long time and over land in the far-distant past, and then redistributed itself within the modern New Zealand archipelago both over land (at Pleistocene times of low sea level) and over water. The biotas of New Zealand and Madagascar are the closest we shall ever come to observing the products of continental evolution in island-like isolation, unless we discover higher life on another planet. Finally, New Zealand is distinctive in the two-stage destructive impacts it received from human colonists, and in the innovativeness with which its biologists are now seeking to mitigate those impacts. All these features make New Zealand one of the world's biological prizes.

WHY ARE NEW ZEALAND'S PLANTS AND ANIMALS IMPORTANT AND INTERESTING?

To understand the answer to this question, think how it would revolutionise our understanding of biology if we could discover and study life on another planet. An extraterrestrial biota would constitute a natural experiment in the evolution of life - an experiment completely independent of the one that has taken place here on Earth. It would thus expand our sense of what is biologically possible.

Unfortunately, such a discovery is extremely unlikely within our lifetimes, and it would cost prodigious quantities of money to follow up anyway. Our next best opportunity, and one that actually exists, is to study oceanic islands, which represent at least partly independent experiments in life's unfolding. Oceanic biotas started off with the same life forms widespread elsewhere on Earth, but some island biotas subsequently enjoyed a long independent evolution. In practice, most oceanic islands are too young, too accessible to new immigrants from continents, and too small and hence cursed with too high natural extinction rates to have generated biotas drastically different from those of the continents. For those reasons the most interesting oceanic islands are New Zealand, Hawaii, New Caledonia, and Madagascar.

All four of these islands are extremely interesting, but there are compelling and obvious reasons for picking a favourite. Hawaii's biota has been limited by Hawaii's small area and young age. New Caledonia's biota, though old, has similarly been limited by small area. Madagascar is both large and old but has been too accessible to Africa, with the result that it has been colonised by many groups of flightless mammals. While those mammals are of great interest, they prevented the evolution of unique non-mammalian taxa to replace mammals.

New Zealand is as close as we will get to the opportunity to study life on another planet. New Zealand is by far the largest remote oceanic island. Dry land has persisted in the New Zealand region for at least the past 100 million years. New Zealand lacks native terrestrial mammals, which are the dominant large terrestrial non-flying animals elsewhere in the world. In the absence of these otherwise ubiquitous dominants, the lack of mammalian competitors and predators permitted New Zealand to evolve taxa that were derived from other animal groups, that served to some degree as functional equivalents of mammals, but that have no functional *and* taxonomic equivalents elsewhere in the world except (in some cases) on some other oceanic islands.

The most familiar mammal replacements on New Zealand are of course the moas, which played the role of the largest dominant herbivores. The only approach to moas elsewhere in the world were the elephant birds of Madagascar plus the surviving ratites of the continents, but none of these other groups of very large flightless herbivorous birds radiated to anything like the degree that the moas did. New Zealand also had medium-large flightless herbivorous birds, including the takahe (paralleled by similar-sized flightless rails on various other oceanic islands) and the kakapo (paralleled by nothing else anywhere).

Less spectacular but equally interesting are the New Zealand taxa that evolved to replace such small mammals as mice and rats. The misnamed Stephens Island wren, which formerly occurred on the New Zealand mainland, was (except for its recently discovered extinct relatives in New Zealand) the world's only known flightless songbird and functioned as an avian mouse. The short-tailed bats are the world's most terrestrial bats and represent the bat family's attempt to produce a mouse. The giant wetas, which constitute the arthropods' effort at mousedom, range up to double the size of our familiar mammalian mice. Many other New Zealand plants and animals are equally notable.

NEW ZEALAND: ISLAND OR CONTINENT?

New Zealand has an additional interest to biogeographers in particular. While we conventionally think of New Zealand as an island, it also rates as a continent, in two senses.

First, New Zealand long ago was part of the large southern continent, Gondwanaland. Hence some of New Zealand's oldest endemics may be surviving relicts of that Gondwanaland biota.

Second, reflect that if one defines an island as a water-girt land mass, then there is no clear distinction between islands and continents except in area. Australia, the Americas, and the Eurasian/African block are also water-girt land masses. Thus, what, if anything, is the distinction between a continent and an island?

The answer is that there is an important biological distinction between continents and islands, depending on their mechanisms of completed speciation - i.e., their opportunities for evolving multiple sympatric daughter taxa from one ancestral taxon. On large land masses, populations of the same species can develop significant geographic variation within the same land mass, and geographic barriers may eventually come to divide conspecific populations. Thus, it is possible for completed speciation to take place within the confines of the land mass. This process is referred to as continental speciation (Diamond 1977). As one considers land masses of decreasing size, one eventually reaches a point where geographic variation or the division of the species' range by geographic barriers is no longer possible. In that case, completed speciation requires water barriers that isolate differentiating populations by water gaps between islands of the same archipelago (so-called intra-archipelagol speciation) or by water gaps between different archipelagos (inter-archipelagal speciation).

Naturally, the actual area required for operation of continental speciation varies among taxa and depends in particular on population densities and mobilities. Sedentary taxa that live at high population densities, like land snails and flightless insects, have speciated on Pacific islands with areas of only a few square kilometres. For birds, however, the smallest land masses on which continental speciation has occurred are New Guinea (compare the radiations of birds of paradise and dozens of other bird groups), Madagascar (the radiations of couas and vangids), and possibly New Zealand. Much bird speciation in New Zealand has surely been across the water gaps separating the North Island and the South Island, as exemplified by present distributions of the whitehead and yellowhead. However, distributions of the species of kiwis and the subspecies of wekas suggest the possibility that New Zealand has been just large enough for continental speciation to have operated in birds within the confines of the North Island or the South Island.

Thus, New Zealand is interesting not only as an island, but also as the world's smallest continent.

LAND-BRIDGE AND OCEANIC ISLANDS

Among islands, biogeographers distinguish between land-bridge islands and oceanic islands. The New Zealand archipelago includes both of these types of islands.

Land-bridge islands are ones separated from nearby continents or larger islands by straits currently less than about 150 m deep. Hence land-bridge islands were connected by dry land to their neighbouring continents or larger islands at Pleistocene times of low sea level, when the sea dropped to about 150 m below its present stand. Familiar examples of land-bridge islands around the world include Britain, Trinidad, Newfoundland, Sri Lanka, Fernando Po, and Tasmania, formerly connected to Europe, South America, North America, Asia, Africa, and Australia respectively. During the Pleistocene many islands of the New Zealand archipelago, such as the North Island, the South Island, Stewart, and many smaller islands, were connected to each other. However, other islands, including the Snares, Chathams, Auckland, Campbell, Macquarie, Raoul, and Antipodes, lacked such connections to the expanded Pleistocene New Zealand mainland (see p. v). These latter islands constitute oceanic islands within the New Zealand archipelago, just as the whole New Zealand archipelago constitutes an oceanic island group vis-a-vis the rest of the world.

The biogeographic significance of this distinction between land-bridge and oceanic islands was made famous by the father of biogeography, Alfred Russel Wallace, on the basis of his studies over a century ago in the Indonesian archipelago. Land-bridge islands throughout the world regularly support a large variety of flightless mammals, such as rhinoceroses and tigers, unable to cross major water gaps. Oceanic islands support only those taxa capable of crossing water gaps, such as volant animals, plants dispersed by wind, waves, and birds, and small vertebrates well adapted to overwater dispersal by rafting.

In the case of islands flanking the major continents, it is thus obvious why the distinction between continental and oceanic islands is of decisive biogeographic importance. Yet it is not so obvious why the distinction should still be important for remote archipelagoes, such as New Zealand. One could be forgiven for assuming that any species capable of getting across the 1500 km water gap separating New Zealand from Australia would also be capable of covering the mere 105 km from the New Zealand mainland to the Snares, or the 640 km to the Chathams. However, most New Zealand species didn't. For some, such as the takahe and weka, the reason is obvious: they are clearly derived from still closely related volant ancestors (similar to the extant swamphen and banded land rail) that flew to New Zealand from Australia, but they subsequently evolved flightlessness on New Zealand and were thus barred from reaching the Snares or Chathams. But why do so many of New Zealand's volant birds still fail to fly to these oceanic islands of the New Zealand region?

It turns out that many bird species that are strong fliers over land behave as if they are flightless when they come to a water gap. Such bird species do not reside on oceanic islands and are never seen to disperse overwater to any island. Such "behaviourally flightless" species have been reported from many parts of the world, including North America, South America, Asia, and New Guinea (Diamond 1972, MacArthur, Diamond and Karr 1972, Diamond 1976, Jones and Diamond 1976, Diamond 1981, Diamond and Gilpin 1983). Among such species in the New Zealand region are the kea, New Zealand scaup, New Zealand dabchick, brown creeper, whitehead, and yellowhead. The kea is a notably strong flier that can be seen on any day within its preferred habitat, flying high and for considerable distances. The scaup and dabchick also fly for considerable distances over land within New Zealand. While the brown creeper, whitehead, and yellowhead are not such notable fliers, they are nevertheless perfectly capable of respectable flights.

The failure of all these volant species of the New Zealand region and other regions to disperse over water involves selective behavioural flightnessness, not mechanical flightlessness. One can think of them as being afflicted by fear of flying over water (Diamond 1984). This phenomenon illustrates two aspects of dispersal, a property of plants and animals that plays a central role in biogeography and population biology.

First, the behaviourial basis of dispersal is subject to natural selection, just as are physiology, mating behaviour, and the anatomical bases of dispersal (e.g., wings). Dispersal involves trade-offs between costs (e.g., the expense of wings, the risk of dying en route, the risk of reaching an area less suitable than the natal area), and potential benefits (the possibility of reaching an area of suitable habitats not already occupied by conspecifics, and hence of founding a new population). The balance between these costs and benefits varies greatly among species. For example, dispersal offers high potential benefits for second-growth species, whose natal areas may soon grow into unsuitable habitats but for which suitable new areas of second growth are constantly appearing elsewhere. However, it may offer few benefits to species of large continuous tracts of stable habitats, such as forest-interior species.

Second, the New Zealand biota also illustrates how dispersal ability evolves with time in phylogenetic lineages, just as do other biological properties. This point is illustrated by the numerous species that colonised New Zealand and other oceanic islands over water, and that then proceeded to evolve mechanical or behaviourial flightlessness.

Thus, the New Zealand biota is of further interest to biologists in offering such rich material for studying the evolution of dispersal ability.

ISLANDS AND EXTINCTIONS

Let us now turn to a darker area of outstanding interest. All oceanic islands so far investigated palaeontologically have yielded evidence of mass extinction waves related to human colonisation. New Zealand is no exception to this rule. However, since New Zealand started off with the most important and interesting biota of any island, the extinctions on New Zealand have been the worst tragedy to befall the world's island biotas. New Zealand actually suffered two extinction waves related to human occupation. The fast wave followed Maori arrival. It exterminated all the moas, Haast's eagle, and many other species throughout their range, and also exterminated mainland populations of such other species as tuataras and Hamilton's frog and confined them to offshore islands. The second, still on-going, extinction wave followed European arrival and similarly eliminated many species (e.g., huia and laughing owl) throughout their range while confining others (e.g., stitchbird and little spotted kiwi) to offshore islands.

For a long time, biologists thought that islands first colonised by people other than Europeans were biologically pristine until European arrival. The first discoveries that would eventually refute this view were of New Zealand's moas and its other subfossil taxa. Subfossil evidence, especially since 1980, has now documented extinctions associated with human colonists before Europeans for every other oceanic island palaeontologically studied. The best known of these pre-European extinctions after New Zealand's moas were of the giant lemurs and elephant birds of Madagascar and the flightless geese of Hawaii. Obviously, the second extinction wave that began on New Zealand with European arrival is far from finished. When I first came to New Zealand in 1965, there were still kakapo on the mainland, the future of Fiordland's takahe seemed reasonably assured, I could still hope to find bush wren, and the status of yellowhead was not of concern. Within the past 25 years the last kakapo have been removed from the mainland, efforts to preserve takahe outside Fiordland have had to be instituted, the bush wren has disappeared entirely, and the yellowhead has joined the list of species whose status must cause alarm.

The pre-European extinctions on Pacific islands have become a contentious issue. Increasingly today, we view extinctions as bad, and people responsible for extinctions as evil. It is thus understandable that native Hawaiians in my own country, as well as the Maoris of New Zealand, should view claims that their ancestors were responsible for an extinction wave as just one more in a long series of racist insults by which Europeans sought to justify depriving them of lands and opportunities.

In fact, from an ethical point of view there is a big difference between the pre-European extinction waves and those of today. Nowadays we read in books about all the extinctions that have already happened, and we have some scientific understanding of population growth rates that can be sustained. For people today to continue to act in ways likely to exterminate species thus constitutes a destructive act performed with full knowledge of the consequences - a moral evil. In this respect today's extinctions differ from those of the pre-literate past, which can only be described as tragedies whose consequences could not have been foreseen by those responsible for the extinctions.

CONTRIBUTIONS BY NEW ZEALAND CONSERVATION BIOLOGISTS

Having mentioned some contributions of New Zealand's biota to our understanding of biology, let me now mention the contributions of New Zealand's conservation biologists to the field of conservation biology internationally. These contributions are easily described as constituting the most imaginative and cost-effective conservation program in the world. The program in New Zealand has integrated boldly imaginative practical measures and fundamental biological knowledge with the stick-to-it patience required to get the last cat off Little Barrier and the last possum off Kapiti. Six contributions of New Zealand's conservation biologists seem to me especially influential

First, New Zealand has led the way in control of introduced pests, including not only Little Barrier's cats and Kapiti's possums but also the elimination of pigs from Aorangi, goats from Cuvier, and rats from two islands of 1.5 km^2 each. If I had been asked a few years ago, I could have imagined few tasks more hopeless than that of trying to eradicate rats from such islands. This breakthrough will be important for the conservation of giant weta, tuataras, native skinks, and native frogs. All these New Zealand pest control programs have expanded internationally our ambitions for pest control, expanded our recognition of what is possible, and transformed pest-ridden islands into ones suitable for introductions of threatened species.

Second, New Zealand biologists have pioneered in the introduction, re-introduction, and transfer of threatened species. Probably the most famous success stories have been the transfers of saddlebacks and of Chatham Island black robins, but transfers of wetas, skinks, and land snails are of equal significance. Such re-introductions have been imitated in the United States for some time in the case of the peregrine falcon, will soon be imitated for our California condor, and are being imitated in Brazil in the case of the golden lion tamarin.

Third, I would cite the spectacular cross-fostering program that enabled the black robin to recover from a low of seven individuals. The United States has been trying to imitate this program for the whooping crane, but with less success at overcoming the problem of cross-species imprinting.

Fourth, New Zealand conservation biologists have pioneered the concept of using offshore islands as refugia for species that would otherwise be doomed on the battered mainland. Americans will probably imitate this program soon for those few native forest bird species of the island of Guam that could be rescued from an extinction wave caused by an introduced snake. Two of these birds are now being bred in captivity and may be reintroduced to snake-free islands near Guam.

A fifth New Zealand speciality has been ecological restoration of battered habitats, as exemplified by Tiritiri Island. Ecological restoration has now become a major subfield of biology in the United States and elsewhere.

Finally, the transfer of surplus saddlebacks from Cuvier Island to other islands transformed Cuvier into virtually an outdoor aviary, and provided increased security for saddlebacks in case disaster strikes Cuvier itself.

All these innovative measures have set international standards in conservation biology and have been imitated elsewhere in the world.

WHAT DOES THE FUTURE HOLD FOR NEW ZEALAND'S BIOTA?

Obviously, big problems remain despite the pioneering efforts that I have just mentioned. Whether the kakapo, New Zealand's most remarkable surviving bird, will be saved promises to be a cliff-hanger. Not just birds but also unique native plants, bats, insects, and land snails are threatened. Conservation measures that have seen only limited application in New Zealand so far will undoubtedly claim further attention. For example, elaborate genetic analyses are now being done on the California condor and on other endangered species in American and European zoos, in order best to conserve genetic diversity by specifying who among the available individual captive animals will be permitted to mate with whom. Genetic diversity of wild populations can similarly be sustained by occasional translocation of individuals between fragmented surviving populations, as exemplified by South Africa's transport of black rhinos and other large mammals between reserves.

How much of New Zealand's present biota is likely to survive into the twenty-first century? The answer to that question depends partly on a hard-nosed reality, partly on a less tangible matter of human tradition. The hard-nosed reality is, of course, money. Not even the most imaginative conservation program can succeed without funds to carry it out. Since New Zealand has the world's most important island biota and the world's most effective conservation biologists, I can only hope that the New Zealand government and private organisations will regard their money as very well spent on conservation programs.

But money alone is not enough. In this connection I am reminded of a poem with which the British poet A.E. Housman began his collection, *A Shropshire Lad.* Reflecting on Britain's future, and on his comrades whom he admired, Housman wrote,

... fear you not,
Be you the men you've been,
Get you the sons your fathers got,
and God will save the Queen.

In that spirit, I am confident that if New Zealand's future conservation biologists are the equal of your present ones, and if they are given the funds to carry out their work, God will save your biota.

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Conservation Sciences Publication No. 2. Department of Conservation, Wellington.

THE SIGNIFICANCE OF THE BIOLOGICAL RESOURCES OF NEW ZEALAND ISLANDS FOR ECOLOGICAL RESTORATION

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ABSTRACT

Islands have historically played a significant role in New Zealand conservation because they contain such a disproportionately large amount of our biological wealth, including primary endemic species that never occurred on mainland New Zealand, pseudo-endemic species that once occurred on the mainland but survive now only on island refugia, and a kind of community structure seldom found outside the New Zealand region. Present knowledge significantly underestimates biodiversity on islands as measured by taxonomic, genetic, and community criteria. In the future, islands will play major roles as sites for ecological restoration programmes, nature sanctuaries, sources of knowledge for restoration goals and methodologies, sources of plant and animal species to be used for translocation to restoration sites, sites for monitoring of macro-environmental change, and examples to be used in conservation education programmes.

INTRODUCTION

On being asked why he robbed banks, a famous felon once replied that he did so because that is where the money is. With a very different intention - to save rather than to steal - biologists can as appropriately note that ecological restoration in New Zealand will begin with islands, because they are the storehouses of much of our biological wealth.

Human alteration of islands has often been as devastating as on the mainland. Nonetheless, many species have survived only because they found refuge, however inadvertently, on inaccessible and isolated islands where human disturbance was limited. Good fortune must also be invoked, because only that can explain the absence of rats and other destructive mammals, for example, on islands such as the Poor Knights or Stephens, which contain such inordinately high proportions of the most spectacular, island-restricted native biota.

In this paper, we present an overview of the biological resources of all New Zealand, focusing especially on the contribution of island biotas to that wealth. Because human habitation of New Zealand is so recent, we consider human-introduced species to be of little value, or detrimental, for restoration purposes and exclude them from consideration other than as subjects of eradication. We briefly discuss the difficulties of understanding and fully describing biological diversity, using the unusual biotic communities of New Zealand islands as an example. Then, we describe some of the ways in which this diversity is likely to be used in ecological restoration programmes in the coming decade and relate these uses to existing legal and theoretical guidelines for biological conservation.

BIOLOGICAL RESOURCES OF NEW ZEALAND

New Zealand comprises less than 0.2% of the land area of the world. Its present temperate maritime climate and turbulent geological history preclude the extraordinarily high diversities often found in tropical communities, and its geographic isolation presents a formidable barrier to colonisation by many taxa.

The representation of native terrestrial plant and animal taxa is thus patchy. Many major taxonomic groups have never reached New Zealand, most notably terrestrial mammals (except for several species of bats), whose numbers and effects so dominate most of the world's continents and whose recent introduction to New Zealand has devastated much of the rest of the biota. At the other extreme, New Zealand contains a disproportionately high level of global diversity of some groups of widely distributed birds: 75% of penguin species breed in the New Zealand region, as do 54% of albatrosses and half the petrels, shearwaters, and prions (Robertson 1985, G. Taylor pers. comm.).

In general, species diversity of the terrestrial biota is low. For groups represented in New Zealand, for example, the number of surviving species is about as great as that expected simply on the basis of proportional land area (Table 1). Representation of taxonomic levels above the species is also relatively low, but for some groups substantially higher than might be from the small land area (Table 2).

Table 1. Taxonomic diversity at the species level for native terrestrial New Zealand vertebrates.

TAXON	NO. OF SPECIES IN NZ / NO. OF SPECIES IN WORLD	NO. OF SPECIES AS % OF WORLD TOTAL
Class Amphibia	4[1] / 2800	0.1%
Class Reptilia	60 / 6000	1%
Class Aves	269 / 9000	3%
Class Mammalia[2]	2 / 4400	0.05%

[1] Including one undescribed species (Daugherty and Bell, unpub. data).
[2] Not including whales, pinnipeds, and sirens.

Table 2. Taxonomic diversity at the familial and ordinal level for selected New Zealand native taxa.

TAXON	NO. OF FAMILIES IN NZ / NO. OF FAMILIES IN WORLD	NO. OF FAMILIES AS % OF WORLD TOTAL
Class Angiospermae (flowering plants)	112 / 306[1]	37%
Order Lepidoptera (butterflies and moths)	37 / 120	31%
Order Anura (frogs)	1 / 23	4%
Order Lacertilia (snakes and lizards)	2 / 15	13%
Class Aves (birds)	49 / 168	29%
TAXON	**NO. OF ORDERS IN NZ / NO. OF ORDERS IN WORLD**	**NO. OF ORDERS AS % OR WORLD TOTAL**
Class Insecta	28 / 31	90%
Class Amphibia	1 / 3	33%
Class Reptilia	2 / 4	50%
Class Mammalia[2]	1 / 16	6%

[1] Classification of plant families follows Heywood (1978).
[2] Excluding whales, pinnipeds, and sirens.

The relative richness of the New Zealand biota appears much higher when assessed on a unit-area basis. The average density of species of vascular plants, for example, is equivalent to that found in other temperate regions, either continental (California) or islands adjacent to continents (British Isles, Japan) (Table 3). Standardised comparison of lizard faunas (Fig. 1) from temperate continental and island regions reveals surprising richness for New Zealand; for example, the lizard fauna of Australia includes about 10 times the number of species known from New Zealand, yet Australia has a land area about 29 times greater. In other words, the predicted number of species in New Zealand, based on the diversity/area relationship found in Australia, is only about 16 species, one-third of what actually occurs. This is the more remarkable, as the isolation of the New Zealand land mass for about the past 80 million years (Stevens 1985) must have greatly limited migration of lizards to New Zealand; the diversity of the New Zealand lizard fauna is therefore likely primarily to result from in situ evolution (Towns *et al.* 1985, Daugherty *et al.* 1990b, Patterson and Daugherty 1990).

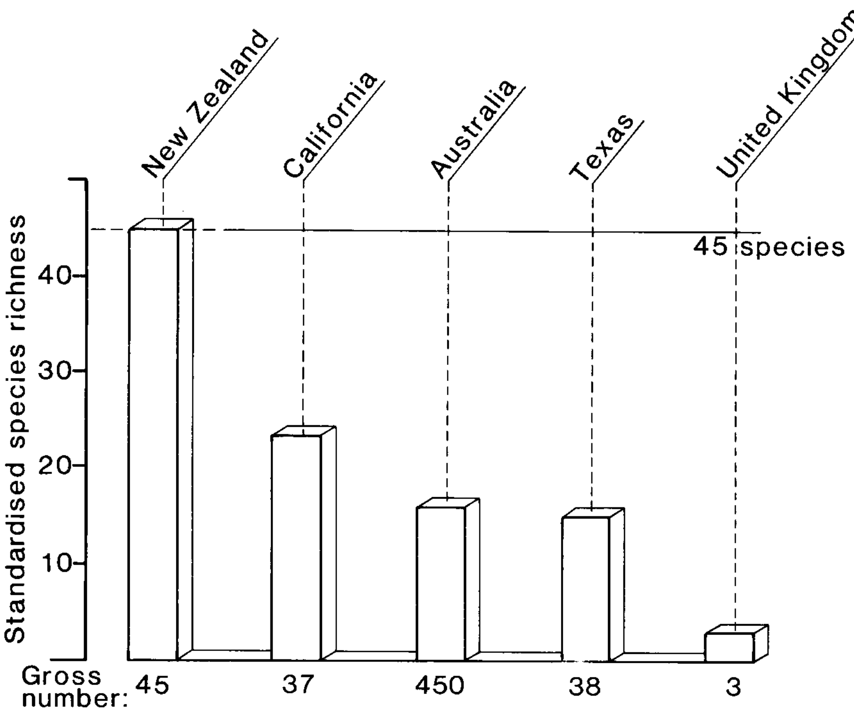

Fig. 1. Area-corrected species richness of lizards in five temperate regions. The number of species for New Zealand (45) represents the number now described, but approximately 10-15 more await description (C.H. Daugherty, G.B. Patterson, and RA. Hitchmough, unpub. data).

Locally, diversities of New Zealand lizards may also be extremely high. Thirteen-hectare Middle Island, for example, supports ten species of lizards, plus the tuatara (Towns *et al.* this conference a). As many as seven species of lizards occur sympatrically at some mainland sites (Towns *et al.* 1985).

In addition to taxonomic diversity, a second important measure of the significance of the New Zealand biota is endemism. At the species level, endemism is exceptionally high (Table 4). Among taxa of low vagility or low salt-water tolerance such as gymnosperms, running water invertebrates (mayflies, stoneflies, caddisflies), amphibians, and reptiles, endemism approaches 100%. Even among highly vagile species such as birds, the proportion of endemic species is reasonably high.

Above the species level, endemism is also high. For example, one family of frogs, one order of reptiles, five families and one order of birds, and two families of insects occur only in New Zealand. New Zealand lacks such major taxa of terrestrial animals as marsupial mammals, terrestrial snakes, land turtles, and salamanders, but it also possesses entire orders found nowhere else - e.g., tuatara and kiwi.

Thus, within selected groups, the biota of New Zealand is highly distinct. Its distinctiveness is partly explained by its antiquity. Many of the most characteristic taxa clearly reflect a Mesozoic origin: tuatara, native frogs, running water invertebrates, Peripatus, podocarps. Equally importantly, the biota evolved in the absence of terrestrial mammals, whose activities have so strongly shaped the biota of most of the rest of the world. In this sense, as Diamond notes (this volume), the New Zealand biota may be as exceptional as that of another planet.

Table 3. Area-corrected species diversity of vascular plants in four temperate geographic regions.[1]

GEOGRAPHIC REGION	TOTAL NUMBER OF SPECIES OF VASCULAR PLANTS	SPECIES / 1000 km^2
British Isles	1702	5.5
New Zealand	2362	8.8
California	3727	9.3
Japan	4022	10.7

1 Data from Godley (1975) excepting New Zealand, where the species total is that of Druce (1989).

Table 4. Levels of endemism among native New Zealand species.

TAXON	% ENDEMIC SPECIES
Ferns[1]	45%
Gymnosperms[2]	100%
Monocotyledonous plants[2]	81%
Dicotyledonous plants[2]	89%
Butterflies and moths	90%
Amphibians	100%
Reptiles	100%
Birds	23%

1 Data from Brownsey and Smith-Dodsworth 1989.
2 Data from Godley 1975.

Finally, the distinctiveness of the New Zealand biota is also due to the absence of humans throughout its long evolutionary isolation. New Zealand was the last major landmass with a diverse biota to be colonised by humans, only 1000 years ago. Despite the widescale effects of humans, glimpses of pre-human New Zealand remain, and nowhere more than on some New Zealand islands.

GEOGRAPHY OF NEW ZEALAND ISLANDS

Consideration of the biological values and uses of New Zealand islands requires an understanding of their geography. Atkinson and Bell (1973) and Atkinson (1989), who review the geography and natural history of New Zealand islands in detail, identify two primary categories of islands. **Outlying or oceanic islands** lie more than 50 kilometres off the coast and were never connected to mainland New Zealand (p. v). **Offshore or continental-shelf islands** lie within about 50 kilometres of the three main islands of New Zealand and were connected to the mainland during glacial periods when sea levels were lower.

Outlying islands range from about 29°-53°S, about twice the span of the main islands of New Zealand, and include the following groups, most of which are volcanic in origin: the Kermadecs, the Three Kings, the

Chatham Islands, Bounty Islands, Antipodes Islands, Snares Islands, Auckland Islands, and Campbell Islands.

The Chatham Islands were the only outlying islands permanently settled by Polynesians. Europeans settled and farmed the Chatham Islands. Attempts at permanent European settlement on the Auckland and Campbell Islands failed.

There are at least 600 islands greater than 1.0 hectare in area within this category, including about 228 greater than 5 hectares (Atkinson 1989). These islands occur in four main geographic groups: (1) the northeastern islands, from North Cape to East Cape, including all the islands in the Hauraki Gulf and Bay of Plenty; (2) the Cook Strait islands; (3) the islands of Fiordland; and (4) the southern islands, in Foveaux Strait and around Stewart Island (see pp. 214, 288). Many offshore islands are volcanic in origin, and all are characterised by low elevation and a temperate marine climate. Virtually none are pristine; Maori undoubtedly visited all offshore islands regularly, following their initial arrival in New Zealand a millennium ago and established long-term settlements on some of the larger ones, e.g., the Poor Knights, Hen and Chickens, Little Barrier, and Kapiti.

Among the important effects of humans on islands and their biotas are land clearing and periodic fires; harvest of seabird or seal populations; and introductions of grazing mammals and mammalian predatory species. Only 13% of offshore islands remain free of introduced mammals and wekas (Atkinson 1989). Management of all islands must therefore be planned and conducted within the context of a history of human alteration (Simberloff this volume a, Towns *et al.* this volume b), even for those islands such as the Poor Knights that have extremely high indigenous biotic values.

BIOLOGICAL RESOURCES OF NEW ZEALAND ISLANDS

Islands are not simply miniature versions of mainland New Zealand (e.g., Meurk and Blaschke this volume). Some species, such as moas and alpine plants, for example, were largely unsuccessful on islands. Conversely, many island species apparently evolved on islands and are not known ever to have occurred on the mainland. These species, known as **primary endemics** (Watt 1986), include such well known examples as the Poor Knights lily (*Xeronema callistemon* - known only from the Poor Knights and Hen Islands); the Three Kings skink (*Leiolopisma fallai*), the liane *Tecomanthe speciosa* and many insect species (Watt 1986), all from the Three Kings Islands; and Forbes parakeet (*Cyanoramphus forbesi*, Triggs and Daugherty, in press) and black robin (*Petroica traversi*) (Robertson 1985) from the Chatham Islands.

Pseudo-endemics (Towns and Robb 1986), on the other hand, are refugee species, previously occurring on mainland New Zealand, but now surviving only on offshore islands. Well-known examples include the largest of all giant weta (*Deinacrida heteracantha* - now known only from Little Barrier Island), tuatara (*Sphenodon*), Duvaucel's gecko (*Hoplodactylus duvaucelii*), Hamilton's frog (*Leiopelma hamiltom*) (Worthy 1987, Pickard and Towns 1988), saddleback (*Philesturn us carunculatus*), and stitchbird (*Notiomystis cincta*).

For a few island species, such as the still unnamed tusked weta (known only from Middle Island in the Mercury group; McIntyre 1989), origins and type of endemism remain unclear.

Considering both primary endemics and pseudo-endemics, the levels of endemism on islands are variable, but often high. About 6% of New Zealand terrestrial vascular plant species, for example, are restricted entirely to islands (Atkinson 1989), but over 40% of giant weta (*Deinacrida*) species, 46% of athoracophorid slugs (Burton 1963, Climo 1973), 50% of frog species (*Leiopelma*, including one undescribed species - C.H. Daugherty *et al*., unpublished data), and both species of tuatara (Daugherty *et al*. 1990a) are island endemics. Nearly all procellariiform seabirds of the New Zealand region now breed only on islands (Robertson 1985).

Rarity and endemism frequently go hand in hand, and many of the species of highest conservation importance are limited to islands. As extreme examples, *Sphenodon guntheri*, two species of *Leiopelma*, the Middle Island tusked weta, and *Deinacrida heteracantha* are found on only one island each. All outlying islands and at least seven offshore islands have endemic species, and 48% of insect species on the Protected Species List (Wildlife Amendment Act (1980)) occur only on islands. Of the 23 rarest species of lizards, 74% have island populations, and 56% are found only on islands (see pp. 213, 287). Thus, a large proportion of the biological wealth of New Zealand occurs as species limited entirely to islands or with a significant proportion of their distributions on islands. Without island refugia, the terrestrial biota of New Zealand would be vastly impoverished, as would the seabird fauna of the entire world.

The above listing also demonstrates that present knowledge underestimates biological diversity on islands, a significant concern because taxonomy provides the essential foundation for determining management priorities (Green and Losos 1988, Avise 1989, Daugherty *et al.* 1990a). Since 1985, systematic studies have revealed the existence of many new species of the single best known group of organisms, terrestrial vertebrates, including tuatara (Daugherty *et al.* 1990a), native frogs (C.H. Daugherty *et al.* unpubl. data), and numerous lizards (Patterson and Daugherty 1990, unpubl. data, R.A. Hitchmough pers. comm.). The number of described lizard species can be expected to increase from about 40 (Newman 1982a, Towns 1985) to about 60 by mid-1990, including many new island species. Even for most species of the highest conservation importance, very little is known of their biology. The life histories of many species of giant weta and lizards, for example, have yet to be described; the extraordinary reproductive cycle of the tuatara has only been described in the past three years (Cree and Daugherty 1988, Cree and Thompson 1988, Cree *et al* in press).

Yet less well understood is the structure and function of the unusual type of community that occurs, or previously occurred, on most offshore islands. These islands lack not only mammals, but also the guild of grazing and browsing moas that dominated mainland New Zealand ecosystems in pre-human times. Kiwis probably were not found naturally on most offshore islands, except a few of the largest such as D'Urville.

These communities consist of four main elements that in combination may seldom have dominated island communities elsewhere in the world:

Low-growing salt- and wind-tolerant coastal trees such as pohutukawa (*Metrosideros* spp.), taupata (*Coprosma repens*), ngaio (*Myoporum laetum*), and coastal hymenanthera (*Melicytus* spp.), that often form a complete canopy over a relatively open forest floor;

Large invertebrates such as giant weta, the Middle Island tusked weta, the Stephens Island weevil (*Anagotis stephenensis*), carnivorous snails (*Rhytida* spp. and *Powelliphanta* spp.), slugs (e.g., *Pseudaneitea* spp.), and the giant centipede (*Cormocephalus rubriceps*);

Reptiles in high densities and diversities (lizards and tuatara); and

Seabirds in high densities and diversities (penguins, petrels, prions, shear waters, gannets, gulls and shags).

Terrestrial bird species such as parakeets (*Cyanoramphus* spp.), kaka (*Nestor meridionalis*), saddlebacks, and bellbirds (*Anthornis melanura*) may be common on these islands, but do not appear to play a dominant ecological role equivalent to that of the seabirds.

Seabirds at high densities appear to function as keystone species (Simberloff this volume a) that support the high biological diversity of these island communities. The enormous numbers of birds that forage throughout the south Pacific and Southern Oceans converge on New Zealand islands to breed. Perhaps half a million fairy prions (*Pachyptila turtur*) return in spring to 150 hectare Stephens Island, for example, along with smaller numbers of several other species. Their faeces enrich the deep soils, giving rise to an abundant invertebrate community that supports populations of seven species of lizards, one species of frog, and at least 50,000 tuatara, the latter occurring at densities as high as 2000/ha, for an animal that weighs 400-500 grams on average (Crook 1975, Newman 1982b, 1987, Carmichael *et al.* 1989). The density of tuatara on Stephens appears to be unusually high, but on other islands densities greater than 100/ha are common (Newman 1986, Thompson *et al* in review, Daugherty, C.H., Cree, A., Hay, J.M., pers. comm.). Densities of lizards on islands can be even higher (Whitaker 1968, Towns 1975).

Ecological relationships within these communities are still poorly understood. Tuatara have been postulated to be dependent on prions and other seabirds (Crook 1974); tuatara not only use seabird burrows but also prey on chicks and injured adults. Energy flows, the ecological roles of insects and other invertebrates, and the levels of dependence of the keystone species - seabirds - on energy imported from marine species such as fish and squid have not been studied. Further, the high levels of species diversity within each of the four dominant elements of these communities mean that generalisations about community structure and function will require substantial further study (see next section); no two islands are the same.

With the predominance of burrowing seabirds, New Zealand island communities differ from those of island communities in the rest of the world. Within the New Zealand region, offshore island communities also differ from those of outlying islands, primarily in the abundance and diversity of reptiles. The Chatham Islands are the only outlying islands once to have had lizard populations, and these are now reduced apparently to only a single species on a few tiny islets that rats have not reached (Pickard and Towns 1988).

In summary, then, New Zealand islands contain a significant proportion of the total biotic wealth of the region and, for some groups, of the world. This wealth occurs in the form of primary endemic species that have never occurred on the mainland and pseudo-endemics that have survived only on island refugia. Despite more than a century of scientific study, these islands contain many species that are poorly known or remain to be discovered. In turn, these species occur in a type of community that may be unique to New Zealand.

TYPES OF BIOLOGICAL DIVERSITY

The increasing threat to biological diversity is now an acknowledged problem of modern life. Few discussions of this threat, however, define biodiversity directly. This probably reflects the complexity of a topic which defies simple description. In this section we illustrate the problem by brief discussion of three types of biodiversity: taxonomic, genetic, and community.

Previous sections have referred mainly to taxonomic diversity, that is, the listing of numbers of species or other formal taxonomic levels. Taxonomies form the basic resource inventory of conservation. They classify natural variation in a hierarchical system of set categories or taxa, a catalogue of diversity and distinctness. Thus, they form the foundation for conservation, by allowing managers to set priorities that recognise the distribution of variation - i.e., the more distinct an organism, the higher its ranking in conservation importance (Soule and Simberloff 1986). As representatives of endemic orders, each with a single genus, tuatara and kiwi can immediately be identified as taxa of the highest importance within New Zealand and worldwide, for example.

Taxonomies, however, have two practical problems. First, the discrete hierarchical structure of taxonomies does not mirror the complexity of the evolutionary process. Evolutionary divergence is a continuum, and categorising populations into discrete, artificial taxa has often been an arbitrary process (Mayr 1957a,b). Thus, debate over the nature of both the classification process and particular taxonomic assignments can be expected to continue indefinitely (e.g., Frost and Hillis 1990, Highton 1990).

A related, second inadequacy is that not only do taxonomies underestimate diversity, but that they can also be wrong. As noted in the previous section, even the terrestrial vertebrate fauna of New Zealand is still being described. Management based on an incorrect taxonomic view of tuatara, for example, has had serious deleterious conservation consequences (Daugherty et al. 1990a). The same may be true for many biological groups, ranging from earthworms to birds, whose taxonomies originate either from nineteenth century work or from mainly morphological analyses (Avise 1989). Contemporary taxonomy of New Zealand birds, for example, derives primarily from the work of Oliver (1955), who made wholesale changes to previous compilations without formal systematic analysis or new data. Most New Zealand bird species have never been subjected to systematic analyses that would meet minimum contemporary criteria.

Despite the limitations of taxonomies, they will - quite properly - continue to form the basis for establishing conservation priorities. Managers and biologists must understand that taxonomies represent hypotheses or models of the distribution of biological variation. These models will continually be subject to refinement and improvement as new data and analyses are brought to bear on specific problems, and they will always underestimate diversity. Acceptance of a particular taxonomy should depend upon the quality of published data and analyses that support the taxonomy. For many taxa, therefore, taxonomic research should be high on the list of a manager's priorities.

For conservation purposes, the limitations of taxonomies have been largely circumvented by general acceptance of *genetic diversity* as an appropriate means for cataloguing biological resources. Since the 1960s, techniques for genetic assessment of natural variation have rapidly developed and been used to test and improve existing taxonomies (Avise 1975, Ryder 1986, Avise 1989). While biochemical and molecular genetic data commonly support prior taxonomic analyses, the discovery of morphologically cryptic species has been a frequent result. Nonetheless, patterns of genetic variation alone are sufficient as a resource inventory upon which to base conservation priorities (Daugherty *et al.* 1990a).

This principle has been accepted as one of three primary goals of the World Conservation Strategy (IUCN-UNEP-WWF, 1980): "preserve genetic diversity." This strategy avoids the partially subjective assignment of taxonomic levels inherent in taxonomic analysis. The World Conservation Strategy avoids explicitly taxonomic statements such as "save rare and endangered species," perhaps recognising that faulty taxonomy can be a death sentence for unrecognised rare species (Daugherty *et al.* 1990a).

Species and individuals can be seen as building blocks that produce the edifice of our third category, *community diversity*. Community diversity is described partly by its components but, more importantly, by the ecological relationships of the components: physical, trophic, energetic, and so on. This type of diversity is more difficult to describe and quantify than the previous types, but the effort is essential because a central goal of ecological restoration is the reconstruction of functioning biological communities (Atkinson 1988, this volume, Towns *et al.* this volume a).

A first step in understanding community diversity is to document the subtle variations that can occur around a superficially similar theme. Examples of this variation can be seen by comparing the complex soil-plant-animal system of Middle Island in the Mercury Group (Towns *et al.* this volume a) with its namesake in Cook Strait 500 km further south (Table 5).

The two locations show surprising similarities in size of the flora, the presence of large weta, tuatara, geckos and skinks, and a similar number of burrowing seabird species. More detailed examination of components of these soil-plant-animal systems reveals many differences. Soils on Middle Mercury Island are derived mostly from volcanic tuff, whereas on Middle Trio they are of sedimentary origin (greywacke and argillite). Pohutukawa (*Metrosideros excelsa*) is prominent in the vegetation of Middle Mercury, but is absent from Middle Trio, whereas akiraho (*Olearia paniculata*) is a predominant species on Middle Trio, but absent from Middle Mercury. The large weta on Middle Mercury is a carnivorous forest-inhabiting species (McIntyre 1989), whereas the giant weta on Middle Trio is a largely herbivorous species of partly forested habitats. The lizard community of Middle Mercury Island is very diverse, and dominated by nocturnal and crepuscular species, four of which are *Cyclodina* skinks (Towns in prep). The lizard fauna of Middle Trio has less than half the species present on Middle Mercury, has no nocturnal skinks, and no species of *Cyclodina* (Pickard and Towns 1988). The burrowing seabirds of Middle Mercury Island include grey-faced petrels and allied shearwaters, neither of which are found on Middle Trio, whereas Middle Trio has sooty shearwaters and fairy prions, neither of which are recorded from Middle Mercury. Thus superficial similarity of communities can mask many significant differences in their components, and these differences will inevitably be reflected in trophic relationships; the edifice may appear the same, but the building blocks have different shapes and colours. What these differences mean remains unknown because details of the interactions in these systems have never been studied.

Community diversity may not be easily described or quantified, but like taxonomic and genetic diversity, it is part of the spectrum of values covered by the New Zealand Conservation Act 1987, under its responsibility to "manage for conservation purposes, all land, and all other natural ... resources ... held under this Act."

Table 5. Comparison of two New Zealand islands.

TRAIT	MIDDLE MERCURY ISLAND[1]	MIDDLE TRIO ISLAND[2]
Location	Off Coromandel peninsula, east of Whitianga, latitude 36° 38' S	near D'Urville Island, Marlborough, Cook Strait, latitude 40° 50' S
Size	13.0 hectares	13.4 hectares
Introduced mammals	None	None
Human history	No human occupation; probably visits by Maori; occasional fires	No human occupation; probably visits by Maori; occasional fires
Plants	70 native species, including pohutukawa (*Metrosideros excelsa*) and milktree (*Strebulus banksii*); other dominant tree species include wharangi (*Melicope ternata*), mahoe (*Melicytus ramiflorus*), karo (*Pittosporum crassifolium*), taupata	70 native species, but no pohutukawa and very little milktree; dominant tree species include karaka (*Corynocarpus laevigatus*), akiraho, mahoe, taupata, ngaio, hymenanthera
Large invertebrates	Tusked weta (new genus)	Giant weta (*Deinacrida rugosa*)
Reptiles	Abundant populations of tuatara (*S. punctatus*) and 10 species of lizards (*Hoplodactylus*, 3 spp., *Leiolopisma*, 3 spp., *Cyclodina*, 4 spp.)	Abundant population of tuatara (*S. punctatus*), unknown numbers of 4 species of lizards (*Hoplodactylus*, 2 spp., *Leiolopisma*, 2 spp.); *Cyclodina* absent.
Breeding species of burrowing seabirds	Little blue penguin, 3 species of shearwater, diving petrel	Little blue penguin, 3 species of shearwater, diving petrel

[1] Data from Atkinson 1964, McIntyre 1989, Towns *et al.* this volume a.
[2] Data from Campbell 1967, Daugherty *et al.*, unpub. obs.

USES OF ISLANDS IN ECOLOGICAL RESTORATION

Ecological restoration is now accepted as one important goal of conservation practice (Wilson 1989). Many New Zealand islands will be suitable for ecological restoration (e.g., Towns et *al.* this volume a). Even islands that are not designated as "restoration islands" can contribute to the restoration process. The values and uses of islands have been the subject of many papers in this symposium and elsewhere (e.g., Atkinson and Bell 1973). In this section, we briefly review some of the uses of islands, focusing specifically on their contributions to restoration.

Nature sanctuaries

Islands have long served as important refuges for threatened species, a major conservation success in the midst of declines and extinctions of native species on mainland New Zealand. As noted above, without islands and the biota they harbour, the present flora and fauna of New Zealand would be vastly diminished. As understanding of diversity on islands increases, so will their importance as sanctuaries.

Islands play such a key role as seemingly secure refuges that it is important to remember how vulnerable they are, and that failures occur. Perhaps the most famous failure is the attempt of Richard Henry to secure the future for kakapo (*Strigops habroptilus*) on Resolution Island at the turn of this century (Hill and Hill 1987), but more recent failures include the extinction of the tuatara population on Whenuakura Island in the early 1980s following an invasion of Norway rats (Newman 1986). Islands will remain an important type of refuge into the foreseeable future.

Scientific knowledge

The biotic species and communities of islands provide glimpses of primeval New Zealand. Despite the fact that islands were never precisely like the mainland, the relatively recent arrival of humans in New Zealand means that some islands are relatively little modified and that species doomed to extinction on the mainland due to human effects still survive. Few other locations in the world allow such a direct view of pre-human nature. Scientific information derived from such primeval locations has two significant uses in restoration:

> Restoration goals: Knowledge of the original biota allows identification of the biological targets of restoration programmes, in the short-term for island communities, and in the long-term for selected sites on the mainland. The present biotic composition of some relatively pristine islands can be used to specify the end-point for many restoration programmes.
>
> Methods for restoration: Knowledge and experience gained in restoration programmes for islands now under way will be the foundations of future restoration programmes, including those on the mainland. As noted by Diamond (1990, this volume), restoration programmes offer unique opportunities to practice and establish protocols for future, perhaps increasingly ambitious, restoration programmes. Thus, restoration activities should be documented and published as thoroughly as any other scientific endeavour.

Sources of plants and animals for reconstructing communities

Because so many species survive now only on islands, these island populations will necessarily be the sources of species to be used in restoration programmes. The establishment of each new population of a rare species decreases the threat to that species, achieving a second significant conservation goal in addition to restoration.

A long-term goal will be the re-establishment of pseudo-endemic species on the mainland, as was attempted with the buff weka (*Gallirallus australis hectori*), for example (D. Merton, pers. comm). It is also conceivable that some island species in modified habitats such as the Brothers Island tuatara (*S. guntheri*) might prove vulnerable to major climatic alteration, such as increased frequency of catastrophic storms, and require removal from their present site.

Ecological monitoring

As a result of the buffering action of the surrounding sea, islands have less temperature variance than mainland sites. Many islands are also free of large browsing mammals which can be a complicating factor when interpreting vegetation responses to climatic change on the mainland. Thus monitoring climatic effects on plant growth and vegetation change at a few island sites such as Little Barrier, Kapiti and Secretary islands could provide important information on climatic trends. Monitoring rates of peat formation on some subantarctic islands would provide a further indicator of gradual changes in climate.

Monitoring changes in the distribution and intensity of sudden and extreme climatic events, such as cyclonic storms, "salt storms" (related to gale-force winds of low humidity) and droughts, is difficult at any site. However, the vegetation of a network of small islands, if regularly monitored, could be used as an "instrument" to measure changes in the geographic distribution and intensity of extreme events, again in an environment free from many complicating influences on the mainland.

Islands supporting populations of surface-nesting or burrow-nesting seabirds, the number of which are regularly censused, can be used to indicate trends in the marine environment, particularly those relating to fish, squid and smaller organisms eaten by seabirds. Systematic monitoring of seabirds breeding on islands could provide an early warning of overfishing, pollution, El Nino and climate change, provided the oceanic fishing areas of these birds is known.

Education

Successful restoration programmes can provide public access for viewing of species and communities not presently available. In fact, they can be designed precisely for public access (e.g., Craig this volume). Education is generally acknowledged as an essential component of conservation and is a goal specified explicitly for the Department of Conservation (Conservation Act 1987). Public display of the results of restoration can be expected to influence public values and acceptance of the values of conservation. Where sites are too sensitive for public access, provision can be made for access of film crews and others skilled at communicating natural values to the public.

CONCLUSIONS

Islands have long played a central role in New Zealand conservation. Their importance now seems set to increase still further due to two major advances in the past decade: (1) the ability to remove rats and other introduced mammals from islands, including islands of considerable size (Veitch and Bell this volume); and (2) international acceptance of ecological restoration as a central goal in conservation (Wilson 1989). The significance of these changes cannot be overstated. It is imaginable that future generations will mark the 1980s as the time when the recovery of nature began, however tentatively. Before the 1980s, rats and other mammals were continually introduced on purpose or by chance to the few remaining mammal-free islands in the world. Now, mammals can be removed, and the islands allowed - and often assisted - to return to much of their former biological glory.

New Zealand islands can play a special place in the development of restoration ecology. Because so much of our biological wealth resides on islands, and because we have so many islands, island restoration and management will be the test case for New Zealand conservation. If we fail on our islands, there is little chance we will succeed on the mainland. Our successes, on the other hand, can offer a guiding beacon to restoration programmes elsewhere in the world - a final test of the significance of New Zealand islands in ecological restoration.

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THE SIGNIFICANCE OF ISLAND RESERVES FOR ECOLOGICAL RESTORATION OF MARINE COMMUNITIES

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ABSTRACT

Most attention to islands has focused on their terrestrially-based life and habitats, but their marine communities are just as likely to be both special and endangered and for the same reasons. Marine reserves, which exclude exploitation, are still rare and relatively new in New Zealand, but, like the earliest terrestrial reserves, they are closely associated with islands.

The presence of Goat Island at the centre of New Zealand's first marine reserve - on the north-east coast, from Cape Rodney to Okakari Point near Leigh - significantly increases the physical and biological diversity as well as providing shelter for public and scientific access. This reserve, now 12 years old, provides many examples of abundances, local distributions, size frequencies and behaviour patterns which are very different from nearby coasts. Except for its protected status, the reserve area is a very typical piece of the open north-east coast, so the simplest and most likely explanation of these differences is a restoration of more natural conditions.

At the second marine reserve, the Poor Knights Islands, 12 km off the north-east coast, strong controls on exploitation have conserved a unique and beautiful underwater fauna; as at Leigh, this has greatly increased its popularity as a tourist and recreation attraction. The protection does not, however, control strong fluctuations of the "subtropical" fish whose populations depend on year-to-year changes in ocean current patterns and sea temperatures.

A proposed marine reserve at the Kermadec Islands would protect New Zealand's unique tropical marine fauna. More marine reserves are urgently needed to conserve, and often to restore, the marine communities of New Zealand. This is particularly true for the more remote islands (Kermadecs, Chathams and subantarctic islands) and for the "inner circle" (e.g. Three Kings, outer Hauraki Gulf, Kapiti, Stewart Island). On the main coasts of New Zealand the little evidence we have strongly indicates that nowhere is "natural" and that a network of representative marine reserves, including nearshore islands, would produce unsuspectedly large amounts of "restoration", with considerable and widespread benefits.

INTRODUCTION

As a terrestrial air-breathing species, humans find marine biology difficult; consequently they mostly ignore it. Indeed, they generally ignore the sea altogether except for seaside holidays, fishing for food, and getting across it to some other land. Although New Zealand is the most maritime country on earth, although scientists are supposed to be objective, and although offshore islands are by definition more marine than terrestrial, the main problem for marine biologists so far has been to get marine matters on the agenda at all. Neither a major review of the natural history of offshore islands in 1973 (Atkinson and Bell 1973) nor the glossy booklet 12 years later on the same subject (Nature Conservation Council 1985) contains one word or reference to marine life that is not air-breathing. Even the seabirds and marine mammals get short shrift, and the publications give no hint that they ever get into the sea or do anything there.

There have, of course, been some honourable exceptions to this attitude. The "two Lucys" made a pioneering study of seashore life on the Poor Knights Islands more than fifty years ago (Cranwell and Moore 1938) and a recent symposium of the Offshore Island Research Group had 20% of its papers on marine topics (Wright and Beever 1986). Nevertheless the prevailing opinion has always been that islands were little bits of land and only interesting as such.

This attitude, although widespread, is completely illogical. It is, of course, easy to explain, but it is not so easy to excuse. Scientists, administrators, politicians and the public can no longer afford to behave as if their perceptions and preferences were more important than the principles of geography and ecology. Ignoring 90% of our hemisphere in terms of effective conservation, given our increasing activity there and our dependence on it, is not just foolish, it is probably dangerous. It would be particularly appropriate to begin making the necessary changes around New Zealand's offshore islands. On these islands there is not only plenty of evidence of previous nonsensical attitudes, but also a growing acceptance that the natural balance should be restored, where that is possible. But it is also a good time to expand the review; to examine our current attitudes to the marine life around these islands; to consider what effect our present actions (and inactions) may be having on the marine biota and whether we wish to modify our attitudes.

The matter is urgent. Even in New Zealand, it is unlikely that pristine marine habitats still exist. Any doubt is largely due to a lack of natural baselines, a lack of study and hence a lack of hard evidence. The resulting uncertainty may suit some classes of politicians and scientists, but it is not likely to comfort our grandchildren. Overseas, hard evidence is coming in of major ecological disruption of island faunas due to human depletion of their marine food (e.g. Avery and Green 1989). The use of gill nets, purse seines and other indiscriminate fishing systems in New Zealand, where commercial fishermen are controlled only by quota, is probably having similar effects, but there is no system to measure them.

There are plenty of simple logical reasons for giving marine conservation - including the effects this can have on science, recreation and economics - a high priority around islands. Although our knowledge of marine ecology is at a much lower level than its terrestrial equivalent, what we do know strongly supports the need for special management care around islands. On a common sense basis, our experience with islands demonstrates clearly that, even if marine restoration is not already the name of the game, prevention is better than cure, and cheaper and quicker.

Because of their isolation, islands may have been spared some types or levels of exploitation and degradation. But because of their small size, they are also more vulnerable to human interference. These points are just as valid for the isolated and small areas of shallow-water habitats round the islands as they are for the terrestrial habitats.

MARINE RESERVES AND ISLANDS

The first marine reserve, at Goat Island Bay, Leigh

The idea of marine reserves is still new, even in New Zealand. The first one, the Cape Rodney to Okakari Point Marine Reserve, near Leigh on the open north-east coast some 100 km north of Auckland, was created in 1977 after twelve years of discussion (see Ballantine 1979). The process included the passing of a general empowering act - the Marine Reserves Act, 1971. After 12 years of actual operation as a reserve - no killing of marine life, no removals, no disturbance - it has proved an almost unqualified success, much to the surprise of nearly everyone.

The results of this experiment were not well predicted either by the proposers, including myself, or the opposers (Ballantine 1980). The proposers thought (correctly) that the reserve would assist some types of scientific experiment, but they were unprepared for the biological changes brought about by complete protection (Ballantine 1987), the opportunities opened up by studies of more natural habitats (Andrew 1988, Creese 1988, Jones 1988, Kingsford 1988, Schiel 1984, 1988) or the behavioural subtleties that could be discovered in undisturbed populations (e.g., Jones 1981, Jones 1984). The opponents of the reserve thought (correctly) that the reserve would prevent many traditional activities, but they were unprepared for the public enthusiasm for looking at abundant natural marine life (Department of Lands and Survey 1984), the increasing belief of the local commercial fishermen that the reserve was a useful stock refuge and breeding ground (Crouch and Hackman 1986), or the large educational, recreational and tourist interests that developed (Ballantine 1989a).

An important feature of the marine reserve at Leigh is the presence at its centre of a small island - Goat Island, about 25 ha in area (see p. 214). The island increases the diversity of marine habitats on an otherwise generally straight and open coast by providing a greater range of wave exposures, aspects, rock types and slopes (Ayling *et al.* 1981). It also makes access much easier, by providing local shelter for small boat launching and for divers entering the water directly. Goat Island acts as a focus for the reserve in many ways, and provides it with much of its character. The reserve is otherwise a typical piece of the north-east open coast. The only special feature of the area is that it is the nearest place to Auckland by road on the open east coast.

The differences between the situation in the marine reserve and similar areas open to exploitation are large, numerous and increasing. They include differences in abundance (crayfish are many times commoner in the reserve; MacDiarmid 1987), in distributions (intertidal sea urchins are much more common in the reserve; Kerrigan 1987), in sizes (red moki are larger; Leum and Choat 1980) and behaviour (fish do not show diver avoidance anywhere in the reserve, indeed near the beach some species are "diver positive" due to feeding!).

In strictly scientific terms, it is difficult to be certain that these differences are a result solely of the protection of the reserve. As yet there is only one reserve on mainland, so studies cannot be fully replicated. There are also problems with properly stratifying samples due to lack of detailed knowledge of marine habitats. Nor is it certain that, even after 12 years of non-extraction, that the Leigh situation is fully natural (crayfish still seem to be increasing in number, and have not yet reached the shallow habitats they occupied in the 1930s and 1940s).

There are very few natural baseline studies in this subject. No one made it their business to record properly any valuable marine populations in New Zealand before their exploitation became widespread and heavy. This applies not just to fur seals and whales in the 1800s, but also to Chatham Island crayfish (*Jasus edwardsii*) in the 1960s, paua (*Haliotis iris*) in the 1970s and squid in the 1980s. It is ironic, to put it mildly, that this lack of investigations before exploitation is now sometimes used to question the value of marine reserves in restoring a more natural balance, or even to cast doubt that any real changes have occurred.

Fortunately, despite these problems, it is clear that the many differences between the marine reserve at Leigh and similar but exploited areas elsewhere are most simply and reasonably explained as a restoration of more natural conditions. Indeed, there are likely to be many more cases that have not yet been discovered, and those that are known are likely to have been conservatively estimated.

If the present situation at Leigh is a restoration, then the effects of exploitation have been much more severe and widespread than most people would like to believe. It also means that over most of the country we have no measure of these effects, and cannot have until more marine reserves are established (see Schaap and Green (1988) for the only alternative). The really important scientific point is that the result of an experiment cannot be stated in advance. Those who do not support more marine reserves are saying they do not wish to know how much natural restoration would occur. They are entitled to that opinion, but not to say they know what would happen.

After following the Leigh reserve throughout its development, having been in close touch with the many research workers who have studied it over the years, and having visited most coastal regions of New Zealand, my opinion is that a reasonably sized non-extractive marine reserve anywhere in New Zealand would, like Leigh, show many large improvements in its marine biota within a decade. The belief that pristine or near-natural marine environments still exist generally around New Zealand seems to me to have no basis other than wishful thinking. Certainly some regions are more natural than others, some species more depleted than others, some habitats less altered than others, but in a connected single system, the sea, these differences do not prove (or even make likely) the thought that one end of the observed scale must be natural. In my view it is time that we made a nation-wide effort to determine natural marine base-lines by the introduction of a network of representative and fully-protected marine reserves around the main islands (Ballantine 1989b). At least 10% by area of all marine habitats in all regions should be protected, not just for normal conservation reasons, but also for their capacity as natural stud farms for commercial species.

In addition to this network of representative marine reserves around the main coast for general restoration and conservation, New Zealand needs special marine reserves to protect unique or particularly vulnerable marine habitats. These special marine reserves will frequently be associated with offshore islands, and one example already exists.

The second marine reserve, around the Poor Knights Islands

Because of their terrestrial habitats and species, the Poor Knights Islands (see p. 214) have long been recognised as an important conservation area and have been a closed nature reserve for many decades. The marine habitats around them are also very special (Doak 1979) and vulnerable (Ritchie *et al.* 1979). These waters, the subtidal cliffs and their marine fauna provide the most spectacular diving in New Zealand (Kelly 1983). Underwater visibility is extremely good, the sessile fauna on the vertical cliff faces is rich and varied (Grange 1986), planktivorous fish school in great abundance (Kingsford and MacDiarmid 1988), and many subtropical species occur including fish (Choat *et al.* 1988), molluscs (e.g. *Volva longirostrata*) and echinoderms (e.g. *Diadema palmeri*). These features promoted its establishment in 1981 as New Zealand's second marine reserve.

This reserve has rather complex rules, with fishing permitted for some species, by some methods, in some areas. These rules were partly a reaction to the demands of the charter boat operators (who were the main users of the area and only people regularly present) and partly a result of the theory that if an activity has not produced any noticeable damage there is no reason to ban it. This very reasonable approach, contrasting with the complete ban on extraction at Leigh, may have facilitated the establishment of the reserve, but has produced continuous difficulties (Ballantine 1987). As time goes by, and more and more people travel from greater and greater distances to see the wonders of the marine reserve, they are less and less impressed to see people fishing. While there are good detailed historical reasons for these fishing exceptions, it becomes more and more tedious for charter boat operators, dive club leaders and tourist couriers to explain them to the ever-increasing number of visitors who are there solely to enjoy the sight of abundant marine life and are not interested in fishing (except to be annoyed by its presence). Recently one of the leading charter boat operators wrote to the Minister for Conservation suggesting a total ban on fishing in the Marine Reserve.

The Poor Knights Islands Marine Reserve has been successful in protecting some unique marine features, in encouraging public and scientific interest in them and in sharpening our understanding of marine conservation. With this experience, it is now clear that complete protection within marine reserves is in the general public interest, despite quite different initial and widespread feelings to the contrary.

Other marine protected areas

At present (November 1989) there are only two marine reserves in New Zealand, despite a history of pressure over 25 years. There are also three marine parks, at Tawharanui (near Kawau Island), at Mimiwhangata (between Whangarei and the Bay of Islands) and round the Sugar Loaf Islands (off New Plymouth). These are organised under different legislation - a combination of a local grant of control under the Harbours Act, 1950 and then local fishing by-laws under the Fisheries Act, 1908. It might be supposed that marine reserves provide strict protection and marine parks a lower grade, but in fact the degree of protection is quite independent of the designation. The Tawharanui marine park has total protection, like the Leigh reserve, and the other two marine parks have certain fishing exceptions, like the Poor Knights reserve.

It is worth noting that the fishing exceptions at the Mimiwhangata marine park have resulted, since its creation, in an *increase* in fishing pressure. The negotiations were conducted widely and with great sensitivity to existing rights, with the result that many people became more aware of these rights and hastened to exercise them in the new park, under the impression it would provide better opportunities! The lesson from Mimiwhangata is that while sensitivity to existing use is advisable, it must be remembered that protection of marine life is the aim and object of the exercise. Even when a complete network of fully-protected marine reserves has been set up, the balance of areas will be at least 9:1 in favour of fishing, and there is simply no point in arranging labels for areas that do not protect marine life.

The public at large are getting disturbed and impatient with the piecemeal but continuous decline in fish and other marine resources. Large numbers of people now support not only quotas and total-take restrictions by commercial fishermen but also active measures to restore and conserve. Those in authority are still listening to the sharp insistence of local and sectional interests about fishing rights and ownership;

they are not yet tuned to the more muted but much wider feeling that if fishing is important the fish stocks must be sustained, not simply shared out as if they were a bunch of lottery tickets. While the public do not always grasp detailed technicalities well, they can and often do have a better feeling for fundamentals than do those people deeply enmeshed in the details. The general feeling now is that management of fish stocks (and other marine biological assets) must contain adequate insurance against the adverse effects of detailed ignorance, general greed, new methods, and political expediency. The public are no longer satisfied with explanations of decline, they want protection from it and restoration wherever possible.

MAJOR BIOGEOGRAPHIC CONSIDERATIONS

The remote offshore islands

A ring of remote islands surrounds New Zealand some 500-1000 km offshore, covering almost three-quarters of the circle. Politically, the Kermadecs, Chathams and most of the subantarctic group are part of New Zealand, but Lord Howe, Norfolk and Macquarie islands are part of Australia. The marine implications of "ownership" of these islands are important in political and economic terms - for example, this greatly increases the size of New Zealand's 200-mile "Exclusive Economic Zone" (EEZ; see p. v) and affects to a major degree the commercial fishing policies. However, in marine biogeographic terms, some of these islands are so different from either Australia or New Zealand as to support distinct faunas. There is little agreement about either the nomenclature or methods of subdivision for marine biogeographic areas (Knox 1963), and data exist only for some marine groups (Gordon 1984, Hay *et al.* 1985, Kingsford *et al.* 1989, Schiel *et al.* 1986) but both the Kermadec and subantarctic island groups (see pp. v, 2, 304) clearly have marine flora and fauna significantly different from those of the main islands of New Zealand.

The Kermadec Island group

The marine biota of these islands is definitely subtropical, with strong tropical elements. While true coral reefs do not occur, several hermatypic coral species have been recorded there in moderate quantity, together with typical associated animals e.g the "crown of thorns" starfish, *Acanthaster.* Both in terms of absences (no *Evechinus* or laminarian algae) and presences (tropical species of fish, corals, bryozoa and algae) the Kermadec marine biota is so different from the rest of New Zealand as to require separate status at a major biogeographic level (see Francis (1987) for fish, Schiel *et al.* (1986) for corals, Gordon (1984) for bryozoa, and Nelson and Adams (1984) for algae.). There seem to be few endemic species, as might be expected from geologically recent and continuously remote islands, but one at least is of considerable interest - the giant limpet, *Patella kermadecensis* (Fleming 1973). The marine communities of the Kermadecs are ecologically important in many ways - special populations (giant groper), interesting absences (neither many of the tropical herbivorous fish nor most of the larger brown algae), populations of species at their geographic limits and with doubtful breeding status (corals and crown of thorns starfish) - but most of all, the simple existence of a shallow-water environment (none eastwards for 10,000 km, none south until New Zealand and none north until Tonga).

The Kermadec Islands are a link between the tropical Indo-Pacific Province (by far the largest and most diverse marine province in the world) and the temperate New Zealand region. Only one other link exists, Norfolk Island - midway to New Caledonia - and that is not under New Zealand control.

So far as is known, the marine fauna and flora of the Kermadec have been little exploited to date and are not in need of restoration, but they are clearly of unique value, highly vulnerable and in urgent need of protection. A marine reserve proposal was made some time ago (Francis 1985) but despite lengthy discussion, and some preliminary fishing controls, it has not yet been gazetted. This should be done forthwith. There are no valid reasons for delay - no regular fishing by New Zealand interests, no permanent residents, and no real opposition. There is ample scientific justification for a marine reserve under existing legislation (Marine Reserve Act 1971), including biogeographic considerations of global significance. It is to be hoped that this conference will provide the necessary stimulus for the immediate creation of a large, non-extractive marine reserve around the Kermadecs.

The subantarctic islands

Just as the Kermadecs (with Norfolk Island) provide the only shallow water habitats to the north of New Zealand in a wide expanse of deep ocean, so the subantarctic islands, especially Auckland, Campbell and

Macquarie islands (see p. 201), provide the only shallow marine habitats between New Zealand and Antarctica. Auckland and Campbell islands, which are under New Zealand control, are on the Campbell Plateau, which is semi-continental in geological terms (generally 500-1000 m deep). They lie in the main belt of westerlies - the "roaring forties" - but north of the antarctic convergence. Sea temperatures are cold, with a small range (5°-9°C at Auckland Island) but with no significant sea ice. Although data are sparse (but see Hay *et al.* (1985) for algae, Kingsford *et al.* (1989) for fish, Powell (1955) for molluscs, and Westerskov (personal communication) for general shore and subtidal communities), the marine fauna and flora appear to be classically subpolar, showing (i) relatively few species but those in relatively great abundance (low diversity and high biomass), (ii) general dominance of algae, especially kelps, and a reduction in herbivores, and (iii) strong seasonality in productivity, reproduction, and (for plankton) actual abundance (with day length rather than temperature controlling the marine biota).

The significance of these islands for air-breathing marine animals - seabirds and marine mammals - has long been recognised both for exploitation (fur-sealers were active here before 1800) and for conservation (legal protection for seals began in New Zealand in 1875). Almost all scientific observations so far have been land-based, including counts of breeding aggregations, behaviour at that time, and survival from year to year (Taylor 1982). Very little has been done to investigate the actual food requirements of these large active predator populations (seals, sea-lions, penguins, albatross, petrels etc.) and nothing at all to ensure that they are getting what they need. Indeed when it was discovered this year that severe losses of Hooker's sea-lions were occurring due to "by-catch" in squid fishing fleet nets, it seemed that for all the care and attention on land, in the sea there was no effective protection at all, nor any system to create protection.

Studies of antarctic marine life, i.e. from Scott Base and McMurdo, have already been carried out quite extensively, despite the extreme logistic and technical difficulties, but the New Zealand subantarctic marine province has been almost totally neglected, despite regular work on the terrestrial biota. Apart from its intrinsic interest, the shallow-water marine life of these islands is the food base for the larger and more "popular" birds and mammals. It should be stressed that, unlike those in the northern hemisphere, shallow water habitats at these latitudes are very rare in the southern hemisphere (no major areas other than around South America and few small ones) and that New Zealand has responsibility for a major part of it. If we claim the EEZ for two hundred miles round these islands we should at least be prepared to study the zone's marine life and, where appropriate, protect it. Indeed, since the shallow habitats are so rare and vulnerable, it would be reasonable to protect large portions of them immediately to ensure their maintenance.

The effects of large active predators in marine food chains are difficult to predict but are likely to be very important and far-reaching. Comparisons of islands with and without sea otters in Alaska have shown major effects on sea urchins (food of the otters), and the sea urchins' food the kelp, and the detritivores dependent on the kelp and their predators (Duggins *et al.* 1989). The shallow water marine habitats of New Zealand's subantarctic islands have not even been surveyed yet, and we know nothing about the effects of "keystone" predators.

The Chatham Islands

The marine biota of the Chatham Islands (see pp. v, 304) differs in two ways from the remote northern and southern groups. In the first place it is not, except by absences, especially different from that of New Zealand. Second, it has been heavily fished for some time by locally-based operators.

Although these islands are at the same latitude as Christchurch and have few endemic marine species, the marine biota of the Chathams is of considerable scientific interest and was the subject of New Zealand's first major marine biological effort, the Chatham Islands Expedition of 1954 (see Knox (1957) and eight further memoirs). At least for the shore and shallow water biota, the Chathams are distinguished by a long list of notable absences, apparently due to the distance from New Zealand and the lack of larval dispersal across it. The species that do occur on Chatham seashores seem to be an almost random selection of the New Zealand "possibles", rather than the ecologically-dominant ones at the same latitude. The only patellid limpet at the Chathams is the one confined to the extreme south of New Zealand, while the only common shore barnacle at the Chathams is restricted to northern shores in New Zealand. Most mussel species common in New Zealand are absent from the Chathams, despite apparently ideal ecological conditions (Morton and Miller 1968).

The marine habitats of the Chathams, as a result of these features, form a large-scale natural experiment from which a great deal could be learnt about the processes that drive and control New Zealand's marine habitats. Almost nothing has been done so far to take advantage of this, largely because New Zealand lacks any effective system to organise coastal marine biological research.

Fisheries research is solely concerned with the currently commercial species and has neither the resources nor a mandate for general marine biology, even when this involves the food and habitat of commercial species. Oceanographic institutes are, quite properly, concerned almost entirely with offshore, deep-water, ship-based research. The universities are naturally obliged to concentrate on student training, and so they select local, inexpensive and convenient topics for research. The museums are hard-pressed even to catalogue and describe the species involved, and the majority of the marine fauna is still undescribed. Despite numerous attempts to organise a coastal research institute over many years, New Zealand still lacks a system capable of organising the kind of research everyone takes for granted on land.

Fishing pressure at the Chathams has been irregular but severe. The best-known example is the crayfish boom of the 1960s, which was conducted with the same speed, waste, and carefree ignorance of a gold rush. Since nothing was done to measure or study the stocks before, during or after, it is hard to be scientific about the matter. The two certain facts are fast, that the boom declined as rapidly as it started due to stock reduction, and second, that the speed with which the large quantity of crayfish were dumped on the market significantly depressed the world price of crayfish. Special exemptions to existing rules were allowed to increase this speed (e.g. permission to tail at sea and transfer to shore by helicopter). Those who attempted to control the matter by enforcing restrictions on boats crossing to the Chathams without proper survey or certificates were forced to retract by loud and widespread accusations of bureaucratic interference. The result was the loss of several lives and a number of boats. It was clear that neither the public nor the politicians at the time were very interested in conservation, even of human life or overall profit, still less of crayfish stocks.

Following the crayfish decline, similar assaults were made by boats remaining at the Chathams on scallops (*Pecten novaezelandiae*), paua, kina (*Evechinus chloroticus*) and other species, but again there was no study of the effects. Indeed it would appear that the general lesson has yet to be appreciated at a political level. When orange roughy (*Hoplostethus atlanticus*) and other deep-water stocks were discovered more recently, while there were scientific studies, the issue of fishing quotas was given political priority over a knowledge of the stocks, their life history or growth rates. When issued quotas of orange roughy at the Chatham Rise seemed inappropriate, some were transferred to other areas, thereby probably spreading the problem.

It is now clear that pre-emptive reservation of significant parts of these stocks (inshore and deepwater) would have been sensible, and that, even now, action on these lines would be highly desirable for restoration.

REGIONAL BIOGEOGRAPHY

The "inner circle" of islands

New Zealand has a large number of islands sufficiently far offshore to have significantly different marine conditions but close enough to have essentially the same biota, or at least a selection of it. These islands form a series of ecological interpretations of the regional biogeography; they are natural experiments and of great theoretical interest. The same point also provides the casual scuba diver, skindiver or shore explorer with a wide variety of communities to look at and enjoy, a much greater range than would occur on a continuous coast.

The Three Kings Islands

These islands are a classic example of the major marine ecological changes that can be produced by a relatively small distance off shore. The Three Kings are open to the influence of current systems over a very wide arc (see p. v). The systems are complex, and include both cold-water up-welling and relatively warm water of subtropical origin (see review in Harris 1985). The resulting biota at the Three Kings is an extraordinary mixture of cold and warm species. Southern bull kelp (*Durvillaea antarctica*) abounds, and the density of large seaweeds rivals the far south (Adams and Nelson 1985), yet several of the commonest fishes at the Three Kings are otherwise confined to the warm east coast of Northland. The common limpet on the island shores is *Cellana denticulata,* which is not found (nowadays) on the main islands except near and south of East Cape.

The explanation of these unique communities is not clear, indeed it is unlikely that there is a single explanation. The strong and almost continuous wave action, combined with cold up-welled water and resulting fog may account for the abundance of bull kelp so far north. The abundance of some northern fish may be the result of differential larval recruitment. The thriving populations of *Cellana denticulata* are probably relict. This species is common in Maori midden material down the north-east coast, where moa bones are also present, although there are no living specimens on adjacent shores.

The "volcanic string" of islands on the north-east coast

A large number of islands occur along the north-east coast from the Cavalli Group to Great Barrier Island (see Wright and Beever 1986) and then on along the east coast of Coromandel and through the Bay of Plenty to White Island (p. 214). Many of these islands are of volcanic origin and, as shallow water marine habitats, are relatively isolated despite their short distances offshore.

They also lie in the general path of the East Auckland Current, which with many eddies, pulses and other variations, moves generally south-eastwards along the shelf as a warm current (Harris 1985). Not only does this current provide warmer conditions, it also transports larvae. Many, if not most, marine organisms have planktonic dispersal stages in their life histories. The result of this is that reproduction is effectively decoupled from recruitment in many marine populations. There is simply no direct connection between the abundance and fecundity of the population and the recruitment of new individuals to that population.

On a continuous coastline the effects of this independence of recruitment may be significant, but around small isolated islands these effects are maximised and frequently override all other factors. The very low numbers of crayfish at the Poor Knights Islands are not due to adverse conditions there (or to fishing pressure) but to lack of recruitment (MacDiarmid 1987). The rarity of *Sypharochiton pelliserpentis* (the commonest shore chiton on the main coasts) on several offshore islands cannot be accounted for by ecological conditions on the islands. It is almost certainly due to a lack of larval transport to these islands (Creese and Ballantine 1986).

The effects of larval dispersal do not just produce absence from islands. The vermetid gastropod, *Novastoa lamellosa,* which forms reef-like crusts on wave-exposed rocky shores, is almost entirely confined to a string of offshore islands from Moturoa (off Cape Karikari) through Poor Knights and Mokohinau to the Bay of Plenty, and also the Chatham Islands! The only place it has been found on the main coast is at Lottin Point, which in terms of the impingement of currents is very like the islands.

Many of the "northern" labrid fish species are confined to, or much commoner around, the offshore islands, apparently as a result of larval dispersal down current (Ward and Roberts 1986). The abundance of islands on the north-east coast, with varying sizes and distances offshore provide a natural laboratory in which, simply by site selection, complex theories on marine dispersal and distribution patterns can be tested (e.g. Kingsford 1989).

One way in which marine animals can avoid the risks of planktonic dispersal is to cut out the larval stage and brood their young. A small unnamed black chiton common on the shores of some offshore islands (and not on the main coasts) broods its young to the crawling stage in its mantle cavity (Creese and Ballantine 1986). The percentage of marine species that exhibit direct development is likely to be higher on offshore islands than on continuous coasts, but there has been no analysis of this in New Zealand.

The East Auckland Current shows fluctuations from year to year in its temperature and strength (Harris 1985). These fluctuations not only affect the supply of subtropical fish larvae, but also their chance of survival after settlement. Since the deviations of temperature are both large ($\pm 2°$ C on an annual range of $6°$ C) and long-lasting (one to three years), these current fluctuations can completely control marginal populations. In the 1970s many subtropical species of fish became quite common at the Poor Knights, but declined or were totally absent by the mid-1980s (Choat *et al.* 1988).

Stewart Island

The marine communities of Stewart Island (p. 288) are especially interesting on several counts. First, they represent the southern extreme, the nearest to subantarctic features, while still retaining the species diversity of the main coast. Second, the coast of the island has some topographic features unique to the region. Third, the biota contains a large number of special communities and populations.

The seaweeds of Stewart Island are specially rich and diverse for New Zealand (Adams *et al* 1974). This reflects not only the high latitude but also the climate (low sunshine hours) and the range of aspect, substrate and degree of wave action. Indeed Stewart Island is probably the only place in New Zealand where the intertidal algae are as abundant in biomass as would be expected from the same latitudes in the North Pacific or North Atlantic.

The north-facing coastlines of Stewart Island and the large, relatively shallow Patterson Inlet are effectively unique to the southern region, offering habitats absent or rare south of Banks Peninsula. Patterson Inlet, especially Big Glory Bay has become the site of intensive salmon culture in recent years. As so often in the past, the entrepreneurial use of marine assets has been encouraged in advance of any study of the assets themselves. Already there have been concerns about detrimental effects due to the very high densities (Southland United Council 1988) and extensive kills due to algal blooms (Hoe Chang 1989). Recently the Department of Conservation made the first basic marine biological survey in an attempt to locate sites for marine reserves (K. Walls personal communication 1988).

The inner ring of islands around New Zealand provides many opportunities for marine conservation and priority sites for marine reserves. Where there are clusters of islands the sensible option would be to have a non-extraction marine reserve around one or more, with the rest of the group in a zone of controlled exploitation (Three Kings, Hen and Chickens, Mercury and Aldermen groups). Where the islands are large - Great Barrier, Mayor, Kapiti, Stewart - part of the coast should be a full marine reserve with the remainder for controlled or open exploitation. The offshore boundaries of the reserves should in each case include a significant amount of open sea, so as to protect localised schools of pelagic species (from purse seining) and the deeper bottom fauna (from trawling).

THE STANDARD MARINE FEATURES OF ISLANDS

In the context of marine conservation, maintenance and restoration, it is worth reviewing briefly some of the characteristics of islands as they affect marine conditions (see Creese and Ballantine (1986) for more detail).

Isolation

For the marine communities isolation measurements need to be related to water depths, but the distance from the continuous coast (rather than from other small islands) is a first approximation. Isolation tends to control (a) the amount of freshwater run-off, which in turn controls the salinity, the suspended sediments, and often the supply of nutrients (nitrates, phosphate and silicate that control phytoplankton growth); (b) the water clarity (depending largely on sediments and/or phytoplankton), which in turn determines the type and depth range of fixed plants (seaweeds); (c) the type, abundance and reliability of larval recruitment; and (d) the distance from human population centres, which in turn affects the type and degree of exploitation. On the more remote islands pollution and continued exploitation are less likely, but quick rip-offs are more likely.

Cross-shelf distance

Although simple distance from coast determines the many land-dependent features of the marine communities around islands, others are better correlated with the distance from the ocean and the main current patterns. If islands are near the edge of the shelf, they are more oceanic in their marine communities, regardless of their distance from land. The Poor Knights Islands are no further offshore than Little Barrier Island but are much closer to the edge of the continental shelf, deep water and the main ocean currents.

Islands near the shelf edge tend to have stronger currents, with less predictable fluctuations (tidal, and seasonal), but greater year-to-year fluctuations. The currents are more likely to be unidirectional. They have more frequent and larger up-wellings, vortices and eddies in their current systems (either directly produced by the islands or general properties of the shelf edge). Their low seasonal ranges in temperature and generally mild climates contrast with relatively strong day-to-day (storm controlled) and year-to-year differences (current controlled). Finally, they have deeper water habitats, steeper slopes and (where exposed) harder rocks.

Size

For marine communities, it is important to measure size at the appropriate depth contour on a chart; nevertheless the size of the island itself gives a first approximation. Small islands tend to be subject to greater wave action; indeed, they focus waves by refraction and have wave exposures greater than theoretically possible on continuous coasts. They have more unpredictable biota, partly due to the absence of some habitats, but also to the increased importance of chance events. In populations dependent on current-borne larval recruitment, chance events are even more significant than they are for terrestrial island species. Small islands also have a milder and more oceanic air climate, with the marine climate more dependent on the local current system than the latitude.

Many of these points interrelate reinforce each other, providing very strong ecological gradients over short distances. For example, the depth of kelp forest (*Ecklonia radiata*) is largely determined by light penetration. The limit is about a metre below low tide in sheltered harbours (the Waitemata), 20 m on the open coast (Goat Island, Leigh) and 50 m on offshore islands (Poor Knights). This 50-fold extension of a major habitat is a product of the inshore-offshore complex - including the interrelated factors of run-off, sediment suspension, depth, wave action, nutrients, currents, temperature, and phytoplankton. Although this gradient may be altered by pollution (e.g. sewage) or increased run-off due to development of catchments, it is basically quite natural and may be very sharp. Within 10-15 km offshore marine conditions, habitats and biota may change more than in several hundred kilometres along the coast. It is this point that makes islands so important for marine conservation. The marine biota of a small offshore island is necessarily different from the adjacent main coast and more vulnerable to exploitation.

THE SPECIAL OR LOCAL FEATURES OF SOME ISLANDS

Features which may make islands of special interest as marine reserves:

Special rock types

Isolated, small offshore islands are almost certainly composed of very hard rock, generally igneous, and frequently of a rare geological type. The obsidian (volcanic glass) on Mayor Island has been specially regarded for over a thousand years by Maori tool makers, and the unusual rhyolites more recently noted with interest. Other rock types of interest include those of Coppermine Island, ignimbrites, andesites, pumice, basalt scoria (see Hayward (1986) for more detail and bibliography).

Recent and active vulcanicity

Rangitoto, Mayor and White islands show a range of recent to active volcanic action. At the last two, underwater vents bubbling gas and devoid of life have been recorded. So far no studies have been made either of colonisation round such vents or of the biological effects of them, although New Zealand (with Hawaii and Iceland) is one of the few places in the world where natural primary colonisation can be studied in shallow water.

Topographic features

The spectacular underwater cliffs, caves, archways and pinnacles of the Poor Knights and their special fauna are well known, but other remarkable marine topographic features occur at the Three Kings, Mokohinau (Creese and Ballantine 1988), Mayor Island (Jones 1989), White Island (Westerkov 1989), the

Auckland Islands, and probably many others still unrecorded or even unseen.

Provision of habitat diversity

Although obvious at the sites, it is worth noting that islands frequently add greatly to the marine habitat diversity of an area. This is not dependent on size or distance offshore; indeed it can be very striking for small nearshore islands, as at Mimiwhangata (Ballantine *et al. 1974*) and the reserve at Leigh (Ayling *et al.* 1981). Islands are often the only habitats of certain types in a large area (Kapiti Island, for example).

Provision of access and shelter

While islands do not necessarily provide shelter, as many yachties know to their cost, they often do, and thus allow easier access to the marine habitats. This can be important even on the main coasts where small islands give much improved conditions for boat launching and diver access. It also applies to deeper and more open water habitats round offshore islands.

Provision of focus

Islands can be very important simply as a focus or a marker. Where straight open coasts are extensive, the existence of small islands or even reefs, while not necessarily significant in themselves, could make excellent markers for reserves (e.g. on Ninety Mile Beach, and in the Bay of Plenty). Islands can also provide markers for essentially open water reserves, and making their location less arbitrary and more easily recognised at sea.

Vulnerability

The marine resources around islands are not just vulnerable because they are small, they also tend to be out of sight. As a result they are specially vulnerable to quick plundering, particularly if the methods are technically legal. Before anyone really knows what is happening the damage is done. It is often difficult to learn what was done and to separate rumour from fact. Repeated stories about the commercial use of gill nets or purse seines round offshore islands, cleaning out and moving on, cannot be documented, but, in my view, are probably true and are a major cause of the known very large differences in fish abundance between some islands and others.

Food for breeding seabirds and marine mammals

Dense breeding aggregations of birds and mammals on islands may be critically dependent on the relatively small, local, shallow marine habitats for food.

Islomania

People like islands; many people are quite fascinated by them. This may well be a problem for those trying to conserve terrestrial biota on islands, but it is a great help in conserving marine biota. The public will almost automatically give extra support to the conservation of marine resources round an island than to an equally-deserving piece of standard coastline or open water. This fact should be used to assist the provision of representative as well as special island marine reserves.

PRESENT POSITION AND CONCLUSIONS

There is ample evidence in principle (Francis 1984), and sufficient evidence in detail, to regard the creation of more marine reserves in New Zealand as an urgent need. Our knowledge of marine ecology suggests that islands are generally prime sites for marine reserves, and this is frequently supported by other points, including biogeographical considerations, existing land reserves on the islands, relative ease of demarcation and policing, and public perception that islands are indeed special.

The Department of Conservation, on its creation in 1987, became the first government department with a mandate for marine conservation. Since then many individuals within the department have made strenuous efforts towards marine reserves, but a combination of factors has prevented any more being set up to date.

These factors include:

- A lack of commitment at the political level: Senior politicians have yet to regard marine reserves as urgent or important.
- A lack of marine experience in the department: Most staff were (naturally) recruited for their terrestrial experience.
- Insufficient funding for new activities: No significant funds for marine reserves were transferred from the Ministry of Agriculture and Fisheries.
- Inadequacies in the existing legislation: The current Marine Reserves Act (1971) was written to permit special cases, not to compel general action.
- The restructuring of the department after only 18 months' operation. This included the abolition of the coastal and marine directorate.
- Excessive fears over public reaction, which is largely unknown and hence particularly inhibiting to sensitive administrators and politicians.
- Simple lack of administrative experience: Only two marine reserves have ever been created in New Zealand, both a decade earlier and by different departments.
- Inappropriate comparisons to land reserves: On land, with more than a thousand reserves of many kinds already in existence, the creation of more is mainly a matter of fine tuning. In the sea, with only two reserves, the general policy is still to be decided.

None of these factors separately would have prevented rapid action, but in combination they have been very effective in slowing progress to a crawl. At the time of writing it has not even been possible to create the Kermadec Islands marine reserve which was proposed by the Ministry of Agriculture and Fisheries as long ago as 1985 (Francis 1985).

However, there are strong indications that the public is becoming much less passive about these matters. Indeed the efforts of many middle echelon staff in the Department of Conservation have created a rapidly-cresting wave of public interest in marine conservation generally and marine reserves in particular. The Royal Forest and Bird Protection Society has recently expanded its interest into the marine field, joining other environmental groups and finding strong public support in its appeal for funds ("Protecting our Coasts: the next conservation frontier" 1989).

Some 9000 submissions were received from the public in response to a discussion paper on a proposed marine mammal sanctuary round Banks Peninsula (Department of Conservation 1988). The vast majority of the replies were in favour of the strictest controls on set nets to protect the endemic Hector's Dolphin. Public questionnaires on regional or local marine reserves have had attracted hundreds of responses, with the great majority in favour of more active protective measures for marine life (including the Bay of Plenty, Coromandel, Gisborne area and Kapiti). Some political leadership on marine conservation is emerging, albeit so far mainly concerned with the use of large-scale drift nets in international waters.

It would seem that the time is ripe for some major changes in attitude. Since there is no scientific basis for pretending that marine organisms and habitats will look after themselves, since the public is becoming increasingly disturbed by the decline in marine resources of many kinds, and since we do have the means to do something about it, perhaps it is time we did make some changes.

For the past decade I have been recommending that at least 10% by area of all types of marine habitats in all New Zealand regions should be non-extractive marine reserves (Ballantine 1980). These would be representative reserves, acting as breeding and stock refuges as well as for all general conservation purposes, including restoration. An additional and special case can often be made for islands. This was recognised in the discussion paper put out by Fisheries for the Auckland region, where 60% of the proposals (18 out of 30) were associated with islands (Ministry of Agriculture and Fisheries 1985). Many island marine reserve proposals would have wide public support and easily-demonstrated scientific value. Not just round the remote islands (for reasons on World Heritage level), but also for the inner circle (nationally justified) and for inshore islands (with regional and advantages).

It took the then government from 1881 to 1894 to buy Little Barrier Island as one of New Zealand's first terrestrial reserves (Hamilton 1961), and it took nearly as long (1965-1977) to establish the first marine reserve (Ballantine 1979). It is to be hoped that, just as we quickly learnt the value of more terrestrial reserves, we will soon be more decisive about marine reserves. Time is not on our side in this matter.

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RECONSTRUCTING THE AMBIGUOUS: CAN ISLAND ECOSYSTEMS BE RESTORED?

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ABSTRACT

The burgeoning field of restoration ecology generates increasing enthusiasm as successes of various sorts and degrees are reported. However, ambiguities hinder progress. The nature of communities and ecosystems in general is itself ambiguous, and one can hardly expect restoration of an entity only partly understood. Natural systems, even climax communities, are not static entities and undergo cyclic or directional change on various time scales. Few restorations have been monitored for long enough to know whether they are successful. Second, one often lacks historical data on the original constitution and function of particular ecosystems that one would wish to restore. Third, the goal of a specific restoration project is frequently ambiguous - partial restoration may be acceptable rather than re-establishment of exactly the same species and processes in the same proportions as in the original system. Criteria for success may be ambiguous, so that survey data do not permit an accurate assessment of the field.

Numerous promising projects suggest that restoration attempts are worthwhile and that, properly monitored, they can contribute greatly to ecological understanding. Chances for at least partial success seem largest on medium-sized islands. The same characteristics that have led islands to play a disproportionate role in the development of academic ecology and evolution - relative depauperation and isolation - augur well for restoration. The low number of species leads to simpler, more easily understood ecosystems, while the isolation allows greater control. Isolation and small size permit removal of exotics. Very small islands are likely to have such small communities that a successful restoration would not be construed as a great victory, and, in any event, the ecology of the island may be dominated by immigration from nearby mainland or larger islands.

INTRODUCTION

Many academic ecologists would probably doubt that restoration of a community or ecosystem could ever be achieved. Current theoretical and empirical research points to a series of impediments and also to difficulties in establishing criteria for success. I begin by outlining some potential impediments to restoration, at least as restoration is currently defined. I then argue that, in spite of these impediments, there is reason for optimism that well-defined restoration goals can be recognised and achieved within a rigorous experimental framework. Next I discuss the singular role of islands in restoration. Species management activities that support restoration will be treated, and compared to the problems entailed in full-scale community and ecosystem restoration. Finally, I will address unique problems that introduced species pose for restoration.

The term restoration is used variously, but there is consensus nowadays in the academic literature, and I will use this consensus definition. Restoration means reproducing exactly the community or ecosystem that was previously present (Magnuson *et al.* 1980, Bradshaw 1987). Thus, restoration is a community or ecosystem-level process, not a population process. Various population processes, such as translocation, replacement, and eradication, may contribute to restoration, but they do not constitute restorations in their own right and may even hinder restoration.

Some community-level processes qualify as partial or incomplete restorations: Recovery is one; this occurs when a disturbed site becomes partially restored without any human facilitation (Webber and Ives 1978) through natural secondary succession. Because secondary succession never re-establishes exactly the community that primary succession had produced, recovery will always be incomplete.

Rehabilitation is another incomplete form of restoration; it is the partial re-establishment, through human intervention, of the original biota and/or ecosystem, but with some change or incompleteness (Magnuson *et al.* 1980, Bradshaw 1987), as in returning fire to a forest system, but with a more regular period and lowered extent and temperature. Much rehabilitation is simply accelerating secondary succession (recovery). One might ask if human intervention can ever accomplish more than rehabilitation. Could it even exceed secondary succession (recovery), and exactly reproduce the original system?

Many community-level activities are not necessarily even part of restoration. Revegetation means establishing some form of vegetation (not necessarily the original), as for erosion control or cover (Proctor *et al.* 1983). Regeneration seems to be used as a synonym.

Replacement is the establishment of a species or community on a site where it did not previously exist, such as pools in phosphate mining sites that had been upland (Bradshaw 1987).

Enhancement means increasing or improving some characteristic of the site, such as increasing wildlife diversity (Magnuson *et al.* 1980, Proctor *et al.* 1983). The last two processes are certainly not restorations, and the previous two need not be.

IMPEDIMENTS TO RESTORATION

The fuzzy target problem

Communities and ecosystems are not nearly so well understood as are populations or individuals. For example, for the vast majority of species there is no argument about where one individual ends and another begins. Even though this matter is not so trivial for a population, one can often find who is breeding with whom and determine something about the population structure of a group of individuals. Yet recognising just where one community or ecosystem ends and another begins is not a trivial matter, unless a physical feature provides a natural boundary (as on an island). In fact, this problem of recognising boundaries between communities and ecosystems underlies a more fundamental problem - a failure to agree on exactly what they are.

This disagreement has led to sharp arguments (Simberloff 1980). At one extreme, some ecologists take an individualistic view of communities and see them as simply collections of populations found in one place at one time, with most interactions among coexisting populations not highly constrained or stylised. At the other extreme, some ecologists view communities as holistic entities, even superorganisms, with component populations intricately and obligatorily linked (Wilson and Sober 1989). For ecosystems the argument has not been as heated, but the same two endpoints can be seen in a gradient. At one end, the ecosystem functions as the inevitable, pedestrian outcome of simply having the component species residing in a particular locality. At the other, the ecosystem is an almost superorganismic entity with energy flow and nutrient cycling quite analogous to an organism's physiology.

These contrasting views find expression in the question of whether communities and ecosystems have emergent properties. Salt (1979) and Simberloff (1976) are sceptical, drawing the distinction between collective properties and truly emergent ones. A collective property is one that is defined for a collective entity, but can be calculated and/or predicted directly from appropriate individual properties of the collective's members. Community respiration is an example. An emergent property, on the other hand, would be wholly unpredictable from knowledge of the component individuals. Whether or not they have any truly emergent properties, we currently have rather little general knowledge of how communities and ecosystems are organised (Paine 1988, Peters 1988).

These considerations about the nature of communities and ecosystems are of great consequence for the goal of restoring island systems. First, if we do not know exactly what the community or ecosystem is, or how many of them we had on the island before disturbance, we cannot precisely answer the question of whether we have restored it or them. It is as if marksmen aimed at a target shrouded in mist, so that its general outline was apparent but the edges rather indistinct, and where an individual shot went could not be seen very well. Second, if communities and ecosystems have truly emergent properties, it would seem by definition that predicting that a particular assembly of species would achieve a restoration would be precluded (Harper 1987), unless, perhaps, we produced exactly the combination of individuals, populations, locations, etc., that obtained before disturbance. For if ecological systems are really more than the sum of their parts plus their interactions, then by definition one would be unable to predict the nature of the system even from thorough knowledge of its components.

The moving target problem

An additional difficulty in attempting to restore a community is that communities are dynamic, not static, and change to some extent even in the absence of anthropogenous disturbance (Inouye 1988). For example, plant communities undergo occasional disturbances, ranging in size from single treefalls to massive fires, that produce changes in species composition and other traits (Pickett and White 1985). Such events, plus other, subtler ones - especially changes in soil texture, chemistry, or microbiology - suggest that even climax communities are never truly unchanging (Connell and Slatyer 1977). Restoration is a game with a moving target whose trajectory cannot be accurately predicted, and the target in any event cannot quite be seen or characterised.

The difficulty of unrecognised deterministic influences

Another factor to consider in trying to restore a community or ecosystem is that rather minor differences in the physical or biotic environment can produce major differences in the relative sizes of component populations. At both the population and community levels, theory as well as laboratory experiments and some field observations suggest the existence of multiple domains or basins of attraction, centred on alternative more or less stable communities (Sutherland 1974, Gilpin and Case 1976, Peterman 1980, Yodzis 1989). Thus, even slight differences in initial conditions (say, sizes of propagules or inocula), well within the range of experimental error, could produce divergent communities or ecosystems through purely deterministic means, yet we would have no practical means (other than repeated trials) of verifying this fact. Worse, some single- and multispecies systems may be governed by deterministic yet chaotic dynamics including strange attractors, so that nearby trajectories diverge exponentially, again precluding long-range prediction (Schaffer 1985). These theoretical conclusions do not arise from chance variation in the physical environment but are completely deterministic. Whether natural systems obey such models and whether these models have been adequately tested in the field are questions open to debate (Connell and Sousa 1983), but their implications for restoration are potentially enormous. The perturbation that sets the stage for a restoration may have taken the system to a new basin of attraction so that the system will not, through its own dynamics, return to a semblance of the original even if many original elements are reintroduced (Peterman 1980).

Community or ecosystem restoration may be complicated by the fact that adding the same set of species in different sequences can lead to different results, at least in the short term. Whether these differing outcomes will persist, and whether they represent alternative stable states, is another matter, but laboratory and small-scale field experiments suggest that such differences may be quite common and stable. For example, in artificial ponds the toad *Bufo americanus* competed better with the frog *Rana sphenocephala* the earlier it was added relative to *Rana,* while *Rana* did worse the earlier it was added relative to *Bufo* (Alford and Wilbur 1985). Furthermore, such historical effects persisted for a very long time in these experimental anuran communities (Wilbur and Alford 1985). Robinson and Dickerson (1987) described similar results for experiments with a source pool consisting of three ciliate species, a rotifer, and some algae in glass beakers, as did Gilpin (1987) for *Drosophila* communities in bottles.

A NULL HYPOTHESIS AND NEW DEFINITION FOR RESTORATION

At this point, one may question whether a community or ecosystem can ever be restored, in the strict sense of restoration. Even with the strict definition (exact reproduction of what was originally present), there are clearly different degrees of restoration. As with all efforts to render an ideal, the effort can become so literal as to be ridiculous. After all, the individuals that had been present are dead, so they cannot be exactly replaced. Researchers may have to define success according to their own set of objectives. Does it suffice to reconstitute the same species-abundance relationships, in terms of either biomass or individuals? Do we really mean all the same species, even microbes? Do we also require the same age structures? What about genetic constitutions and structures of the component populations? For no natural community do we have complete information for all species on any of these matters. For few do we have much in the way genetic information. So even if we had restored a system fully in all these senses, and even ignoring for the moment the problem that communities and ecosystems are dynamic and vaguely defined, we would really have no way of assessing whether we succeeded. In other words, a sceptic could always argue that restoration can never be demonstrated.

On the other hand, an epistemologist could always argue that nothing can ever be demonstrated and debate endlessly about what is meant by demonstrated (Scheffler 1965, Pappas and Swain 1978), so it is unfair to hold restoration ecology to a standard that arguably cannot be met by any science. Let us agree that a restoration will be considered fully successful if it produces a system whose structure and function cannot be shown to be outside the bounds generated by the normal dynamic processes of communities and ecosystems. In other words, if we cannot falsify the hypothesis that we have reproduced the state that would have obtained without the disturbance, we will conditionally accept the proposition that we have achieved restoration, granting that the likelihood of type II error may be high. As noted above, even secondary succession generally does not exactly duplicate the results of primary succession, so we have every reason to believe that, by the strictest definition, restoration is a very difficult goal. However, even if all we can do is to accelerate secondary succession, the effort surely seems worthwhile and the strict definition is still useful as a part of the criterion for success. Further, it is not inconceivable that we could do better than nature, and perfect secondary succession, producing a system indistinguishable from the one that would have obtained if disturbance had never occurred. For now, it would be difficult to specify the system that would have existed without disturbance, but there is no reason in principle why we cannot improve such specification.

However, a problem that bedevils restoration ecology as a science is lack of scientific control and replication. Many authors have noted that attempted restoration of a community or ecosystem is an experiment on a grand scale (e.g., many papers in Jordan et al. 1987) and that experiments on communities and ecosystems are rare. In fact, it seems as if restoration ecology could fill a near void in community and ecosystem ecology (Gross 1987). Yet traditional treatments of experimental design emphasise control and replication and argue that uncontrolled and unreplicated experiments will inevitably be ambiguous. Diamond (1986) suggests that experiments actually fall on a gradient from controlled through uncontrolled and argues for a pluralistic acceptance of natural experiments, particularly in community ecology, as a valid albeit imperfect method. Connell and Sousa (1983) offer a diametrically opposite view.

Restoration efforts are almost always performed without a control. In fact, in classifying the contribution of 17 authors in their book, *Restoration Ecology*, Jordan and his co-editors drew a distinction between field conditions and controlled conditions, with no contribution spanning both approaches. This fact is recognised as a problem in restoration ecology. For example, Rosenzweig (1987) argues that, "no good experiment gets done without adequate controls and replications." But what would be a replicate or control for, say, Guam? Is it really necessary to have a replicate or control for Guam in order to know why its birds are disappearing and what would be required to restore them? Similarly, the proposition that snowshoe hare cycles are part of an intrinsic predator-prey oscillation would seem to be disproved by the fact that on Anticosti Island in the Gulf of Saint Lawrence, hare cycle in the absence of lynx, the predator customarily assumed to affect them most (Keith 1963). Does one really require a control for Anticosti Island?

Certainly the impossibility of a replicate or a control makes interpretation of various patterns much more difficult. For Guam, for example, there was argument over whether the introduced Australian brown tree snake (Savidge 1984, 1985) or organochlorine pesticides (Jenkins 1983, Diamond 1984, Diamond and Case 1986) led to the bird decline. Finally, massive amounts of data and meticulous chronological and geographic reconstruction (e.g., Savidge 1987) seem to have implicated the snake, even to the satisfaction of previous sceptics (e.g., Diamond 1989). Finerty (1980) argues that the absence of lynx from Anticosti Island does not disprove the hypothesis that hare cycles are part of a predator-prey system because Anticosti has abundant foxes. In fact, there is still no accord on the relation of hare cycles to predation (Taylor 1984). So the fact that no island has a real control or replicate need not prevent either restoration of islands or our understanding of the process, but it will make the latter much more difficult. It is much more difficult to learn from an experiment if it is not controlled and replicated. However, more controlled and replicated experiments in restoration ecology are possible, particularly in large-scale projects (Zedler 1988). Accurate pre-restoration data are a *sine qua non*. Even better would be accurate data from before the disturbance that generated the need for restoration.

ISLANDS AND RESTORATION

Islands, particularly medium-sized islands, seem to present the best prospects for successful restoration for the same reasons that they have played a disproportionate role in the development of academic ecology and evolution- isolation and fewer species than otherwise similar mainland. On an island, at least if it is not too large, one can feel confident that an individual is actually part of the island community and ecosystem, and not simply a transient from some adjacent system. Thus one can more easily delineate such features as energy budgets and species-abundance curves. Further, the relative depauperation produces simpler systems whose workings are more readily and unequivocally deduced. For example, it is no coincidence that an island system - the wolves, moose, and vegetation of Isle Royale in Lake Superior - demonstrated that an added predator can partially stabilise an interaction between plants and a large herbivore (Botkin 1977, Taylor, 1984, Peterson and Page 1988). Similarly, the recognition that grazers on competitors for space can increase species diversity first occurred on a small Welsh island, Ynys Seriol, where the spread of myxomatosis reduced the rabbit population with consequent increase in the number of plant species (references in Harper 1969). Island communities are often used to test biological control projects because the fewer species and more clearly delineated populations allow unambiguous observations. For example, release of irradiated sterile male screw-worm flies was first tested on Florida's Sanibel Island, then on Curacao in the West Indies. The boundedness and small size of islands makes removal of exotics more feasible (see below), and the isolation hinders reinvasion.

Larger islands with their larger communities and more complex ecosystems become increasingly like mainland. On the other hand, very small islands may also be difficult to restore, for the following reason. Some ecosystem processes cannot be maintained in small sites, requiring a large landscape scale for continued operation (Baker 1989). In many parts of the world, New Zealand included, small islands that were once part of larger regional systems have been either maintained or partially restored while adjacent mainland or larger islands have been permanently altered. Thus, whatever regional processes routinely maintained the island ecosystem may have been obliterated. Worse, the nearby, larger replacement ecosystems may dominate the dynamics of the undisturbed or restored island. For example, many small islands receive a heavy rain of propagules from nearby large islands or mainland, an influx that can dominate subsequent community and ecosystem processes. Unless nearby source areas are also restored, restoration of such an island would be a Sisyphean task. Fort George Island, off the north-east coast of Florida, contains an intact 100 ha hardwood forest (the Rollins Sanctuary) in the midst of its 500 ha. Part of the remainder is lightly developed, and virtually all such habitat on the nearby mainland has been replaced by ornamental lawns and forests. The rain of propagules into the hardwood forest must be heavily influenced by this surrounding matrix, suggesting that just maintaining the current community structure will require active removal of seedlings.

POPULATION MANAGEMENT AIDING RESTORATION

Population enhancement

Perhaps the minimal partial restoration is the addition of individuals of one or a few species into a community in which they were formerly more numerous or more widespread but have been rendered rare or narrowly distributed by some disturbance such as human activity. There are two reasons why this sort of density- or range-enhancement is a common goal, especially on islands, even if it requires cloning and other expensive preparation. Many island species are represented by such shockingly small populations and/or ranges that a single minor disaster could destroy them. The madder *Hedyotis parvula* is known from one specimen growing at the base of a cliff on Oahu (Shabecoff 1988), while the palm *Pritchardia munroii* is also represented in the wild by only one individual, at a site on Molokai where severe rat predation prevents germination (McMahan 1989). On Santa Catalina Island, introduced goats have reduced the population of an endemic mahogany (*Cercocarpus traskiae*) to seven trees in one canyon (Rieseberg 1988).

Such augmentation of individual species' populations would seem often to be a straightforward matter, at least if the existing population provides an adequate source of propagules. In the Canary Islands *Senecio hadrosomus* was grown in tissue culture from explants collected from many wild individuals, then reintroduced into existing populations (Bramwell 1989). Losses were initially high, but surviving individuals are thriving. Similarly, in northern California Menzies' wallflower (*Erysimum menziesii*) was propagated from seed collected from a remnant population. Seedlings were then planted in newly protected adjacent dune areas from which it had been extinguished by human traffic; most survived (Ferreira and Smith 1987).

One might want to increase the genetic diversity of a local declining population by adding individuals from elsewhere, depending on whether the species is an outbreeder or inbreeder and how genetic diversity is normally distributed (within-population or between-population). On the one hand, a population suddenly reduced greatly in numbers and cut off from normal gene flow may undergo a decline in vitality and reproduction because of increased homozygosity. Also, it may be hindered in subsequent evolution by absence of sufficient genetic variability, though the extent of this threat is debatable (Simberloff 1988). On the other hand, the influx of new genes accompanying an augmentation from other sources, though it would alleviate both these problems, could result in the break-up of coadapted gene complexes providing adaptation to the local environment, and in any event may entail individual alleles not adapted to this environment (Ledig 1986, 1987; Templeton 1986). Whatever the genetic consequences, quite frequently transplanted individuals from other sites are apparently sufficiently unsuited to their new residence that they require intensive management simply to stay alive (Ashby 1987).

Reintroducing populations

Reintroduction of a single species to a site from which it had been completely extirpated is the next most ambitious partial restoration. Of course, unless the original stock has been saved (by seed storage, for example), there will certainly be genetic differences between the restored population and the original, which may produce a need for intensive management (Ashby 1987). For plants there seems to be no systematic survey of how often species reintroduction has been attempted or the frequency of success, but some apparent successes are known. For example, the Malheur wire-lettuce (*Stephanomeria malheurensis*) was completely extirpated in nature, but seed had been collected and propagated for several years (Falk 1987). Seeds from the propagated plants were germinated and then transplanted to the original site, where they are thriving under intensive management.

Griffith *et al.* (1989) surveyed attempts to translocate at least 93 species of native birds and mammals in Australia, Canada, New Zealand, and the United States, many involving repeated efforts and multiple releases. Success rate was high, reaching 86% for native game animals and 44% for species classified as threatened, endangered, or sensitive. Further, success rate was higher when the target area was in the core of a species' historic range than when it was in the periphery or outside it. These attempts entailed varying pre-release preparation, sizes of propagules, and degrees of management, so perhaps the best that can be said is that there are some grounds for optimism if one is willing to expend the effort. In most instances the genetic composition of the propagules certainly differed from that of the extinguished populations they were intended to replace.

Cuvier Island, New Zealand, presents two examples of reintroduction of bird species that had been completely eliminated (Atkinson 1988). Extirpation of goats and feral cats was followed by reintroduction of saddlebacks (*Philesturnus carunculatus rufusater*) and red-crowned parakeets (*Cyanoramphus n. novaezelandiae*). Of course the genetic constitution of the restored populations is not identical to that expected if the island had not been disturbed. For example, some of the parakeets may have been of hybrid origin (Atkinson 1988). However, as noted above, when the original genetic constitution is unknown, and would likely have evolved anyway, it is unreasonable to expect complete genetic identity.

The importance of multiple releases in such attempts should be emphasised. The literature on introduced species includes many instances in which propagules at first failed, after which an apparently similar propagule succeeded. Best known is the introduction of the house sparrow (*Passer domesticus*) to the United States (Long 1981), in which a successful release in 1853 from Brooklyn, New York, ultimately led to establishment over much of North America, often in great abundances. However, previous releases of seemingly very similar propagules in the same region failed. In the biological control literature are many examples in which only one of several similar propagules succeeded (references in Simberloff 1989). There must be deterministic reasons for the aberrant success in each case; for example, the genetic constitutions among propagules are probably never identical. But, as a practical matter, we will likely never know enough about a system to remove an apparently stochastic element from the fate of propagules, suggesting that repeated attempts may be worthwhile if an initial one fails.

Many more reintroduction efforts probably fail than succeed, though it would be very difficult to prove this because many reintroductions are probably more or less *ad hoc* and unrecorded, and failures are less likely to be recorded in the literature than are successes, quite analogously to attempted introductions of exotic species (Simberloff 1981). One would hope to learn much from those reintroductions that have failed, or at least are less than full successes. Again the problem of lack of control and replication may make inference difficult, but careful research into natural history suggests reasons in some instances.

Many reintroduced species fail to survive because the habitat has changed in subtle or obvious ways (e.g., Hall 1987). This is probably also the key reason why exotic species fail, even when deliberately introduced, as in biological control projects (Simberloff 1989) or songbird introductions (Simberloff and Boecklen 1989). And this is likely also probably the explanation for most species biogeographic range limits (e.g., Neilson and Wullstein 1983). This is not viewed as a particularly recondite or interesting conclusion - if some species interaction or disease caused the failure, the result would probably be more easily published. However, it is worth noting that the habitat feature causing an introduction failure or range limitation is often very subtle and surprising, and the research to detect it may be both arduous and ingenious (e.g., Neilson and Wullstein 1983). But, when sought with sufficient care, such habitat limitations are usually found, so habitat limitation should probably be the null hypothesis for species reintroduction failure as for introduction failure or range limitation, and one should require more than an impressionistic statement that the habitat was the same. Also, of course, the physical environment for some species can be composed of or generated by other species - forest trees can determine the critical features of the physical environment for ground-cover plants and some animals.

Morton (1987) provides two interesting examples of failed bird reintroduction on Barro Colorado Island, Panama. In both instances subtle habitat requirements turned out to be critical. His initial hypothesis for the song wren (*Cyphorhinus phaeocephalus*) was that failure to reinvade was caused by either failure to cross water to get to the island or competition from increased antwrens and antbirds. However, when he added seven pairs of song wrens, they survived, evidenced no food shortage, and reproduced. However, predators ultimately discovered all the nests, probably because of a slight habitat alteration. There are now more trails on the island than previously, and the birds, which typically nest in trees bordering slow streams, apparently recognised the trailside habitat as similar to their natural nest site. Many predators use the trails and eventually found all nests. The white-breasted wood wren (*Henicorhina leucosticta*) turned out not to be a bird of damp forest undergrowth as is indicated by guides (e.g., Davis 1972, Hilty and Brown 1986) but rather favours either second growth or large treefalls, suggesting that its original disappearance was a successional matter and its reintroduction failed because of missing habitat, not failure to cross water.

Interactions among species are myriad and often remarkably subtle and complex (e.g., Simberloff 1988). So it is not surprising that some reintroductions have failed because species with whom they have obligatory interactions are either missing entirety or in lower density.

Reintroduced plants of bloodroot (*Sanguinaria canadensis*) and wild ginger (*Asarum canadense*) grew and reproduced but failed to disperse their seeds in an attempted sugar maple community restoration at the University of Wisconsin arboretum. Woods (1984) determined that both species are ant-dispersed, and that nearby natural forest had about two hundred times more ants than the restored forest and twice as many ant species. As a result, far more of the seed in the restoration was eaten by seed predators before being dispersed. Similarly, in the restored Curtis Prairie in Wisconsin there has been little invasion of ants after fifty years (Kline and Howell 1987). In addition to hindering the regeneration of ant-dispersed plants, this absence can have other effects. Some ant species are key cultivators of tallgrass prairie (Baxter and Hole 1967) and may also provide small-scale disturbance that could be critical to some species' establishment (Kline and Howell 1987). Exactly why there are fewer ants in the restored prairie and forest, and how long it will take them to reinvade, are unanswered questions. One might imagine that soil properties are involved. In any event, it should not surprise us that absence of certain ants could hinder certain reintroductions of species and even entire communities. The fynbos shrublands of South Africa have been invaded by the Argentine ant *Iridomyrmex humilis*, which appears to be replacing native ants critical to seed-dispersal of many species, thus threatening the entire community (Bond and Slingsby 1984). Absence of a key pollinator could be as devastating to a species' reintroduction as absence of a dispersal agent. For example, *Iridomyrmex humilis* has also been introduced to Hawaii, where it has depressed populations of native arthropods in high-elevation shrublands, including endemic pollinators of obligate outcrossers (Medeiros *et al.* 1986).

Biogeographic range and habitat for plant species can be absolutely determined by associated mycorrhizal fungal associates, which in turn can be limited by nutrients or other abiotic soil factors (see, e.g., Berliner *et al.* 1986). Miller (1987) argues that much of the course of terrestrial succession is governed by mycorrhizae and describes how absence of appropriate mycorrhizae can greatly impede restoration of aridlands disturbed by coal mines. In particular, in stockpiled and mixed soil the seeds of plants that trap mycorrhizal spores are depleted, thus retarding the accretion of mycorrhizae in the soil and the subsequent development of a normal, diverse community. An implication for restoration in general is that simply removing contaminated soil and replacing it with other than carefully processed, virtually identical, fresh soil, as has been done to the radioactive soil of Bikini, is unlikely to prove an effective aid to restoration. Clewell (pers. comm. 1989) was able to replace topsoil in a phosphate mine with fresh soil from a virtually identical marsh about to be mined and apparently succeeded quite well in reproducing the original marsh plant community. But such a ready source of fresh, similar soil is unlikely to be so readily available.

RESTORING COMMUNITIES AND ECOSYSTEMS

To restore an entire community or ecosystem is the most ambitious restoration project and, given the problems associated with augmenting and reintroducing individual species, might seem an almost hopeless task. Earlier I noted that just defining exactly what constitutes a community or ecosystem is problematic, though perhaps not so much so on a moderate-sized island. Atkinson (1988) points out a further complication: the further in the past the state we wish to restore, the less likely we are to have thorough information on species composition, so we are to some extent forced to infer the target community structure from our knowledge of individual species and similar but undisturbed islands.

However, aside from the fuzzy target problem, perhaps the restoration of communities and ecosystems is no more difficult, if time and budget permit, than reintroduction of species. The main problems are likely the same; most difficulties will entail either subtle habitat requirements for particular species or interactions among component species that are not well understood. For example, an effort to restore areas of Canarian laurel forest from stock collected near the restoration sites has been complicated by the apparent requirement of some endemic and currently rare understorey shrubs for canopy gaps. Thus, more detailed knowledge of canopy species age structure, spatial arrangements, and dynamics will be required to restore the understorey fully (Bramwell 1989) - in other words, a thorough community study.

A full-fledged attempt to reintroduce every species and to recreate the physical conditions of an island as closely as possible (e.g., soil and hydrological properties) may circumvent many problems that would arise in a species-by-species approach. In other words, one may hope that, by attempting to reintroduce a set of species as similar as possible to the one that originally obtained, there is a high probability that at least a semblance of the key interactions and processes will be reestablished and that subsequent secondary succession will carry the system near the range of variation of the original trajectory. In any event, no current general community or ecosystem theory allows more precise specific guidance about how to go about restoration.

The concept of keystone species should provide some grounds for optimism in a full restoration. One may at least be able to recognise small groups of species that are crucial for successful community and/or ecosystem function. Paine (1969) suggested that certain predators, though possibly neither numerous nor playing key roles in energy flow, can greatly modify the structure and function of entire systems - he termed these keystone species. The concept of keystone species has been expanded to include those with other effects, for example, keystone mutualists (typically plants) that support large numbers of other species (Gilbert 1980). Of course dominant plant species that provide a physical structure for much of the community would also be keystones; their key roles are so obvious that no one has felt it necessary to make the formal designation. Recognizing keystone species is still a rather ad hoc affair; often their identities become clear upon the introductionor removal of a species. What is important, however, is that the concept seems to have wide application. Many studies have indicated particular species as keystones. Furthermore, detailed natural historic research is able to rationalise these keystone roles, so it ought to be able to predict some of them. Thus an attempt to re-establish an entire system ought to be facilitated by particular attention to the requirements of keystone species, and perhaps de-emphasis of others.

Of course a full restoration attempt is likely to be expensive, though perhaps not impossibly so. Atkinson (1988) describes just such a project, so far apparently successful on Nonsuch Island, Bermuda. This island is only six hectares, but, if ecologists are serious about restoration, efforts on much larger areas should be possible.

It is a commonplace of modern ecology that secondary succession never leads to exactly the same climax community as primary succession had, but I noted earlier that there is no such thing as a completely stable climax community and suggested that the criterion for successful restoration should be that we cannot distinguish between what is there now and what would have been there without the disturbance. It would be an ambitious but attainable goal to achieve restorations as satisfying to us as long-term secondary successions are, but in less time than secondary successions take. To accomplish even more than this would be a remarkable feat. We should bear in mind that communities and ecosystems are terribly complicated entities; that is exactly why they are not well understood. However many successes the combination of serendipity and good natural history may produce, we should anticipate a high degree of failure and not view individual problems as an argument against the entire method.

If one is willing to settle for something short of restoration - say, replacement or rehabilitation - then a certain amount of species-substitution may be possible within the broader goal of producing a functioning, stable system that bears some resemblance to the original (Werner 1987). Many communities and ecosystems have been created that are far from perfect reconstructions but that serve meteorological, hydrological, aesthetic, and other specific purposes quite well (e.g., many papers in Jordan *et al.* 1987, Cairns 1988). The question then becomes, which particular species can be substituted without great violence to the integrity of the entire system? Atkinson (1988) suggests that we might seek close relatives of species that are now extinct or that cannot be transplanted for some reason. From a philosophical standpoint this seems an attractive course, though two sorts of empirical observations argue that we will suffer some disappointments. First, introductions of congeneric and apparently ecologically similar species may produce very different results (Simberloff 1985, Ehrlich 1989), often because of differences that might have been considered trivial had the experiment not been done. The introduction of ferrets, stoats, and weasels into New Zealand is a good example (King 1984). Second, as noted above, different genotypes of the same species often perform quite differently when placed in the same site. Thus, it could well be that a more distantly related substitute species would produce the better functional, if not aesthetically pleasing, substitute.

Finally, good species management, even of endangered species, need not coincide with restoration goals. For example, if a species no longer found on the mainland is translocated to an island it did not originally occupy, this project thwarts a community restoration to a greater or lesser extent. Even if the species is native to the island, management to facilitate its reproduction can conflict with restoration. For instance, if one were to enhance an animal's favoured food plant beyond what would have obtained on the island without disturbance, the enhancement, by definition, hinders restoration. Though a species-enhancement program may, again by definition, conflict with community restoration, it is possible that it has no further, propagated effect beyond its own artificially high population size. For example, it may be that having even twice as many kiwis (*Apteryx* sp.) on an island as existed before human settlement will have little or no impact on any other species. The subtleties of species interactions and habitat requirements, however, suggest that such an assertion should not be made casually.

EXOTIC SPECIES AND RESTORATION

In many instances, removal of an introduced species is an absolute prerequisite (but may not suffice) for either natural recovery or active restoration. I have already mentioned the role of rats and goats in driving some island plants to the brink of extinction. Another example is California's Santa Cruz Island, in which feral introduced sheep and pigs reduced many plant species to tiny remnant populations in inaccessible canyons. However, an aggressive fencing and hunting program initiated by the Nature Conservancy has cleared much of the island of these grazers, led to dramatic recovery of many species (Hansen 1987, Van Vuren and Coblentz 1987), and set the stage for restoration of entire communities. On Phillip Island in the Norfolk Island group, eradication of rabbits, rats, and other mammals led to some recovery of endemic plant species, though removal of the exotic African olive will be needed to achieve further plant restoration and vigilance is required lest rats be reintroduced and hinder animal recovery and restoration (Atkinson 1988). Atkinson (1988) gives other examples of successful eradication and subsequent partial restoration.

It is now clear that, on small islands, aggressive measures can lead to the successful removal of some exotics (Veitch, this volume). Even on very large islands, persistent efforts can effect extirpation, as witness the successful removal of coypu (*Myocastor coypus*) from Britain after a twenty-year campaign (Gosling 1989, Usher 1989). Not only does the isolation of islands hinder reinvasion by locally extirpated species, but it also hinders activities of animal rights advocates who interfere increasingly with mainland eradication efforts. In Wisconsin, for example, animals rights activists have killed several trees (including single representatives) in an arboretum that had removed white-tailed deer whose browsing was threatening specimen plants, while the decision to kill mountain goats in the Olympic National Park (Washington) to preserve rare endemic plants has aroused the ire of animal rights activists such as the Fund for Animals and forced the modification of the removal plan (Luoma 1989). Island extirpation projects are less likely to be publicised, simply by virtue of the isolation, and in any event sabotage is much more difficult if one first has to reach the site in a boat. I have little doubt that the Santa Cruz Island project would have been far more controversial had it occurred on the mainland. Removing exotic plants usually engenders no such complications. Such activities as the widely advertised annual Bush Bash to rip out introduced bush lupine from northern California dunes arouse no outrage. However, there has been active, vocal opposition to removal of exotic eucalypts from Angel Island off California (Azevedo 1990).

Most attention to date has been focused on how exotic species, such as ship rats, can affect particular other species. Exotic species can destroy obligatory linkages among natives and thus hinder not only reintroduction of particular species with which they interact but restoration of entire segments of a community. For example, on Hawaii feral sheep have reduced coverage by the dominant mamane tree (*Sophora chrysophylla*) (Scowcroft and Giffin 1983). The mamane, in turn, is the primary food and nesting habitat of the endangered palila bird (*Loxioides bailleui*) (Berger 1981, Scott et al. 1986). Thus, sheep removal will be critical in the recovery of the palila, as well as any other species that depend on the mamane.

Extermination methods have so far focused primarily on vertebrates (mostly mammals) and have chiefly entailed trapping, poisoning, and hunting (see, e.g., Moors et al. 1989). Yet from the standpoint of full community restoration, introduced insects and plants will often be even more important (references in Simberloff, this volume). Eradication of some of these species by current means would be exponentially more difficult, though perhaps not impossible on small islands. I suspect that for both insects and plants as well as invertebrates, eradication will eventually be largely by means of genetic engineering and will allow much more ambitious projects.

The possibility of genetic means to eliminate insect pests has been broached for many years (e.g., Hamilton 1967, Whitten 1970, Smith and von Borstel 1972). One key recurring idea is to use meiotically driven alleles associated with decreased fitness, such as sterility. The driven allele would increase in frequency and the population would ultimately disappear. The existence of such alleles as the t-allele in house mice and segregation distorter allele in *Drosophila* (references in Hard 1977, Hedrick 1983) fostered optimism, but the method has never come to fruition, for two reasons. First, such alleles are rare in nature. Second, in nature they seem not to eliminate species (though how would we know if this happened in the past?) because suppressors and modifiers are selected that counteract either the drive or the allele's effects on fitness. Another variant of the same scheme would be if the driven allele determined sex or were on a sex chromosome; Hamilton (1967) showed that extinction would be rapid, as one sex disappeared from the population. Such an allele was isolated in *Aedes aegypti*, the yellow-fever mosquito (Hickey and Craig 1966) and other insects (Hard 1977), but the method has never been perfected as an eradication technique. One might expect it to be more promising on an island because there would be fewer genetic variants in the pool from which suppressors and modifiers would have to be selected.

The other major genetic eradication scheme involves various combinations of conditional lethal mutations and chromosomal translocations (Smith and von Borstel 1972, Hedrick 1984). A conditional lethal allele is one whose effect is expressed only under certain conditions, such as the presence of a chemical or pathogen, which can be produced once the allele has spread. The problem is to get the allele to spread in the first place. One way would be if it is meiotically driven. Another would be to produce a translocation (with the translocated segment containing the conditional lethal allele). If homozygotes for both translocation karyotypes are more fit than the heterozygote, an unstable equilibrium results and selection can further increase the frequency of the new karyotype until it completely replaces the original one. The conditional lethal has increased along with its chromosome. The process could be aided by further releases of individuals with the new karyotype. On an island the prospects for success would be even better, because the progress of the translocation karyotype and its conditional lethal would not be impeded by immigration of the original wild-type from outside the population.

Until recently, such schemes were intriguing but unfruitful. Producing, isolating, and combining the right mutations was extremely difficult. Now, with the advent of modem genetic engineering techniques, such matters are well within the realm of possibility. In fact, similar projects are already being done. Many schemes for weed control entail adding genes for herbicide resistance to desired crop plants, then using massive doses of herbicide to eliminate the weeds (the chemical plough). Conditional lethals are often suggested as genetic leashes that will allow the elimination of genetically engineered organisms that have inadvertently been released to the environment, or whose effects had not been foreseen. Several projects have already incorporated this approach. Although I know of no recombinant DNA project that entails a driven allele, it would now be possible to transfer genes from one species (e.g., house mouse) into another (e.g., rats) much more easily than when driven alleles were first considered as means of extinguishing populations. Nowadays it is even possible to put animal genes into plants or microbes.

Probably the current dearth of genetic engineering applied to eradication results from the low potential economic benefit to genetic engineers rather than failure of imagination or difficulty of the problem. An insecticidal protein from the bacterium *Bacillus thuringiensis* is presently being engineered into kiwifruit in New Zealand to make it resistant to leaf-roller caterpillars (University of Auckland Research Bulletin 1989). Surely a team that can perform this feat can get rid of Norway rats on Kapiti Island. But kiwifruit is New Zealand's largest horticultural export, yielding over half a billion dollars annually. What incentive to eliminate exotic species can be given to genetic engineers that can compete with the inducement offered by agriculture?

CONCLUSION

An ideal definition may be useful as a benchmark but should not stymie worthwhile practical efforts. The fact that no restoration is ever likely to be exact carries much less weight in light of the fact that even nature never restores exactly. Certain technologies for managing species in ways that aid restoration are already well established, and improvements in others (such as genetic manipulation for extirpation of exotic species) are likely. Ecologists have less experience with full-fledged community and ecosystem restoration than with species management. Though such projects are larger and more expensive than single-species management, they will probably not be much more difficult in principle, and the chief problems are likely to be the same as those for single-species management - subtle habitat requirements and critical but recondite interactions among species. Current general community and ecosystem theory provides little guidance in restoration efforts, but experimental tinkering should be profitable. In fact, restoration projects should always be conceived of as experiments, and it is much easier to learn from experiments if they are controlled and replicated. Medium-sized islands are perhaps the most promising locus for community and ecosystem restoration by virtue of their size and isolation.

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HOW REPRESENTATIVE CAN RESTORED ISLANDS REALLY BE? AN ANALYSIS OF CLIMO-EDAPHIC ENVIRONMENTS IN NEW ZEALAND

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ABSTRACT

Offshore and outlying islands are increasingly seen as the last bastions of New Zealand's native flora and fauna and of relict or restored vegetation-soil systems. There are also many endemic forms confined to islands, and for these the islands provide their natural context. But how representative of the New Zealand Biogeographic Region are the environments and habitats of islands? By moving endangered animals (or plants) to predator-free islands we should be clear that we are creating some form of Noah's Ark or botanical garden, not the authentic ecological and evolutionary setting of the species involved. This may be legitimate so long as we know enough about the source and target environments.

This paper attempts to characterise the range of climates and soils of New Zealand inshore, offshore and outlying islands. We set up a matrix of broad bioclimatic and edaphic zones for New Zealand, and this provides a framework for assessing the representativeness of island environments. Significant references to climates and soils of New Zealand islands are contained within the bibliography.

Whereas predator-free islands may be the only chance for many endangered animals they should not be seen as a substitute for mainland protection of representative examples of vegetation-soil systems. Islands have their own characteristic climates and soils and hence habitats and vegetation. These characteristics are functions of the extreme oceanicity and windiness of the climate, limited altitudinal range, restricted range of species and soil parent materials, and imprint of maritime aerosols and marine animals. Successful restoration of even a wide range of island environments would represent only a small part of the range of New Zealand Temperate environments. On the other hand, New Zealand's Subtropical, Subantarctic and Low Antarctic environments occur only on offshore islands. Island restoration should always be carefully researched, use local genetic material, and be stratified according to the landforms, soils, microclimate and drainage patterns within the island. Objective setting is fundamental to any island manipulation.

INTRODUCTION

Biogeography is relativistic ecology. It purports to interpret local biological phenomena in terms of their global relationships (space) and their histories (time). Unfortunately our vision is frequently under great constraint. The use of islands as refuges for endangered species may be a case where we are so focused on the animal or plant that we forget that the new habitat may be quite different from the homeland, at least in some important respect This could be detrimental to the target species and the foster home alike. It is acknowledged that in a number of life or death situations there is no alternative to expeditious translocation of species onto islands, and the choices of islands with the necessary credentials - predator free, reasonable size, some natural shelter - are generally very limited. And no doubt many of our wildlife managers have a highly developed intuitive feel for the suitability of one island over another. Nevertheless, we should understand our management decisions and reassess and refine them where necessary. We should be explicit about the roles we give to islands, understand their material conditions, potentialities and limitations, and their relationship to mainland environments. We should be definite about the management objectives - a species or ecosystem approach? To do this we need to know as much as possible about the physical and biological environments of potential host islands.

The global environment has traditionally been generalised in terms of temperature and moisture (Holdridge 1967, Tukhanen 1980, Nix 1982, Wellman 1983, Meurk 1984, Wace 1990), soil fertility (Scott and Groves 1989) and the corresponding vegetation (Ahti *et al* 1968, Bliss 1975, Walter and Box 1976, Hamet-Ahti 1981, Tukhanen 1984). Apart from the three principal environmental dimensions there is a fourth factor, "continentality", which is to some extent correlated with moisture status (Tukhanen 1980). Humid stations are generally more oceanic - that is, less continental.

In this paper we try to summarise and characterise the climate and soils (the climo-edaphic environment) of New Zealand's islands. Our reference list includes a bibliography of all significant references known to us of soils and climate information for New Zealand islands. We compare and contrast the islands with the mainland, using scattergrams and composite matrices of climatic and soil zones. Using these scattergrams and matrices as a guide, we then ask how representative of New Zealand's total environmental diversity are islands? How unique or distinctive are they? How should we determine the most suitable islands for conservation or restoration work for particular species? What then are our conservation priorities on islands and the mainland?

We consider the whole of the New Zealand Biogeographic Region (Cockayne 1928), ranging from the Kermadec Islands in the north to Macquarie Island in the south. This region spans 25° of latitude, 3760 m of elevation, and superoceanic to subcontinental conditions. Climatic and soil parameters vary continuously between these extremes.

New Zealand islands are conveniently described in the following four groups (pp. v, 214, 288, 304):

Northern islands: All islands north of 38°S. The largest is Great Barrier Island (28,510 ha).

Central islands: All islands between 38° and 44°S. These are all relatively close to shore and most occur in the Sounds-Wellington Ecological Region. The largest is D'Urville Island (16,800 ha).

Chatham Islands: The largest island is the 90,700 ha Rekohu (Chatham Island).

Southern islands: All islands south of 44° except the Chathams Group. This group is the most widely spread, with a latitude range of nearly 10° including Macquarie Island. It also has the greatest altitude range, 5 islands rising above 500 m a.s.l. and Mt Grono on Resolution Island reaching 1194 m a.s.l. Stewart Island at 174,000 ha is by far the largest landmass that we treat as an island (see below).

We generally follow Atkinson and Bell's (1973) distinction between outlying and offshore islands, expanding this geographical treatment to include the terms "inshore" (in bays, harbours, sounds or fiords) and "inland" (in lakes). We use these, plus the terms "oceanic", "continental" and "coastal", to describe climate as well.

ESTIMATION OF CLIMATIC INDICES

The magnitude of climatic indices can be defined by reference to basal zone conditions (i.e. at or near sea level) with a correction for elevation (lapse rate). It is convenient to determine these basal and lapse factors for climatically homogeneous regions. We used the New Zealand Meteorological Service's climate region categories (A-I) for establishing the lapse rates of hydrological phenomena by linear regression. In some cases we lumped or divided these categories - as for example in segregating interior from coastal gradients.

Mean January air temperature was used as the standard measure of the relative warmth of the growing season (New Zealand Meteorological Service 1973). Lapse rates were based on Norton (1985), Barringer (1986) and Meurk (1982). An average value of -0.55°/100 m was used, with higher values known from the Craigieburn Range (McCracken 1980) and the exposed Central Otago plateaux. There is a positive summer lapse rate at low elevations between the coast and inland basins.

The contrast between winter and summer temperatures, with a correction for latitude, is incorporated in Conrad's (1946) Continentality Index in which values range from about -5 (superoceanic) to a theoretical, supercontinentalvalue of 100 (Meurk 1984). Actual maximum values are in the order of 90, at the South Pole and in central Siberia. Although we use the term "mainland" for the North and South islands, on a world scale New Zealand nowhere approaches true continental status, the highest values occurring in the interior of South Canterbury (17.4) and Central Otago (16) and for the North Island a mere 12.5 at Minginui. Stewart Island is treated here among the "islands" largely because its index is close to zero (Fig. 1). In New Zealand, continentality generally increases by +1 to +4/100 m from sea level to about 700 m as this corresponds to the progression from the coast to the inland (continental) basins where summer heating and winter inversions are most intense. On long, even, mountain slopes however, the lapse rate from a few stations averages -0.3/100 m.

Moisture status is calculated in various ways: annual precipitation (R), actual evapotranspiration (AE), and the difference between R and potential evapotranspiration (PE). R and PE are relatively easy to measure or estimate but, whereas there are long term records for the mainland, data are recorded for only some of the islands. Estimates and extrapolations have to be made where data are absent. Lapse rates for R are positive for our ranges of altitude and latitude, but vary considerably in magnitude due to orographic effects (Griffiths and McSaveney 1983). Thus, the following values were used: +300 mm/100 m for Northland to Auckland; +125 mm for eastern New Zealand and Waikato/northern Taranaki; +200 mm from Taranaki lowlands to Mt Egmont; +140 mm from Manawatu to Tongariro; +400 mm from Manawatu to Egmont and for North-west Nelson/Westland; +500 mm for central Westland; and *ca.* +700 mm in Fiordland.

As with Continentality and summer temperature, PE increases (+20 mm/100 m) from sea level to 2-300 m in the interiors, but otherwise declines at a rate of *ca.* -12 mm/100 m as temperature decreases normally with altitude. Estimates of AE are much more problematic as factors for soil drainage and moisture holding capacity have to be incorporated. This can usually only be attempted somewhat crudely at a catchment level. AE was determined from a series of curves (Fig. 2) based on available catchment studies from New Zealand and overseas (at equilibrium AE = R - RO) where R, runoff (RO) and PE were recorded or calculated. A full bibliography of the catchment studies consulted is available from the authors. In some instances AE was considerably above Penman PE, presumably reflecting non-normalised data, advection anomalies, departure from standard vegetation surfaces, or leaky catchments. Condensation of fog by tussocks (Mark *et al.* 1980) would tend to have the reverse effect on the results. In general the curves are founded on the assumptions that over 90% of annual rainfall is evaporated or transpired from zonal soils when temperature is not limiting, and AE is approximately equal to PE when R is 2-3 times PE. Thus in temperate or warmer climes, where R <500 mm, most of R will be evapotranspired, and where R >2-3000 mm, AE will approach PE.

It must be stressed that these data are indicative rather than specific, and are mostly (conservatively) estimated for the islands from the nearest mainland information.

CLIMATES OF NEW ZEALAND ISLANDS

Northern islands

The Kermadec Islands, at the southern fringe of the Subtropical zone (zonal terminology as in Meurk 1984) and south-east trade windbelt, have a warm, humid climate with periodic incursions of cool, southerly conditions in winter (Atkinson and Bell 1973). The other northern islands are Warm Temperate becoming Cool Temperate/Upper Montane on the highest ridges. Prevailing winds are west to south. Annual rainfall is *ca.* 1000 mm near the Bay of Plenty coast with summer deficits occurring, especially on steep, free draining slopes. Some islands, close to shore, may have higher continentality indices than suggested in Figure 1 as a consequence of cold winter air draining off the volcanic plateau.

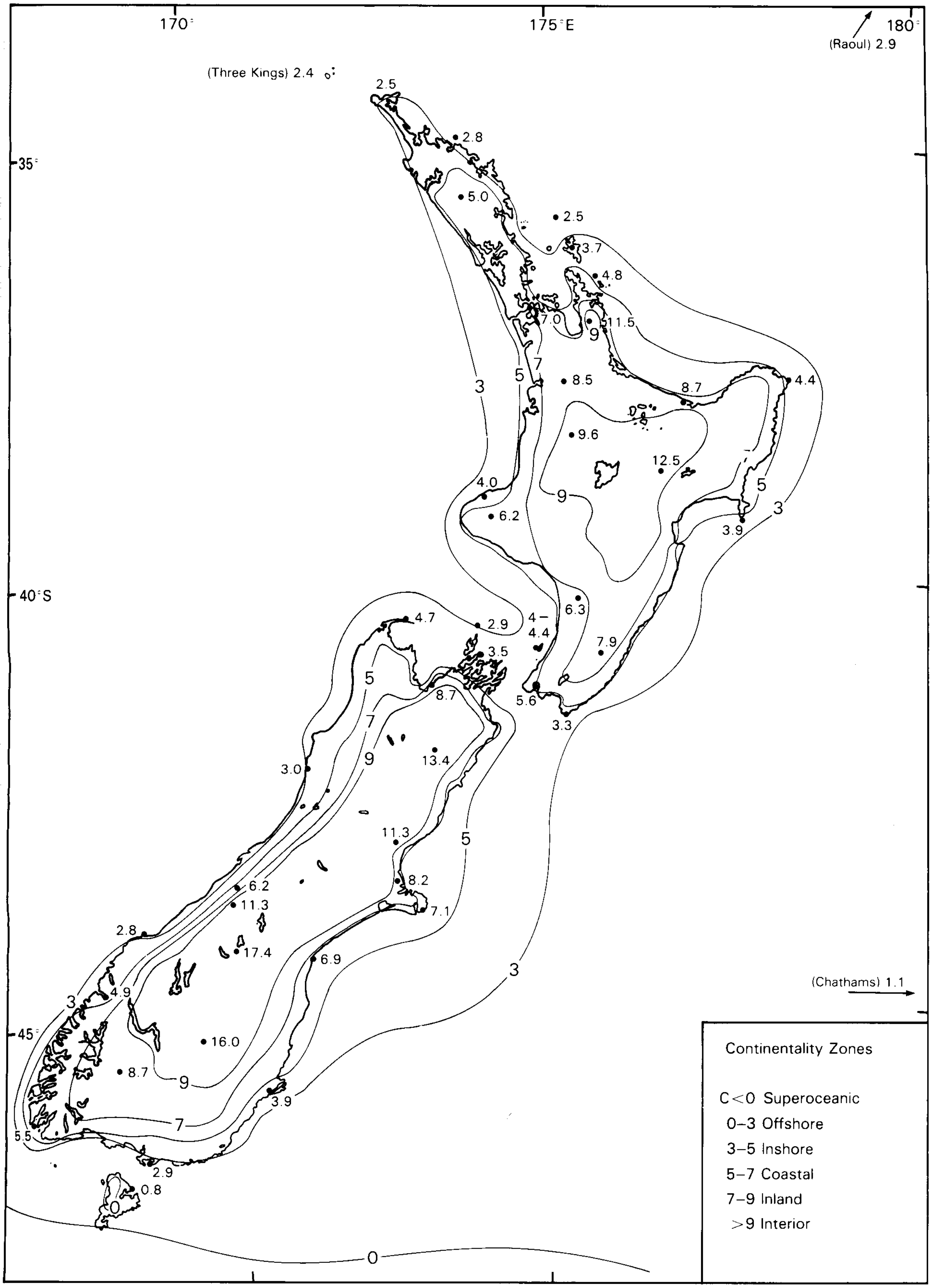


Fig. 1. Isollnes of Conrad's Continentality Index in the New Zealand region, with representative calculated values shown. This index is calculated from the formula: $k=[1.7A/\sin(\theta+10°)]-14$, where A = difference between mean air temperature of warmest and coldest months, θ = latitude. Values of <0 are classed as superoceanic and occur in the southern islands (not shown on map). Values between 0-3 relate to most other outlying, offshore and some inshore islands and western coastal areas. Other coastal or lowland areas fall between isolines of 3-5 with some up to 7 reflecting the drainage of cold winter air out to the coasts. The 7-9 belt largely encompasses inland stations, with values above 9 being confined to interior basins - the most continental parts of the country.

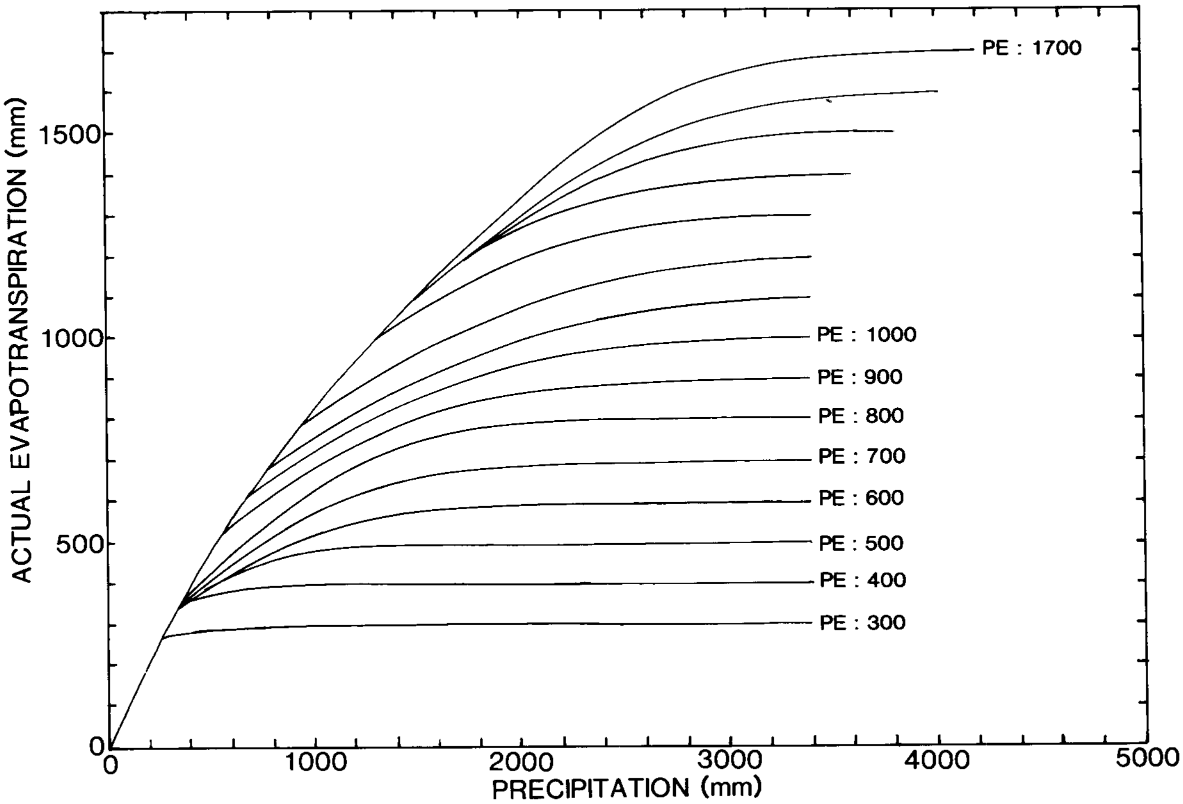


Fig. 2. Potential evapotranspiration curves used to estimate actual evapotranspiration from annual precipitation, derived from various New Zealand and overseas sources (see text).

Central islands

The climate of these islands is Warm Temperate, becoming Upper Montane on the D'Urville Island uplands with predominantly north-east to south-west winds, severe near Cook Strait. Islands off the east coast may receive as little as 750 mm annual precipitation with annual as well as seasonal deficits. On the other hand the Marlborough Sounds island summits probably have excesses of almost 2000 mm. Although the islands are all classed as "coastal", the Continentality Index may be higher than 3 on inshore locations such as Motunau and Quail islands.

Chatham Islands

Climate is Cool Temperate, oceanic with a strong westerly air stream. Rainfall is quite variable from place to place - with as little as 600 mm (Given and Williams 1984) and an annual deficit, and up to 1500 mm on the southern tablelands.

Southern islands

Cool Temperate to Subantarctic, to Low Antarctic on Macquarie Island. The islands are classically oceanic to superoceanic with strong, moist westerly winds and continual cloud cover. Antipodes Island, with its low topography attracting a modest rainfall of less than 800 mm (Meurk 1985), may be anomalous.

COMPARISON OF ISLAND AND MAINLAND CLIMATES

New Zealand's islands encompass a wider range of sea-level (basal) summer mean temperatures than the mainland because of the wider latitudinal spread of the former (29-54.5°S compared to 34.5-46.5° S) although the higher mainland relief results in much colder conditions than on any island. Mean January air temperatures for the North and South islands are 14°C to 20°C at sea level and down to −3.7° on the highest peaks. This compares to 4°-14°C in the southern islands, 13-15° in the Chatham Islands, 12-16.5° in the central islands, and 15-22° in the northern islands (Fig. 3). The Continentality Index in lowland environments ranges from 1.5 to 18 on the mainland and -5 to 5 on the islands (Fig. 1).

R shows an enormous, orographically induced, range (Fig. 4) between 300 and 15000 mm annually on the mainland, contrasting with ca. 800-2000 mm covering most islands (but with 8000 mm on Fiordland islands). Water Balance covers a lesser range, but substantial parts of the mainland experience annual deficits. Normal (30 year) PE ranges from 700 to 950 mm in the mainland low country, with advection giving rise to values in excess of 1100 mm. PE is assumed to be near zero on the highest mountains. Island PE varies between ca. 400 mm in the deepest south and up to ca. 1100 mm in the Kermadecs. AE is < 300 mm to 950(-1100) mm on the mainland compared to ca. 400-900 mm on islands (Figs 4, 5).

From this synopsis it is apparent that the mainland differs from the islands in at least the following respects: islands may be warmer, less continental, and with a more mesic water balance than on the mainland. The considerable numerical overlap in these climatic parameters shown in Figures 3-5 is deceptive. Firstly, the R and Water Balance scales are not linear. And on a geographical basis the overlap applies to only a very narrow fringe of coastal environments. For over 90% of the mainland the single most important distinction is the "continentality" regime. This is a complex factor which subsumes frostiness, dryness or humidity, growing-season length, windiness, and, as we shall see below, soil characteristics.

SOILS OF NEW ZEALAND ISLANDS

The soils of New Zealand's islands have been described in many soil survey reports and scientific papers. Most of these are cited in our bibliography, but inevitably their level of characterisation and description is uneven. We are trying to bring together here the available information, particularly as summarised in descriptions of the soils of New Zealand Ecological Regions and Districts by Cowie (1986) and later incorporated into the Extended Legends for the Third Edition of the Ecological Regions and Districts of New Zealand map series (McEwen 1987).

We investigated a number of soil parameters as a basis for comparison, particularly those related to soil nutrients or soil fertility. The methods both for assaying available nutrients and their relevance to plant growth are both so diverse that no standard was found to cover all soil types and textures. However soil acidity is one factor that is relatively independent of texture and bulk density. A summary of chemical properties of selected soils is given in Table 1. Ratings of the chemical analyses are as given in Blakemore *et al.* (1987). In the end, a broad classification of soil groups was felt to provide the best basis for comparison of island and mainland environments. The soil groups discussed in this section are those of the New Zealand Genetic Soil Classification (New Zealand Soil Bureau 1968). A modern, non-technical description of these soil groups is provided by Molloy (1988).

Northern islands

Soil parent materials of the Kermadec and northern islands (Hayward 1986) are mainly derived from volcanic rocks. These include weathered Tertiary andesites, rhyolites, dacites and basalts, recent basaltic tephras on Raoul and Rangitoto islands, and volcanic colluvium and alluvium on Raoul and Little Barrier islands. On several of the Northland offshore islands and Great Barrier Island, greywacke and argillite are important soil parent materials, and small areas of Tertiary sedimentary rocks of various lithologies, alluvium, peat and dune sands occur.

A variety of soils occurs on these volcanic parent materials. The most extensive are brown granular loams and clays derived from the older volcanic rocks. Very deeply weathered red and brown loams also occur on these older rocks, especially on Great Barrier Island, while yellow-brown loams occur where basement rocks have been overlain by Quaternary tephras, such as on Raoul, Motiti and Matakana islands, and yellow-brown pumice soils and recent soils occur where more recent volcanic deposits have formed the soil parent material, such as on Rangitoto, Motutapu, Mayor, White and Whale islands. The most extensive soils from non-volcanic parent materials are yellow-brown earths formed from greywacke and other sedimentary rocks. Skeletal soils on steep slopes and coastal cliffs occur extensively on many of the islands (Hayward 1986). Small areas of yellow-brown sands (Matakana, Great Barrier and Whale islands), recent soils from alluvium, colluvium and rockfall debris (Great Barrier, Little Barrier and Whale islands) and organic soils (Great Barrier Island) also occur.

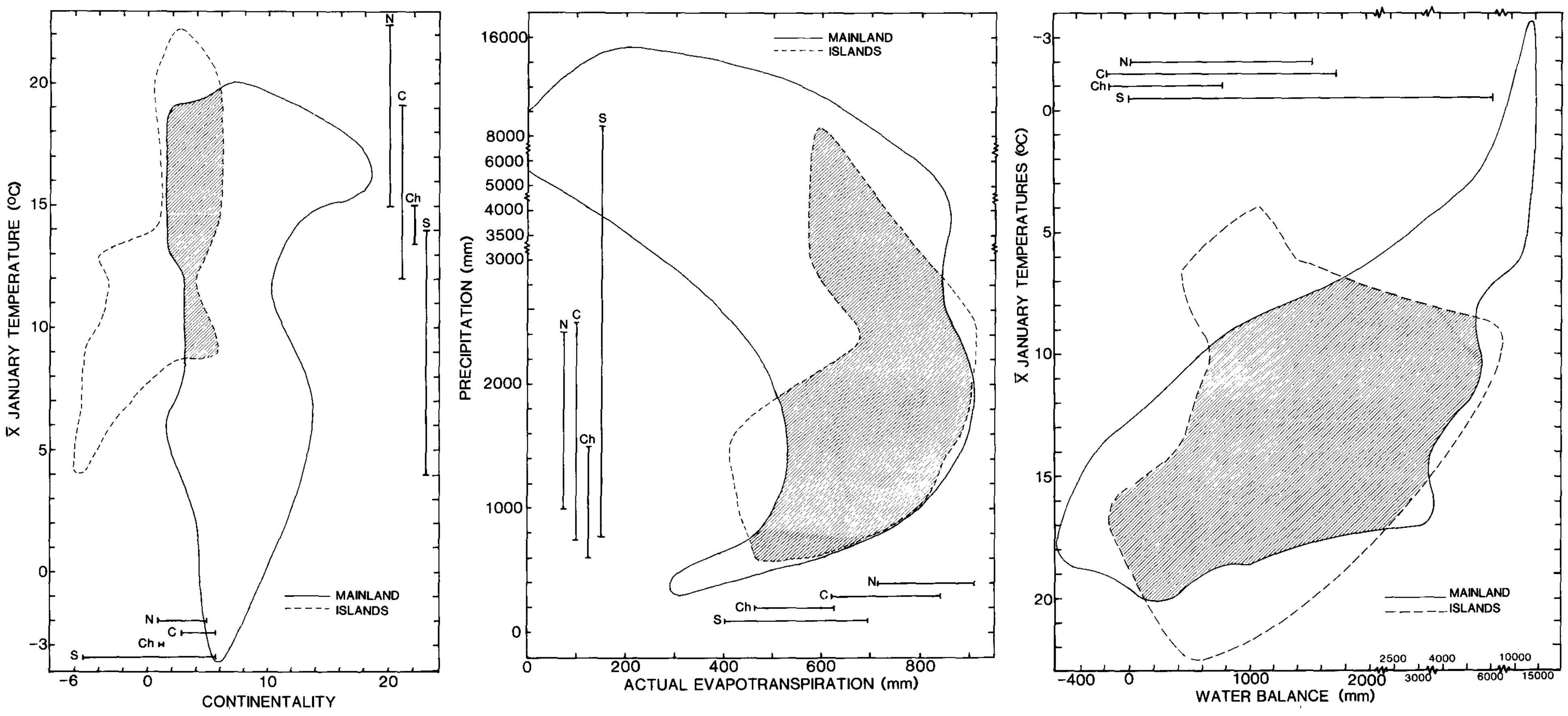


Fig. 3. (left) Scattergram showing distribution boundaries of mean January air temperature and Conrad's Continentality Index for islands (including Stewart and Macquarie islands) and the mainland with the overlap hatched. The values for individual island groups are represented by the bars (N = northern islands, C= central islands, Ch = Chatham Is, S= southern islands).

Fig. 4. (centre) Scattergram showing distribution boundaries of annual precipitation and actual evapotranspiration (derived from Fig. 2) for islands and the mainland.

Fig. 5. (right) Scattergram showing distribution boundaries of mean January air temperature and water balance (annual precipitation - potential evapotranspiration) for islands and the mainland.

As with mainland soils in the northern part of the North Island, soils tend to be strongly weathered, moderately to extremely acid (Table 1) and have low nutrient levels, except where Quaternary tephras have weathered to form yellow-brown loams, notably on Raoul Island, where the possibility of developing a citrus fruit industry has been discussed in the past (Wright and Metson 1959). Total carbon and nitrogen levels are generally low to medium, while cation exchange capacities (CEC) and base saturation levels, although very variable, tend to be low. Phosphorus levels are generally low except where modified by burrowing seabirds, in which case they are very high. In this regard it has been suggested that the high phosphorus levels in some Raoul Island soils are relict, indicating formerly large seabird populations (I.A.E. Atkinson pers. comm.).

Central islands

Soil parent materials in this group of islands are similar to those in adjacent mainland areas: dominantly greywacke and argillite, with various grades of induration, and include hard sandstones to low-grade schist in some islands of the Marlborough Sounds. Significant areas of ultramafic rocks occur on D'Urville Island. Minor reas of loess, conglomerates, gravels, marine alluvium and beach sands occur.

Soils of the central islands are fairly similar in profile morphology to those on adjacent mainland areas, but chemically are strongly influenced by the windswept coastal environment and by high seabird populations (Ward 1961, Webb and Atkinson 1982). The most extensive soils occurring in this region are yellow-brown earths and yellow-grey earths (the distinction depending on rainfall) and intergrades between the two groups. Shallow soils and lithosols on steeplands are common and dominate many smaller islands. Soils in the higher rainfall uplands of the Marlborough Sounds are moderately to strongly leached, and include strongly podzolised yellow-brown earths on the tops of D'Urville Island. (Laffan *et al.* 1987). By contrast, the few islands off the mainland east coast, from Portland Island in Hawke Bay to Motunau Island in North Canterbury, have a pronounced dry season and soils are strongly developed yellow-grey earths on loess. There are also small areas of yellow-brown sands (Kapiti and Mana islands) and recent soils from alluvium (Rabbit Island in Tasman Bay).

Soils on these islands are generally moderately to strongly acid, with low to medium values of organic carbon and nitrogen, variable CEC and base saturation and with high soluble salt levels. Although phosphorus levels are generally low in yellow-brown earths and yellow-grey earths on adjacent mainland areas, they are locally very high on the many smaller islands which have large seabird populations.

Chatham Islands

Organic soils formed on peat cover about 60% of the area of the largest island in the group, Rekohu (Chatham Island). Some of the peats are at least Pleistocene in age and are bituminous (Milne *et al.* 1972). Apart from peat, soil parent materials include andesitic tuff, basalt, schist, limestone, windblown sand and alluvium.

Soils formed on this range of mineral parent materials include brown granular clays and loams, podzolised yellow-brown sands and earths, gleyed recent and recent soils. The loams are apparently unique to the Chathams, being superficially similar to those of Waikato and Northland, but having developed under much cooler and less leaching conditions. Steepland soils occur on the coastal fringes, but the relief of Rekohu is generally subdued. This association of organic soils and soils formed on a variety of other parent materials, make the pattern unique in New Zealand (Wright 1959).

Organic soils are strongly acidic and have high total carbon levels. Soils formed on andesitic tuff also have high total carbon and CEC levels, and C/N ratios, while other soils are generally strongly weathered, acid and have low nutrient levels. However there are few chemical data for these soils and to our knowledge there are no observations from other islands of the Chathams group. Soils on Pitt Island, which is composed of basalt and tuff, may be predominantly brown granular loams.

Southern islands

Basement rocks in this group of islands are primarily metamorphic (gneiss and schist), diorite, granite, or eroded basalt or andesite, but the rock is extensively overlain by blanket peat. Peat has been accumulating for millennia (Leamy and Blakemore 1960, Fleming *et al.* 1976, N.T. Moar pers. comm.) and in some places is lignitic (Bruce and Risk 1983). Small areas of calcareous sandstone, limestone, windblown sand, alluvial sand, beach sand, gravels and colluvium also occur.

The most extensive soils are organic soils formed on peat. Campbell (1981) recognised three classes of organic soils on Campbell Island, based on the depth of peat. Where soils have formed on a mineral parent material, they are classified as lowland or upland podzolised yellow-brown earths, or related steepland soils. There is a thin or patchy peat cover over many of these soils. On Stewart Island, several intergrades between the above groups have been mapped (Leamy 1974). There are small areas of yellow-brown sands, calcareous soils, recent and gleyed recent soils from alluvium, mainly on Stewart Island, and also possibly unmapped brown loams on some basaltic parent materials (e.g. on Antipodes Island). On craggy summits of the high islands, soils of the uplands may intergrade into alpine lithosols.

Soils of the southern islands are moderately to extremely acid, with pH values ranging from 4.0 to 5.6 (Foggo and Meurk 1983), the higher values from salt-spray-saturated sites and the calcareous soils of Chalky Island (Fiordland). The peat-derived soils have high total C and a high C/N ratio. CEC is variable, and base saturation is generally low, but high near the coast. In podzolised soils there are iron-rich subsoils and occasional formation of iron pans. P is generally high where modification by seabirds or marine mammals has taken place, but low elsewhere. On some islands, e.g. Bounty Island, soils on flattish sites are essentially guano deposits, although the temperature/precipitation relationships controlling guano formation on these islands (Hutchinson 1950) have not been studied.

A MATRIX OF CLIMO-EDAPHIC ENVIRONMENTS ON THE NEW ZEALAND MAINLAND AND ISLANDS

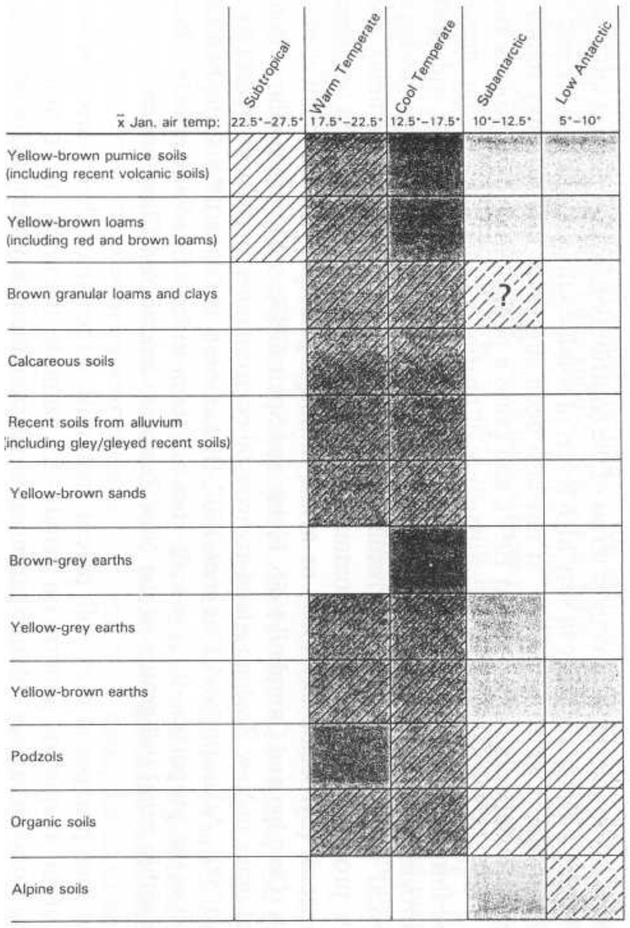
Having summarised the climates and soils of New Zealand's islands, we can now compare them with those of the mainland.

We do this by setting up a matrix of soil groups and climatic zones (Figs 6, 7) and thereupon depicting the occurrence of various climo-edaphic zones. On the vertical axis of both figures are the soil groups of the New Zealand Genetic Soil Classification. Some groups have been amalgamated for simplicity. On the horizontal axis is a bioclimatic zonation (Fig. 6), and a continentality zonation (Fig. 7). The climo-edaphic overlap between mainland and islands can thus be seen.

Figure 6 shows that the New Zealand Biogeographic Region occupies 37 "temperature x soil group" cells. Ninety-five percent occur on the mainland and 68% on islands, although a third of the latter are extremely limited in extent. Of the 37 cells 32% occur only on the mainland, 5% only on islands, 27% (mainly lowland environments) are strongly shared by mainland and islands and a further 35% have weak overlap with very limited island representation (see definitions in Fig. 6 caption). A similar matrix (Fig. 7) demonstrates that 85% of 26 actual "continentality x soil" combinations occur on the mainland and 58% on islands, one-fifth of which have limited representation on the islands. Forty-two percent of the 26 cells occur only on the mainland, 8% only on islands, 38% have strong representation in both and 12% are weakly shared.

The geographical extent of these overlaps is exaggerated by this portrayal. A plot of R x AE (Fig. 4) shows an overlap of about one third, but over half of the islands' contribution to that overlap derives from Stewart and the Fiordland islands. On the other hand the "Temperature x Continentality" plot (Fig. 3) provides a more realistic appraisal of the coincidence of climo-edaphic environments among islands and the mainland. This amounts to about 13% and would be even further reduced if soil and rainfall dimensions were incorporated.

Some major differences in the distribution of climo-edaphic environments between the mainland and islands become evident in Figures 6 and 7. A number of bioclimatic environments (Fig. 6) are only represented on islands, notably those of the Subtropical "volcanic soils" and the Subantarctic and Low Antarctic peats and podzolised soils. On the other hand, a number of fairly extensive mainland environments are not represented at all on islands. The most significant of these are the loamy pumice lands and loamlands (Molloy 1988) of the Cool Temperate central North Island, continental South Island brown-grey and yellow-grey earths, the northern kauri gumland podzols, and the continental high mountain



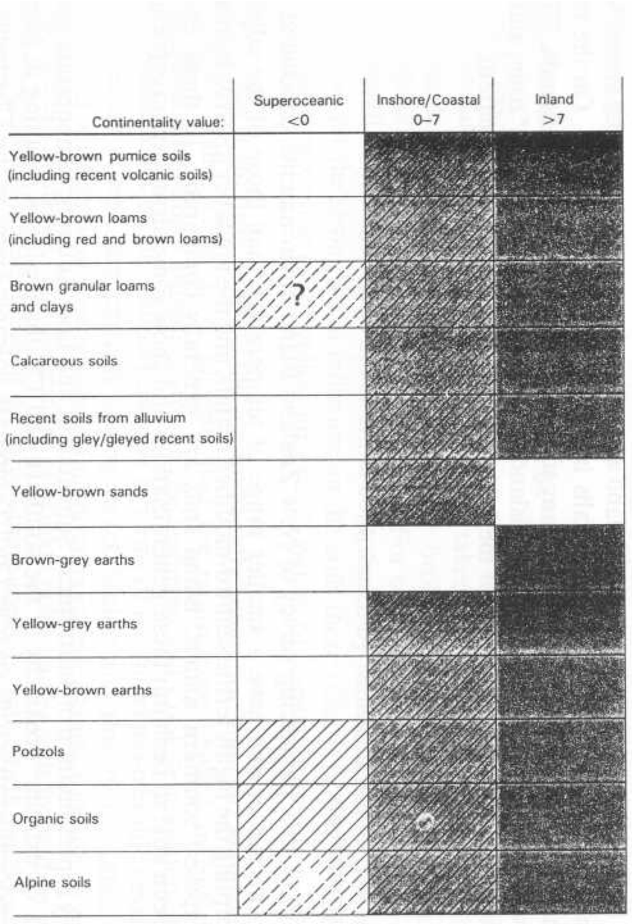


Fig. 6. Matrix of soil groups and bioclimatic zones on New Zealand's mainland and islands. Bioclimatic zones are based on mean January air temperature. Heavy shaded cells = basal zone mainland environments. Light shaded cells = alpine mainland environments. Solid hatched cells = island enviromnents. Broken hatched cells = island environments represented by small areas only, i.e. soil group mentioned in island survey or known to exist, but extent insignificant (<1%) compared with total area represented by cell.

Fig. 7. Matrix of soil groups and continentality zones on New Zealand's mainland and islands. Continentality zones are based on Conrad's Continentality Index. Cell shading and hatching as for Fig. 6.

and nival zones. Furthermore, many more soils are only represented by very small areas on larger islands. These include calcareous soils, recent soils from alluvium, gleyed soils and yellow-grey earths generally, and yellow-brown sands in the north.

In Figure 7, the limited overlap between mainland and island environments is shown even more vividly in terms of continentality. The mainland, predictably, shows a full range of "coastal/inshore" and "inland" environments, except for a lack of yellow-brown sands inland and brown-grey earths in coastal areas. Well over 90% of the area of the North and South islands falls into the inland zone (Fig. 1). On the other hand, the "inland" zone is completely unrepresented for any soil groups in even the largest islands. There is a full overlap of environments between mainland and islands only in the "coastal/inshore" zone, and the distinctiveness of the climo-edaphic environment of the superoceanic islands is readily apparent.

DISCUSSION

Features of island environments

Atkinson and Bell (1973), in a pioneering survey of New Zealand island environments, concluded that their climates tend to be milder and have a smaller range of temperature than those of the adjacent mainland, but that excepting the highly fertile seabird-modified islands, and the tendency towards increased peat formation on exposed southern islands, island soils are generally comparable to those of the mainland. We have been able to flesh out these generalisations and show some significant exceptions to them.

Islands include the only representation of Subtropical, Subantarctic and Low Antarctic temperature zones. They show the effects of extreme oceanicity in the southern and Chatham islands resulting in blanket peats. They have occasional unique soils such as Cool Temperate volcanic loams in the Chathams and raw volcanic soils derived from basalt.

Nevertheless soils show less diversity than might be expected over a latitudinal range of more than 25°. This appears to be a consequence of the relatively restricted range of soil parent materials, and the overriding and unifying imprint of oceanicity. Corresponding to the parent materials described earlier, islands feature a wide range of "volcanic soils" - actually wider than on the mainland - and also a considerable variety of organic soils (Campbell 1981; Meurk unpub.). Soils of poorly-drained lowlands and alluvium are not well represented in northern and central islands.

Oceanicity is expressed in island soils most directly in terms of the contribution from persistent salt-bearing sea winds (especially during storms), resulting in very high levels of soluble salts and often in Cl^- and Na^+ saturation (Gillham 1960, Meurk *et al* in prep.). It has also been suggested that salt may retard the breakdown of soil organic residues in peats (Wright 1959), and cause a podzolisation-type process known as saluviation (Gibbs 1986). A second important consequence of proximity to the ocean is the presence of large numbers of seabirds and marine mammals. These animals fertilise the soil, raise soil nutrient levels, especially of nitrogen, phosphorus and potassium, and decrease pH levels. Animal burrowing also has a significant physical effect on the soil and results in organic matter and nutrients being evenly distributed through the profile (P.L. Searle pers. comm.). Seabird-modified soils have been occasionally referred to as ornithogenic (Syroechtovsky 1959) or avian, although principally in the context of and antarctic environments (Claridge and Campbell 1966, Heine and Speir 1989). Although similar soils have been described several times in New Zealand island and coastal environments (principally by Leamy and Blakemore 1960, Ward 1961, Atkinson 1964, Cox *et al.* 1967, Blakemore and Gibbs 1968, Campbell 1981) the heavy modification to the properties of these soils does not seem to have been adequately reflected by their submergence within zonal soil groups of the New Zealand Genetic Soil Classification.

It is the combination and juxtaposition of soil parent materials rather than their variety which is responsible for many of the unique soil patterns on islands - for example, the range of "volcanic soils" on northern islands arising from the various volcanic parent materials, and the relationship of brown granular loams and organic soils on Chatham Island. Brown granular loams occur on the volcanic rocks of the Chatham Islands and even possibly on Antipodes Island as well as more typically on the northern islands. Indeed, these combinations of soil parent materials appear to have as much influence on the overall soil pattern as climatic variability, and certainly more so within each of the four island groups described above.

The effect of mass movement, often localised to certain parts of the landscape, has also been described as an important determinant of the detailed soil pattern in a variety of island environments (Wright and Miller 1952, Campbell 1981, Webb and Atkinson 1982). Exposed coastal cliffs with recurrent mass movement erosion and low-statured shrubby or tussock vegetation are common. On most islands smaller than about 100 ha, as a consequence of their high edge/area ratio, steepland soil phases and lithosols are dominant, and even on many larger islands appear to be overrepresented in the overall soil pattern compared to the mainland.

Representativeness of New Zealand islands

Within the limitations of the data, it can be seen that islands represent only a small fraction of the total New Zealand environment. When factors are taken two at a time (Figs 3-7) the overlap is about 13-50% (bearing in mind that the rainfall scales are broken beyond 2000-3000 mm). If 3 or 4 factors are considered at once, the overlap is even less. For example, a large part of the relatively continental and low rainfall end of the island spectrum is contributed by Motunau Island (for which data are estimated only) and yet the strong avian influence on the soils there (Cox et al. 1967) means that this ecosystem is not at all comparable to the yellow-grey earth system of coastal Canterbury.

The strong separation between the predominantly "inland" or "interior" mainland and the predominantly "oceanic" islands (Figs 1, 7) suggests that the equivalence implied in Figure 6 between the Montane/Subalpine/Alpine altitude zones on the mainland and Cool Temperate/Subantarctic/Low Antarctic bioclimatic zones is only a superficial one in terms of the full climo-edaphic environment. These two sets of zones are at best only partially analogous (cf. Walter and Box 1976). Also, in spite of the relatively large area of uplands on Stewart Island and the subantarctic islands, truly alpine environments are not well represented on islands. The dominance of blanket peats and/or soils formed on weathered basalt renders island uplands unrepresentative of the large alpine areas on both North and South islands of yellow-brown earths and skeletal soils formed on the weathered, indurated, sedimentary and metamorphic rocks of the axial ranges.

Our comparative analysis of climo-edaphic environments has some implications for the concept of representativeness, as applied in the use of Ecological Districts as survey units for the New Zealand Protected Natural Areas Programme (Kelly and Park 1986). We have shown here and elsewhere (Blaschke 1985) the utility of climatic and soil parent material parameters in defining the physical environment. Although Ecological Districts are convenient units for survey and identification of Recommended Areas for Protection, has their delineation been too heavily influenced by the primacy of biological communities and landscape units? We feel, rather, that for useful ecological comparison, New Zealand biogeographical units should embrace a defined range of soil parent materials, a basal mean January temperature range of ca. 1°C, comparable, objectively defined ranges of precipitation, AE, and continentality, and a homogeneous altitudinal lapse rate regime. A total of 268 ecological districts, or even 85 ecological regions, is a large number of units to categorise in terms of the range of climo-edaphic environments we have here identified. Unpublished work by ourselves and I.A.E. Atkinson suggests that there are ca. 30 definable climo-edaphic environments on the New Zealand mainland. This estimate is consistent with the total number of climo-edaphic cells shown in the present analysis (Figs 6,7).

Implications for conservation

From a biogeographic viewpoint an appropriate method for determining the most suitable islands for endangered species translocation would be to map the natural range of the species (geographically, altitudinally and historically), determine the environmental definition of this range, and match this to the available islands. With so few available islands this might seem to be a pointless exercise, but it may help to pinpoint the problems animals (or plants) are having in a particular case, and what steps, in the way of shelter, exposure, ecosystem nutrient base, etc., might be manipulated to enhance the prospects of survival.

We cannot escape the conclusion that major effort is still required in the protection of significant mainland habitats which are not duplicated on islands. Some of the most important mainland environments from a conservation viewpoint, virtually absent from islands, are those associated with fertile alluvial plains, terraces (with or without loess), and swamps. These systems are some of the richest and most productive, supporting the greatest array of plants and animals. Islands are either excessively fertilised through maritime and biotic influence or excessively leached and acidic (either from rainfall or recent vulcanism). Unfortunately, many islands that are most similar to mainland environments are themselves highly modified, many having been farmed. Restoration projects are going ahead on some of these now deserted islands (Smale and Owen this volume), and this should be further encouraged, especially where the islands are relatively continental and dry, and support the zonal soils of the adjacent mainland. Examples are Whale Island in the Bay of Plenty, Mana Island near Wellington, Motunau Island off North Canterbury, Quail Island in Lyttelton Harbour, Green Island off the Otago Peninsula, and islands in our high country lakes - both natural and those created by hydroelectric dams such as at Benmore. Certainty there are advantages over the mainland in restoring islands - regulation of access, restricted sources of pests and weeds - but unique climo-edaphic island environments mean that techniques for restoration of mainland and island situations are not necessarily interchangeable.

Habitat restoration of all islands must be done with awareness of the range of environments present. Landforms, soils, microclimates and drainage units need to be defined and planting or other management techniques stratified accordingly. Ultimately, nature will sort out the patterns of species and environments, but in the meantime we should attempt a "best guess" arrangement so that founder effects do not have too significant an influence on the future ecosystem.

Many island climo-edaphic environments occur on only one of four islands: Great Barrier Island, D'Urville Island, Stewart Island and Rekohu. These, the largest of each of our island groups, probably have conservation values greater than those for mainland areas of the same size. Apart from their own endemic species, they offer a greater range of habitats, including those closest to mainland environments, than all other islands. They are therefore of great importance as biological reservoirs, especially for species with large or specialised habitat requirements (Atkinson 1989). But it is precisely those islands which also share mainland conservation problems such as alien predators, herbivores and "weeds" that are difficult to control, and mixed land tenure including farmed private land.

Figure 7 points to the importance of islands within gulfs, sounds, and harbours in terms of potential conservation value. These inshore islands are not strongly oceanic and may have a fairly similar climo-edaphic environment to their neighbouring coastal mainland areas. This can be most clearly seen in the closeness of island and mainland portions of the Sounds-Wellingtonand Fiord Ecological Regions. Inland islands (islands within lakes, braided rivers etc., not included in Figures 6 and 7) are even more significant in this respect because they are the only type of island whose climo-edaphic environments can be truly comparable to those of most mainland areas. Examples of this type of island are Mokoia Island in Lake Rotorua, Pigeon and Pig islands in Lake Wakatipu and the unnamed islands in Lake Benmore and other hydro lakes. In the last case, and for cultural or habitat islands (Saunders this volume), which have been literally part of the mainland in the recent past, their significance in terms of representativeness of mainland environments is especially worthy of note. However, such islands are mostly degraded, often with a history of fire, grazing, predator, herbivore and "weed" invasion. Their accessibility causes additional problems; sometimes they are even physically connected to the mainland during low water conditions. The conservation potential of these islands will be realised only with rehabilitation and continuing conservation management.

Reserved inland (relatively continental) lowland environments may need to have "island" refuges created within them (habitat islands) so that the combination of climates, soils, species and processes, free of exotic influences is authentic in all measurable respects. This will require very intensive management to keep small areas predator-free and perhaps hand weeded. Ultimately such controlled areas (cf. the black stilt protection zone near Lake Tekapo: Murray and Reed in prep) may be receptive to birds that have been held on geographic islands. The importance of islands in lakes, rivers and harbours will also provide reference points for natural vegetation of inland, modified areas, and every effort should be made to secure these and manage them accordingly.

CONCLUSIONS

There are still important gaps in our knowledge of the climo-edaphic environments of New Zealand's islands. The most significant would include the soils of Great Barrier, Auckland, Antipodes and Pitt islands, and the water balance of most of the northern and central islands.

Islands are unique environments that engender unique biological adaptations and trophic interactions. They bear the unmistakable imprint of maritime climate, exposure, inputs from salt spray, seabirds and marine mammals. They generally have less habitat diversity because of limited size, high edge/area ratio, exposure, and limited array of parent materials, topography and soils. They can represent only a very small and specifically coastal part of the mainland combinations of thermal, water balance and edaphic environments.

The few large, more diverse islands, sharing mainland characteristics also share mainland problems such as alien predators, herbivores and "weeds" that are difficult to control, and mixed land tenure including farmed private land. Small, inshore accessible islands - including those in harbours and lakes, often provide the closest approximation to the decimated, lowland, semi-arid ecosystems of the eastern mainland and the only opportunity for benchmark reserves of such threatened soils and (potentially) their vegetation. Priorities for protection, restoration and conservation management should include, apart from islands in their own right, unique mainland environments such as dry eastern basins and plains and fertile alluvial plains, terraces and swamps.

The implications for translocation are that we must be cautious about introducing animals or plants to islands, keeping in mind the biological concept of the species we are trying to protect -ie., acknowledging the relativity between their genetic makeup and their evolutionary context (environment). We must be clear about what we are doing in using islands, and where possible see them as temporary holding pens awaiting successful restoration of mainland refuges. Successful habitat restoration on even a wide range of islands would represent only a small part of the range of temperate environments in New Zealand.

ACKNOWLEDGEMENTS

We are greatly indebted to Ian Atkinson for his encouragement and continual supply of stimulating ideas. We thank him and James Barringer, Graeme Claridge, Ben Clayden and Geoff Mew for useful comments on the manuscript, Jewel Davin for considerable assistance in compiling the bibliography, and Derek Milne for initiation of this work.

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Table 1. Properties of selected New Zealand island soils

SOIL GROUP	ISLAND	SOIL NAME*	PARENT MATERIAL	Sample depth (cm)	pH	Total C %	Total N %	C/N ratio	Extract. P mg %	CEC	Base Satn %	Na me.%	REFERENCE*
						Northern Islands							
Recent volcanic soils	Raoul I.	Pokekohu loamy sand	Rangitahua ash	0-5	6.7	6.5	0.45	14	5[1]	28.5	98	~0.8*	Wright & Metson 1959
Recent volcanic soils	White I.	Unnamed	Andesitic ash	0-8	3.6	12.6	0.56	23	0.45[1]	38.0	16	-	SB5511*
Steepland soils related to recent volcanic soil	Raoul I.	Kopikopiko stony silt loam	Ash and young volcanic rock	0-15	6.8	5.0	0.35	14	6[1]	41.2	97	0.7	Wright & Metson 1959
Steepland soils related to yellow-brown pumice soil	Whale I.	Motuhora steepland soil	Rhyolitic and basaltic ash	2-10	5.7	3.9	0.23	17	68[2]	-	-	0.24	SB8537
Yellow-brown loams	Raoul I.	Oneraki black sandy silt	Moumahakai ash	0-10	7.0	10.6	0.86	12	31[1]	41.6	100	1.4	Wright & Metson 1959
Brown granular clays	Little Barrier I.	Unnamed (B1 greyish brown clay)	Hypersthene andesite and tuff	0-8	4.6	6.0	0.22	27	1[1]	12.9	21	0.3	Wright 1961
Recent soils from alluvium	Motuhora I.	Opouraio fine sandy loam	Alluvium from ash and sedimentary rocks	15-30	5.6	3.1	0.24	13	28[2]	-	-	0.09	SB8532*
Recent soils from alluvium	Little Barrier I.	Unnamed (RR3 pinkish grey peaty sand)	Rock fall debris	4-5	4.6	11.0	0.5	22	10[1]	23.2	36	1.0	Wright 1961
Yellow-brown sands	Motuhora I.	Kopeopeo sand	Windblown sand	0-10	6.2	1.0	0.07	14	32[2]	-	-	-	SB8531
Yellow-brown earths	Noises I.	Horopapa hill soils	Weathered indurated argillite	0-20	7.6	6.6	0.51	13	68	37.1	100	1.38	SB9493
Steepland soils related to yellow-brown earths?	Middle Mercury I.	Unnamed (M1 burrowed very friable clay loam)	Andesite	0-8	4.3	3.8	0.34	11	17[1]	23.5	33	0.76	Atkinson 1964
"Bird-modified soils"	Flat 1	Alderman loamy sand	Weathered rhyolite or volcanic ash	0-15	3.3	6.5	0.42	15	344	30	17	2.4	SB8405
						Central Islands							
Yellow-grey earths	Stephens I.	Ketu hill soil	Weathered sedimentary rocks	0-5	4.9	1.3	0.25	5	6[1]	9.1	49	0.5	Ward 1961
Yellow-grey earths	Motunau I.	Unnamed (Unit 1)	Loess over greywacke and conglomerate (seabird burrowed)	0-12	4.6	5.9	0.47	13	86[1]	22.5	64	0.2	Cox *et al.* 1967
Yellow-brown earths	Stephens I.	Ketu hill soil, friable variant	Weathered sedimentary rocks	0-5	5.5	8.1	1.05	8	39[1]	35.2	98	1.7	Ward 1961
Steepland soils related to yellow-brown earths	Stephens I.	Takoporewa soils	Weathered sedimentary rocks, influenced by seabirds	0-15	3.8	8.3	0.76	11	201[1]	38.0	14	0.7	Ward 1961
						Southern Islands							
Calcareous soils	Chalky I., Fiordland	Chalky peaty loam	Calcareous sandstone	0-10	6.6	41?	2.59	16	3.9[1]	110.1	100	2.6	Wright & Miller 1951
Recent soils from alluvium	Stewart I.	Topeheti silt loam	Diorate alluvium	0-23	3.6	44	1.47	30	5[2]	112	8	2.3	SB8496

SOIL GROUP	ISLAND	SOIL NAME*	PARENT MATERIAL	Sample depth (cm)	pH	Total C %	Total N %	C/N ratio	Extract. P mg %	CEC	Base Satn %	Na me.%	REFERENCE*
Gley recent soils	Stewart I.	Freshwater silt loam	Alluvial sand	6-28	5.3	36	1.31	27	4[2]	57.9	28	2.3	SB8493
Intergrades between yellowbrown pumice sands and recent soils	Stewart I.	Riverton loamy sand	Windblown sand	0-15	4.9	2.9	0.24	12	11[2]	9.8	84	0.27	SB8499
Yellow-brown earths	Resolution I., Fiordland	Resolution sandy loam	Granite, gneiss and schist	0-12	4.2	10	0.28	35	0.5[1]	16.3	21	0.4	Wright & Miller 1951
Podzolised yellow-brown earths	Stewart I.	Rakiura peaty silt loam	Weathered diorite	0-18	4.6	11.3	0.55	21	8[2]	35.2	23	0.43	SB8501
Upland podzolised yellow-brown earths	Stewart I.	Anglem silt loam	Diorite	0-8	5.0	11.7	0.55	21	6[2]	26.8	12	0.31	SB8494
Steepland soils related to podzolised yellow-brown earths	Stewart I.	Rakiura steepland soil	Weathered diorite and colluvium	0-30	4.6	7.9	0.39	20	6[2]	27.0	16	-	SB8930
Organic soils	Stewart I.	Pegasus soil	Blanket peat	0-25	4.5	29	1.06	27	-	71.6	14		SB8497
Organic soils	Campbell I.	Thin peat soil	Peat	15-25	4	52	1.2	44	6[2]	176.3	26	12.0	Campbell 1981
Organic soils	Campbell I.	Shallow peat soil	Peat	5-15	4.7	24	1.35	18	30[2]	70.0	33	3.6	Campbell 1981
Organic soils	Campbell I.	Unnamed (Nest site soil (occupied))	Peat over basalt	0-10	4.6	48	2.59	19	60[2]	123.9	33	5.1	Campbell 1981
				Chatham Islands									
Brown granular loams and clays	Chatham I.	Tiki brown clay	Andesitic tuff	0-8	5.2	7.8	0.46	17	10[1]	39.2	42	0.9	Wright 1959
Brown granular loams and clays	Chatham I.	Hokopai hill soil	Basaltic rocks	0-10	4.7	21.8	1.13	19	42[1]	85.0	29	2.2	Wright 1959
Calcareous soils	Chatham I.	Ohuku sandy clay	Soft limestone	0-10	7.2	12.2	0.81	15	306[1]	75.9	-	1.5	Wright 1959
Podzolised yellow-brown sands	Chatham I.	Te One loamy sand	Aeolian sand	0-15	5.1	4.7	0.31	16	17[1]	17.6	88	1.3	Wright 1959
Organic soils	Chatham I.	Rekohu fine sandy loam	Peat	10-35?	4.2	5.4	0.08	68	1[1]	15.6	19	0.3	Wright 1959

*as used in reference.

[1]in 1% citric acid
[2]in 0.5M H_2SO_4
[3]in 0.001 M H_2SO_4.

*Value for Pokekohu gravelly loam

*This and subsequent SB numbers refers to New Zealand Soils Database, held by DSIR Land Resources, Private Bag, Lower Hutt.

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ECOLOGICAL RESTORATION ON ISLANDS: PREREQUISITES FOR SUCCESS

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ABSTRACT

On islands it is sometimes possible to restore biotic communities to a condition that approaches the semi-pristine state. Prerequisites for success in this endeavour include a clear definition of restoration goals, an understanding of natural restorative processes, practical skills for establishing plant and animal species, and commitment by individuals and organisations to particular restoration programmes. However, in New Zealand, conflicts of interest are arising between the function of islands in protecting relict species of the mainland, the need to use some islands for the recovery of species not originally present on those islands, and programmes for restoring island communities. These conflicts can be reduced by answering specific autecological questions relating to the species of concern, and by developing a national strategy for island management. Some essential components of this strategy should include the identification of island conservation values, a listing of species requiring islands for recovery, analysis of the possible impact of those species on islands seen as suitable for them, and integration of species-centred recovery programmes with the broader aspects of island management.

WHAT DO WE MEAN BY ECOLOGICAL RESTORATION?

A common view of ecological restoration is that it is an attempt to reinstate biotic communities in their original pre-human pristine state. There is much to be said for this view as an idealistic model to work towards but it can seldom be seen as an achievable goal, unless one adopts a very loose definition of the pristine state. The post-human state of an island can also be an inappropriate goal for ecological restoration. If for example we aimed to restore Hen Island (east of Whangarei, New Zealand) to its 1700 condition, we would be aiming for a landscape rather devoid of forest (except in the steeper valleys), and rather depleted of bush birds, burrowing seabirds, tuatara, lizards and larger invertebrates, compared with the pre-human state. More (*Rattus exulans*) would be abundant, particularly near human habitation, and an elaborate series of stone-walled terraces on the slopes would be producing kumara with perhaps a few taro in moist gullies. The whole system would be of great interest to anthropologists and archaeologists, but scarcely an appropriate end point for restoring part of our biological heritage.

To restore in an ecological sense means no more than to put back what has been there at some earlier time. What that time is, whether last century or even last year, will depend on the kind of biotic community that is identified as of particular interest. In theory it could include communities of pines or eucalypts, but in practice the motivation to restore biotic communities has focused on indigenous communities. There is however no reason why an indigenous community lost only a few years ago should necessarily be less interesting than one lost in earlier times. Fundamentally the choice will depend on value judgements by the interested parties (Diamond 1987), although scientific analysis can assist in identifying and characterising communities worthy of being restored.

Notwithstanding the impossibility of reinstating the pristine state of most terrestrial communities, we have greater opportunities on islands than on the mainland to push the restorative process towards systems that may approach a semi-pristine state. Two reasons for this are apparent: the increasing facility with which introduced mammals are being removed from islands, and the freedom from major human disturbance that many New Zealand islands have enjoyed since early last century (Atkinson 1973: 111). To take advantage of these opportunities it is essential to have clearly defined restoration goals (Atkinson 1988) but, as pointed out in that discussion, we know less and less about the composition of a community the further we go back in time. Furthermore, because some changes cannot be reversed, such as loss of species through extinction, changes in weather patterns, introduction of marine and aerial pollutants, and introduction of certain species of plants and animals, it may not be possible to replicate some communities of even the relatively recent past.

Some of these problems are discussed by Simberloff, who suggests (in this volume) that "a restoration will be considered fully successful if it produces a system whose structure and function cannot be shown to be outside the bounds that are generated by the normal dynamic processes of communities and ecosystems. In other words, if we cannot falsify the hypothesis that we have reproduced the state that would have obtained without the [human] disturbance, we will conditionally accept the proposition that we have achieved restoration...."

The advantage of Simberloffs approach is that it does not assume that all the original species must be restored, nor that their age structures and genetic constitutions must be identical. Given that the original system was never static it provides for more latitude in the allowable biotic composition of the community to be restored provided this does not generate new kinds of ecological interaction or evolutionary process that were formerly not operative. The need to identify clearly what is being aimed for in a particular restoration programme must again be stressed.

PREREQUISITES FOR SUCCESS IN ISLAND RESTORATION

Although what follows is not necessarily complete, there are certain components of a restoration programme that can be readily identified as necessary for success.

Comprehensive information

This should be readily available for the physical, biological, archaeological and cultural attributes and values of all our islands. Without such information, appropriate islands for restoration cannot be identified.

A functional classification of islands

Restoration is only one kind of management; different islands perform differing conservation functions and therefore require different kinds of management. In our work in the Mercury Islands (Towns *et al.* this volume a) we found that we needed a functional classification of islands based on their conservation use. This is illustrated in Figure 1 and expanded in Table 1.

> Minimum-impact islands include those with plant or animal species endemic to them, with very fragile biotic systems, or with relatively unmodified systems. The primary aim of management is to minimise human interference.
>
> Refuge islands include a majority of our island nature reserves which protect not only common lowland and coastal plants and animals but also provide refuge for many relict species of the mainland. It may sometimes be necessary to use some refuge islands to ensure survival of mainland species not originally present on the island.
>
> Restoration islands are a minority group of islands because restoration is a labour-intensive activity and is only appropriate where natural restorative processes cannot be expected to secure the future for certain threatened species and communities. The level of public involvement with restoration on such islands would vary widely according to ease of access and vulnerability of the restored communities to human use. The educational benefit of involving the public in restoration programmes, whenever possible, should never be underestimated. With skilful interpretation it will lead to a broader appreciation of the value of nature conservation.

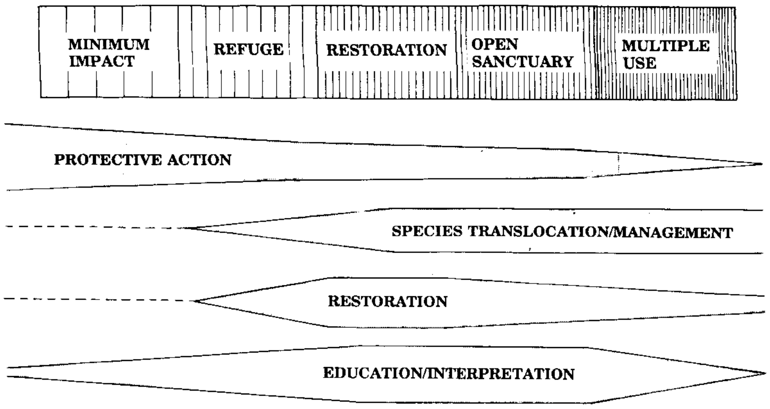


Fig.1. Functional categories for island management showing the relative importance of protection, recovery programmes for individual species, restoration, education and interpretation, in each category.

Open sanctuary islands are also a minority group because they combine extensive programmes of public interpretation of the New Zealand biota with labour-intensive species-specific management of plants and animals, including those threatened by extinction or destruction.

Multiple-use islands are those with some conservation function but it is secondary to other uses such as farming, forestry or recreation. Farm parks and many privately owned islands could be included here.

These five categories should not be seen as water-tight boxes but rather as identifiable colours in a spectrum of conservation use. Although the classification is based only on terrestrial criteria, it can be used in conjunction with other kinds of classification to decide management appropriate for different islands, including their suitability for restorative actions.

Defining restoration goals in an island context

The concept of restoration includes a number of different kinds of action, even within the context of islands (Table 2). The first group of actions is centred on recovery of threatened species and can vary from very minor manipulation of a species' habitat to restoration of several biotic communities in order to provide habitat for the species of concern.

Replacement of extinct animal taxa by related extant species (Atkinson 1988) may, at first sight, be seen only as a further kind of species-centred restoration. In fact, in so far as it allows restoration of a more complete trophic structure to biotic communities formerly present, it should be seen as an option that significantly increases our opportunities for successful restoration in terms of Simberloff's definition (quoted above). We may choose to use a taxon related to an extinct species that was formerly part of a particular island community (option Ila of Table 2) or formerly part of a mainland community (option IIb). If the latter, an island is likely to be the only kind of place where such an experiment could be conducted.

An example will illustrate the concept of species replacement. New Zealand once had seven species of small acanthisittid wren (Dr P.R. Millener, pers. comm.), an endemic family of birds that may be more ancient than moas and kiwis (Sibley *et al.* 1982). All but two of these species, the rifleman (*Acanthisitta chloris*) and the rock wren (*Xenicus gilviventris*) of the South Island alpine zone, are extinct. Notwithstanding a few possible sightings, the last lowland of *Xenicus* (*X. longipes*) was probably lost during the 1962-63 rat irruption on Big South Cape Island (Atkinson and Bell 1973). There is thus a case for attempting to re-establish a lowland population of *Xenicus*, particularly if it can become adapted to forest, so that ecological and evolutionary processes associated with these wrens can be reactivated in at least a few places. The rock wren provides the only possible source for a founder population of *Xenicus* and, because of mammalian predators on the mainland, an island lacking these predators is likely to be the only possible site. Nevertheless, as with any other proposed translocation to an island, there are critical questions that must be asked, and as far as possible answered, before proceeding with such a proposal (Table 3, Appendix 1). Although takahe from a subalpine environment have now bred successfully on islands, there is no way of predicting whether rock wrens would do the same. Somes Island, Wellington Harbour, provides an opportunity to test the feasibility of breeding rock wrens in a lowland environment where open rocky habitats are available. Although this island is highly modified and used primarily as an agricultural quarantine station, regeneration of native scrub and forest is occurring on some slopes, assisted in places by plantings.

Restoration of biotic communities can vary from repair work with one or two species (option IIIa, Table 2) to restoring a complete island community involving the re-establishment of many species formerly present (option IIIc). We can also use a very modified island to partly restore a mainland community, for an island may be the only place where absence of problem predators and herbivores makes it feasible (option IIId). The potential for restoration of some very modified islands should not be underestimated.

Engineering a completely new kind of community for a specific conservation purpose (option IV), for example planting a mixture of pines and native plants as habitat for kiwis, is not restoration in the strict sense. But in its aim of providing habitat for a species that may be threatened, this kind of management does have a restorative dimension.

Understanding the restorative process

Scientific understanding of natural restorative processes, i.e., plant successions and their effects on animal numbers, is needed if the identified goal of community composition is to be achieved. Our understanding of the development of some kinds of island community is very incomplete at present. However, the instability and exposure of many island sites means that it is possible to maintain a series of successional stages *without human intervention.*

The sequence in which species can be re-established artificially is of some importance. Many plant species of a mature forest cannot be used as pioneers on open sites. Adding a top predator such as the tuatara at too early a stage of community development, may reduce the chances of successfully establishing animal species lower in the food chain (see Towns *et al.* this volume a). More generally, an appreciation of the nutritional requirements of all the major plant and animal species involved in a restoration programme will often be necessary to ensure that the restored community will be self-perpetuating after human intervention is withdrawn.

We must also recognise that restoring particular kinds of community may sometimes have to be very site-specific. The plants associated with an unstable fertile soil on a steep slope may be a very different combination from those of a stable infertile soil on a plateau. Similarly the animal populations of a community can be directly or indirectly influenced by site conditions: for example, there would be little chance of establishing a colony of small seabirds such as diving petrels or white-faced storm petrels on a site where soils were compact and difficult for digging burrows.

In some circumstances it may be possible to shorten the natural successional process by using appropriate species but, given that unforeseen difficulties are likely with any major restoration project, trials should be used to identify the most ecologically effective and therefore cost-effective method for restoring a particular community. Every restoration programme should include replicated and documented trials in its design so that methodological errors can be identified. Only in this way can the restorative process come to be properly understood.

Relevant practical skills

A theoretical understanding of restorative processes is of limited value to a restoration programme if certain practical skills are not available. Apart from the organisational, boating and survival skills necessary for living and working on an island safely, a successful restoration requires skills in plant propagation, quarantine and establishment, skills in handling animals and estimating their numbers, and acute observational powers to apprehend and understand why some species may be failing. Such people are not common and are always in demand for other management tasks. We need schemes for nurturing and training those that have the potential to develop this expertise.

Commitment by individuals and organisations

A major restoration programme extends over a long period. Goals cannot be achieved by a flurry of activity in one year and forgetting about the programme in the next. Thus although commitment by the individuals involved in the work is a necessity, so also is long-term commitment by the organisations for whom they work.

CONFLICTS IN ISLAND RESTORATION

Translocations and their effects on island communities

An increasing number of translocations of species to islands is creating management conflicts. Figure 2 illustrates the numbers of translocations of native vertebrate species to islands since the 1890s, when Richard Henry pioneered the method in New Zealand. Although not all vertebrate translocations are included in this data (Appendix 2), the majority are shown. The number of translocations for the 1981-90 period has more than doubled compared with that for the previous decade. The number of proposed translocations is very much greater.

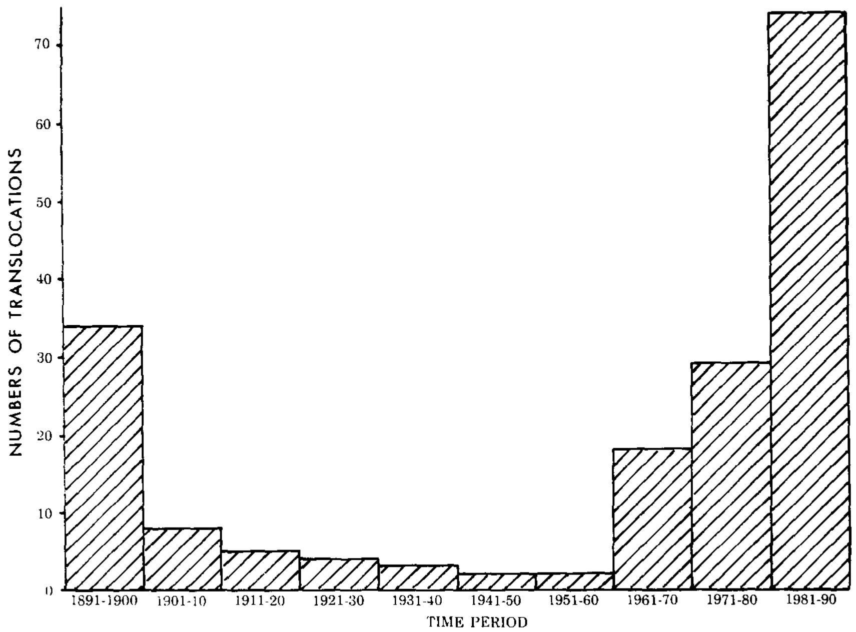
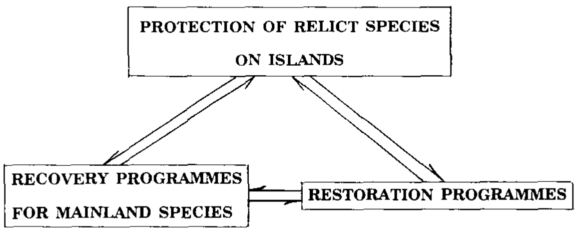


Fig. 2. Numbers of translocations of indigenous vertebrates to New Zealand islands in 10-year periods since 1891. Data from Appendix.

Although there is a need to use some islands as refuges for the recovery of a few nationally endangered species, particularly vertebrates, many plant and animal translocations have been made to islands for rather different reasons, some in the interests of island restoration. Thus we have a conflict triangle developing between the function of islands in protecting mainland species that have survived on islands, the need to use some islands for the recovery of nationally endangered mainland species that were not originally part of the island's biota, and the growing interest in island restoration (Fig. 3).

The solution to these conflicts is by no means clear and it may require some change of attitudes before it is resolved. Islands are not floating soup bowls (or zoos) into which species can be ladled in or out according to what seems best at the time. An island community, like any ecosystem, is a complexly interacting system in which different parts behave in different ways. To picture this system one can focus on the dependent relationship between herbivores, plant producers, soils and site factors; and then identify who eats who among the predators - what ecologists call the trophic structure of the community (Fig. 4). No species can be added or removed without affecting some parts of the system, whether these effects are acceptable or not, and the addition of new predators, herbivores or certain species of plant will invariably change options for management.



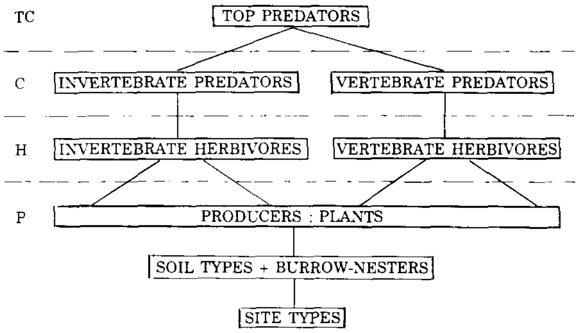


Fig. 3 (left). The triangle of potential conflicts in island management resulting from the uses of islands for (i) protecting relict species of the mainland (or of larger islands, e.g. Chatham), (ii) recovery of endangered mainland species not originally present on the island and (iii) ecological restoration of particular biotic communities.

Fig. 4 (right). Generalised trophic structure of a biotic community illustrating the dependence of the top predators (TC) on other predators (C) that feed on herbivores (H) supported by vegetation (P) whose composition is largely determined by soil (and on islands, sometimes by nesting seabirds). The whole system is controlled by climate, rock type, slope, water-table and the biota available as propagules (Jenny 1941, 1958), expressed locally through the type of site.

Takahe on Mana Island

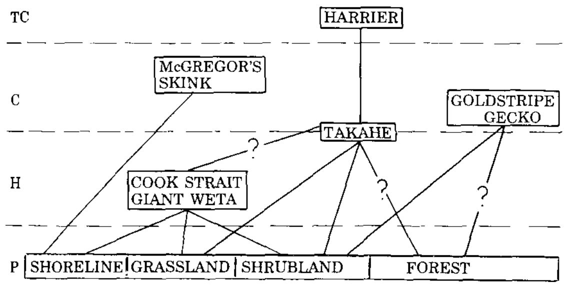
This conflict triangle can be illustrated by reference to Mana Island, a 217 ha scientific reserve near Wellington covered largely by rank grassland and shrubland (Timmins *et al.* 1987a). As a result of a current programme to eradicate mice, the island may now be free of all introduced mammals. Lack of information prevents illustration of the complete trophic structure of Mana Island's biotic community so that we must focus on species of critical interest.

Mana Island has three animal species that can be regarded as relicts from the mainland now surviving on islands : the Cook Strait giant weta (*Deinacrida rugosa*) with a natural distribution that also includes Stephens and Trios Islands; McGregor's skink (*Cyclodina macgregori*), also present naturally on two small northern islands; and the goldstripe gecko (*Hoplodactylus chrysosireticus*), known also from a few localities in Taranaki.

In 1988 a decision was made to introduce a nationally endangered rail, the takahe (*Porphyrio mantelli*), to Mana Island. This followed their introduction to Maud Island in 1984 as part of a trial to determine whether takahe can be self-sustaining on an island (Mills *et al.* 1982). Although the natural range of takahe has become restricted to the Murchison Mountains in Fiordland, there is evidence that the species formerly occurred in the lowlands (Beauchamp and Worthy 1988) and thus a case could be made for re-establishing takahe at low altitudes. However, the role of islands in this endeavour, identification of the most suitable islands, and the timing of any proposed translocations have, in my view, neither been adequately appraised nor properly communicated to the public. Setting aside these shortcomings, we must assess the new situation that has been created on Mana Island, paying particular attention to the feeding habits of takahe (Fig. 5).

The takahe is an avian herbivore adapted to feed on the basal meristems of tussock-forming grasses, sedges and herbs as well as on seeds and fem rhizomes. On Mana Island it feeds in grassland and shrubland, within the confines of temporary enclosures. During chick rearing takahe increase the protein content of their diet by taking insects (Dr J.A. Mills, pers. comm.). Thus it is possible that on Mana, free-ranging takahe may feed on giant wetas, either nymphs or adults, sheltering in tauhinu (*Cassinia leptophylla*) bushes or amongst long grass.

Some people may think that safeguarding the future of takahe is rather more important than safeguarding that of giant wetas although this is a value judgement. Giant wetas have apparently survived only in New Zealand, although remains of these "invertebrate dinosaurs", not dissimilar from the living species, have



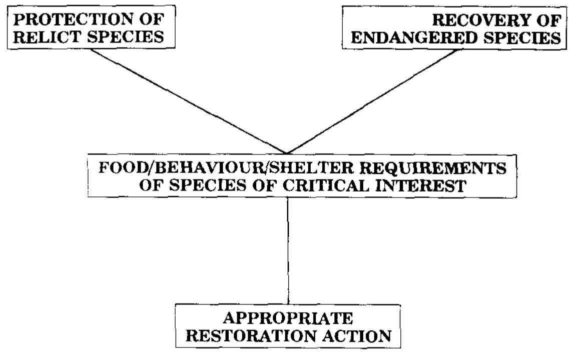


Fig. 5 (left). Indigenous species of critical interest in the trophic structure of the Mann Island biotic community. Continuous lines show known connections through herbivory or predation. Lines broken by question marks illustrate possible herbivory or predation at present unsupported by observation. Takahe straddle the boundary between predator and herbivore trophic levels because of their habit of feeding on small animals during the chick-rearing period.

Fig. 6 (right). The triangle of potential conflicts in island management (Fig. 3) can be partly overcome by answering specific questions relating to the feeding habits (or nutritional requirements in the case of plants), social behaviour and shelter requirements of the species of critical interest.

been found fossilised in Queensland among deposits 190 million years old (Mends in press). The origin of giant wetas may therefore pre-date the origin of takahe as a distinct species. A balanced conservation programme should provide for the long-term security of healthy populations of both giant wetas and takahe. The naturally occurring Cook Strait giant weta population of Mana Island is by far the largest and densest population of this species, and we should know whether takahe will significantly reduce it before proceeding with plans for free-ranging takahe on the island.

Further questions arise from the seasonal predatory habits of takahe. Would they eat McGregor's skinks or goldstripe geckos? Both these lizards have very small populations such that any extra losses arising from any predator could take them to extinction on the island.

These three questions relate to possible conflicts between our interests in both protecting relict species and establishing an endangered species on the same island. What of the restoration part of the conflict triangle? The aim at present is to restore forest to a substantial part of the island, its composition to be consistent with that which formerly characterised forest on lowland and coastal sites of the Sounds - Wellington Ecological Region (Timmins *et al*. 1987b). Will this forest restrict habitat for the giant weta or the goldstripe gecko? The weta, and most likely the gecko also, are considered to be principally species of non-forest habitats, though these include woody vegetation (M.J. Mends, pers. comm.). Will the new forest also restrict habitat for takahe, or will it benefit them, given that they may formerly have used some kinds of lowland forest (Beauchamp and Worthy 1988).

REDUCING THE CONFLICTS: NEED FOR A NATIONAL STRATEGY FOR ISLAND MANAGEMENT

Mana Island should not be seen as an unusual conflict situation; similar examples could have been drawn from several other islands. What is to be done to reduce such conflicts?

The first priority is to ensure that certain questions relating to the likely effects of introducing a new species to an island (whether or not it was there previously) are asked and answered. A format for such questions is outlined in Table 3 and Appendix 1. Some of these questions require systematic observation of the behaviour and ecological responses of individual species (autecology) coupled sometimes with simple experiments. Such questions will not be answered by committees of experts speculating about what might happen. In the case of interaction between the takahe and the giant weta, for example, it may be necessary to risk loss of a small number of wetas of differing ages by placing them within takahe enclosures at different times of the year to test their vulnerability to predation.

This priority cannot wait until a handful of overstretched scientists do the needed work. We must not forget that many field managers, as well as others, are first-class observers in their own right. With help from scientists or other skilled personnel, I think a lot of these questions can be answered by field staff, *provided somebody is asking the right questions in the first place and managers are giving them priority for action.* With respect to animals (and to a lesser extent plants) conflicts of interest can be reduced by placing specific autecological questions relating to the species of concern (particularly habits of feeding, shelter and social behaviour) in the centre of the conflict triangle (Fig. 6) and then ensuring that answers to these questions are obtained.

The second priority is to develop a comprehensive national strategy for island management that identifies a sequence of essential steps in planning an island's management; when followed in the correct order, these steps will minimise conflicts of the kind discussed.

TOWARDS A NATIONAL STRATEGY FOR ISLAND MANAGEMENT

A robust and effective national strategy for island management requires more input from interested parties than possible for this paper. However we can identify some of the steps or components that should be included in such a strategy.

1. Identify the critical conservation values associated with each island of biological significance using the following criteria:
    - vascular flora and presence of rare or threatened taxa
    - invertebrate and vertebrate fauna and presence of rare or threatened taxa
    - biotic communities present, both those representative of widespread community types and those unique to the island.
    - unusual geology or landforms
    - human history (including archaeological, social and recreational values)

2. Identify those islands where the most stringent preventative measures should be taken against the establishment of rats or mice (cf. Moors *et al.* 1989) and other predators, parasites and diseases.

3. List all threatened indigenous species that require islands for recovery or security of population numbers, bearing in mind the need to maintain genetic diversity.

4. Identify the most suitable islands for each threatened species based on its requirements for habitat and maintenance of genetic diversity.

5. Analyse the likely impact on each island's conservation values of those species proposed for translocation (Table 3, Appendix 1). With animals, particular attention must be paid to their trophic relationships (predation and competition) and likely density.

6. Select the appropriate recovery measures for all threatened species requiring islands as refuges.

7. Integrate species-centred recovery programmes with all other aspects of management, including restoration programmes for biotic communities and management of the adjacent marine environment.

8. Expose the national strategy to public scrutiny and input, both with respect to recovery measures for particular species requiring islands and to proposed management for individual islands.

9. Decide on the action to be taken.

10. Interpret the selected management action to the public and whenever possible involve them in its implementation, in order to build a broader base of public support for conservation.

Any strategy of this kind would require regular review and revision in the light of new information, new techniques and new understanding. The steps outlined reflect both the interactive values of communities of species as well as the species-oriented approach needed to save threatened species from extinction. The emphasis on the latter is justified by the fact that species populations are the building blocks of communities; if we fail to save a species we have no second chance. Failure of an attempt to restore a community, however, provides us with useful information for making another attempt.

JUDGING THE SUCCESS OF RESTORATION MEASURES

How can we judge whether our various restorative actions (Table 2) have been successful? With recovery of individual species or replacement of extinct taxa, establishment of self-maintaining populations of the species concerned will be a sufficient measure of success. With the restoration of biotic communities, attaining a state that does not require regular human inputs of labour (apart from continuing protective action) can be used as a criterion. With reference to Table 1, when as a result of a specific programme we can re-classify a restoration island as a refuge, minimum impact or open sanctuary island, than we will know that genuine success has been achieved.

ACKNOWLEDGEMENTS

I wish to thank D.V. Merton, C.C. Ogle, Drs D.R. Given and J.R. Hay, M.J. Meads and B.D. Bell for critical comment or additions to an earlier draft of this paper.

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TABLE 1. Functional categories for managing islands of conservation significance (I.A.E Atkinson and D.R. Towns)

	FUNCTIONAL CATEGORIES OF ISLANDS				
	MINIMUM IMPACT	REFUGE	RESTORATION	OPEN SANCTUARY	MULTIPLE USE[1]
PRIMARY CONSERVATION FUNCTION	Protection of indigenous species and communities, particularly those distinct from mainland communities	Protection of indigenous species and communities, both those of islands and those of the mainland	Recovery of viable populations of threatened species and restoration of particular communities	Protection and interpretation to the public of indigenous species and habitats, including those threatened by extinction or destruction	Protection and enhancement of selected conservation values
CRITERIA FOR RECOGNITION[2]	Presence of island endemics; freedom from introduced mammals; significant areas of indigenous habitat; high vulnerability to human interference; all sizes of islands, both modified and largely unmodified	Presence of mainland endemics as island survivors; introduced mammals sometimes present; significant areas of indigenous habitat; moderate vulnerability to human interference; all sizes of islands; all degrees of modification except those largely unmodified	Opportunities for restoring habitats of threatened species and for restoring threatened communities, both those of islands and those of the mainland; modified and extremely modified islands of all sizes	Opportunities for providing habitats for rare and threatened species; opportunities for public education; medium and large islands, both modified and extremely modified	Conservation values secondary to other uses such as farming, forestry and recreation. Mostly extremely modified islands that are sometimes farm parks or privately owned
PROTECTIVE ACTION FOR SPECIES AND BIOTIC COMMUNITIES	Special precautions against establishment of introduced plants and animals and against illegal visits and fires[3]	Consistent precautions against establishment of introduced plants and animals (excepting certain threatened species, see below) and against illegal visits and fires	Consistent precautions against establishment of introduced plants and animals (with certain exceptions, see below) and against illegal visits and fires	Consistent precautions against some species of alien plants and animals[4]. Special precautions against fires	Variable approach depending on kind and extent of conservation use
PROTECTIVE AND RESTORATIVE ACTION FOR ARCHAEOLOGICAL SITES	Protection restricted to sites of outstanding archaeological value	Protection restricted to sites of outstanding archaeological value	Sites of archaeological value protected with restoration of selected sites[5]	Protection and interpretation of archaeological and historic sites; major restoration of such sites where appropriate	Sites of archaeological and historic value protected whenever possible
RESTORATIVE ACTION FOR BIOTIC COMMUNITIES	Restricted to re-establishment of a few species in a few small reas	Restricted to minor areas relative to size of island	(A) Restoration of island communities formerly present and extension of some still existing (B) Restoration of mainland communities where appropriate on islands free of limiting factors of the mainland	Restoration of island or mainland communities according to requirements of native plant/animal species of interest	Restoration of island or mainland communities when identified as a conservation objective for the island
TRANSLOCATION OF SPECIES NOT NATURAL TO THE ISLAND	Excluded except as an extreme short-term measure	Excluded for plants except in special circumstances[6]; permitted for selected species of nationally endangered animals?	(A) Island communities: as for refuge islands excepting use of certain introduced plants as temporary cover (B) Mainland communities (on islands): permitted for appropriate mainland species and, in special cases, for animal taxa from the Pacific or Australian regions[8]	Permitted according to ecological appropriateness, educational and species conservation needs, and risk to other biota in the region	Undertaken according to particular conservation objectives adopted and risk to other biota in the region

	MINIMUM IMPACT	REFUGE	RESTORATION	OPEN SANCTUARY	MULTIPLE USE[1]
HABITAT MANIPULATION FOR PARTICULAR SPECIES	Restricted to minor manipulation	For threatened species: restricted to modified areas; should exclude major changes in composition of community	(A) Island communities: choice of communities to be restored sometimes influenced by habitat requirements of threatened species (B) Mainland communities (on islands): major manipulation of habitats sometimes needed	Major manipulation of plant and animal habitats	Major or minor manipulation of plant and animal habitats according to particular conservation objectives adopted
SCIENTIFIC ACTIVITY	Monitoring of changes; identification of biological values	Monitoring of changes; identification of biological values; process studies not possible elsewhere	Experimentation using carefully monitored trials to measure progress of programme	Experimentation using carefully monitored trials to measure progress of programme	Monitoring of enhancement programme; identification of biological values
EDUCATION AND INTERPRETATION	Minimal activity that can only be carried out on the island and that allows people to appreciate island values through books, radio, film, etc	(i) Low impact activities that cannot be done on a restoration or open sanctuary island (see min. impact islands) (ii) permitted visitors to a few selected islands with interpretation/supervision by rangers	(i) Low impact activities not possible in an open sanctuary (ii) permitted visitors to a few selected islands with interpretation/ supervision by rangers (iii) volunteer help with restoration work on some islands	Major function of island: open access with interpretation programmes; ranger supervision when necessary	Visitation and visitor movements dependent on permission from owners
SUGGESTED EXAMPLES	Three Kings Islands; Poor Knights Islands; Pupuha L, Chicken group; Sail Rock; Snares Islands; Disappointment and Adams Islands, Auckland group	Hen I.; little Barrier I.; Rangitoto I.; Kapiti I.; Maud I.; Codfish I.; South East I, Chatham group	Restoration (A): Cuvier I.; Mana I.; Mangere I., Chatham group. Restoration (B): Motuora I. (south of Kawau); Mahurangi I.	Tiritiri I.; Somes I.;	Great Barrier I.; Kawau I.; Great Mercury I.; Mayor I; Arapawa L; Chatham I.; Pitt I.; Chatham group

Footnotes

Other islands, where there is no conservation use, are excluded from this classification.

2 Only terrestrial criteria have been used. Allocation of an island to a functional category is often partly a value judgement. The criteria given can be used as a guide but it is not essential that all criteria listed for each category need be met

3 Introduced plants and animals include those native to New Zealand though not natural to the island in question.

4 Alien plants and animals are introduced species foreign to New Zealand ("exotics")

5 Site selection would give preference to extremely modified parts of the island thus minimizing disruption to existing or restored communities

6 Special circumstances could include the planting of temporary food sources in already greatly modified parts of an island in order to secure survival of a species of nationally endangered animal. However, in these circumstances, control of the introduced plant may be necessary to ensure it did not spread to other parts of the island.

This assumes that a proper case for introduction of a nationally threatened animal has been made and the likely impact assessed (see Appendix 1).

8 Introduction and establishment of animal taxa from other parts of the New Zealand region, or from Australia or the Pacific, could be attempted where the forms are related to taxes now extinct on the mainland (Atkinson 1988). Such attempts at replacing extinct species should be restricted to substantially modified islands and should be carried out as controlled experiments to measure the impact of the new introduction on the island's biota. The new introduction must be removable from the island at any time if the need should arise.

Table 2. **Kinds of management action associated with island restoration**

I.	**RECOVERY OF THREATENED SPECIES (PLANTS AND ANIMALS)**	
	a.	Minor manipulation of species habitat
	b.	Enhancement of species habitat[1]
	c.	Restoration of particular biotic community (as habitat for the threatened species)
	d.	Restoration of several biotic communities (as habitat for the threatened species)
II.	**REPLACEMENT OF EXTINCT TAXA**	
	a.	Restoration of a pre-existing community
	b.	Establishment of a community not originally present on the island
III.	**RESTORATION OF BIOTIC COMMUNITIES**	
	a.	Re-establishment of one or a few species formerly present
	b.	Re-establishment of many species formerly present
	c.	Restoration of specific island communities
	d.	Partial restoration of mainland communities on islands
IV.	**ECOLOGICAL ENGINEERING**	
	Establishment of new kinds of biotic community	

1 See Simberloff 1990 for definition of enhancement

Table 3. Critical questions relating to translocation of rock wrens (*Xenicus gilviventris*) to Somes Island, Wellington Harbour[1]

A Why translocate rock wrens to an island?

(a) Immediate benefits :
- (i) To provide an opportunity for people to see a rare and interesting native bird in an accessible semi-natural environmental.
- (ii) To increase opportunities for further study of the behaviour and ecology of the rock wren
- (iii) To widen the habitat range of the rock wren and thus increase security for the species in the event of detrimental changes in the mountains such as increased predator numbers.

(b) Long-term benefits:
- (i) If possible, to re-establish forest-inhabiting populations of *Xenicus* in a lowland environment as a substitute for the extinct *X. longipes*.
- (ii) If possible, to replace part of the trophic structure of New Zealand lowland forest at particular sites selected for ecological restoration.

B. (a) Why choose Somes Island? (b) Are its resources adequate to support a population of rock wrens? (c) Were rock wrens formerly present on the island?

(a)
- (i) Circumstantial evidence suggests that survival of rock wrens in the South Island mountains has occurred because predation by rats, mice, stoats and cats has been significantly lower in this environment than in forests where the closely related bush wren formerly occurred. Thus an island free of mammalian predators is required Somes Island is currently being cleared of its only mammalian predator, *Rattus rattus*.
- (ii) Open habitat with loose rocks, sometimes covered with scrub, is present on Somes Island, whose topography and vegetation structure fall within the range currently used by rock wrens.
- (iii) Somes Island has developing forest and this could provide opportunities for rock wrens to use forest
- (iv) The island is accessible to people, including those who would monitor the experiment

(b)
- (i) Small island size (23 ha) may not be limiting if territorial size of rock wrens is comparable to that in the mountains (0.6-4.2 ha, Heath 1989). However, a rock wren population will not necessarily persist on an island of this size.
- (ii) Rock wrens feed on a wide variety of small invertebrates. In the absence of rats or mice, Somes Island should support adequate food supplies of small invertebrates and small fruit that are occasionally eaten by rock wrens.
- (iii) Adequate cover should be available. Southerly conditions in the Wellington Harbour are sometimes severe but no more so than in the mountains where rock wrens live.
- (iv) Unacceptable interactions with other fauna seem unlikely[2] (see C below)
- (v) Conflicts with other island uses such a quarantine for farm stock or recreation appear to be unlikely.

(c)
- (i) Rock wrens are unlikely to have ever been present on the island. Bush wrens may have been but there is no evidence.
- (ii) Success in establishing rock wrens on Somes Island would result in an extension of the species' geographic range but this would carry no risk of hybridisation with related species.

C. What impact would rock wrens have on the island's biota?

- (i) Present information (M.J. Meads, pers comm) indicates that no unusual species of invertebrate, vulnerable to rock wrens, has survived the *R rattus* invasion and earlier changes on the island. Nevertheless, an invertebrate survey would be needed to confirm this.
- (ii) Competition for food may occur between rock wrens, pipits and fantails but if so it is unlikely to have unacceptable consequences.
- (iii) Dispersal of rock wrens to other islands (e.g. Ward Island) or to the mainland is unlikely because of the wrens' weak powers of flight
- (iv) It will be possible to monitor other impacts of rock wrens on the biota of Somes Island if the need should arise.

D. Would the translocation foreclose important conservation options for the future?

- (i) Apparently not; Somes Island is not regarded as a potential refuge for endangered species.
- (ii) Rock wrens could be removed from the island if the need should arise

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E. What are the requirements for a founder population of rock wrens?

Questions relating to the most appropriate source population[3], the number of individuals to be translocated, their sex ratio and age distribution, the timing of release, and the effect of their removal on the source population, have still to be answered Further questions that will also require investigation relate to the number of releases, the most suitable sites on the island for release and the method of release, e.g. whether to hold birds temporarily in an aviary on the island prior to their release.

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1 Sources of information used in compiling this table include Heath 1989, Oliver 1955, Robertson and Baker 1985 and Shaw 1985.

2 Mana Island probably has greater potential for the establishment of a viable population of rock wrens than Somes Island. However, until the possibility that rock wrens may feed on the nymphs of giant wetas (*Deinacrida rugosa*) is checked (e.g. by introducing some giant wetas to Somes Island after rock wrens are established), it would be unwise to introduce this bird to Mans Island

3 Rock wrens occur less than 350 m a.s.l. in the Fox region of the South Island west coast (Dr J.R. Hay, pers. comm.).

Appendix 1. Guidelines and critical questions relating to translocations of indigenous plants and animals to islands

A translocation is the intentional release of plants or animals to the wild in an attempt to establish, re-establish, or augment a population (IUCN 1987). Seven guidelines for making a translocation are listed below together with specific questions that relate to fulfilment of each guideline.

A. There must be a SOUND REASON FOR TRANSLOCATING A SPECIES to a particular island

1. What is the primary reason for translocating this species to the island?

   (i) To reinforce a species population already present?
   (ii) As a short or long-term measure to increase the species' chance of survival?
   (iii) As part of a programme to restore a particular biotic community as a fully functioning system?
   (iv) To establish the species for a specific purpose such as education, scientific study (including coexistence with other species), nature tourism, hunting, etc.?

The ISLAND CHOSEN SHOULD BE THE BEST AVAILABLE CHOICE for the translocated species

1. Is habitat on the island likely to be large enough to support a viable population of the species? If not, is there a case for making further translocations at intervals to reinforce the population?

2 Are nutrient and water resources on the island likely to be adequate to support a population of the translocated species?

3. With animals, will cover and places to breed be adequate to give the new population sufficient protection from predators and extremes of weather?

4. Are unacceptable interactions with other species of plants or animals likely (see section C)?

5. Will the translocation result in conflicts with other uses of the island?

6. Is there evidence of the former existence of the species on the island?

   If "yes", what were the reasons for its disappearance? Are they still operative or have they been remedied?

   (ii) If "no", is it likely that the translocation will move the species substantially beyond its natural range? What are the implications of extending the range of the species in this way?

C. The possible IMPACT of the translocated species on the island and its biota MUST BE ASSESSED

1. Will the translocated species have any unacceptable effects on populations of native plants and animals already present on the island?

   (i) Through predation?
   (ii) Through competition for food or nest-sites?
   (iii) Through hybridizaton?
   (iv) Through introduction of disease or parasites?
   (v) Through indirect effects on the habitats or social behaviour of other species present?

2 What is the translocated species capacity for dispersal? Could it reach other islands or land beyond the island of release? If so, does this matter?

3. Will the rate of spread of the translocated species be promoted by fires, droughts, floods or mass-movement erosion?

4. Will the new population facilitate the spread of weed species or boost the numbers of an alien animal species on the island?

5. Can the impact of the translocated species on the island's plants and animals be monitored?

D. The translocation SHOULD NOT FORECLOSE IMPORTANT CONSERVATION OPTIONS for the future

1. Will the translocation prevent or make difficult, control or eradication of problem plant or animal species on the island?

2. Will the translocation foreclose options for translocating other species to the island in the future? In particular, will options for the establishment of certain endangered species be lost or compromised?

3.. Could the translocated species be removed or controlled in the future if its effects became unacceptable?

E Specific REQUIREMENTS FOR ESTABLISHING A FOUNDER POPULATION on the island must be assessed

1. What is the most appropriate source(s) of individuals for translocation?

   Distance between source and release should be chosen to minimise geographic displacement. Translocated individuals should be of known parentage and genetic identity (if possible, of measured genetic heterozygosity). With animals, captive-reared individuals should not be released into the wild unless bred from known parent stocks (Towns *et al.,* in press) and adequately socialized, e.g. parent-raised stock.

2. How many individuals should be translocated?

3. What should be the sea ratio of the founder population? Is there reason to use juveniles rather than mated pairs? With plants, what type of material should be used: mature plants, juveniles, seedlings, seeds or a mixture of these? Should the mixture be varied in subsequent translocations?

4. What should be the timing of the release?

5. Will the removal of the translocated individuals have any unacceptable demographic or genetic effects on the source population? (Towns *et al,* in press).

6. If more than one release is possible, how many should be made? (Towns *et al,* in press)

7. What is the most suitable site on the island for establishment of the founder population?

8. What method of release for animals should be used? Should they be held in captivity on the island for a period before release? Is a temporary lifeline approach involving supplementary feeding required following their release?

9. If captive-reared animals are used for the founder population, how can the risk of disease introduction be minimized?

F. TRANSLOCATION PROPOSALS with answers to the above listed questions, SHOULD BE MADE AVAILABLE TO THE PUBLIC, including specialists outside the managing department

G. DETAILS OF A TRANSLOCATION SHOULD BE RECORDED in an easily retrievable manner, whether the translocation is a success or failure

Note: For further discussion of transfer protocols the reader is referred to both Towns *et al.* (in press) and Towns *et al* 1990b.

Appendix 2. Translocations of indigenous animals to New Zealand islands

Details of translocations of indigenous species of animals to New Zealand's islands have never been brought together in one place although information for some individual species has been published. What follows is a first approximation towards a comprehensive summary for translocations of indigenous animals. It has been compiled from published sources (particularly Henry 1895-1908, Merton 1975), minutes of and reports to the Fauna Protection Advisory Council, information from B.D. Bell, R Colbourne and D.V. Merton, C.R. Veitch, (pers. comms), and the writer's knowledge. It is hoped that gaps in this summary will be filled and the tabulated material regularly updated.

OFFSHORE ISLANDS (< 50 km from mainland)	ANIMAL SPECIES AND TIME OF TRANSLOCATION[1]
ALLPORTS, Queen Charlotte Sound	South Island robin (1973); weka (c.1974)
ANCHOR	kakapo (1897, 1898)[2]; South Island brown kiwi (1897, 1898); little spotted kiwi (1898)
ARID, Great Barrier group	North Island weka (1951)[3]
BETSY, western Stewart I.	South Island saddleback (1969)
BIG (STAGE), western Stewart I.	South Island saddleback (1964)
BLUMINE	Western weka (1972)
BREAKSEA	South Island kiwi (1900)
CODFISH	Stewart Island weka (?1890s); kakapo (1987, 1988, 1989, 1990)
COOPER, Dusky Sound	kakapo (1898); little spotted kiwi (1903)
CUVIER	North Island saddleback (1968); parakeet (c.1974)[4]; stitchbird (1982, 1984, 1985)
ENTRY, Dusky Sound	kakapo (1900)
FANAL	flax snail (*Placostylis hongii*) (1000-1800 A.D.); North Island saddleback (1968, 1985)
GREAT BARRIER	flax snail (*Placostylis hongii*) (1000-1800 A.D.);
HARBOUR, Dusky Sound	South Island brown kiwi (1897)
HAWEA, Breaksea Sound	Fiordland skink (1988)
HEN	stitchbird (1980, 1981); little spotted kiwi (1988, 1989)
INDIAN, Dusky Sound	kakapo (1895); South Island brown kiwi (1895, 1896)
JACKY LEE	South Island saddleback (1970's or 80's)
KAIMOHU, western Stewart I.	South Island saddleback (1964); Stead's bush wren (1964)
KAPITI	Stewart Island weka (1896)[5]; North Island weka (1896)[5]; Western weka (c.1905)[5]; South Island brown kiwi (1908, 1912); kakapo (1912); North Island brown kiwi (1915, 1931, 1935, 1940); North Island saddleback (1925, 1981, 1982, 1983, 1987, 1988, 1989); brown teal (1968); takahe (1968, 1970, 1989); stitchbird (1983, 1984, 1990);? little spotted kiwi[6]

OFFSHORE ISLANDS (< 50 km from mainland)	ANIMAL SPECIES AND TIME OF TRANSLOCATION
KAWAU	North Island brown kiwi (19th century); weka (1970s)
KAWHITIHU (STANLEY), Mercury group	North Island saddleback (1977)
KORAPUKI, Mercury group	Whitaker's skink (1988)
KUNDY, western Stewart I.	South Island saddleback (1978); weka (post-1936)
LITTLE BARRIER	North Island brown kiwi (1900-1903, 1919); kakapo (1903, 1982); great spotted kiwi (1915); North Island saddleback (1925, 1984, 1987); kokako (1981, 1983); black petrel (1986, 1987, 1988, 1989, 1990)
LONG, Queen Charlotte Sound	little spotted kiwi (1982, 1987, 1989)
LONG, Dusky Sound	kakapo (1895, 1896, 1897); South Island brown kiwi (1896); little spotted kiwi (1896)
MANA	takahe (1988)
MAORI, Dusky Sound	South Island brown kiwi (1900)
MAROTIRI, Chicken group	North Island saddleback (1950, 1971)
MAUD	kakapo (1974, 1975, 1980, 1981, 1985, 1989, 1990); Cook Strait giant weta (1978); little spotted kiwi (1979, 1980); South Island saddleback (1980, 1982); takahe (1984); South Island robin (c.1984)
MOKINUI, Moggy group, Stewart I.	Stewart Island weka (c.1980)
MOKOIA, L. Rotorua	North Island weka (1958)
MOTUARA, Queen Charlotte Sound	South Island robin (1973)
MOTUHOROPAPA, Noises group	flax snail (*Placostylis hongii*) (1934)
MOTUKAWANUI, Cavalli group	North Island saddleback (1983, 1984)
MOTUNGARARA, Kapiti group	weka (c.1980)
MOTUNUI, eastern Stewart I.	South Island saddleback (1981)
MOTUROA, Bay of Islands	North Island robin (c.1983); bellbird (c.1983)
MOTURUA, Bay of Islands	North Island robin (c.1985)
MOTUTAPU	North Island brown kiwi (c.1978-79)
NORTH, eastern Stewart I.	South Island saddleback (1972)
NUKUWAIATA, Chetwode group	weka (c.1921, 1928); South Island saddleback (1965, 1969)
PARROT, Dusky Sound	South Island brown kiwi (1896, 1897); kakapo (1900)
PONUI	North Island brown kiwi (1963)
POOR KNIGHTS	flax snail (*Placostylis hongii*) (1000-1800 A.D.)
PROVE, Dusky Sound	South Island brown kiwi (1900)
PUTAUHINA	South Island saddleback (1974, 1976, 1984)
RED MERCURY	North Island saddleback (1966); little spotted kiwi (1983)

OFFSHORE ISLANDS (< 50 km from mainland)	ANIMAL SPECIES AND TIME OF TRANSLOCATION
RESOLUTION	kakapo (1895, 1896, 1897, 1898, 1905, 1907)[2]; South Island brown kiwi (1895, 1896, 1898); little spotted kiwi (1896, 1897, 1898)
STEPHENS	yellow-crowned parakeet (1970); Antipodes Island parakeet (1986)
TIRITIRI	North Island saddleback (1984); parakeet (1973)[4]; whitehead (1989); weka (1980s); brown teal (c.1980)
TRIO	weka (1950)
WAIHEKE	North Island brown kiwi (c.1988); bellbird (c.1988/1989)
ULVA, eastern Stewart I.	Stewart Island brown kiwi (1980s)
WHALE	parakeet (1985-86)[4]
WHATUPUKE, Chicken group	North Island saddleback (1964)
WOMENS, eastern Stewart I.	South Island saddleback (1972)
OUTLYING ISLANDS (> 50 km from mainland)	
CHATHAM	buff weka (1905)
MANGERE, Chatham group	Chatham Island snipe (1970); shore plover (1970, 1972, 1973); black robin (1976, 1977, 1983-1989); Chatham Island tomtit (1987, 1988, 1989);
PITT, Chatham group	buff weka (c.1970)
SOUTH EAST, Chatham group	black robin (1983-1988); Chatham Island pigeon (1984, 1985)

1 Times of translocation are given regardless of whether successful establishment followed

2 Where more than one translocation of a species to the same island has occurred in the same year, only the year is listed. However, not all of R Henry's translocations were recorded so that records for islands in Fiordland are incomplete.

3 The dates of many introductions of wekas to islands are unknown, particularly those in the southern islands. Thus many islands with wekas are not included in this list.

4 These birds were possibly of hybrid origin (Triggs and Daugherty 1988).

5 AJ. Beauchamp, pers. comm.

6 Although it is likely that little spotted kiwi were introduced to Kapiti Island in the early 1900s, there remains some uncertainty whether such an introduction did occur (R. Colbourne, pen,. comm. 1990).

Pages 91-108 in Towns, D.R, Daugherty, C.H., and Atkinson, I.A.E. (Eds), 1990. *Ecological restoration of New Zealand islands.* Conservation Sciences Publication No. 2 Department of Conservation, Wellington.

THE POTENTIAL FOR ECOLOGICAL RESTORATION IN THE MERCURY ISLANDS

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ABSTRACT

The Mercury Islands, off the eastern Coromandel Peninsula, offer outstanding potential for restoration programmes which would lower the vulnerability of some rare species to extinction, decrease the threats to rare communities of the Mercury Islands, and re-establish lost trophic links in ecosystems. Key biotic resources in the Mercury Islands are identified, and ways of reconstructing lost communities are suggested using species that have survived on smaller rat-free islands in the group. A particular impediment to planning for management of islands is the present lack of a functional national classification that recognises differing conservation potentials between islands. Five functional categories that define the primary objectives for management are applied to the Mercury Islands. Short- and long-term restoration goals are defined within the context of this classification. As a case study, actions proposed specifically for one island in the group, Korapuki Island, are detailed.

INTRODUCTION

Major advances have been made in the eradication of problem alien animals from islands over the last decade. The most significant advances have been in rodent eradication. As recently as 1978, the prospects for removing rodents from islands looked bleak, but by 1988 rats had been eradicated from several New Zealand islands up to 170 ha in area (Towns 1988, Veitch and Bell this volume). These advances have raised the prospect that active management can partly or completely restore biotic communities as fully functioning systems (Atkinson 1988).

Restoration has three essential elements: a restoration goal, which is a conceptual model based on historical information or biogeographic interpretation; active intervention, to restore plants and/or animals formerly present; and finally, monitoring of progress and further intervention and active management of the restored area when necessary (Atkinson 1988). Some restoration goals are being met to a limited extent already in New Zealand and could result in enhanced prospects for species that have been in a vulnerable state for decades.

Both short- and long-term benefits can be gained from ecological restoration. With respect to islands, restoration can be aimed at lowering the vulnerability to extinction of rare species, decreasing the threats to rare communities, and in the longer term, re-establishing lost trophic links in ecosystems, thereby restoring (at least in part) natural processes of evolution. Restoration is thus a practical means of decreasing the rate of global decline in biodiversity.

We will consider the terrestrial biota of the Mercury Islands, a group of islands with outstanding potential for restoration of rare species and communities.

The Mercury Islands, 6 km off the Coromandel Peninsula, consist of seven islands ranging in area from three to 1860 ha and about six small unnamed stacks and islets (see p. 214). Though not a large group, they do encompass a wide range of the biological, administrative and management problems that arise over many of the 700 or so islands around New Zealand.

The Mercury Islands are volcanic landbridge islands that were joined to the North Island during the last ice age, and became separated from the mainland by rising sea levels between 10 000 and 8 500 years ago. Much of the typical lowland mainland fauna and flora would initially have been present on these newly isolated islands. Great Mercury (Fig. 1) was probably most similar to a mainland lowland forest ecosystem, but the smaller islets, some of which are smaller than one hectare, would have had much less diverse communities composed of species able to withstand the effects of salt and extreme drought.

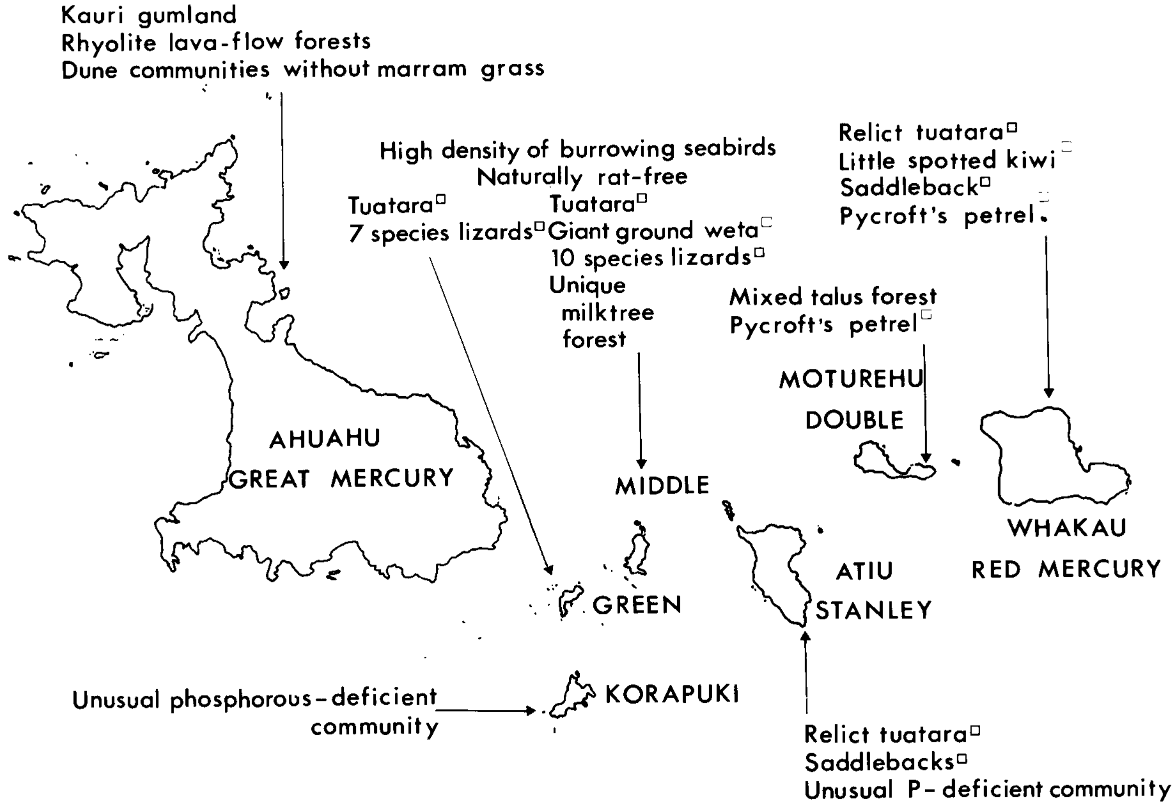

Fig. 1. Biological resources of the Mercury Islands with species or communities of high conservation status defined (square symbol).

For the larger islands the most dramatic changes occurred with the arrival of humans about 1000 years ago. Great Mercury Island has a long history of Maori occupation and is regarded by some anthropologists as the actual site of the Hawaiiki referred to in New Zealand Maori folklore (Ell 1982). Archaeological evidence and local tradition suggest that it was a major population centre for Maori, who either departed after a disastrous fire in about 1670 (Wright 1976a), or stayed to be decimated by tribal wars in 1820 (Ell 1982).

By the 19th century Pacific rats (kiore, *Rattus exulans*) would have been established on the larger islands and periodic burning to ease access for mutton-birding would have destroyed much of the original vegetation. Around the beginning of the 20th century rabbits (*Oryctolagus cuniculus*) were introduced to Stanley and Korapuki Islands, and then both islands were extensively burned again. Red Mercury also experienced a major fire in the 1930s (Millener 1972). Fortunately the smaller islands, of which Middle (13 ha), and Green (3 ha), are the most important, have remained relatively unmodified and free of all introduced mammalian predators. Middle Island in particular is a biological treasure trove (Fig. 1). With the exception of Great Mercury Island, which is privately owned, all islands in the group are currently administered by the Department of Conservation as part of the Hauraki Gulf Maritime Park.

In this paper we suggest ways in which species that have survived on Middle and Green Islands can be used to reconstruct ecosystems elsewhere in the group. We propose that a restoration programme of this kind should become part of a broad management strategy for the Mercury Group as a whole.

There are four restoration possibilities for the Mercury Islands: (1) restore coastal and lowland communities or ecosystems that have become extremely altered on the mainland; (2) extend the area of unique seabird-reptile-invertebrate-plant communities that have become confined to one or two very small islands; (3) rehabilitate certain populations of tuatara (*Sphenodon punctatus*) that are on the verge of extinction; and (4) restore habitats for, and establish new populations of, the less "glamorous" species, including reptiles and insects. These prospects have arisen through new techniques in animal husbandry on one hand and feral mammal eradication on the other, both developed within the last three years.

DEFINITION OF THE PROBLEMS

There are four management issues (problems) encompassed within this proposal

1. There has never been a management plan developed for the Mercury Islands as a group. Therefore previous activities have tended to be narrow in focus, either island-centred or species-centred. The approach which we suggest would result in a comprehensive view of islands as ecosystems, thereby providing a model that can be applied elsewhere.
2. The success with eradication of kiore from Korapuki in 1986 suggests that techniques could be developed for larger islands (Towns 1988). At present it is unclear what these campaigns might cost. Because successful eradication of rodents is a prerequisite to most restorative action in the Mercury Islands, the most cost-effective techniques need to be defined.

   In addition, it is unclear whether the speedy eradication of kiore from Korapuki was a function of a highly effective technique on its own, or was accelerated by the presence of rabbits which had reduced alternative plant foods for the rats. The kiore eradication methods need to be tried on an equivalent-sized island free of rabbits.
3. Two islands, Stanley and Red Mercury, house residual populations of tuatara that are on the verge of extinction. The cause for this is almost certainly recruitment failure as a result of predation of young and/or eggs by kiore, possibly coupled with past habitat modification through burning.
4. Small islands in the group (15 ha or less) house some unique communities that are vulnerable to disturbance and continually at risk of invasion by mammalian predators.

APPROACH

There are three steps which we follow in proposing a conservation strategy for the Mercury Islands:

1. Define the vulnerable species and communities in the group.
2. Outline appropriate land-management categories for the islands within which measures to decrease vulnerability can be applied.
3. Detail programmes and timetables for action within each landuse category and for each of the vulnerable components.

The Mercury Islands have some advantages not always found elsewhere. First, there is a useful information base which can be drawn on to define the resources. So far we have located 55 references identifying the high quality and unique natural and historic resources of the Mercury Islands. Second, new technology has provided options that can be applied within the Mercury Islands because of their size. Third, the solutions we propose could yield rapid and tangible results, something which is vital when seeking funding.

There are some additional points that have governed our approach. The group must be treated as a whole that includes Great Mercury Island, even though it is privately owned and outside the Hauraki Gulf

Maritime Park. This is necessary because Great Mercury is close to Green and Middle Islands, and activities on Great Mercury will certainly affect other locations. For example, it is fortunate that stoats (*Mustela erminea*) have never been released on Great Mercury, because if they had, all islands in the group would be accessible to them.

Although the most biologically valuable islands (Middle and Green) are small enough for rodent eradication to succeed if they were invaded, it is likely that lizards and many invertebrates could undergo a rapid loss in numbers even if the invasion was discovered and treated quickly. It is likely also that the extent of such damage to terrestrial communities by rats increases as island size decreases.

Any measures proposed should be long-term solutions, rather than short-term palliatives. We regard solutions that are expensive in the short term, but require little long-term input, much more desirable than less costly short-term measures that will require expensive modification in the future.

SPECIES AND COMMUNITIES IN THE MERCURY ISLANDS THAT WOULD BENEFIT FROM RESTORATION

The Mercury Islands support a number of unusual biotic communities now very restricted in distribution. They also provide refuge for several rare species of plants and animals, some of which are endangered (Fig. 1, Tables 1, 2). A carefully planned restoration programme could increase the area, and therefore the security, of some of these threatened communities, while simultaneously providing habitat for translocated rare or endangered species. The biotic communities of particular interest for restoration are:

Kauri forest and related gumland scrub and sedgeland communities of southern Great Mercury Island. Rhyolite is widespread along the eastern flank of Coromandel Peninsula (Schofield 1967) and occurs also on a number of northern offshore islands. That of Great Mercury Island is by far the most extensive area of old rhyolite at low altitude where restoration of communities comparable to those present last century in lowland Coromandel would be possible.

Lava-flow forest at Undercliffs and Urututu, Great Mercury Island (Wright 1976b). These are likely to represent a more advanced stage of development than the young rhyolite flows of Mayor Island (Atkinson and Percy 1956). Restorative action in these communities would need to concentrate on the exclusion of browsing animals.

Other biotic communities (sites) of special interest on Great Mercury Island. High-fertility wetland communities dominated by *Cyperus ustulatus* or raupo (*Typha orientalis*), estuarine communities dominated by *Juncus maritimus*, *Leptocarpus similis* and marsh ribbonwood (*Plagianthus divaricatus*), and spinifex grassland on dunes without marram grass. Exclusion of browsing animals is again a prerequisite for the restoration of these communities which, like the gumland and lava flow communities, is only possible on Great Mercury Island. Other islands in the group lack the appropriate sites for these communities.

Seabird-reptile-invertebrate-plantsystem of Middle and Green Islands. Perhaps the most unusual feature of the animal life on Middle and Green Islands is the coexistence of very dense populations of small seabirds (particularly diving petrels, *Pelecanoides urinatrix*) with a very high diversity of invertebrates and reptiles. The latter fauna comprises 10 species of lizards, and includes the only New Zealand location (Middle Island) supporting four species of *Cyclodina*, as well as tuatara. The soil-plant-animal systems of these islands are small, fragile and vulnerable to disturbance by humans or their introduced animals.

The long-term survival of such communities can be greatly enhanced by their replication on islands such as Korapuki and Double in the short term, and later on Stanley and Red Mercury. This would include the restoration of communities such as:

> **Milk tree forest/bird-burrowedfriable clay.** This community is at present restricted to the two plateaux of Middle Island (Atkinson 1964) but with further study, and elimination of kiore, replication of this community type may be possible at selected sites on Korapuki, Double or Stanley Islands.

Wharangi-mahoe forest/bird-burrowed friable clay. This community occurs on gentle to steep unstable slopes on Green and Middle Islands (Atkinson 1964). Again it is possible that, by eliminating kiore, replication of this community type can be attempted on other islands in the group.

Because of site conditions peculiar to Korapuki and Double Islands, restoration may in addition recreate communities of plants and animals no longer represented in the Mercury Group.

Rare or endangered species for which restorative action is either desirable or essential to achieve recovery of their populations are:

The unnamed species of giant tusked ground weta, at present restricted to Middle Island. This species is apparently associated with the bird-burrowed clay communities mentioned above, but it is possible that other rat-free habitats within the Mercury Group could be suitable for it.

Whitaker's skink. A recovery programme for *Cyclodina whitakeri* has begun with the transfer of 28 animals to Korapuki Island (Towns *et al* in press). It may be possible to establish this animal in other rat-free habitats within the Mercury Group as they become available.

Robust skink. This rare skink (*Cyclodina alani*) requires further rat-free habitats if its future is to be assured.

Tuatara. Neither of the tiny remnant populations of this animal which persist on Red Mercury and Stanley Islands is likely to survive indefinitely if kiore remain on these islands.

Pycroft's petrel. Red Mercury and Double Islands are important breeding grounds for this rare gadfly petrel (*Pterodroma pycrofa*). There is some evidence that its eggs are occasionally eaten by kiore (Stead 1937). It is possible that the size of breeding colonies on these islands would increase if kiore were removed.

Little spotted kiwi, takahe and others. A breeding population of the endangered little spotted kiwi (*Apteryx owend*) is now established on Red Mercury Island and, if cats were removed from Great Mercury Island, a much larger population could possibly be established there.

Removal of cats from Great Mercury Island would open the further option of establishing takahe (*Porphyrio mantelli*) on the island. It is likely also that cat removal would allow the natural re-establishment of a breeding population of New Zealand pigeons (kereru, *Hemiphaga novaeseelandiae*). Kereru can fly easily between islands in the Mercury Group, and a population on Great Mercury is likely to have positive benefit for natural seed dispersal between the smaller islands.

The relatively large size of Great Mercury Island makes it a potential habitat for the North Island kaka (*Nestor meridionalis septentrionalis*), which is currently declining, as well as the endangered North Island kokako (*Callaeas cinerea wilsoni*). It is likely, however, that viable populations of these birds could not be established on the island without first eradicating the ship rat (*Rattus rattus*).

Loxsoma cunninghamii. This rare fern is known from widely scattered localities on the mainland, but its island distribution is restricted to Great Barrier and Great Mercury Islands. Whether restoration of its habitat on Great Mercury is either appropriate or necessary for safeguarding the population there has yet to be determined.

LAND MANAGEMENT CATEGORIES

A listing of the islands and their resources is provided in Table 3. The most obvious feature of this list is the wide range of habitat qualities under the current "pristine island" classification applied by the Maritime Park to all islands (except Great Mercury) in the group (Mossman and Millar 1986). We propose that vulnerability to disturbance and potential for restoration be addressed in relation to a more realistic classification that reflects the way an island is to be managed. This approach identifies functional categories of islands which differ from each other in their primary objectives for management, but which overlap to the extent that a primary objective in one category may be a compatible secondary objective in another. The following suggested categories are a summary of those presented by Atkinson (this volume) and Towns *et al.* (this volume), with examples given for the Mercury Islands:

Minimum impact islands

The primary aim of management of these islands is to minimise both human interference and the influence of introduced plants and animals, which would be removed where feasible. They are islands that have many naturally occurring species of high conservation status. This category would therefore include fragile islands sensitive to human use, not only those seen as "pristine" or little modified, but some more modified islands as well. Since introduced plants and animals include those native to New Zealand, but naturally absent from these locations, such islands would not usually be used as recipient sites for translocations of any species previously unknown from the location. Islands showing a degree of endemism, such as the Poor Knights and the outlying islands (more than 50 km from the mainland) also would generally be excluded from this function. Minimum impact islands could, however, form the primary source of plants and animals used in restoration campaigns. Examples: Middle Island and Green Island.

Restoration islands

The primary aim of management of these islands is to restore whole biotic communities as fully functioning systems. In the Mercury Islands the first priority would be to restore island species and communities of high conservation status that were formerly present. The danger that this poses is that the resources required for restoration from Middle and Green Islands might not withstand long-term harvest for this purpose. We therefore suggest that Korapuki Island be designated as a temporary nursery for maximising productivity of selected animal species required elsewhere in the Mercury Group. This use of Korapuki would sometimes influence the sequence of species re-introductions during restoration. Examples: Korapuki Island, Double Island.

Refuge islands

The primary aim of management is to ensure the survival of species and biotic communities already on the island, as well as the survival of certain vulnerable or endangered species that are considered compatible with the island's biota. Restorative action would vary from the simple removal of introduced plants and animals to restoration of habitats necessary for the survival of threatened species. In a few instances an island could be used as a source of founder populations of threatened species for translocation to other islands, but only as long as this does not adversely influence the maintenance of indigenous rare species at the source location. Examples: Stanley, Red Mercury Islands.

Open sanctuary islands

The primary aim of management is to provide an island where the public can have controlled access in order to appreciate and enjoy native plants and animals, some of which may have high conservation status, in a dominantly indigenous environment. This aim is therefore one of education and interpretation and would be met by maintaining an interesting array of native plants and animals in a semi-natural environment. (This category is not represented in the Mercury Islands.)

Multiple-use islands

In contrast to the specific conservation uses associated with the four categories just described, many islands are currently managed under several different uses, not necessarily related to nature conservation. Although there may be few, if any, naturally occurring species of high conservation status, some of these islands have a high potential conservation value. Thus on an island that is farmed, used for exotic plantations, or for various kinds of recreation, it would often be possible to develop limited restoration programmes for indigenous biotic communities or imaginative management programmes for native species (including those of high conservation status) in suitable habitats that use native and/or exotic plants. The brown kiwi (*Apteryx australis mantelli*) population of the Waitangi pine forest is one example of a vulnerable native bird that has found a suitable habitat in exotic vegetation. Islands used as farm parks as well as some privately owned islands would fall into this category. Example: Great Mercury Island.

Restorative action, regardless of its extent, should gain considerable public support and interest if correctly handled. The most effective way to foster this would be to make one of the larger islands in the group open to strictly controlled visits. Stanley Island might be suitable for this as a secondary objective, but the intent to provide public access and the way it should be directed require planning at an early stage so that the restoration and public access elements can follow complementary paths.

A summary of the kinds of management categories linked to long-term goals proposed here for the Mercury Group is given in Figure 2. There are some short-term goals which also should be recognised by continuing the species and community restoration programmes already under way:

Complete the transfers of Whitaker's skink to Korapuki Island. The project was approved by the Hauraki Gulf Maritime Park Board in 1986.

Eradicate kiore from Double Island to compare general effectiveness of hand-laid (silo) bait with aerial drop techniques against kiore. This project is now under way.

Assess genetic identity and status of tuatara on Stanley and Red Mercury Islands. This project is now under way.

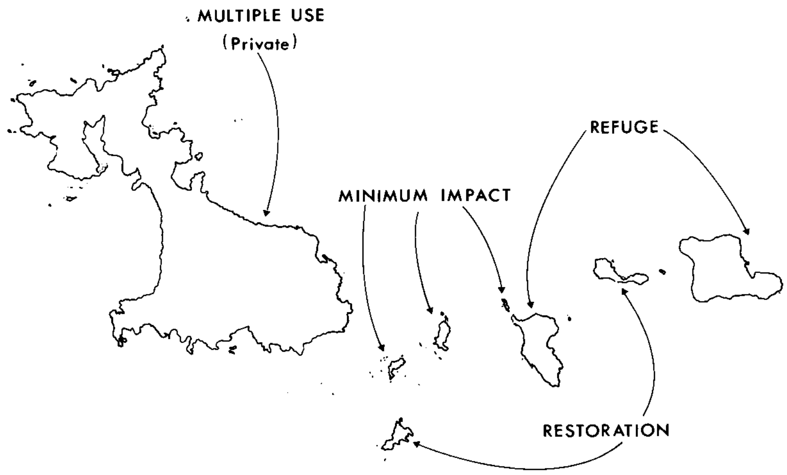

Fig.2. Proposed island management categories for the Mercury Islands.

SPECIFIC RECOVERY AND RESTORATION PROPOSALS

Mechanisms for the rescue of tuatara

The viability of the tuatara populations on Stanley and Red Mercury Islands was assessed in February and March 1989. These expeditions succeeded in confirming the presence of tuatara on both islands, but found that the populations were on the verge of extinction. Islands of a similar size can support many thousands of tuatara. For example Stephens Island (150 ha), which is 42% smaller than Red Mercury, is estimated to support over 50 000 tuatara (Newman 1987). With fewer than 30 known animals between them, and no evidence of recruitment, the two tuatara populations on Red Mercury and Stanley cannot be regarded as viable beyond the present generation.

Recent advances in understanding the nesting ecology, sex hormone cycles and hatchling behaviour of tuatara (Daugherty *et al* in press, Cree and Daugherty in press) raise the possibility of rescuing the tuatara populations on Stanley and Red Mercury Islands. This would involve careful coordination of rodent eradication campaigns, and breeding, headstarting and release programmes for the tuatara. The latter will need to be based on an understanding of when tuatara females are gravid (hormone assays and/or laparoscopy), induction of egg deposition, artificial incubation of eggs, and the release of juveniles. The techniques for all stages (except the last) in this process are now understood and have been tested on wild populations. A strategy flow diagram for the rescue of Mercury Island tuatara is given in Figure 3.

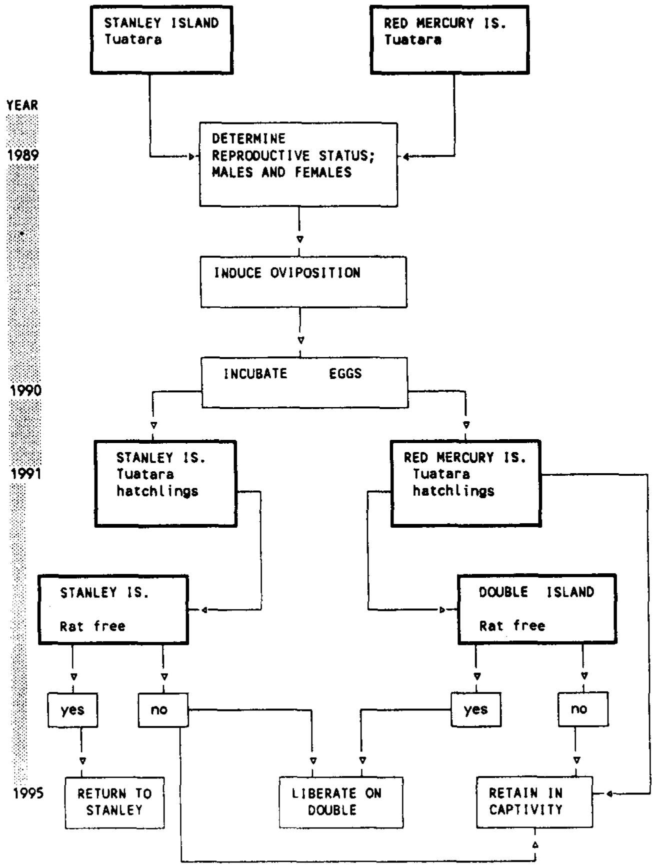

Fig. 3. Flow chart for tuatara recovery in the Mercury Islands: 1989-1995.

Restoration on Korapuki Island - Plant species and vegetation

Restoration of Korapuki Island began with the eradication of kiore in 1986 and rabbits in 1987, and the translocation from Middle to Korapuki of the rare Whitaker's skink in 1988 (Towns 1988, Towns *et al* in press). This limited action has set the scene for the more comprehensive approach to restoration which is outlined here.

Success in restoring many kinds of biotic community is directly dependent on using plants and animals that are ecologically appropriate for the physical conditions of the site or range of sites encompassed within the area to be restored. For example, the dry bouldery slopes of the south-west side of Korapuki Island are certainly not suitable for establishing all community types present on Green or Middle Islands.

Soil profile descriptions together with examination of slope and aspect suggest that the most suitable sites on Korapuki Island for establishing the two community types of particular interest on Middle and Green Islands (see above) are:

Korapuki Island	Source Island: **Middle and Green**
1. South-western plateau	Milk tree forest on plateaux
2. South-western slope, south of pohutukawa/ mahoe boulder forest.	Wharangi-mahoe forest on unstable slopes

Management of individual plant species (as well as possible management of invertebrate and reptile populations) will be necessary to achieve these restoration goals. Most of the plant species required are already on Korapuki Island. However a few have been so reduced by the browsing and seed consumption by rats and rabbits that they survive only as scattered plants on cliffs; their recovery is likely to be a slow process, perhaps exceeding a hundred years in some instances. Intervention is necessary in such cases if either the time for effective restoration is to be reduced or if the long-term capacity for natural recruitment of species on the island remains in question. The management action (or non-action) for each of the woody plant species important in the two communities of interest are outlined in Table 4.

Study of the actions suggested in Table 4 shows that they are consistent with three guiding principles of restoration:

Protecting other biotic communities present. Representative areas of the typical as well as the unusual biotic communities already present on the island are excluded from interference. Thus the pohutukawa forest characteristic of the island's slopes is left unmanaged over much of the island. Also, the peculiar ratstail/patotara grassland associated with phosphorus-deficient soil in the central part of the island is left without interference.

Minimising interference at the restoration sites. Techniques for restoration should emphasise minimum interference required to establish seed sources for the major species of the community to be restored (cf. Wright and Cameron, this volume). Any species of particular interest already established on a restoration site should remain. For example, even though taraire (*Beilschmiedia tarain*) cannot be considered as part of a restoration goal for milk tree forest, it would be short-sighted in the extreme to remove the two self-established seedlings from the southern plateau of Korapuki Island. This is a natural experiment that should be allowed to run its course.

From Table 4 it can also be seen that much of the required regeneration on the two sites is likely to be achieved through successional processes already activated by the removal of rabbits. In the five cases where artificial establishment of seedlings is seen as necessary, stock for three species can come from elsewhere on Korapuki Island. Seedlings of the other two species can be obtained from places on Middle Island where density-dependent mortality of such seedlings occurs every year. Only one of these species, *Parsonsia heterophylla,* is not known to be on Korapuki Island at present.

Establishing trials. There is not enough information at present to be sure that either of the proposed sites is suitable for establishing the biotic community of interest. It is therefore of the greatest importance to recognise our present state of ignorance and to treat the planting proposals of Table 4 as trials to be monitored before committing major resources to a more comprehensive restoration on these sites.

Restoration on Korapuki Island - Fauna

Completion of the reintroduction of Whitaker's skink to Korapuki Island is only one step in restoration of the island's terrestrial animal communities. Possibly because of the relatively small size of the island, and the recent burning which has occurred, rats and rabbits have had a particularly severe impact on Korapuki Island communities. These impacts can be illustrated as a conceptual model derived by comparison of Korapuki with the nearby rat- and rabbit-free islands (Fig. 4).

Forest-dwelling species of lizards and the tuatara were apparently eliminated from Korapuki by rats and habitat destruction (Towns in prep). For the same reasons the invertebrate communities of the forest litter are severely depleted, with beetles being very poorly represented (P. McColl pers. comm.). Even tree wetas (*Hemideina* sp.) have not survived on Korapuki (Hicks *et al.* 1975). Consequently, re-establishment of many of the key species from Middle, including the bizarre giant ground weta, may in the long term hinge on reconstructing the invertebrate communities that formed the base of the food chain. This could require a comprehensive restoration campaign.

Both the rabbits and rodents had a direct impact on the vegetation of Korapuki Island, and this has a number of indirect consequences. Seedling density was very low and regeneration of several species had terminated as a result of browsing (I. Southey pers comm.) when campaigns against rabbits and rats began in 1986. Thus litter was prone to drying rapidly and decomposer density was low (Hicks *et al.* 1975). The density and diversity of invertebrates was probably further influenced by direct predation from kiore (Hicks *et al.* 1975, Newman and McFadden 1990).

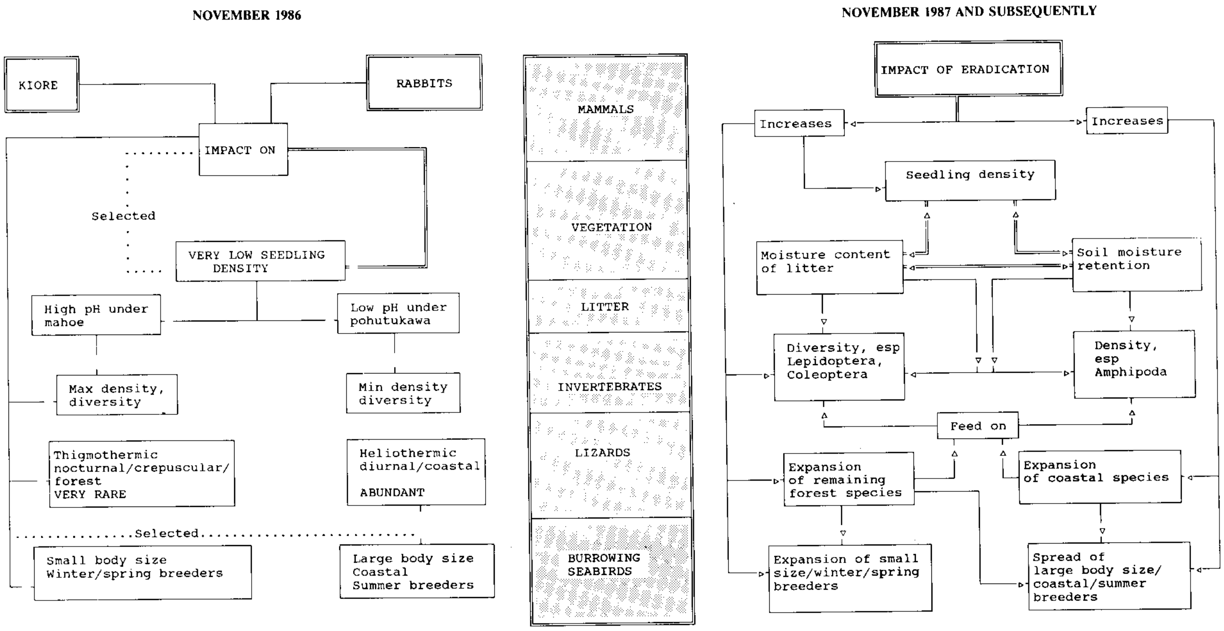

Fig. 4. **Conceptual models showing impacts of Pacific rats and rabbits, and the effects of their removal, on the lizard fauna of Korapuki Island. Note that although interactions between elements of the communities have been re-established, processes have not been restored because of the elimination of key invertebrates and lizards. After Towns *et al* in press, with data from Hicks d al. 1975, P. McColl, pets. comm., Towns in prep.**

The lizard fauna is at present dominated by heliotherms (sun-seeking lizards) such as the shore skink (*Leiolopisma smithi*), which are diurnal, coastal, small (5-7 g) and have a relatively high individual productivity (maximum litter size of 4-6). The rare species on Korapuki are forest-dwelling (plus coastal), cool-adapted and thigmothermic (seek warmth by contact). They are also nocturnal or crepuscular, tend to be larger (up to 100 g) and have a relatively low individual productivity (maximum litter size of 2). Likely changes to the island now that it is free of rabbits and rats are quite complex. These include dramatic increases in seedling density, possibly leading to increased soil moisture levels as the dry pohutukawa litter becomes progressively more shaded and more evenly distributed, increased invertebrate densities and accelerated litter decomposition. The litter invertebrate diversity should increase also, with reappearance of some of the larger species such as aerially dispersed ground-dwelling Coleoptera. With release from predation there is likely to be a spread of the lizards with highest productivity - i.e. the diurnal heliothermic species - but these may ultimately decline in many areas as the more open situations become covered by vegetation. Eventually the nocturnal, forest-inhabiting species should benefit from the increased invertebrate numbers and diversity. Increased density of seabird burrows, as the birds respond to their release from egg and chick predation, could also benefit forest-inhabiting lizards (Fig. 4). This should provide an environment much more similar to that on Middle Island, one that should be particularly attractive to forest-inhabiting species.

Forest-inhabiting lizards and flightless invertebrates do not have the ability to disperse across water barriers and will need to be reintroduced to Korapuki. The re-introductions will need to be designed so that those species which might be introduced to other islands in the group have the best prospects for expansion on Korapuki. Because the most significant resident predator on islands free of rats is the tuatara, it would be unwise to reintroduce tuatara to Korapuki until success with other aspects of the restoration programme is assured (Table 4).

The transfer of species to Korapuki, and within the Mercury group in general should be tested against the protocols developed by Towns *et al.* (in press) and Towns *et al.* (this volume), especially in view of the high potential for loss of genetic information with each new transfer.

DISCUSSION

Ecological processes

The high significance of the New Zealand islands on a global scale is discussed by Daugherty *et al.* (this volume) and Diamond (1990, this volume). The Mercury Islands are typical of many islands off the north-eastern North Island with energy and materials used in terrestrial ecosystems being imported by seabirds from outside individual island boundaries.

Transport of materials within the group would also have occurred. The seven larger islands in the Mercury Group are separated by water gaps that do not exceed 1500 m. For some groups of animals, such as flightless invertebrates and some terrestrial reptiles, these water barriers cannot be crossed. However, for most flighted birds 1500 m is not a significant barrier, and as a result the islands can be viewed as a single system within which birds are able to commute.

Events around the smaller islands have irreversibly changed the way many of these processes operate. The extensive habitat modification on Great Mercury Island, following many centuries of human occupation, coupled with the establishment of cats and ship rats, has had severe consequences for its forest birds, and these influences are reflected to a lesser degree in the avifauna of the smaller islands. The dense cover of podocarp-kauri forest and coastal broadleaf forest which once occurred on Great Mercury (Wright 1976b), probably would have supported a forest avifauna somewhat similar to that still found on Little Barrier and Kapiti Islands. Comparison with these two islands suggests that extinctions from Great Mercury most likely include saddleback (*Philesturnus carunculatus rufusater*), stitchbird (*Notiomystis cincta*), North Island robin (*Petroica macrocephala toitoi*), tomtit (*P. australis longipes*), rifleman (*Acanthisitta chloris grand*), whitehead (*Mohoua albicilla*) and yellow-crowned parakeet (*Cyanoramphus auriceps*). Like Little Barrier and Kapiti, Great Mercury would have supported very large populations of tui (*Prosthemadera novaeseelandiae*), kereru and kaka. Today these species occur infrequently in the Mercury Islands. Tui may be important as pollinators, whereas kereru are known to be important seed dispersers and foliage browsers (Clout and Hay 1989). The decline of these two species on Great Mercury has to some extent influenced forest dynamics in all seven islands. The land bird fauna that remains today is small (30 species), and on Great Mercury, includes a high proportion of introduced species (Table 1). Introduced birds are less prominent on the smaller islands where the most common native species are bellbirds (*Anthomis m. melanura*) and red-crowned parakeets (*Cyanoramphus n. novaezelandiae*).

The most significant birds on these islands, both in terms of numbers, and their impacts on soils and other biota, are the burrowing seabirds. Once again, Great Mercury stands out more for what has gone than for what has survived. Cats, habitat destruction, and to a lesser extent, rats, have reduced this part of the avifauna on Great Mercury to two species: little blue penguin (*Eudyptula minor iredalei*) and grey-faced petrel (*Pterodroma macroptera gouldi*), and even the latter species is rare (Grace 1976). By contrast, eight species of seabirds have now been recorded as breeding on Korapuki Island (Hicks *et al.* 1975, Towns unpublished), but even here the past impact of kiore means that bird-burrow densities are generally only 10% of that recorded on Middle Island (I. Southey pers comm.). On Middle, Green and some of the unnamed islets, there are vast numbers of seabirds, dominated by the small diving petrel.

Because of their burrowing activities, the petrels on these smaller islands maintain soil aeration at a high level and their droppings result in topsoils with high potassium, medium to high total nitrogen and very high available phosphorus values (Atkinson 1964). These soils provide favourable conditions for rapid plant regeneration in canopy gaps, and the surface litter of the soils is inhabited by a diverse and dense litter fauna. Three groups of predators benefit from these conditions. The first group includes the top invertebrate predators. On Middle Island these are the unique Middle Island ground weta (undescribed) and the large centipede *Cormocephalus rubriceps.* The latter species is widespread on islands free of rats, and is known to feed on lizards as well as other invertebrates. The second group includes all lizard species. On Middle Island this fauna, with 10 species, is unusually diverse, exceeding the sympatric diversity of lizards recorded in most North American deserts (Pianka 1986). Two of the lizards, Whitaker's skink and the robust skink, are also very rare. This diversity is part of a pattern of increasing diversity on rat-free islands that can be followed from the Three Kings Islands through the Mercury Group to the Aldermen. South of the Aldermen diversity declines, as the southern limit of the range of several species is exceeded (Towns *et al.* 1985).

The third predator is the top resident predator on many small rat-free islands: the tuatara. They feed on carrion, seabird chicks, lizards, their own young, and invertebrates (Southey 1985, Newman 1987). Tuatara have been recorded on rat-free islands at densities of around 500/ha (Newman 1982), and in favourable areas may reach 1400/ha (Newman 1987). Even higher densities (averaging $10/m^2$) have been reported for shoreline-inhabitingskinks (Towns 1975). The tuatara and most of the lizards of these northern islands are nocturnal or crepuscular (Towns *et al.* 1985), so that it is only at night that the significance of the dense seabird and reptile populations becomes apparent. On rat-free islands the forest-dwelling lizards tend to be large species (e.g. up to 70 g for *Cyclodina alani* and over 100 g for *Hoplodactylus duvaucelii*), which added to the biomass of tuatara and seabirds, must produce total animal biomass figures that are quite extraordinary. To our knowledge there has been no attempt to measure either this combined reptile-seabird biomass or the remarkable associated energy flows.

From a biological viewpoint the most interesting islands are therefore the smaller, rodent-free ones. Besides their value as refuges for rare species and unique communities, these small rodent-free islands have biogeographic and genetic value because they cover a range of island sizes isolated for a considerable period. The different faunal assemblages on these islands, which range from 0.1 to 13 ha, represent differing abilities to withstand major environmental catastrophes such as cyclones, provide examples of the physiological abilities of a range of species to overcome exposure to salt and lack of fresh water, and provide living lessons on the impacts of inbreeding, genetic drift, and colonisation abilities.

Directions and priorities

Two questions are likely to be asked of restoration programmes: "why bother?" (e.g. King 1984), and " what should you restore the place to?" There are two responses which should be made to the first question. First, the Mercury Islands present a special case because of the uniqueness and vulnerability of key communities. Left alone, small islands such as Middle Island may not be invaded by predators such as rats or, if that did occur, it might be possible to eradicate them. However, a lesson to be learned from Whenuakura Island is that the eradication campaign against Norway rats (*Rattus norvegicus*), which followed their invasion by between 12 and 24 months, was too late to save several species of lizards and a thriving population of tuatara (Newman 1986). In addition, the discussion above illustrates that the removal of rodents (or other introduced predators) by itself will not necessarily enable re-establishment of the pre-rodent ecological processes. Without active restoration these trophic links could remain permanently dislocated because of the limited dispersal abilities of some key elements (e.g. some reptiles and large flightless invertebrates).

Second, the Global 2000 report to the President of the United States estimated that between half a million and two million species, or 15-20% of all species on earth, could become extinct by the year 2000. The main cause of this wave of extinctions is loss of wild habitats (Shaffer 1987). The Mercury Islands provide remnants of communities that contribute significantly to the biological diversity of our islands. The time to ensure the long-term prospects of these remnants is now.

In answer to the question of what to restore to: the response will depend on what conservation goals are defined. On small islands near-complete restoration is feasible (Simberloff this volume), although some introduced birds will probably always remain. But on very large islands complete restoration can never be realised because with the extinction of moa (Dinornithidae) around 1400 AD, an entire plant-herbivore system disappeared (Caughley 1989). With reference to the Mercury Islands, removal of rats from all the smaller islands will be necessary because many species being conserved cannot coexist with them. Great Mercury Island, being privately owned, is not subject to any management regimes applied to the island reserves. Nevertheless, if desired by the owners, livestock control and removal of cats would enable the island to contribute very significantly both to the conservation of some endangered animal species, and to options for limited restoration of some indigenous biotic communities.

CONCLUDING COMMENT

The key to success of this proposal will be in planning and coordinating effort. If the aims of several species-centred recovery programmes are combined with the object of total restoration for some biotic communities, the potential exists for achieving conservation goals that a few years ago would have seemed unrealistic. Particular realisable objectives are:

The unique seabird-reptile-invertebrate-plant communities of Middle and Green Islands can be re-established on at least one if not two other islands in the Mercury Group. This would reduce the risks associated with the present very restricted distribution of these communities.

Coincident with this, additional suitable habitats can be created for Whitaker's skink, robust skink, and the unnamed species of giant ground wets on islands from which rats have been removed.

The numbers of tuatara in populations in the Mercury Group can be enhanced, thereby improving the prospects for this species.

The numbers of little spotted kiwi in the Mercury Group can be enhanced, thereby contributing to the recovery programme for this species.

With the interest and cooperation of the owners of Great Mercury Island two further realisable objectives can be identified:

Kauri forest and related communities, once characteristic of the Coromandel Peninsula, can be partly restored on Great Mercury Island.

Breeding populations of little spotted kiwi, takahe, kereru and tui can be established on Great Mercury Island.

ACKNOWLEDGEMENTS

Achievements made in the Mercury Islands to date would not have been possible without the competence, dedication and companionship provided by Ian McFadden, to whom we offer our sincere thanks. Thanks are also due to the Auckland and Waikato Conservancies of the Department of Conservation, who frequently provided field assistance and equipment, to the Hauraki Gulf Maritime Park Board for permission to conduct the work and to the Zoological Societies of Dallas and San Diego for their assistance with funding. Our thanks to Drs Chris Green, Mick Clout, Colin Meurk, Richard Sadleir, Theo Stephens, and to Mary Cresswell, Don Newman and Stu Moore for their comments on the manuscript.

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Table 1. List of reptiles and birds recorded by location in the larger Mercury Islands (>2 ha) by Atkinson (1964), Edgar (1962), Fogerty and Douglas (1972), Grace (1976), Hicks et al. (1975), Skegg (1963, 1972), Southey (1985), Thoresen (1967), Towns (unpubl), Towns et al. (in press), and Whitaker (1978). Species marked +, present; ., probably present; v, present, but probably not breeding; I, introduced; *, adventive; seabirds marked b, breeding.

Species	Great	Red	Stanley	Double	Korapuki	Middle	Green
REPTILES							
Tuatara		+	+			+	+
Common gecko		+	+	+	+	+	+
Duvaucel's gecko			+	+	+	+	+
Pacific gecko						+	+
Copper skink		+	+	?	+	+	
Marbled skink						+	+
Moko skink		+	+	+	+	+	+
Robust skink						+	+
Shore skink		+	+	+	+	+	+
Suter's skink		+		+		+	+
Whitaker's skink					I	+	
LANDBIRDS							
Bellbird	+	+	+	+	+	+	+
Blackbird*	+	+	+	+	+	+	+
Brown quail*	+						
Chaffinch*	+	+	+	.	+	+	+
Dunnock*	+	+	+	+	V	+	+
Fantail	+	+	+	+	+	+	+
Goldfinch*	+					V	
Grey warbler	+	+	+	+	+	+	+
Greenfinch*	+					V	
Harrier	+	+	+	+	+	+	+
Indian myna*	+						
Kaka		V					
Kingfisher	+	+	+	+	+	+	+
Long-tailed cuckoo	V						
Little spotted kiwi		I					
Morepork	+	+	+	+	V		
Wood pigeon	+	.	+	V			
NZ pipit		V					
Red-crowned parakeet	+	+	+	+	+	+	+
Redpoll*	+						
Saddleback		I	I				
Shining cuckoo	+	+	+	.	+	.	.
Silvereye	+	+	+	+	+	+	+
Skylark*	+	+					
Songthrush*	+		+		V		
House sparrow*	+		+		V	V	
Starling*	+	+	+	+	+	+	+
Tui	V	V			V		
Welcome sparrow					+		
Yellow hammer*	+						
WADERS AND WATERFOWL							
Banded dotterel	+						
Brown teal?	+						
Grey duck	+						
Mallard*	+						
Paradise shelduck	+						
NZ dotterel	+						
Pied stilt	+						
Pukeko	+						
BURROWING SEABIRDS							
Little blue penguin	b	b	b	b	b	b	b
Grey-faced petrel	b	b	b	b	b	+	
Pycroft's petrel		b	b	b	b		
Flesh-footed shearwater		?	?	?	b	b	b
Fluttering shearwater		b	?	b	b	b	b
Allied shearwater		b	?	b	b	b	b
Sooty shearwater			b		b		
White-faced storm petrel						+	
Diving petrel			b		b	b	b
OTHER SEABIRDS							
Black-backed gull			b		+		
Red-billed gull					+		
Black-billed gull					+		
Oystercatcher					+		
Gannet			+		+		
Reef heron	+	+			+		
White-faced heron	b				+		
Caspian tern						+	
White-fronted tern					+		
Black shag	+				+		
Pied shag	b	b	b		+		
Little shag	b				+		

Table 2. Animals with high conservation ratings known from the Mercury Islands. Species marked as follows: endangered (E); threatened M, regionally threatened (C) or rare (R) (sensu Bell 1986).

Species	Islands
INVERTEBRATES	
Darkling beetle (*Mimopeus opaculus*)	Rat-free islands
Giant weta (New genus and species)	Middle Island
REPTILES	
Tuatara (C)	Red Mercury (remnant), Stanley (remnant), Middle, Green
Duvaucel's gecko (C)	Stanley, Korapuki, Middle,Green
Marbled skink (C)	Middle, Green
Whitaker's skink (T) (introduced)	Middle, Korapuki
Robust skink (T)	Middle, Green
BIRDS	
Pycrofts petrel (R)	Double (small numbers elsewhere)
North Island saddleback (R)	Introduced to Stanley and Red Mercury
Little spotted kiwi (E)	Introduced to Red Mercury
Red-crowned parakeet (C)	Great Mercury, Red Mercury, Stanley, Double, Korapuki, Middle, Green

Table 3. General resource inventory of the Mercury Islands. Islands are artificially divided into groups depending on the amount of human-induced modification that can be identified. Island areas based on Taylor (1989) and, if >0.5 ha, approximated to nearest 0.5 ha.

GROUP 1. LITTLE-MODIFIED LSLA.NDS

- No introduced predators
- Isolated faunas and floras separated from other landmasses for over 8 000 years
- Large populations of burrowing seabirds (as long as soil is present)
- Extremely dense and diverse faunas of invertebrates
- Extremely dense and diverse faunas of reptiles, including tuatara (if equal to /greater than 3 ha)
- Unique vegetation types (on some islands)
- Little evidence of Maori occupation
- Under Crown control (Hauraki Gulf Maritime Park)

Middle (13 ha)
Green (3 ha)
Stack N or Stanley (15 ha)
Rock between Double and Red (1.0 ha)
Stack W or Green (0.2 ha)
Stack N of Korapuki (0.2 ha)

GROUP 2. MODERATELY MODIFIED ISLANDS

- Partly or wholly burned within the last 2 centuries
- More present
- Large populations of some seabirds present
- Some rare species naturally present, others introduced
- Naturally regenerating forest present with diverse flora
- Evidence of Maori occupation
- Under Crown control (Hauraki Gulf Maritime Park)

Red Mercury (225 ha)
Double (33 ha)

GROUP 3. 11EAVILY MODIFIED ISLANDS

- Extensively burned within the last 100 years
- Kiore present
- Rabbits present
- Moderate populations of some seabirds present
- Highly modified vegetation with low species diversity, dominated by pohutukawa/mahoe forest
- Some rare species present, others introduced
- Evidence of Maori occupation
- Some successful eradication campaigns completed (Korapuki)
- Under Crown control (Hauraki Gulf Maritime Park)

Stanley (100 ha)
Kompuki (18 ha)

GROUP 4. EXTREMELY MODIFIED ISLAND

- Extensively burned, farmed and deforested
- Kiore (?), ship rat, cats and goats present
- Little native vegetation remaining
- Few burrowing seabirds
- Few rare species known
- Considerable evidence of long Maori occupation
- Private ownership

Great Mercury (1860 ha)

Table 4. Management action required for establishing; communities of Middle island on Korapuki Island

Species	Common Name	Present status on Korapuki Island	Middle I community and proposed site (vegetation) on Korapuki I	
			Wharangi-mahoe forest on unstable slope	Milk tree forest on stable plateau
PLANTS			South-western slope at southern end of Korapuki (pohutukawa/mahoe forest)	Plateau at southern end of Korapuki (pohutukawa forest)
Coprosma macrocarpa	coastal karamu	Spreading from a few surviving adults	No action: allow natural regeneration and further spread of existing population	
Corynocarpus laevigatus	karaka	Adults restricted to rocky eastern peninsula; a few seedlings	Establish seedings as a future seed source at northern edge of south-west slope where it abuts pohutukawa/mahoe forest on boulders	
Macropiper excelsum	kawakawa	Spreading slowly from a few surviving adults	No action: allow natural regeneration and further spread of existing population	
Melicope ternata	wharangi	Two adult plants, one with seedlings close to parent	Establish seedlings from Korapuki I. in 3 areas of more open forest	No action: seed sources on island will allow species to enter community.
Melicytus ramiflorus	mahoe	Widespread and abundant	No action: mahoe already abundant	No action: mahoe uncommon on this site.
M. novae-zelandiae	hymenanthera	Spreading slowly from survivors	No action: allow natural regeneration and further spread of population	
Metrosideros excelsa	pohutukawa	Major component of vegetation	No action required in the short term	
Parsonsia heterophylla	kaihua	Extinct	No action required	Establish seedings from Middle I. in 3 areas
Pittosporum crassifolium	karo	Spreading rapidly from survivors	No action: allow natural regeneration and further spread of population	
Planchonella novo-zelandica	tawapou	A few adult plants restricted to rocky sites; regenerating locally	Establish seedlings from Korapuki I. in 3 areas on slope	No action: seed sources on island will allow species to enter community
Pseudopanax lessonii	houpara	Spreading slowly from survivors.	No action: allow natural regeneration and further spread of population	
Solanum aviculare	poroporo	Abundant	No action required	
Streblus banksii (=*Paratrophis banksii*)	broad-leaved milk tree	A few adults restricted to eastern peninsula. No seedlings up to 1989	No action required	If seedlings do not appear on Korapuki I. by 1990, established seedlings from Middle I. in 3 areas

Species	Common Name	Present status on Korapuki Island	Middle I community and proposed site (vegetation) on Korapuki I	
			Wharangi-mahoe forest on unstable slope	Milk tree forest on stable plateau
ANIMALS			South-western slope at southern end of Korapuki (pohutukawa/mahoe forest)	Plateau at southern end of Korapuki (pohutukawa forest)
	invertebrates		No action: allow natural spread; review the possible reintroduction of flightless species	
Cyclodina alani	robust skink	Extinct	Transfer from Middle Island into mahoe forest	
Cyclodina oliveri	marbled skink	Extinct	Transfer from Middle/Green Islands into boulder forest	
Cyclodina whitakeri	Whitaker's skink	Reintroduced from Middle Island, 1988	Complete reintroductions until at least 50 released (if necessary)	
Hoplodactylus pacificus	Pacific gecko	Extinct	Transfer from Middle Island into coastal forest	
Leiolopisma suteri	Suter's skink	Extinct	Transfer from Middle/Green Island into boulder beach	
Sphenodon punctatus	tuatara	Extinct	No action: Review when lizards established.	

Pages 109-112 in Towns, D.R, Daugherty, CH., and Atkinson, I.A.E. (Eds), 1990. ***Ecological restoration of New Zealand islands*****.**
Conservation Sciences Publication No. 2 Department of Conservation, Wellington.

MOTUHORA: A WHALE OF AN ISLAND

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ABSTRACT

Motuhora (Whale Island) is easily accessible from the Bay of Plenty coast, a few kilometres off Whakatane, and it is a popular stopping place for boaties. Current development of the island as a refuge takes a high degree of public access into consideration. Fertile soils and a benign climate are resulting in a surprisingly high rate of natural regeneration.

Crown management since 1984 has been characterised by enormous enthusiasm but no clearly defined goals. The lack of an operative management plan for Motuhora - taken with the lack of both a national context for island restoration and national policy on species introduction - has allowed a number of conflicts to arise over management actions undertaken to date. These conflicts basically have to do with the differences between a purist ecological approach to management and the development of an island as an offshore 'zoo'.

Botanists were holidaying on Motuhora in the summer of 1987/88. On coming across planted puriri (*Vitex lucens*) thriving in a nurse crop of regenerating duneland manuka (*Leptospermum scoparium*) they are reported to have been so incensed that they pulled out some of the offenders. The trees had been planted as part of a habitat enhancement programme initiated by the New Zealand Wildlife Service and continued by the Department of Conservation.

The incident highlights a contemporary island conservation dilemma. Management of protected areas in such a way as to maintain them in (or restore them to) something resembling an 'original' state is a strong conservation imperative in the late 1980s. Species-oriented wildlife conservation programmes, on the other hand, offer one of the last respectable justifications for interventionist programmes aimed at establishment of 'unnatural' systems. A decision on the key management approach for Motuhora (Whale Island) in the eastern Bay of Plenty (see p. 214) currently sits squarely astride the horns of this dilemma.

BACKGROUND

The human species has been a player on the Motuhora stage since early in New Zealand prehistory. Archaeological sites indicate that a small self-sufficient community was resident on the island in pre-European times (Hayward *et al* in press). The first written mention of Motuhora and its inhabitants was by Captain Cook, who wrote: '. . . large double canoes full of people came off to us; this was the first double canoe we had seen in this country' (Beaglehole 1968). During the last century, traditional activities continued on the island although it was no longer permanently inhabited. And in spite of a change of ownership from Maori to European title in the 1800s, muttonbirding by the Ngati Awa and Tuhoe tribes continued until 1962, when dwindling bird numbers led to its closure.

European occupation and activities have been short-lived but have had a long-term impact Goats were released early, probably in the late 1800s, to provide food for shipwrecked sailors. Mining and quarrying were undertaken, with rock quarried in 1914 for the Whakatane Harbour Board. At about this time a small-scale farm was established. It is likely that Norway rats and feral cats arrived then, too. Sheep were barged to and from Whakatane and grazed the south side of the island extensively until the mid-1940s.

Joint Wildlife Service/Lands and Survey interest in acquisition in 1963 resulted in declaration of the island as a Wildlife Refuge in 1965. By the early 1980s the owners had decided to sell, attracting considerable interest from developers. Motuhora was finally purchased by the New Zealand Wildlife Service in 1984.

CONSERVATION VALUES

McGlynn (this volume, abstracts) detailed the depauperate state of vegetation cover at the time of purchase. The ravages of goats and rabbits were largely responsible for reducing the original forest cover to sparse remnants with low species diversity.

In wildlife terms, sea and shore birds are the most significant. Along with Whakaari (White Island), Motuhora has about 40,000 pairs of grey-faced petrels (*Pterodroma macroptera*) one of the largest breeding colonies in New Zealand (Imber 1969). Although we do not have conclusive evidence to prove it, it is suspected that Norway rats were the main cause of the decline in petrel numbers first noticed in 1962. (There have been no ship rats.) The only other petrel breeding there is the sooty shearwater (*Puffinus griseus*) in a small colony of about 500 pairs.

Fluttering shearwaters (*Puffinus gavia*) used to breed on the island but were probably exterminated by feral cats and rats. It is likely other petrels also bred on Motuhora but went the same way.

The most significant of the breeding shore birds is the New Zealand dotterel (*Charadrius obscurus*).

Among land birds exotic species are predominant; the depauperate native vegetation cover limits habitat values for indigenous birds.

Lizard fauna is small compared with that of other islands. The common gecko (*Hoplodactylus maculatus*) and two skinks, the spotted skink (*Leiolopisma lineocellatum*) and the copper skink (*Cyclodina aenea*), are the only species found. Low species numbers are again almost certainly due to predation by Norway rat.

Thermal activity in Sulphur Valley and on the south-west flanks of the central volcanic cone includes steaming ground, vents and bubbling hot-water springs and enhances conservation and scientific values.

Archaeological sites, vegetation, wildlife including land snails, and thermal activity are all well documented (Hayward *et al* in press, Ogle in press a, b, Moore in press).

CONSERVATION MANAGEMENT

The New Zealand Wildlife Service shot over 1,000 goats on the 143-hectare island in 1964. Natural regeneration which had been severely checked until then came away markedly after the initial cull. Kanuka (*Kunzea ericoides*) and pohutukawa (*Metrosideros excelsa*) recolonised open areas, and an understorey of mahoe (*Melicytus ramifiorus*) developed in remnant pohutukawa forest. Bare earth and rock became clothed in a tall grass sward. In 1968 or 1969, however, the illegal release of rabbits to provide bait for crayfishing halted further regeneration. By 1972 rabbit density had reached 250 per hectare, reducing much of the island once more to bare soil and rock.

A series of rabbit poisoning operations by various agencies began in 1973 and culminated with eradication of rabbits in 1987. The last goats had been eliminated by 1977. It was observed after rabbit operations in 1985 that rat numbers too were being heavily reduced. Quick action was taken to exploit this situation by integrating rat control measures with subsequent rabbit poisoning. No sign of rats has been seen since December 1986.

With the eradication of goats and rabbits, the fertile soils and benign climate are now encouraging a rate of natural regeneration which surprises the most optimistic of ecologists. Pohutukawa regeneration is spectacular; there is profuse germination and good survival of seedlings even under and through a tall, dense grass sward. This is in marked contrast to the results of the recent comprehensive survey of mainland pohutukawa by a Forest Research Institute team, which found that pohutukawa regeneration does not occur in grassland.

Natural regeneration has been supplemented since 1984 by the planting programme described by Mike McGlynn (this volume, abstracts), success of which has also been impressive.

As habitat values for indigenous wildlife improve dramatically, and with the disappearance of rats in particular, more common land birds such as bellbird (*Anthornis m. melanura*) and pigeon (*Hemiphaga n. novaezelandiae*) will self-introduce, and others such as kaka (*Nestor meridionalis septentrionalis*) may become more frequent visitors.

Since purchase of the island red-crowned kakariki (*Cyanoramphus n. novaezelandiae*) have been intentionally introduced, more because of their easy availability than on the basis of any clear strategy. There has been some concern that hybridisation of the parent stock would cast doubt on the scientific value of the population established, but recent genetic testing has largely allayed this concern (S. Triggs and C. Daugherty, pers. comm.).

Lying just seven kilometres offshore from Whakatane and with safe anchorages on its southern side, Motuhora is a prominent landmark from the mainland, has a high public profile and has long been a popular stop-off point for the boating public. Free public access has been maintained though access permits have been required for some time, even while the island was privately-owned. The high public demand for access is recognised and it has always been envisaged that the island would be developed as a showcase for the conservation values and management requirements of offshore islands.

Together with other local landmarks including Putauaki (Mt Edgecumbe) and Kohi Point, the prominent headland forming the backdrop to the town of Whakatane, Motuhora is a feature of considerable cultural significance to Ngati Awa. The tribe can be expected to maintain a keen interest in the island and its management.

"FAVOURED SPECIES MANAGEMENT" OR "ECOLOGICAL RESTORATION"?

It has always been intended that Motuhora be used for marooning of threatened wildlife. This was the primary reason for purchase of the island and is the thrust of the draft management plan inherited by the Department of Conservation (New Zealand Wildlife Service 1985).

Eradication of rats has now greatly enhanced Motuhora's national significance as a potential refuge for wildlife at risk. The range of species which can be considered as candidates for marooning is much wider than could have been foreseen five years ago. Success of this rat eradication and the more recent removal of rats from Mokoia, a 136-hectare bush-covered island in Lake Rotorua, also indicates that with improving techniques and developing expertise, prospects for further rodent eradications may be better than we have generally anticipated.

The paucity of predator-free islands traditionally available for marooning has generated a logical focus on use of those few islands for that purpose. Predator-free islands have automatically been seen as serving national needs in this regard. Improving prospects mean that we now need to consider a wider range of management approaches, including ecological restoration, for such islands.

Active favoured species management programmes are already under way on a number of other accessible and highly-modified offshore islands including Tiritiri Matangi and Mana (Timmins *et al.* 1987). Keenly aware of the lack of a national framework and policy for island management, and of the need for an integrated approach (McNamara 1986), Bay of Plenty Conservancy of the Department of Conservation is still considering its management approach and goals for Motuhora.

If a decision is taken now to follow a favoured-species management approach, introducing plants and animals from throughoutthe country, it will be difficult to change tack to restoration further out. We have already had to contemplate the logistical, and more importantly the public relations difficulties, which would have resulted from a decision to remove the red-crowned kakariki already introduced, had the level of hybridisation been shown to be significant.

We have an opportunity with Motuhora to take an ecological restoration approach that is community- rather than species-orientated. This would concentrate on filling in the gaps in local communities by using areas nearby as a model and as a source of the plant and animal species which had a high probability of being on Motuhora in the past. Tuatara (*Sphenodon punctatus*) and fluttering shearwater would be the priority animal species for reintroduction.

It would be relatively easy to change to a favoured species management programme should a need arise at some later date. At this point no major management actions have been undertaken which would compromise the adoption of a true ecological restoration approach. Nor is there any pressing need to take such action; few of the species from outside the Ecological Region which could be established on Motuhora are under immediate threat. Some of them are already being actively managed by other Department of Conservation conservancies.

Our experience with Motuhora convinces us that the time is right for a reassessment of our approach to island management. This is an essential prerequisite to the development of a national framework and policy which provides the basis for an integrated approach to the use of islands. We thank and congratulate the organisers of this conference for what we see as a useful first step in this process.

In the meantime, we are not aware of any comprehensively planned ecological restoration being attempted on any New Zealand island at present. Motuhora could be a good place to start.

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MANA ISLAND REVEGETATION: DATA FROM LATE HOLOCENE POLLEN ANALYSIS

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ABSTRACT

Mana Island, off the Kapiti Coast, Wellington, has recently become a scientific reserve after 150 years of European pastoral farming. A palynology study was undertaken to discover the pre. settlement vegetation and thus assist with a revegetation programme currently in progress. Palynomorphs and charcoal fragments from 15 sediment and soil samples and two surface samples were counted. Pollen analytical results show that a manuka/kanuka-dominant (*Leptospermum/Kunzea*) scrub, similar to that of the existing forest remnant on the island, was widespread on the island before the present grassland: a radiocarbon date at the base of the sequence indicates that this scrub existed at 560 ± 160 years BP. Low frequencies of microscopic charcoal fragments at this level suggest that the manuka/kanuka scrub preceded prehistoric Polynesian settlement of the island. However, since settlement of parts of New Zealand occurred perhaps 1000 years ago, the scrub may be a result of human interference before 560 years BP; to examine this possibility the pollen sequence would have to be extended back another 500 years. Although the results of this particular study were limited by lack of suitable deposits, it demonstrates a role that palynology can play in ecological restoration.

INTRODUCTION

Mana Island, on the Kapiti Coast, Wellington, has recently become a scientific reserve after 150 years of European pastoral farming. The primary objective of this study was to obtain the vegetation and fire histories of Mana Island over the last 2000 years. From this we hoped to be able to determine the undisturbed pre-settlement vegetation on the island and to date first human settlement as revealed by vegetation disturbance. It was hoped that this would provide information which would assist with the revegetation programme currently being undertaken and with reconstructing the prehistory and history of Mana Island as an aid to public education programmes. Mana Island is 4 km from Titahi Bay and just 2.5 km from the North Island at its closest point (Fig. 1). It is approximately 2.5 km long and 1-1.3 km wide and has a total area of 217 ha.

The island has a plateau-like surface sloping gently from about 122 m above sea level in the north-west to about 80 m in the south-cast. Despite its flat appearance from the mainland, this ancient land surface is deeply dissected. The eastern half is drained by a deeply incised stream system which forms a sheltered amphitheatre on the east coast. Coastal cliffs up to 115 m high drop abruptly to the sea around most of the remainder of its coastline. Shingle Point, a prominent gravel spit on the north-east corner is an exception. This actively growing spit marks the western end of a submerged shoal linking Mana Island to the mainland.

Basement rocks of the island are indurated, alternating sandstone and siltstone, similar to those occurring on the mainland. High terraces have shore face gravels of Pleistocene age deposited as the island was uplifted. Loess overlies the gravels in some places (Williams 1978: 653-4). The soil on the island can generally be described as silt loam or fine sandy loam in texture, well drained except on the high plateau.

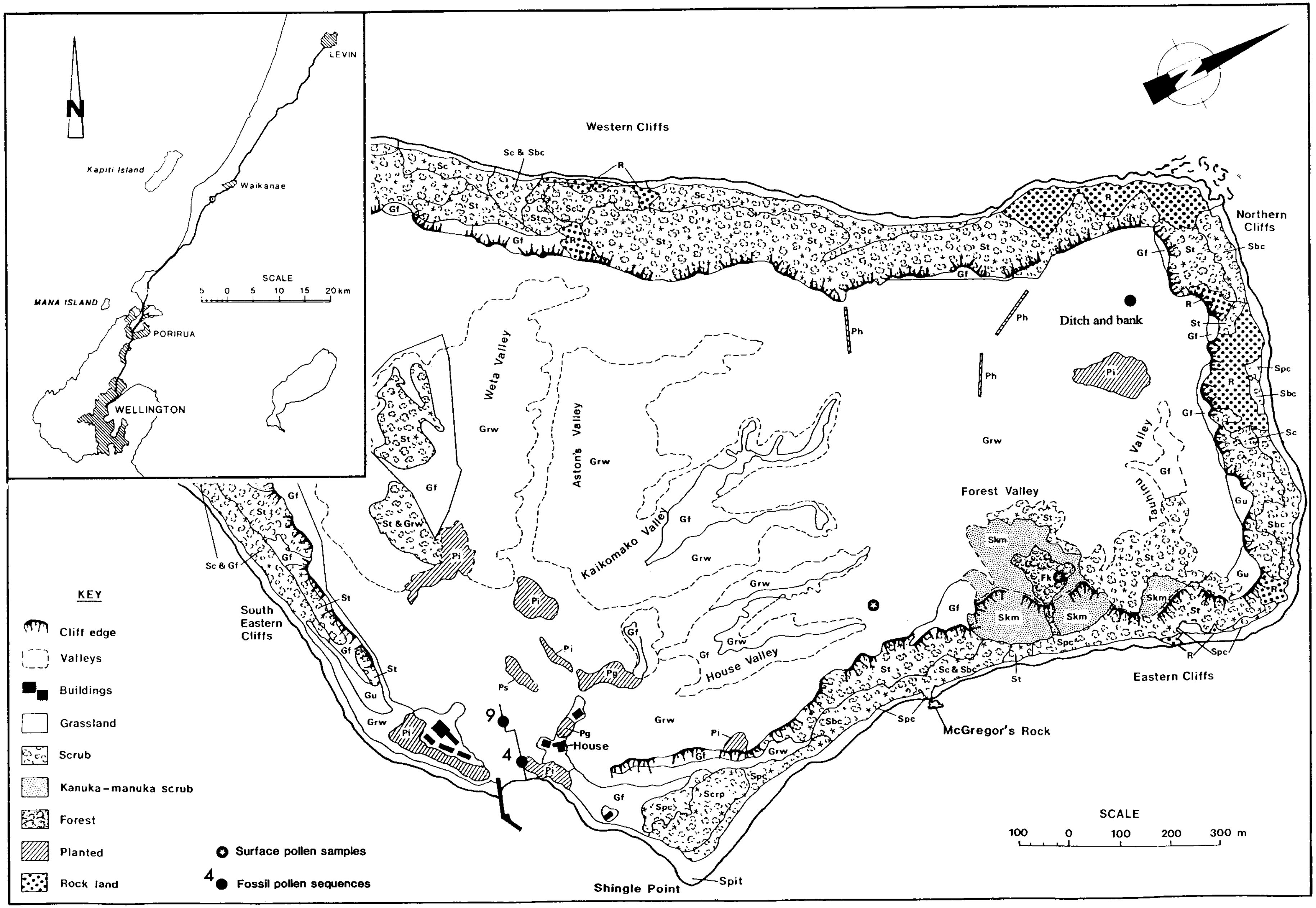

Fig. 1. Mana Island (after Timmins *et al.* 1987: 46-47).

The island has been occupied by both Maori and Europeans. The date of first occupation is unknown, but two Maori chiefs of the Ngati Toa tribe had houses on the island with cultivations in the 1820s (Day 1987: 5). Furthermore, there is evidence for prehistoric gardening - for example, kumara storage pits, and the mixing of subsoil with topsoil (Jones 1987: 21).

The island was farmed by Europeans from 1832. In the mid 1970s, Mana was used by the Ministry of Agriculture and Fisheries as a sheep quarantine and breeding station. Following a suspected scrapie outbreak in 1978, the Department of Lands and Survey resumed control of the island and farmed cattle, principally to keep the grass short and minimise fire risk (Timmins, Atkinson and Ogle 1987: 58-59).

At the time when grazing was stopped, in 1986, 70% of the island was covered with exotic pasture, predominantly ryegrass (*Lolium perenne*) and white clover (*Trifolium repens*). However, some valleys supported patches of tauhinu (*Cassinia leptophylla*) shrublandand kanuka-manuka (*Kunzea ericoideslLepto-spermum scoparium*) scrub. There was kanuka forest in one valley with a few individuals of the broad-leaved karaka (*Corynocarpus laevigatus*), kohekohe (*Dysoxylum spectabile*), milk tree (*Paratrophis banksii*), akiraho (*Olearia paniculata*), and wharangi (*Melicope temata*). Native coastal vegetation was present on the cliffs and shore and included low shrublands of tauhinu (*Coprosma propinqua*) and small-leaved pohuehue (*Muehlenbeckia complexa*) (Timmins, Atkinson and Ogle 1987: 59). It was a much modified vegetation. Even in 1843, Dieffenbach observed that the island was "covered by fern, native and artificial grasses, and clover...." (Dieffenbach 1843: 112).

Palynological studies of nearby Pauatahanui Inlet (Mildenhall 1979) indicate that for the last 8000 years or more a broadleaf-podocarp forest with *Dacrydium cupressinum* dominant existed in that area, but because of the island's exposed coastal situation this cannot be used as a guide to its former vegetation. No pollen analysis has previously been done on Mana Island. Botanists involved in the revegetation programme on Mana Island have had to consider such physical factors as climate and aspect, and remnant plant communities present on both the island and nearby coastal areas to reconstruct the original native plant communities (Timmins, Atkinson and Ogle 1987: 60, Timmins pers comm. 1987).

It is apparent from recent palynological studies that most of New Zealand was covered with forest when first human settlement took place (McGlone 1983: 15), probably about 1000 years BP (Davidson 1981) but perhaps up to 1400 years BP (Chester 1986: 268). However, we know only the broad outline of Polynesian impact on the New Zealand landscape.

In other parts of New Zealand the Polynesian Maori are known to have cleared land by fire for the cultivation of their traditional crops of kumara (*Ipomoea batatas*), taro (*Colocasia antiquorum*), yams (*Dioscorea* sp.), and gourd (*Lagenaria siceraria*) (Dana 1849, Best 1925, Leach 1984: 53). In fact, in favourable conditions they probably practised swidden agriculture, a type of shifting horticulture in which they cleared and burnt forest (Leach 1984). They also practised frequent burning of scrub to encourage the growth of bracken (*Pteridium esculentum*) (Shawcross 1967a, b).

Mana Island is between the North and South Islands of New Zealand and offers a most suitable stop-over port for canoe trade routes between the two islands, and has a sheltered landing place. Because of its position on the edge of the mainland, the possibility of it having been settled early in the original settlement of New Zealand by voyaging Polynesians also can not be dismissed. Indeed, the Maori name of the island (Te Mana o Kupe ki Aotearoa, 'the ability of Kupe to cross the ocean to Aotearoa') includes a reference to the voyages of Kupe (Day 1987: 1). It is known that the island was occupied by Maori at the time of initial European contact.

METHOD OF INVESTIGATION

Field work

It was hoped that a sequence of palynological samples could be extracted from a wet deposit, ideally peat, old enough to span the time of first human settlement on the island. By identifying pollen and spores and any other fossilised plant material present in the samples and determining what plants were present on the island, plant communities could be inferred.

No peat deposits were found on Mana Island. After augering several possible sites a former wetland on the east side of the island, enclosed by a beach ridge, was chosen for collection of pollen samples. It was considered the best site for pollen preservation. This site is also close to the area which would have been suitable for Polynesian Maori horticulture and where evidence for Maori occupation is concentrated (Jones 1987). In addition, the wetland has a large pollen catchment area which would give a good overview of the island's original flora.

A transect of auger holes was bored, running west from the beach across the former wetland to the base of a low ridge. A sequence of pollen samples was collected from two of the auger hole locations (Fig. 1).

Pollen samples were also collected from one of the ditch and bank enclosures in the northern upland of the island, because of the enclosure's archaeological significance and to provide a comparison for the wetland sequences. These enclosures have been described by Jones (1987) and are thought to have been a type of fencing used by Europeans to exclude stock from gardens dating to the period 1830-80.

Surface pollen samples were collected to assist with interpretation of the pollen sequences. One was collected from sediment in a cattle water tank on the eastern side of the island (the lee side) and one from moss collected over a 6-m area beneath the only remnant of native forest left on the island, the *Leptospermum/Kunzea*-dominated stand (Fig. 1).

Laboratory work

Although the fossil pollen samples were taken from deposits in which soil-forming processes have been active, and there was the potential for problems with preservation and displacement of pollen (resulting from earthworm activity, stock trampling, or possible discing), it was considered worthwhile processing the samples collected to see if they contained an interpretable pollen sequence. Pollen, spores and microscopic charcoal fragments were extracted from the samples using standard palynological laboratory procedures and were mounted on microscope slides. The preservation of the pollen and spores was poor and variable (pollen extracted from non-peat samples is usually less well-preserved than that extracted from peat). Thus relative percentages of the different pollen and spore types have a greater than usual statistical uncertainty. Pollen abundance varied between samples but was adequate in all cases except one. This sample was from 1.6 m below surface level in auger hole 4 and was from sandy, possibly marine sediment that was probably deposited before recent slight uplift initiated deposition of nonmarine sediments.

RESULTS

Surface samples

The two surface pollen samples were collected from entirely different local environments on the island so that the relationship between the pollen rain and vegetation could be examined. The pollen spectra were markedly different and closely reflected the local vegetation surrounding the sampling sites. The pollen spectrum of the *LeptospermumlKunzea* dominant forest sample is dominated by that type (63% of the pollen sum), while the spectrum of the water tank sample from the open grassland environment is dominated by Gramineae (grasses) pollen (74%).

Ditch and bank enclosure[1]

A trench was cut from the foot of the ditch to the crest of the bank (Fig. 2). 'Channel' samples were collected since the deposit consisted of soil which would have formed in situ and movement of pollen by soil animals was likely. Each sample spanned a particular soil horizon and would thus be more representative of the horizon than a point sample within the horizon.

Gramineae and *LeptospermumlKunzea* pollen types are the most significant in this pollen diagram (Fig. 2). While the *LeptospermumlKunzea* pollen type is dominant at the base of the sequence and declines in

[1] Geological Society of New Zealand Fossil Record File locality R26/f206.

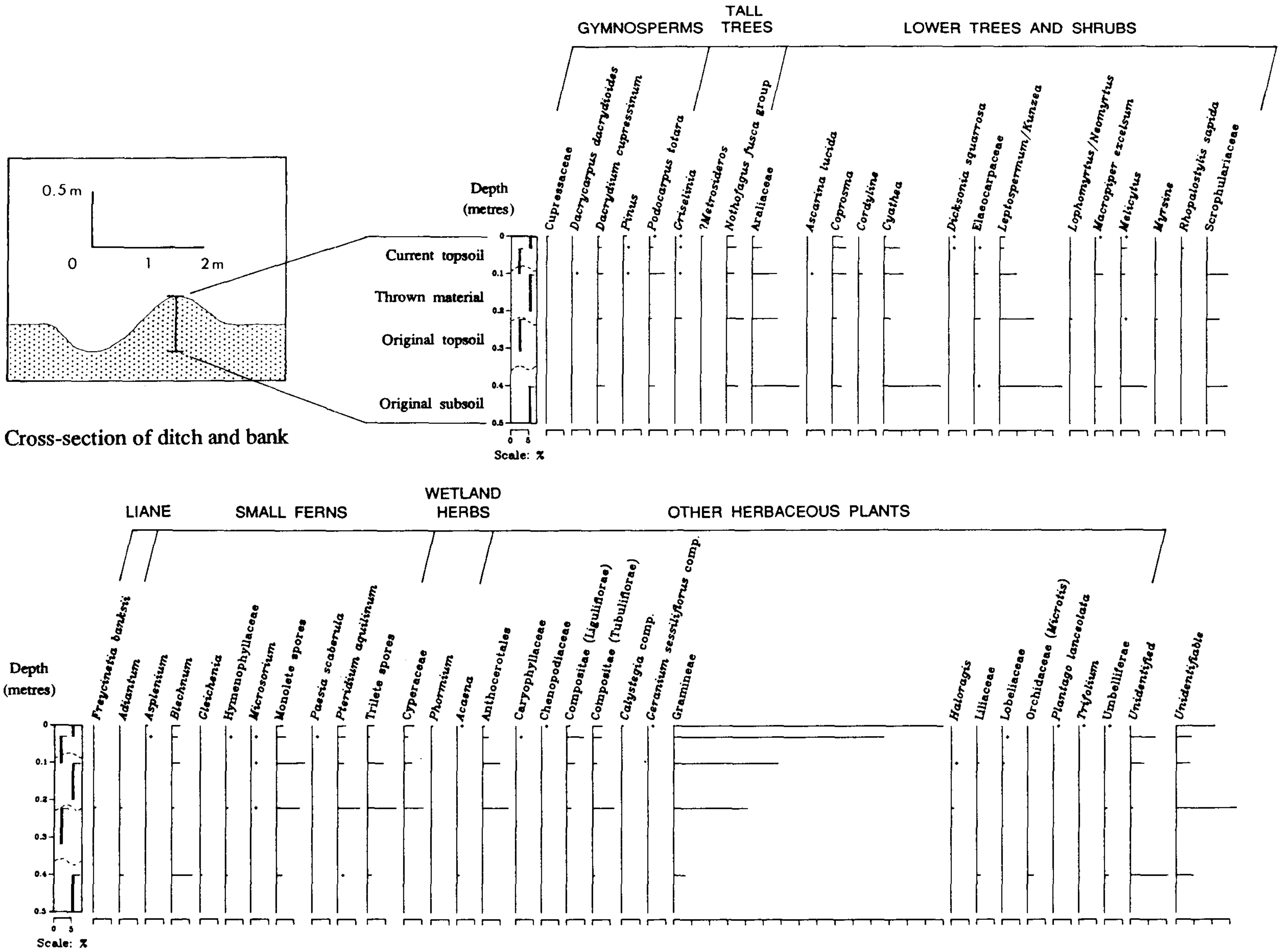

Fig. 2. Pollen diagram, ditch and bank enclosure.

abundance towards the top of the sequence, the reverse is true of Gramineae. Significant percentages of *Cyathea* and Araliaceae pollen types also occur in the pollen diagram and follow the same pattern as the *Leptospennum/Kunzea* pollen type.

The relative pollen and spore percentages of the original topsoil suggest that at the time of building the ditch and bank enclosure, either there was grassland on the site with a shrubby forest, similar to that on the island today, close by, or that shrubby forest covered the site and grassland was close by. The dominance of shrubland species in the original subsoil suggests that *LeptospermumlKunzea* shrubland formerly covered the whole local area, and thus the presence of grassland at the time of enclosure building is interpreted as resulting from prior clearance.

The next higher sample was collected from the material thrown to form the bank. The relative percentages of this horizon, which is a mixture of the lower two horizons, match the original topsoil most closely, probably because of the greater pollen/spore abundance in the topsoil relative to the subsoil.

The two upper samples were both collected from the current topsoil, which has formed since the ditch and bank enclosure was constructed. The most significant change in the relative percentages in these two samples from the three below is the great increase in Gramineae and decline in *LeptospermumlKunzea* and small ferns. The pollen percentages from the upper topsoil are comparable to those in the sample from the water tank and reflect the current extensive grassland.

Increased abundance of such pollen types as Compositae (Liguliflorae), which include introduced species, from the original topsoil upwards may be the result of European farming. The appearance of *Pinus* in the thrown material dates this horizon to post-European settlement and is further evidence that the ditch and bank enclosure was constructed during European times, probably in the period when a nearby lighthouse was in use, 1865-1880, some 33 years after European farming began on the island.

Wetland sequences

The sediments in the centre of the transect (holes 4-9), overlain by a thin layer of brown silt loam turf, comprise mostly a black friable organic-rich silt/fine gravel unit (Fig. 1). The amount of silt increases westwards until in hole 8 the unit comprises mostly greyish, yellow brown silt/loam. Only non-marine palynomorphs were recovered from this unit, which is interpreted as alluvial fill deposited behind a beach ridge formed after uplift.

To the east, seawards, this unit is replaced by beach pebbles which are overlain by turf and organic-rich black soil, perhaps partly prehistoric Polynesian midden material.

Below, the silt/gravel grades into a clean sand unit. The fine sands are yellowish brown in hole 4, becoming more grey by hole 8. With increasing depth the colour grades into olive yellow with orange mottles, probably due to water-logging. Although no shells (or palynomorphs, marine or otherwise) were found in this unit, the even grain size, absence of stratification, plant material or pebbles, and extent all suggest marine deposition. Clay appears at the base of hole 9 as well as rare angular greywacke pebbles, probably derived from erosion of colluvium.

To the west, close to the ridge the sand unit is replaced by a bright brown to bright yellowish brown clay with light grey mottles. This unit slopes seawards with a pavement of pebbles on top. Rare angular greywacke pebbles c. 2 cm diameter are present in the clay unit. The pebbly clay is interpreted as hill-slope colluvium. The pebble pavement may be the result of wave washing before deposition of the sand unit.

Five palynological samples were analysed from the silt/gravel unit in each of holes 4 and 9.[2] Pollen and spore preservation is poor, resulting in many grains being unidentifiable, although preservation was better in hole 9 than in hole 4; a pollen diagram for hole 9 is shown in Figure 3. The two pollen sequences exhibit similar patterns - notably the charcoal-poor, *LeptospermumlKunzea-rich* lower layers and the Gramineae-rich upper level.

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[2] Fossil Record File locality numbers R26/f205 and R26/f193, respectively.

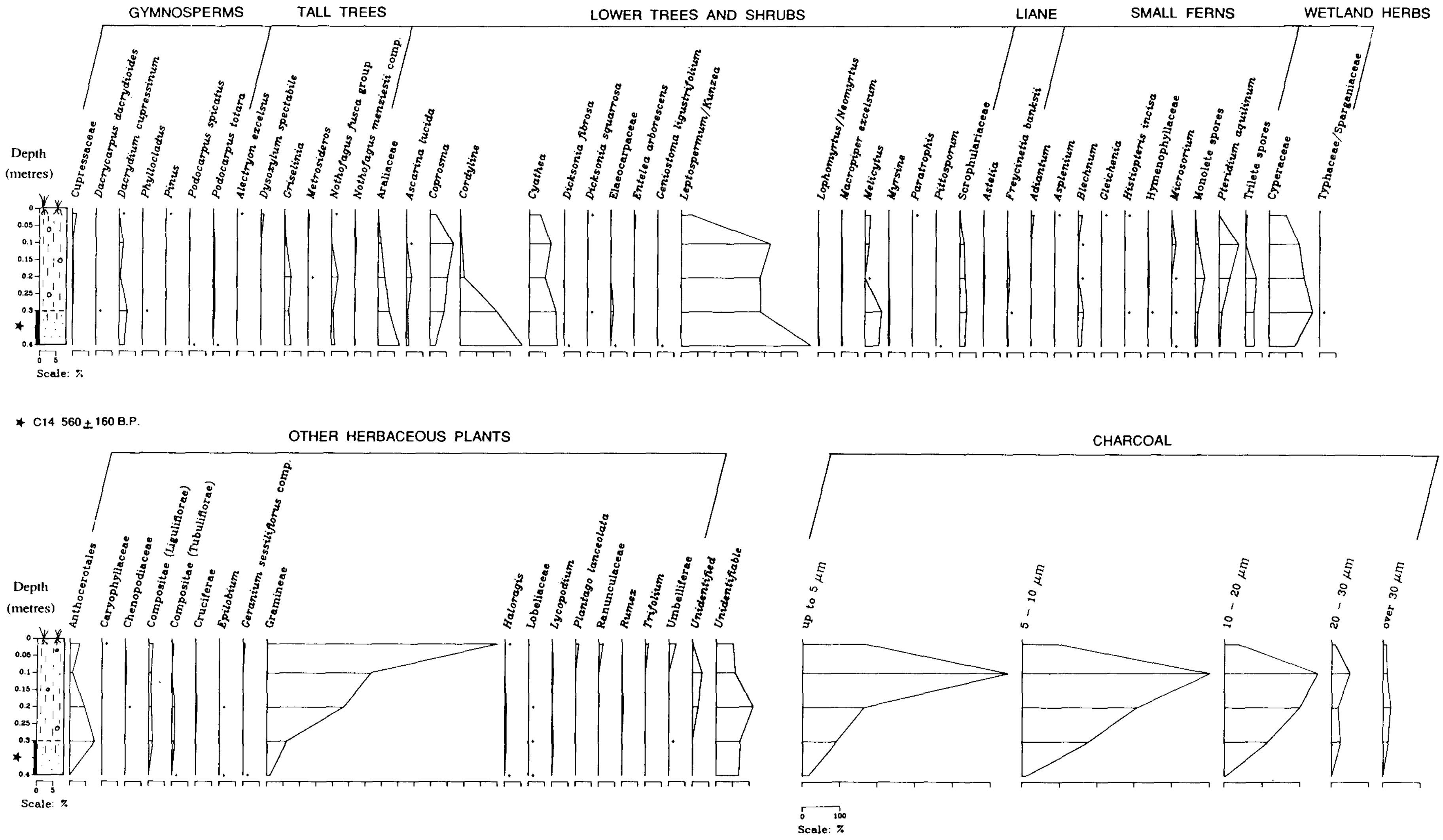

Fig. 3. Pollen diagram, auger transect hole 9.

The pattern of abundance of charcoal is the same in each hole, increasing from the bottom upwards until it peaks at 10 cm, then dropping substantially. Charcoal is, however, much more abundant in hole 4. This may be due to its proximity to prehistoric Polynesian middens.

At 40 cm below surface level the relative percentages of the pollen groups in the two auger hole sequences are similar to the relative percentages in the remnant forest surface sample. The major component of the dominant pollen group, "Lower trees and shrubs", is the pollen type *Leptospermum/Kunzea*.

The pollen spectra at the top of the sequences are similar to that of the water tank sample in their overwhelming dominance of Gramineae. The relative abundances of the "Lower trees and shrubs" and "Small ferns" groups are slightly higher in the auger samples, suggesting that some shrubbery remained.

The relative percentage of wetland herbs, represented almost entirety by Cyperaceae, remains at almost the same level through the sequences suggesting that a small wetland existed continuously in this area until very recent times when it was drained. However, wetland plants such as flax apparently did not grow in the area during the period represented.

Tree and shrub pollen decreases in abundance gradually up to c. 10 cm below surface level, while charcoal increases. At c. 10 cm below surface level *Leptospermum/Kunzea* pollen decreases dramatically and Gramineae pollen increases sharply. Charcoal abundance is greatest at this level. Much clearance of the shrubby *Leptospermum/Kunzea* vegetation by fire probably took place at this time.

Age of wetland sequences

The relative ages of the samples collected from the auger hole transect are suggested by several factors: the amount of charcoal, the presence or absence of pollen of European introductions such as *Pinus*, and the relative abundance of Gramineae.

Before the arrival of humans on the island the only charcoal incorporated into the pollen record would be either from natural fires on the island, manifested as a sporadic record, and distant fires (either natural or of human origin), manifested in the record as small (wind-blown) fragments. The charcoal record in the two sequences from the auger hole transect is continuous, suggesting the latter source. However, the low abundance of charcoal fragments in the lowest level (40 cm below surface level) in hole 9 suggests that fires were distant and not local. The remainder of the record contains larger fragments, suggesting that at least some fires were local. Peak charcoal abundance at 10 cm corresponds to a high fire frequency which probably dates to the period of European settlement and clearance.

The presence of pollen of adventive plants is an indication of European settlement. In hole 4 *Pinus* appears at 10 cm below surface level suggesting that European settlement had occurred. In hole 9 only the uppermost sample contains pollen of adventive plants, these being *Pinus, Plantago lanceolata* and *Trifolium*.

A conventional radiocarbon age of 560 ± 160 (one standard deviation) years BP[3] was obtained from a sediment sample collected between the two lowest pollen-bearing samples in hole 9. The most likely calendar date of the sample is between 1275 and 1516 AD, which is after the settlement of New Zealand by prehistoric Polynesians but before European settlement. The age of the sample approximates the date of initial disturbance of the *Leptospermum/Kunzea* shrubby community seen at the base of the pollen sequence. It is close to the date estimated by Mildenhall (1979: 590; based on palynological evidence) for the arrival of Polynesians in the Pauatahanui Inlet.

DISCUSSION

The pollen analyses of the ditch and bank and the wetland sequence both show that scrub was extensive

[3]Laboratory number R11710, Radiocarbon Laboratory, Institute of Nuclear Sciences, DSIR, Lower Hutt.

on the island until early European times. Two interpretations for the presence of this *Leptospermum/Kunzea* community could be proposed. Either the scrub was the pre-Polynesian settlement vegetation - that is, the natural original vegetation on Mana Island - or it was the result of human interference.

If the first interpretation is correct, the remnant forest on the island at the present time is representative of the natural vegetation of the island. This vegetation would be different from that of the co-existing *Dacrydium cupressinum* broadleaf/podocarp forest on the adjacent mainland (Mildenhall 1979: 585) or from the present-day remnant native forest on adjacent coastal areas (Timmins, Atkinson and Ogle 1987), but similar to the present-day forest on the island (Timmins, Ogle and Atkinson 1987). The *Leptospermum/Kunzea* shrubby community may be a response to the exposed conditions and harsh climate on the island. The prevailing wind is from the seaward side (the north-west) and is often of gale force; in summer there is little or no fresh water at the surface (Timmins, Atkinson and Ogle 1987: 57). In this interpretation the radiocarbon date of 560 ± 160 years BP relates to the initial settlement of the island.

The second interpretation implies that earlier, prehistoric Polynesian settlement took place and that the island was cleared of large forest trees. It was then abandoned (perhaps only partially) and at least some of the forest began to regenerate. The island was resettled and at the time of European settlement the *Leptospermum/Kunzea* scrub was cleared. In this case it is assumed that a mature forest similar to that currently growing on adjacent coastal areas grew on the island before the times represented by the lowest levels of the pollen sequence. This interpretation is preferred because small islands of similar exposure around the New Zealand coast are covered by broadleaf forest. Furthermore, *LeptospermumlKunzea* communities are elsewhere demonstrably a successional stage in regeneration of mixed broadleaf/podocarp forest after destruction by fire. Broadleaf species are present within the Mana Island forest remnant, and succession to a broadleaf forest will presumably occur in the absence of fires.

CONCLUSION

This study demonstrates the role that palynology can play in ecological restoration by revealing the history, composition, and extent of various plant communities, providing that suitable deposits can be found.

In this case, results were limited by lack of pollen-bearing deposits of sufficient age, although it is not impossible that further exploration would discover some. As analysis of the ditch and bank sequence has shown, soils as well as sediment sequences can yield useful information.

ACKNOWLEDGEMENTS

We would like to thank the following institutions and individuals for the assistance they gave us: the Department of Conservation; Geology Department, Victoria University; New Zealand Geological Survey, DSIR; Kevin Jones, Susan Timmins, Colin Ogle, Directorate of Science and Research, Department of Conservation; Dr Ian Atkinson, Land Resources Division, DSIR; Trevor Hook, Mana Island. This project was partially funded by the Department of Conservation; a detailed report is being prepared for publication in that department's Science and Research Series.

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THE SILENT MAJORITY: A PLEA FOR THE CONSIDERATION OF INVERTEBRATES IN NEW ZEALAND ISLAND MANAGEMENT

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ABSTRACT

Because of the public's low appreciation of the invertebrate fauna, and hence of its significance to conservation, we must consider the value of invertebrates in a different light from the high-profile birds and reptiles. The conservation significance of island invertebrates is discussed under four headings (biodiversity, genetic resources, biogeographic resources, ecological resources) in order to stress its scientific merit. Some guidelines for island management that take particular account of the invertebrate fauna are proposed.

INTRODUCTION

Why do we undertake island restoration? Is it to satisfy future generations (and our consciences?) that we were able to reverse the destructive trend of human settlement by saving a few high-profile organisms from extinction? Is it to enhance the educational and recreational potential of the islands? Or is it to set aside representative examples of New Zealand biota, isolated from further human intrusion? This conference debated these questions and tried to set management priorities. The main thrust of all the arguments usually centred around certain vertebrates. This paper is a conscious attempt to counter the overwhelming influence of the high-profile vertebrates by putting the case for the other side - the forgotten invertebrates, the "silent majority". Because of their low profile we need to consider the conservation of invertebrates in a different light from that of birds or reptiles.

Creepy-crawly invertebrates do not engender much public support, and yet it is clear that the public must be involved in conservation planning. This conflict of sympathies can be resolved in the context of island restoration management by regarding the invertebrates collectively as a priceless resource for science. In other words, rather than arguing that it is worth conserving and restoring island invertebrate populations on behalf of the public (which, of course, is still true) we can argue the case for certain management strategies in terms of the scientific value of islands. Hopefully, the better-educated future generations of our public will come to appreciate and support the creepy-crawlies along with the more spectacular vertebrates. Hence this paper is directed towards a sympathetic scientific audience and itemises the values of island invertebrate communities and species as resources for research. Clearly the scientists of tomorrow will not thank us if our management efforts today ruin this irreplaceable resource.

The special values of island invertebrates can be discussed as resource material in four fields: biodiversity, genetics, biogeography, and ecology. These headings are, of course, not unique to invertebrates or to islands, but all are of special significance in relation to New Zealand's offshore islands. I will also briefly review the threats to island invertebrates and outline what I see as important guidelines for management.

BIODIVERSITY

As anyone who has worked on islands is aware, each one is different. This inherent diversity is the basis of much of our interest in islands. Management and restoration efforts must not destroy that uniqueness. This advice sounds simple, but it has not always been followed in the past.

With the arthropods, whilst the majority of New Zealand's diversity is on the two main islands of our archipelago, a disproportionate number of "special" species are restricted to islands. Nearly half (48%) of all the species of arthropods designated as protected species occur only on offshore islands. Furthermore, a remarkable number of islands are home to unique species of endemic invertebrates. For example, off the north-west coast there are the Poor Knights Islands (with their weta, *Deinacrida fallai*), Mokohinau (stagbeetle, *Dorcus ithaginus*), Little Barrier (*Deinacrida heteracantha*), Great Barrier (chafer beetle, *Seriocospilus watti*) and Middle Island (Mercury Group) (the tusked weta, still undescribed). On Cook Strait's Stephens Island there is the endemic weevil *Anagotus stephenensis* and carabid *Mecodema punctellum*. Other endemic island species are the Maud Island (Marlborough Sounds) weevil, *Tychanopais* sp., and on Herekopare Island (near Stewart Island) the weta *Deinacrida carinata*.

These are large, conspicuous organisms, and if the list were extended to include the smaller, "insignificant" invertebrates, it would undoubtedly become very much longer. Watt's comprehensive survey of the Poor Knights Islands (1982) found 273 species of terrestrial arthropods, of which 43 species were "probably or possibly endemic". Most islands have not been searched so thoroughly.

GENETIC RESOURCES

I have distinguished between biodiversity and genetic resources in order to emphasise our responsibility for conserving genetic variety as well as the value of island populations for genetic research. Either way, we must avoid mixing populations from different islands if at all possible - again, advice that has not always been followed in the past.

Islands provide discrete, isolated populations, which are ideal raw material for genetic research. Recent studies on tree wetas (*Hemideina*) can be cited by way of illustration. Moller (1985) noted that, compared with other populations in the Cook Strait region, the Stephens Island tree wetas are bigger and the males have larger heads. Although Salmon (1950) had given the Stephens Island population species status (*H. crassicruris*), Moller's (1985) observations of the species' diagnostic characters suggested that they were inappropriate and that its taxonomic status needed re-examining. In 1989, Richards investigated karyotype and allozyme variation in *Hemideina* populations from the Cook Strait region. Her data, together with unpublished observations by Paul Barrett at the Wellington Zoo, show that despite distinctions involving size, colour, growth rates and behaviour, there is not enough genetic evidence for separate species status for the Stephens Island tree wetas (Richards 1989). Islands such as Stephens Island are a natural laboratory for studying the effects of isolation on evolutionary trends. Opportunities to make such studies would be lost if management were to make inappropriate translocations. This, of course, holds just as true for vertebrates or plants.

BIOGEOGRAPHIC RESOURCES

The value of island populations in terms of their use as a biogeographic resource emphasises even further the need to manage islands as unique entities. Introduced organisms, as distinct from reintroduced ones (see Towns *et al.* this volume), will undermine this value. Two examples from the invertebrates will illustrate the importance of island faunas for unravelling the history of New Zealand's biota.

The distribution of three closely related species of *Anagotus* weevils is shown in Figure 1 (from Craw 1988). The host plant of *A. stephenensis* is almost certainly ngaio (*Myoporum laetum*), and the plant associations of the other two species, while unknown, are unlikely to limit their distribution. Although we are unsure of the full extent of their pre-human distribution, the present geographic pattern of these three species clearly shows that not only have islands been essential for their survival but also that we have been provided with a fascinating data base for biogeographic analysis. In this case the interest lies in the historical interpretation of a disjunct island pattern, parts of which are congruent with a number of other organisms (Heads 1989).

A second biogeographic example concerns the flax snail (*Placostylus*). Climo (1973) described the snails from the Three Kings Islands, noting that they represent a distinct subgenus (*Basileostylus*) from those of the Aupouri Peninsula, eastern Northland and the Poor Knights islands (*Maoristylus*) (Fig. 2). The special

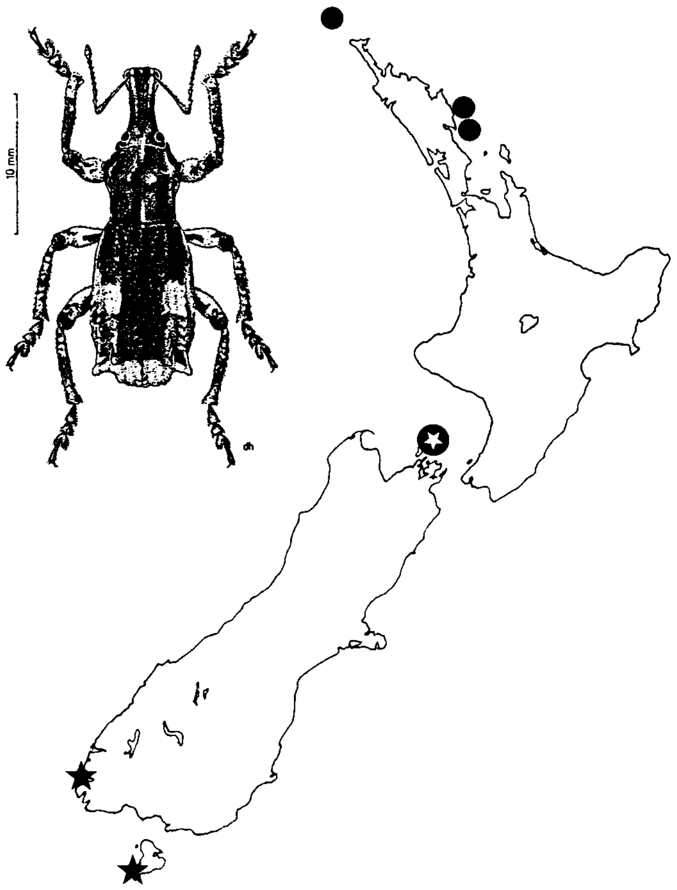

Fig. 1. Distribution of three species of *Anagotus* (Coleoptera: Curculionidae) in the *A. turbotti* group: *A. turbotti* (circle); *A. stephenensis* (circle star); undescribed species (star).

biogeographic interest in this example is due to the presence of Maoristylus on Lord Howe Island. Thus, although it is much farther from Northland than the Three Kings snails, the Lord Howe snail is actually much more closely related to those on the New Zealand mainland than are those of the Three Kings. The offshore and outlying islands of New Zealand hold a vast library of information for future biogeographic studies.

ECOLOGICAL RESOURCES

Finally, we can view the invertebrates in the light of their role in the community. Although little studied around New Zealand, island invertebrates are a highly significant component of the whole biota; they play a role in pollination, forest succession, litter breakdown, and as food for reptiles and birds. Their activities in the nutrient cycling of seabird islands and all manner of predator-prey relationships will form the nucleus of future ecological researches on islands.

THREATS AND ISLAND MANAGEMENT

Few, if any, islands remain in their pristine state. We humans have built fortresses, villages, lighthouses; we have set up bases for animal exploitation (sea-birds, seals, whales); we have cleared vegetation for farming; introduced exotic mammals and plants; and more recently, in the name of conservation, have translocated all sorts of animals. All these activities threaten the unique values of islands that I have been discussing. Rodents have been introduced to at least 119 of the 273 islands larger than five hectares (Atkinson 1989), none of which supported them in the past; saddlebacks (*Philesturnus carunculatus*) have been introduced to more than 10 islands, some of which did not support them in the past. Both prey upon invertebrates.

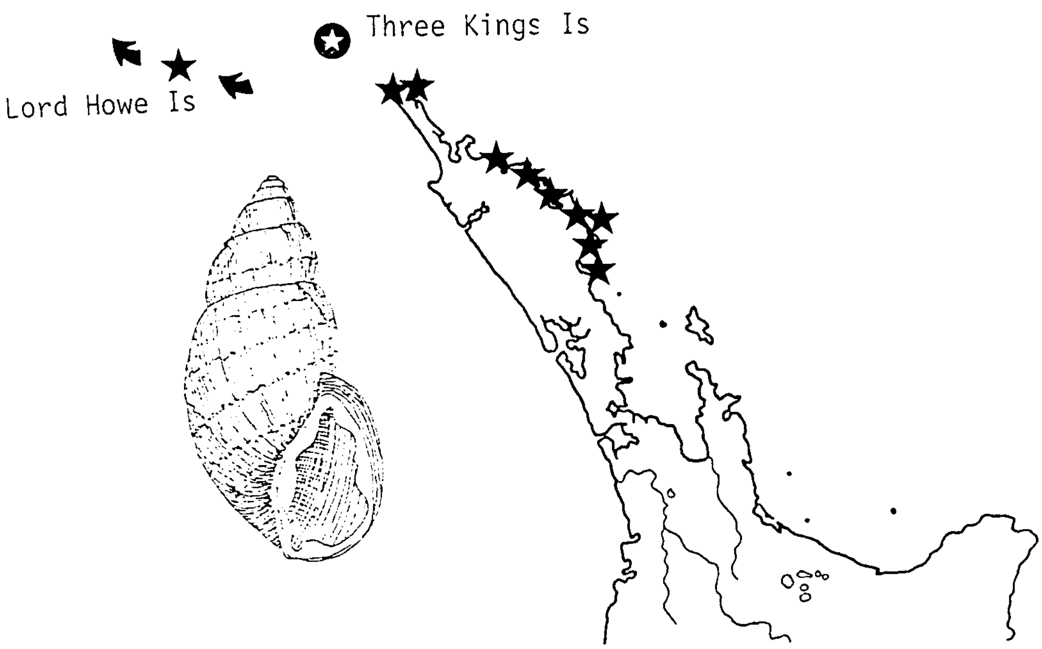

Fig. 2. Distribution of two subgenera of *Placostylus* (Bulimulidae: Placostylinae): *Basileostylus* on the Three Kings Islands (circled star); *Maoristylus* on Lord Howe Island, the Aupouri Peninsula, the Poor Knights Islands, and eastern Northland (star).

We would agree that proper island management and restoration must recognise the intrinsic value of each island while at the same time using some islands to save certain endangered species. My hope is that this Conference will mark a change in direction from the ad hoc, species-by-species, approach of the past to a more community-based management, which takes account of invertebrates in terms of their intrinsic values and not just as food for vertebrates.

After considering the invertebrate viewpoint, I have drawn up six guidelines for future management of New Zealand's islands:

1. Give the highest priority to exotic mammal eradication. Very encouraging results are being obtained by the current methods. It would be most desirable to monitor the impact on invertebrate populations as the control is taking place.

2. Carry out basic research on community structure and dynamics on the more pristine islands, especially those rich in sea-birds.

3. Avoid the temptation to translocate available birds to available islands without proper investigation of their potential impact.

4. Translocate invertebrates only when they were known previously on the island or when movement is within an island group.

5. Don't transfer bags of litter or soil. This applies particularly to revegetation schemes, where there is a danger of introducing weeds, pathogens and exotic soil organisms.

6. Keep published records of all transfers.

Maud Island is one of New Zealand's rodent-free islands where an effort has been made to document the invertebrate fauna and assess its intrinsic value (Notman 1984). It turns out to be a rich fauna in terms of diversity, density and the occurrence of unique species. Because of its predator-free status and varied vegetation it has served as a managed refuge for various endangered birds, including kakapo, saddleback and takahe. An important step in our management of islands is to classify and rank them in terms of our management strategies. What, for example, should be the management strategy for Maud Island? To preserve it as a unique community of high intrinsic value? To use it as a suitable predator-free sanctuary for holding and experimenting on certain endangered birds? To use it as a public zoo for display of predator-sensitive birds that cannot be seen on the mainland? All are valid uses. But not all are compatible. My point is simply to stress that invertebrate values deserve attention in overall management strategies.

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COMMUNITY EFFECTS OF BIOLOGICAL INTRODUCTIONS AND THEIR IMPLICATIONS FOR RESTORATION

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ABSTRACT

Certain classes of introduced species are prone to have effects propagated throughout the entire community. These include (1) plant species that produce forests in formerly treeless areas, (2) animal or plant species that change the physical environment to the detriment of dominant plants, and (3) species that remove most or all of an entire large taxon. Eradication of some exotic species is already possible, especially on small islands, and new techniques spawned by genetic engineering will probably aid eradication greatly. After eradication, in many instances natural recovery (secondary succession) will redress the effects wrought by the invader. However, some effects may persist and hinder restoration. Physical and chemical changes in the soil may be subtle yet crucial, and not easily overcome. Also, when a introduced species has caused local extinction, restoration will be greatly complicated.

INTRODUCTION

Spurred by the prospect of the release of genetically engineered organisms (Halvorson et al. 1985), there is a resurgence of interest in the ecological effects of introduced species, leading to a program on the ecology of biological invasions organised by the Scientific Committee on Problems of the Environment (SCOPE) in 1982. This program generated several symposium volumes, culminating with the publication of *Biological invasions: A global perspective* (Drake *et al.* 1989).

Nevertheless, the ability to predict effects of introduced species efficiently and quickly, based on a few easy measurements, remains elusive. There are no rules for forecasting the ecological impact of an introduced species. The best reflection of this state of affairs is the striking difference between fates of apparently similar species introduced into the same region.

The classic example is that of the house sparrow (*Passer domesticus*) and tree sparrow (*P. montanus*), introduced into the United States in the nineteenth century (Long 1981). The house sparrow rapidly occupied most of North America. The tree sparrow has remained in the vicinity of Saint Louis, Missouri; it numbers a few thousand individuals. The exact community roles of these species are unknown; the house sparrow causes agricultural damage and has displaced several native species, but there is no reason to think the tree sparrow affects any resident. Why? Both species associate with human habitats; they use similar foods. In some parts of the world (e.g., southeastern Australia) the tree sparrow has spread dramatically even where the house sparrow was also introduced. Four mongoose species (*Herpestes*) have been released in many localities; three have had little obvious impact, but the fourth (*H. auropunctatus*) has preyed catastrophically on native species almost wherever it was introduced (Ebenhard 1988). Many other related species have had very different ecological effects (Simberloff 1985, Ehrlich 1986, 1989, Ashton and Mitchell 1989).

There are generally far too few data to demonstrate how introduced species affect native communities (Simberloff 1981). Introductions can be seen as natural experiments, but controls are almost always absent and it is easy to be misled by superficial observations. For example, the North American mink (*Mustela vison*) was brought to Britain in 1929 and began to spread rapidly in the mid-1950s, approximately when otters suddenly declined (Chanin and Jeffries 1978). This coincidence suggested a cause-and-effect relationship (Lever 1977). In Sweden the mink was introduced at about the same time as in Britain and began to increase at approximately the same time as the otter decline there, again suggesting a cause-and-effect relationship (Erlinge 1972). In both countries, however, hunting records demonstrate that the otter declined slightly before the mink increased. The mink may help to limit otters to optimal habitat, but the otter affects the mink much more than vice versa, while organochlorine pesticide pollution appears to have caused the otter crash (Erlinge 1972, Chanin and Jeffries 1978).

Every surviving introduction affects its target community, if only by changing species composition. One might anticipate no further effect if an introduction occupies an empty niche. However, even though niches are said to be empty (Lawton 1984, Price 1984), close examination generally casts doubt on this proposition (Herbold and Moyle 1986). After all, resources are metabolised in some way, if only by bacteria, so an introduced species must affect at least the topology of energy flow and nutrient cycling.

The main focus of studies on introduced species has been how an invader directly affects particular residents, for example by predation, herbivory, competition, or vectoring a disease. However, the effect may then ripple through the community as changes in populations of one affected species in turn affect others. In less than fifty years, the chestnut blight, an Asian fungal disease (*Cryphonectria parasitica*), has virtually eliminated the American chestnut (*Castanea dentata*), a dominant in many eastern North American deciduous forests (von Broembsen 1989). Oaks and hickories have replaced chestnuts in these forests (McCormick and Platt 1980, Krebs 1985). Though Vitousek (1986) suggests little effect on ecosystem structure, there are simply too few data to judge this matter. At least sixty moth species feed on the chestnut; seven are host-specific (Opler 1978). Some of these may be extinct. Species that feed on these moths are not well known but may well be affected. The oak wilt disease (*Ceratocystis fagacearum*) has increased on native species because the susceptible red oak, *Quercus rubra*, increased when the chestnut disappeared (Quimby 1982). So indirect ripple effects of chestnut blight may be quite far-reaching and subtle. But indirect effects have generally been de-emphasised in modelling of communities (Yodzis 1988).

Three efforts to assess the introduction literature (Simberloff 1981, Ebenhard 1988, W. Dritschilo *et al.* pers. comm.) all conclude that demonstrations of major ecological impact on an entire community are lacking in the great majority of cases. However, the difficulty of proving even substantial impact suggests that such reviews are underestimating ecological effects (Herbold and Moyle 1986). On the other hand, the fact that innocuous introductions are less likely to be noticed and published may indicate that even these reviews are overestimates. Perhaps the most that can be said now is that there do not seem to be major effects by most surviving introductions, but evidence of indirect effects has not been sought very assiduously.

Restoration is, by definition, a community phenomenon: an attempt to reproduce exactly the entire community that had been present before some disturbance (Magnuson *et al.* 1980, Bradshaw 1987). Thus, introduced species that affect a large segment of a community, and not just one or a few species, are likely to present a particular obstacle to restoration. Some introduced species can be extirpated by assiduous hunting, trapping, and poisoning, particularly on islands (Veitch this volume). It is likely that modern genetic engineering techniques will greatly increase the prospect of extirpating exotics like insects and plants that had formerly been virtually ineradicable (Simberloff this volume). Ecological impacts of some introduced species are likely to disappear with their extinction. Others, however, may leave their stamp on a community long after they are gone, and thus may require more than just eradication efforts from restoration ecologists.

WHY DO SOME SPECIES AFFECT ENTIRE COMMUNITIES?

Because the organisation of communities and ecosystems is itself not very well understood (cf. Paine 1988, Peters 1988), it is not shocking that there are no rules for community-wide impact by an introduced species. Communities are so idiosyncratic that even exhaustive knowledge of how one is structured does not allow us as much insight as we would wish into apparently similar communities. Our record of precisely predicting the effect of an extinction or other disturbance is not good, so we should not expect to do better predicting the effect of an introduction on a community.

If anything, an introduced species' impact should be harder to predict than that of other perturbations because the species is dynamic; it evolves by natural selection, drift, or hybridisation. There is some study of morphological evolution of introduced species (Johnston and Selander 1964, 1971, Selander and Johnston 1967, Pietsch 1970, Pankakoski and Nurmi 1986), but no consideration of how evolution will modify ecological impact, except for the evolution of benignity of disease (Fenner and Ratcliffe 1965, Allison 1982, Levin *et al.* 1982, Ewald 1983). Even aside from this evolutionary aspect of an introduced species' effect, current community ecological formal theory does not offer the prospect of accurate prediction of impact. In particular, short-term observations are unlikely to yield theoretical insights into the long-term behaviour of the system, and indirect effects, at several removes from the direct, immediate impact of an introduced species on particular resident species, are likely to be very important (Yodzis 1988).

That there is no easy criterion for predicting community-wide effects of introductions does not mean the situation is hopeless. The concept of keystone species should help us to predict at least which types of introductions might be especially likely to affect entire communities. Certain predatory species, though they may not be major energy-transformers or even very numerous, can greatly change community structure. Paine (1969) called these keystone species in his examination of marine invertebrate predators. For example, the starfish *Pisaster ochraceus* prevents its favourite prey, mussels, from eliminating other species by competition for space (Paine 1966). The essence of a keystone species is that it prevents a particular prey species from excluding others. The keystone concept has been generalised, and Gilbert (1980), for example, describes as "keystone mutualists" plant species that support many animal species that are themselves crucial to other species. The tree *Caesuria corymbosa* is a keystone in this sense; it maintains several frugivores that disperse seeds of many other plants (Howe and Westley 1988). Dominant tree species that provide physical structure for many other members of a community surely also qualify as keystones.

Introduced species have played many keystone roles. Some constitute a new structure with diverse microhabitats for other species. Others create but do not constitute a new structural habitat. Finally, some have affected many other species (e.g., by predation) other than through initial modification of the structural habitat Some introduced species have more than one of these effects. For example, introduced trees and shrubs can be habitats for other species but also can change the soil and thereby affect other plants.

Species that constitute new habitats

The salt cedar (*Tamarix* spp.) and Russian olive (*Eleagnus angustifolia*) have established new forests in the dry American Southwest, producing major ecological effects (Knopf and Olson 1984, Vitousek 1986). Once *Tamarix* established, its deep roots allowed it to persist where most plants would be temporary residents at best For example, the Glen Canyon Dam on the Colorado River controlled flooding and allowed *Tamarix* to establish on previously barren riverbanks. Now there are many small forests of *Tamarix* trees. It is possible that, even were these to be removed, the stabilisation that has already occurred would affect any subsequent plant community. Transpiration by *Tamarix* drains desert oases (Vitousek 1986). For example, *Tamarix* invaded Eagle Borax Spring in Death Valley about 50 years ago; by the 1960s it had drained a large marsh. Fortunately, surface water reappeared after *Tamarix* was removed, and the original biota seems to have largely been restored. Russian olive is generally upstream of *Tamarix*. Its monocultures often replace original riparian vegetation (Knopf and Olson 1984) with catastrophic effect on native birds. The entire cavity-nesting guild is absent

Mangroves cover intertidal soft substrate in most of the tropics, but not in Hawaii, where *Hibiscus tiliaceus* dominated sparse beach vegetation until 1902, when a sugar company planted red mangrove (*Rhizophora mangle*). Mangroves have since spread on Oahu and to other islands, replacing *Hibiscus* and forming tall, dense forests in some bays. Though the arboreal arthropods are primarily cosmopolitan tramp species, there is substantial folivory (pers. obs.). There has been very little study of either arboreal or aquatic mangrove microhabitats. Mangrove swamps drop almost 10 tonnes of leaves/hectare/year, and the roots accumulate sediment (Holdridge 1940) and constitute a critical habitat for fishes and shrimp (Carey 1982), so the effect of this introduction on energy flow, nutrient cycling, and succession must be enormous. There is probably no reason why these effects could not be completely obliterated if vigorous cutting and uprooting were to eliminate the mangroves.

Species that modify existing habitat

Marram grass (*Ammophila arenaria*) was introduced to California to stabilise sand dunes (Slobodchikoff and Doyen 1977). It traps sand and stabilises dunes. But species typical of stabilised dunes then replace the marram grass. Native California dune plants adapted to loose sand are replaced by marram grass (Barbour *et al.* 1976), which changes light (Mooney *et al.* 1986) as well as dune topography (Barbour and Johnson 1988) and severely depresses dune arthropod populations and species richness (Slobodchikoff and Doyen 1977). The stabilised dunes are not favourable to the native plants, so even if the marram grass could somehow be extirpated, restoration would be a major undertaking and would entail modifying dune structure.

Water hyacinth (*Eichhornia crassipes*) was introduced from South America to Florida in the late nineteenth century. Removal programs were only partly successful and dense mats of water hyacinth eventually covered more than 35,000 hectares of lakes and streams, shading and killing the native aquatic plants and greatly reducing fish, turtle, alligator, and waterfowl populations (Ehrenfeld 1970, Schardt 1985). Water hyacinth rafts uprooted native vegetation and greatly increased sedimentation (Schardt 1985). Even where water hyacinth is removed, sedimentation and other changes present great impediments to restoration.

Plants that change soil characteristics can produce a ripple effect by aiding colonisation by other exotics. The later species can themselves have major impacts. Yellow bush lupine (*Lupinus arboreus*) was introduced to the lower North Spit of California's Humboldt Bay, previously sparsely vegetated by low plants. By 1984 the lupine was largely responsible for displacing 65% of the original dune vegetation (Miller 1988). The probable cause is that nodulating bacteria carried by the lupine allow it to thrive in the nutrient-poor dune mat. It modifies the environment, possibly by moisture retention and shade, to support other introduced species which, in turn, increase nitrogen and organic matter in the soil and replace the original community (A. Pickart, pers. comm. 1989). The Nature Conservancy sponsors a "Bush Bash" at least once a year which has been quite successful at restricting the extent of the lupine, and native vegetation has partially recovered. However, the nitrogen and organic matter will persist and complicate restoration.

The introduced African ice plant, *Mesembryanthemum crystallinum*, has also destroyed much native vegetation in California by modifying the soil (Vivrette and Muller 1977, Macdonald *et al.* 1989). This annual accumulates salt; when it dies, fog and rain leach the salt into the soil, suppressing growth and germination of native species. It also shades out other species, and introduced weeds, not native species, invade small openings. Even if removal of the ice plant were practical, the residual effects on the soil would hinder restoration of the native plants.

Introduced plants can change fire regimes with enormous propagated effects. *Melaleuca quinquenervia* displaces less fire-resistant species throughout south Florida wherever fires occur frequently (Ewel 1986), by virtue of its morphological and chemical adaptations to hot fire. Not only has it replaced native plants, but fires throughout its root systems have caused the ground to collapse several inches in peat areas of the Everglades (pers. obs.). There is no apparent way to eradicate this plant; even if there were, its effects on the soil in some areas would prevent restoration.

The coast of northeastern North America was originally mud flats and salt marshes, not rock as now. The European periwinkle, *Littorina littorea*, effected this change (Bertness 1984, Dean 1988). This snail eats algae on rocks and also marsh grass rhizomes. When it is excluded experimentally, rocks are covered by algae and mud, which are then invaded by grasses. In addition to modifying the structure of the entire intertidal, the periwinkle directly affects many other species. For example, it displaces its native congener, *L. saxatilis* (see Yamada and Mansour 1987), prevents establishment of *Fucus* germlings and barnacle cyprids (Lubchencoand Menge 1978, Lubchenco 1983, Petraitis 1983), and competitively excludes a native mud snail, *llyanassa obsoleta*, from many habitats (Brenchley and Carlton 1983). The small-scale exclosure experiments suggest that, if the snail could be eliminated, the entire coastal community might recover quite quickly, but an eradication of this magnitude would be a remarkable accomplishment.

Introduced pigs (*Sus scrofa*) change entire communities and ecosystems. In the Great Smoky Mountains National Park in North Carolina and Tennessee they root largely in high-elevation deciduous forests during the summer, reducing understorey cover and species richness while changing species composition (Bratton

1975). They have locally extinguished plant species by selectively feeding on those with starchy bulbs, tubers, and rhizomes (Ebenhard 1988). They change soil characteristics by thinning the forest litter, mixing organic and mineral layers, and creating bare ground, accelerating the leaching of many soil minerals (Singer *et al.* 1984). In some areas, rooting has nearly eliminated two litter mammals, the southern red-backed vole (*Clethrionomys gapperi*) and the northern short-tailed shrew (*Blarina brevicauda*) (Singer *et al.* 1984). In Hawaii feral pigs modify soil as in the Great Smokies (Vitousek 1986). They also disperse exotic plants (Loope and Scowcroft 1985) and feed selectively on particular native species, while their rooting and defecation aid exotic invertebrates (Stone 1985). Pig extirpation is possible (for example, on California's Santa Cruz Island) and subsequent recovery is surprisingly rapid (Hansen 1987). So long as no extinction has occurred, none of the pigs' effects are intractable to restoration efforts. Coypu (*Myocastor coypus*) escaped and began to spread in Great Britain in 1932. They changed wetlands by digging into banks and feeding on marsh and water plants (Lever 1977, Usher 1986, Gosling 1989, Macdonald *et al.* 1989). They destroyed rhizomes, trampled marsh vegetation, and destroyed vast areas of reed-beds, threatening the habitat of many marsh bird species and driving certain food plants locally extinct. A campaign to eradicate them gradually restricted their range and seems to have extinguished them (Gosling 1989, Usher 1989), but the recovery of the native community remains to be seen.

Keystone species that do not change habitat

On the South African Cape, the fynbos shrublands include many endemic plants in the Proteaceae. Over 170 species are ant-dispersed (Bond and Slingsby 1984). The recently introduced Argentine ant, *Iridomyrmex humilis,* has replaced other ants in many parts of the world (Crowell 1968). It is inefficient at fording, moving, and burying seeds of at least one fynbos species. Thus germination is greatly reduced, and the whole community may be threatened by loss of seed reserves and seedlings. The Argentine ant acts as a keystone species through its interference with dispersal mechanisms. In high-elevation shrublands of Hawaii this species greatly depresses native ground-dwelling arthropods, including pollinators of endemic herbs and shrubs (Medeiros *et al.* 1986). It is difficult to imagine an eradication campaign of the sort currently mounted against insects (Dahlsten 1986) that could succeed against *Iridomyrmex* except, perhaps, on a very small island.

The forest bird species of Guam have recently declined dramatically. Several species may be extinct and the remainder so reduced that Ralph and Sakai (1979) call Guam "the most massive avian desert we have ever seen...." Consequences to other species, such as plants with fruits that might have been eaten by birds or insects that might have been prey to birds, must be staggering, though no one has yet studied these propagated effects systematically. The Australian brown tree snake (*Boiga irregularis*), introduced to Guam in the late 1940s or early 1950s, is the reason for this change (Savidge 1984, 1987). This case of a reptile eliminating an insular avifauna is not unlike the many examples where introduced mammalian predators have wrought havoc (King 1984). Even if the snake were now removed, restoration would be problematic because of the missing birds.

The Nile perch (*Lates niloticus*) was introduced into Lake Victoria in the late 1950s. It has devastated the more than 200 endemic haplochromine fishes (Hughes 1986, Payne 1987), which had never encountered such a large predator and had evolved traits, like mouth-brooding and swim-bladders that cannot be rapidly adjusted, rendering them easy prey for the perch. Many populations have already declined greatly. The native fishes are now so rare that the perch feed primarily on their own young and a small prawn.

CONCLUSIONS

I noted at the outset that idiosyncrasies of individual ecological communities defeat efforts to predict introduction effects. However, the above examples suggest classes of introductions that might be especially likely to have great impact, and those whose effects may be particularly refractory to restoration efforts.

First, any plant species that generates a forest in a previously treeless habitat, such as the mangrove and salt cedar, will almost certainly affect native plants, provide new habitats for insects, and have physical effects (such as on soil or sediment) that will lead to an entirely new community.

second, a plant can be a keystone by changing the physical environment to the detriment of existing dominant plant species. Marram grass, water hyacinth, ice plant, yellow bush lupine, and the fire facilitators are in this category. Animals (like pigs in Hawaii and North America, coypu in Britain, and periwinkles in northeastern North America) or pathogens (like the chestnut blight in North America) can similarly be keystones by controlling dominant plants that physically structure the community.

Third, a species that removes an entire taxon will probably have its effects propagated in many ways and drastically modify the community. The Argentine ant in South Africa and Hawaii will have so many direct and indirect effects on other animals and plants that it must surely be counted a keystone species. The tree snake on Guam and other introduced bird predators probably also fall in this category, though the indirect, community-wide effects are not as well-studied as the destruction of birds. The Nile perch represents a similar common catastrophe - introduction of predatory fishes into communities whose native fishes had evolved in their absence (Moyle *et al.* 1986, Payne 1987).

In many instances, removal of the introduced species will probably be followed by natural recovery (secondary succession), which will take more or less time and may even be accelerated by human intervention (Simberloff this volume). The ecological damage caused by the few successful insect eradication programs to date suggest that such efforts might hinder restoration as much as it will help it (Dahlsten 1986). However, more efficient, highly focused, "surgical" extermination techniques using various forms of genetic engineering offer the prospect of enhanced ability to extirpate may species without additional effects on the community (Simberloff this volume). But the legacy of some introduced species may be very persistent. Two such effects seem particularly likely. Changes in the soil chemistry or structure brought about by introduced species may be particularly persistent and subtle. Simply replacing the existing soil might not be a trivial affair, as the seed bank and mycorrhizal fungi might be critical to the original plant community (references in Simberloff this volume) and may be modified in the new soil. The other frequent persistent effect of some introduced species is extinction. If the extinction is local, another population may be used as a source for reintroduction, but the genetic constitution may differ in ecologically important ways from that of the original resident population.

Finally, I would note that the cases I chose to exemplify community effects of introduced species all entailed ex post facto explanations of observed effects, though some of these hypotheses have been tested by elegant experiments (such as controlled pig and periwinkle exclusion), intensive observation, and thoughtful historical reconstruction. Is it possible to forecast the effects of an introduction before it happens? Elsewhere (Simberloff 1985) I have argued that careful study of the potential invader and key elements of the target community should often allow prediction on a case-by-case basis with the investment of about one PhD dissertation's worth of effort. J.R. Pickavance performed exactly this sort of doctoral research on *Dugesia tigrina*, an introduced flatworm, and accurately predicted its effects on native species (Reynoldson 1985). Other such efforts should be at least as successful, and should also suggest subtle difficulties that might thwart restoration. Restoration ecology resembles introduction ecology in an absence, at least for now, of a theoretical framework that produces useful predictions for specific projects (Simberloff this volume). In both, detailed biological knowledge of key species in the system should permit not only insight but prediction.

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ERADICATION OF INTRODUCED ANIMALS FROM THE ISLANDS OF NEW ZEALAND

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ABSTRACT

A wide range of exotic animals has been introduced deliberately or accidentally by humans to the majority of offshore and outlying islands in the New Zealand region. We consider most of these to be detrimental to the original biota of the islands. The eradication of 12 mammals and one bird (the weka) from 60 islands, continuing work on 17 operations and the failure or stopping of nine is recorded.

Eradication of these animals makes sense only for islands beyond the animals' natural swimming range. Future eradications may be considered where changes can be made to the island or adjacent mainland which will prevent migration and re-invasion. The reasons for success of operations to eradicate animals from islands are discussed and some principles for future eradication projects proposed.

INTRODUCTION

Since the beginning of human occupation of New Zealand, animals have been introduced either deliberately or accidentally to the mainland and to the offshore islands. The accidental liberations were mostly the smaller rodents and invertebrates. Cats commonly accompanied European colonisation and also readily became feral, as did some farm animals. Deliberate liberations were primarily to provide emergency food, although some animals were released for the fur industry or recreational hunting. Liberations of indigenous species have been made in attempts to conserve the species.

Around New Zealand there are more than 700 islands, over 273 of which are larger than 5 ha (Atkinson 1989). Most of these islands now have exotic animals which have either been introduced deliberately or accidentally by humans or which have swum from mainland New Zealand.

Without exception, mammals have harmed the biota (Gibb and Flux 1973). Evidence of changes caused by the earliest introduction, kiore, is based on circumstantial comparisons (Atkinson 1978); effects of more recent introductions to islands are based mainly on observations, with little quantitative data (Bell 1978). Following the eradication of introduced species dramatic changes to islands have been reported but have seldom been quantified.

For this paper, a wide group of people was canvassed for data in a standardised form. We collected information beyond our expectations. We include here all known instances of intentional removal of animals from New Zealand islands. We record some instances of removal before breeding started and also refer to instances where introduced animals died out without human intervention. The features of successful and failed eradication projects are given, and principles and methods for future projects discussed.

DATA SUMMARY

Some 21 exotic mammals, 18 endemic and 18 exotic birds, two endemic and one exotic snails, two endemic and one exotic lizard, and an unknown number of insect taxa have been introduced to and established viable populations on the offshore and outlying islands of New Zealand. Some introductions may be "natural" extensions of a species range from the mainland or an adjacent island which was colonised with human assistance. In this paper we consider the successful or attempted eradications of 14 vertebrates from all except the two main islands of New Zealand.

There have been a number of deliberate introductions which failed. Taylor (1968) shows 26 instances of failure for the Auckland Islands alone, including such species as goats, cattle and pigs. Some have survived from subsequent liberations or on other islands within the group. Rudge (1976) adds Snares, Antipodes and Campbell islands as places where goats were liberated but failed to establish. If all attempts to introduce animals to islands were documented we could well see that relatively few were successful.

A total of 13 species have been intentionally eradicated from 60 islands in 85 distinct operations (Table 1). A further nine eradication operations have been planned, and begun, but they failed or were stopped (Table 2). Work is continuing on 17 eradication projects (Table 2).

WHY OR HOW WERE ANIMALS INTRODUCED

Four of the species listed were placed on islands for food or for farming. In the 1890s it was government policy to establish animals on remote islands as food for shipwrecked mariners. Rabbits may have been introduced for either food or fur or, as in the case of Whale Island, baits for rock lobster pots (Paul Jansen pers. comm.). Possums were put on islands for the fur trade. Almost without exception, cats accompanied European settlement. Kiore were taken to islands for food or accidentally transported in canoes, while European rats and mice arrived accidentally from vessels hauled ashore, vessels tied up overnight, shipwrecks and possibly on drifting rubbish (Atkinson 1986). The weka was introduced for food and/or aesthetic reasons.

Some examples of introductions which have not established populations and hence are not included in the tables:

> Twice at Mana Island, a rat was intercepted on the barge. One jumped overboard and reached the shore, where it was killed (Mike Meads pers. comm.). While stores were being unloaded at Raoul Island a pregnant female mouse was killed (Chris Smuts-Kennedy pers. comm.). After kiore were eradicated from Korapuki Island, a ship rat was caught in a monitoring trap (Ian McFadden pers. comm.). During snap-trapping to monitor kiore on Codfish Island, a Norway rat was killed (Andy Cox pers. comm.).
>
> Twice there appeared to be a single rat on Takangaroa (near Kawau) (Taylor 1989) and Poutama (Southwest Stewart Island) (Andy Cox pers. comm.). Breeding populations apparently did not establish, and no further signs were seen after poison baits were laid.
>
> During her studies of endoparasites of kiore Mere Roberts (pers. comm.) found evidence that European rats may have reached islands that have only kiore now, so there may have been many more instances of rats and mice reaching islands without becoming established.
>
> Rock wallabies (*Petrogale penicillata*) were deliberately introduced to Great Barrier Island and then eradicated before breeding occurred (Warburton 1986).

IMPACT ON ECOSYSTEMS

The larger browsing species make a more noticeable impact and hence have been a more frequent target for eradication. Combinations of problem species also appear to make a greater impact than they do separately. The impact of cats and goats on parakeets (*Cyanoramphus* spp.) is an example. Where cats and kiore (as on Little Barrier) or goats and kiore (Macauley Island) co-exist, parakeets survive; when goats, cats and kiore are present, such as on Raoul Island in the 1880s, the parakeets disappeared (Cheeseman 1887).

Removal of problem species does not always allow a return towards a natural ecosystem without further management. This is particularly so with severely browsed islands such as Motunau, where invasion by weeds was a problem after the rabbits were eradicated.

There are few instances where data on the abundance or effects of pest species have been collected before the eradication attempt, and there appear to be few instances where data on the condition of the ecosystem were collected for a long period beforehand. Data have been collected after several eradications and these in general verify the very visible change to the ecosystem.

REASONS FOR ERADICATION

The main reason should be to restore the intrinsic values of islands. Every island has its own plant and animal species, sometimes including endemic ones. No modified habitat will return to its pristine condition after introduced animals have been eradicated, but it can in time resemble it. Immediate results may be spectacular but a long time is required for a maturity and mixture of vegetation similar to that of the original community to develop.

In addition to protecting and enhancing the island's own values, eradication of animals can provide habitats for threatened indigenous plant or animal species. Some islands have a very high ecological value now and should not have new indigenous species introduced to them. If an island is to be used for more intense management, one of the heavily modified islands where animals and people have had a long and profound influence would be a better choice.

The objective must be clearly set at the beginning and it must be attainable. Usually this will be eradication (complete removal of the target species); only rarely should control (sustained reduction in numbers) be considered. Even if eradication is initially more costly, in the long term it will be less expensive. On the other hand, control could be justified to protect a threatened species until other measures can be taken.

PLANNING AN ERADICATION PROGRAMME

Few of the early eradication operations were planned as we would plan them today. However, detailed planning is not by itself a recipe for success. Knowledge, ability and dedication of staff have, in a number of successful operations, made up for limited planning. While some projects have been stopped because of changes in work priorities or conflict with other projects, the majority of failed eradications have been due to a lack of adequate planning, resulting in failure to recognise all the problems or to commit sufficient resources to the task.

The better the planning the more chance of success. Knowledge of the general topography, plant cover, availability of water, climate, wet and dry seasons and temperature will assist in deciding the best time to conduct a campaign, either so that the task will be more amenable for the work force, or so that natural forces may concentrate the animals into specific areas, make them hungry or attract them to a particular food source.

The operators should be aware of all the methods which are available and they should be prepared to use any or all of these methods. Life cycles of possible non-target species must be well known so that operations can be planned to eliminate or reduce the possibility of trapping or poisoning non-target species. When using poisons consideration has to be given to secondary poisoning.

Some islands have a single animal problem; others have several. In the latter case it is important to remove the animals in the correct order. The removal of one may trigger an increase of the second or may make the second more difficult to find or remove. Likely changes to the ecosystem following the initial knockdown of numbers of the introduced animals should be recognised. This is important for herbivores in particular, as vegetation can quickly grow and become a problem for hunters trying to find the last few animals.

The plan must recognise that a daily record of the eradication work should be made and that time is needed following completion of the project to record and report on the success or otherwise of the operation.

ERADICATION METHODS

The methods used for the 84 successful operations that are listed have been reasonably consistent from species to species. Many operations have been successfully completed by only one method. Of the eight failed eradication operations there were four instances of the animals swimming back, incidents that increased our knowledge of the ability of animals to invade islands. A further four eradications failed due to insufficient planning and hence an inadequate commitment of resources.

Methods will vary from species to species and may vary even between very similar species, such as the two European rats. There are few commercially available methods for the eradication of introduced animals from islands. Previously proven methods have to be used or new methods have to be designed. For some animals though, particularly rodents, there are very effective commercial poisons available.

There is still room for improvement to methods for almost all species. Research is continuing, and during each operation improvements continue to be made. Staff doing the work should be given the flexibility to change as the task proceeds.

NECESSITY FOR TOTAL COMMITMENT

Once the objectives are established and eradication plan approved there must be a total commitment to make the necessary funds and staff available to achieve them. The selection of staff is extremely important, because they must have, above everything else, commitment and persistence. The challenge is as much mental as physical. It is relatively easy to maintain interest and application when the kill rate is high but much more difficult in the later stages of the campaign when few animals remain. For example, the capture rate of cats on Little Barrier Island was 35 cats for 5459 trap nights, about one cat per 156 trap nights in 1979; in the final year, 1980, only five cats were caught for 32 165 trap nights, one cat per 6500 trap nights. Only the right mental approach and a dedication to the objective gives a successful result.

PUBLICITY AND PUBLIC RELATIONS

It is essential that any eradication programme be discussed with the appropriate people and agencies from the beginning of planning. This will reduce misunderstanding and undesirable or ill informed publicity. Should opposition remain then opponents should be asked to put forward a viable alternative; that should be fully discussed. This often helps the public realise how well considered the original proposal is.

MONITORING

Monitoring the impact of introduced species on ecosystems is desirable if priorities are to be established for eradication projects or changes following eradication are to be documented. The absence of such monitoring should not, however, be seen as a reason for delaying an eradication project.

Independent programmes monitoring effectiveness are not usually required, since the hunters will know where animals are, whether or not they are successfully removing these animals, and when none remain. Recording the cost and effort required to achieve eradication can be beneficial when planning future operations. If a person or organisation wishes to obtain data during the course of an eradication operation which may be of interest or use later, but which has no immediate benefit to the operation, then this should be permitted, provided it does not interfere with the actual work of hunting.

Monitoring is needed, either to detect undesirable changes (such as weeds) or to determine when the habitat is suitable for the introduction of new species. Monitoring for these purposes may need to be long-term. Our experience suggests that bird numbers should be monitored for at least 10 years before the eradication of a predator or competitor, and for at least 10 years afterwards if real changes to numbers of these species are to be demonstrated.

AVOIDING FUTURE INVASIONS

There are many ways to keep islands free of predators or browsing animals. Most larger animals were deliberately introduced, and it is no longer legal to introduce any mammals to islands for other than domestic purposes. Our real problem in conserving island ecosystems is the accidental introduction of smaller animals, particularly rats (Moors *et al.* 1989), mice, stoats and cats. Islands prone to reinvasion can have permanent bait stations and traps around the shores. Traps would have to be checked daily. With present-day rodent poisons, these would have to be refreshed every six months; this work would be ongoing.

There is also a need for a high level of publicity aimed at both amateur and commercial boat users to convince them that mooring vessels overnight at a wharf may allow rats aboard, with the high chance of their getting off again near islands. It is also highly likely that rats (and, more particularly, mice) can get to islands in dinghies stored in sheds, and in stores and equipment inadequately packed and left in buildings before departure. It is very important that Department of Conservation staff and other regular users of islands use all the methods that are known to stop rodents getting to islands. These methods should be widely publicised.

Finally, rodent contingency plans, similar to that prepared by Jansen (1989) for the Bay of Plenty, should be prepared and implemented by all Department of Conservation conservancies who have responsibilities for islands.

ACKNOWLEDGEMENTS

We are indebted to the following people who supplied information during the preparation of this paper: John Allen, Shaughan Anderson, Ian Atkinson, Derek Brown, Pat Burstall, Peter Carter, Bill Cash, Bill Chisholm, Andy Cox, Dave Crouchley, Duncan Cunningham, Peter Daniel, Rex Gilfillan, John Greenwood, Hal Hovell, Paul Jansen, Lionel Lobb, Tim Lovegrove, Philip Macdonald, Ian McFadden, Mike Meads, Don Merton, B.P. Neureuter, Ron Nilsson, John Parkes, Richard Parrish, Ron Peacock, Chris Roberts, Mike Rudge, Rodney Russ, Lou Sanson, Chris Smuts-Kennedy, Rowley Taylor, Graeme Taylor, Bruce Thomas, Kingsley Timpson, Phil Todd, Graham Turbott and John von Tunzelman.

We are particularly thankful for the detailed comments on drafts of this paper provided by Dave Hunt, Peter Jenkins, John Parkes and Dave Towns.

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Table 1: Eradications.

ISLAND	AREA (ha)	DATE INTRODUCED	ERADICATION LEADER	START ERADICATION	METHODS	COMPLETED ERADICATION	REFERENCE
MAMMALS							
POSSUM (*Trichosurus vulpe cula*)							
Codfish	1336	<1925	Andy Cox, Gary Aburn	1984	Poison, traps & dogs	1987	Andy Cox pers. comm.
Kapiti	2023	1894	G Alexander, B Cairns	1980	Poison, traps & dogs	1986	Peter Daniel pers. comm.
RABBIT (*Oryctolagus cuniculus*)							
Korapuki	17	c1900	I McFadden	1986	Poison, shooting	1988	Ian McFadden pers. comm.
Mangere	130	<1890	?		Cats	?	Brian Bell
Mokopuna (Leper)	<1	1946	Logan Bell	1947	Poison & traps	1954	Anon 1951
Motunau	3.5	<1867	Motunau Rabbit Bd.	1958	Poison & shooting	1962	Cox et al 1967
Native (Stewart)	66	c1942	Snow Corboy	c1949	Traps & shooting	1950	Rowley Taylor pers. comm.
Otata	15	?	Capt. Wainhouse	?	Shooting	1945	B P Neureuter pers. comm.
Stewart (Part)	174 600	1942	Dept Agriculture	c1948	Traps & shooting	1950	Rowley Taylor pers. comm.
Takangaroa	6	<1930	T.Clarkson	?	Shooting	<1950	Taylor 1989
Tiritiri Matangi	196	<1894	Everard Hobbs	c1900	?	c1920	Anon 1987
Whale	173	1968	Paul Jansen	1985	Poison & traps	1987	Paul Jansen pers. comm
MOUSE (*Mus musculus*)							
Allports	16	c1900	Derek Brown	1989	Poison	1989	Brown 1990
Motutapu (by Allports)	2	?	Derek Brown	1989	Poison	1989	Brown 1990
Whenuakura	3	?	Ian McFadden	1983	Poison	1984	Ian McFadden pers. comm
SHIP RAT (*Rattus rattus*)							
Awaiti	2	?	David Taylor	1982	Poison	1982	Taylor 1984
Kauwahaia	0.7		Graeme Taylor	1989	Poison	1989	Graeme Taylor pers. comm
Mokopuna (Leper)	<1	c1961	Rod Sutherland	1988	Poison	1990	Ian McFadden pers. comm
Somes	32	c1961	Rod Sutherland	1988	Poison	1990	Ian McFadden pers. comm.
Tawhitinui	21	?	David Taylor	1983	Poison	1983	Taylor 1984
NORWAY RAT (*Rattus norvegicus*)							
Breaksea	170	1800s	R Taylor, B Thomas	1988	Poison	1988	Taylor & Thomas 1989
David Rocks	0.3	< 1960	Don Merton	1960	Poison	1960	Moors 1985
David Rocks B	0.2	<1960	Don Merton	1960	Poison	1960	Moors 1985
David Rocks C	0.2	< 1960	Don Merton	1960	Poison	1960	Moors 1985
Hawes	9	1800s	R Taylor, B Thomas	1986	Poison	1986	Taylor & Thomas 1989
Maria	1	<1960	Don Merton	1960	Poison	1960	Moors 1985
Mokoia	133	?	Paul Jansen	1989	Poison	1989	Paul Jansen pers. comm.
Motuhoropapa	8	<1962	Phil Moors	1979	Trap & poison	1987	Moors 1985
Motuhoropapa A	0.2	<1962	Phil Moors	1979	Trap & poison	1987	Moors 1985
Otata	15	c1956	Phil Moors	1979	Trap & poison	1987	Moors 1985
Otata A	0.2	c1956	Phil Moors	1979	Trap & poison	1987	Moors 1985
Takangaroa	6	Unk	T Clarkson	Unk	Unk	Unk	Taylor 1989
Te Haupa (Saddle)	6	?	Rex Gilfillan	1989	Poison	1989	Rex Gilfillan pers. comm.
Titi	32	?	Brian Bell, Don Merton	1970	Poison	1975	Gaze 1983
Whale	173	?	Paul Jansen	1986	Poison	1986	Paul Jansen pers. comm.
Whenuakura	3	c1982	I McFadden, M Wilke	1983	Poison	1984	Ian McFadden pen. comm
KIORE (*Rattus exulans*)							
Double	32	?	Ian McFadden	1989	Poison	1989	Ian McFadden pers. comm
Korapuki	17	?	Ian McFadden	1986	Poison	1987	Towns 1988
Lizard (Mokohinau)	1	1977	Dick Veitch	1978	Poison	1978	McCallum 1986
Rurima	7	?	Ian McFadden	1983	Poison	1984	Towns 1988
STOAT (*Mustela erminea*)							
Maud	309	c1980	Bill Cash	1980	Trapping	1983	Brian Bell
Otata	22	?	Capt. Wainhouse	?	Shooting	1955	B P Neureuter pers.comm

Cuvier	170	c1889	Don Merton	1960	Traps & shooting	1964	Merton 1970
Herekopare	28	6925	Dick Veitch	1970	Traps & dogs	1970	Ftzgerald & Veitch 1985
Kapiti	2023	?	Dick Fetcher	?		1934	Wilkinson 1952
Little Barrier	3083	< 1870	Dick Veitch	1977	Traps, poison, dogs	1980	Veitch 1983
Motuihe	195	?	Steve Boyle	?	Shooting	**c1981**[1]	John Allen pers. comm.
Stephens	180	c1892	Lighthouse keepers	c1910	Not known	1925	Veitch 1985
PIG (*Sus scrofa*)							
Aorangi	110	c1820	Major Yerex	1936	Shooting & dogs	1936	Challies 1976
Blumine	377	<1957	Mike Finch	1988	Shooting & dogs	1989	Clarke & Dzieciolowski in press
Inner Chetwode	194	c1900	Unknown	?	Shooting	1926	Internal Affairs Files
Inner Chetwode	194	6954	D Cummings	1959	Shooting & dogs	1963	Internal Affairs Files
Motuara	59	?	?	>1950	?	?	Clarke & Dzieciolowski in press
Outer Chetwode	81	6948	Unknown	1953	Shooting	1953	Internal Affairs Files
Outer Chetwode	81	6955	D Cummings	1964	Shooting	1964	Internal Affairs Files
Pickersgill	96	?	?	>1950	?	?	Clarke & Dzieciolowski in press
Stewart (Part)	174 600	?	K.Purdon, H.Vipond	1948	Shooting & dogs	1948	Holden 1982
Tuputupungahau	13	1950s	Owners	?	Not known	c1966	Wright 1977
GOAT (*Capra hircus*)							
Burgess	62	?	Dick Veitch	1973	Shooting	1973	Veitch 1973
Cuvier	170	1890s	Brian Bell	1959	Shooting	1961	Merton 1970
East	13	1906	George Goldsmith	1959	Shooting	1960	Hal Hovell pers. comm.
Ernest (Masons Bay)	25	< 1948	Muttonbirders	19809	?	6980	Parkes 1990
Great (Three Kings)	407	1889	Logan Bell	1946	Shooting & dogs	1946	Turbott 1948
Herekopare	28	1973	Muttonbirders	1975	Shooting	1976	Ron Tindall pens. comm.
Kapiti	2023	c1830	A.S.Wilkinson	1928	Shooting	1928	Wilkinson 1952
Macauley	236	< 1836	Brian Bell	1966	Shooting	1970	Williams & Rudge 1969
Maud	309	c1965	Brian Bell	c1970	Shooting	c1976	Brian Bell
Mokoia	133	1987	Phil Alley	1989	Shooting & dogs	1989	Paul Jansen pers. comm.
Nukutaunga (Cavalli)	13	?	Chris Smuts-Kennedy	1972	Shooting	1972	C Smuts-Kennedy pers.comm.
Ocean (Auckland)	8	1865	CAPE Expedition	1941	Shooting	1942	Rudge & Campbell 1977
Raoul	2941	<1836	NZ Forest Service	1972	Shooting & dogs	1984	Parkes 1990
South East	218	<1900	Mr McLurg	1914	Unknown	1916	Ritchie 1970
Whale	173	6890	Wildlife Service	1964	Shooting	1977	Ogle in press
CATTLE (*Bos taurus*)							
Campbell (Part)	11400	1902	Ron Peacock	1984	Shooting	1984	Lands & Survey files
Kapiti	2023	6837	J.L. Bennett	1916	Shooting	1917	Wilkinson 1952
Stewart (Part)	174 600	?	Dept Internal Affairs	1940s	Shooting	1940s	Taylor 1976
SHEEP (*Ovis aries*)							
Kapiti	2023	<1896	Peter Rodda	c1930	Shooting	1969	Peter Daniel pens. comm.
Mangere	130	c1900	Brian Bell	1968	Shooting	1968	Brian Bell
South East	218	1915	Brian Bell	1956	Shooting	1961	Ritchie 1970
BIRDS							
WEKA (*Gallirallus spp*)							
Awaiti	2	?	David Taylor	1982	Poison	1982	Taylor 1984
Codfish	1336	<1850	Andy Car, Euan Kennedy	1980	Poison, trap & shoot	1985	Andy Car pers. comm.
Herekopare	28	6920	Mutton birders	1940s	Not known	**<1968**[1]	Fitzgerald & Veitch 1985
Kundy	19	6937	Ron Nilsson, E Kennedy	1981	Poison, trap, dog	1985	Internal Affairs Files
Rabbit (French Pass)	5	6974	Aston Family	6975	Shooting	c1975	Brian Bell
Tawhitinui	21	?	David Taylor	1983	Poison	1983	Taylor 1984
Middle Trio	11	c1950	Logan Bell *et al*.	1951	Shoot & trap	1964	Campbell 1967

[1] Subsequently re-introduced.

Table 2: Incomplete or failed eradications.

ISLAND	AREA (ha)	DATE INTRODUCED	ERADICATION LEADER	START ERADICATION	METHODS	STATUS AS AT 1/6/90	REFERENCE
POSSUM							
Allports	16	<1980	Trevor Neal	1982	Poison & traps	Failed	Derek Brown pers com.
Allports	16	<1980	Derek Brown	1989	Poison	Incomplete[1]	Brown 1990
RABBIT							
Browns (Hauraki Gulf)	57	c1975	Fred David	1985	Trap dog shoot poison	Incomplete[2]	C Roberts pers. comm.
Quail	81	c1855	John Trotter	1989	Poison	Incomplete[1]	John Trotter pers. comm.
MOUSE							
Mana	217	1800s	Phil Todd	1989	Poison	Incomplete[1]	Hutton 1990
Rimariki	22	?	Chris Smuts-Kennedy	1989	Poison	Incomplete[1]	C Smuts-Kennedy pers.comm
SHIP RAT							
Duffers Reef	2	<1983	David Taylor	1983	Trap & poison	Failed[3]	D Brown pers. comm.
Moturako (GBI)	0.8	?	Graeme Taylor	1990	Poison	Incomplete	Graeme Taylor pers. comm
Opakau (GBI)	4	?	Graeme Taylor	1990	Poison	Incomplete	Graeme Taylor pers. comm
Oyster (GBI)	0.3	?	Graeme Taylor	1990	Poison	Incomplete	Graeme Taylor pers. comm.
Saddle (GBI)	2	1961	Graeme Taylor	1990	Poison	Incomplete	Graeme Taylor pers. comm
Wood (GBI)	1	?	Graeme Taylor	1990	Poison	Incomplete	Graeme Taylor pers. comm.
Wood Stack A (GBI)	0.3	?	Graeme Taylor	1990	Poison	Incomplete	Graeme Taylor pers. comm
KIORE							
Motuopao	30	?	McKenzie & Parrish	1989	Poison	Incomplete[1]	R Parrish pers. comm.
STOAT							
Adele	87	<1977	Rowley Taylor	1980	Trap	Failed[3]	Taylor & Tilley 1984
CAT							
Raoul	2941	c1850	Dick Veitch	1972	Traps	Stopped	Dick Veitch
PIG							
Mayor	1131	?	Pat Burstall	1963	Shooting dogs poison	Failed	Paul Jansen pers. comm.
RED DEER (*Cervus elaphus scoticus*)							
Secretary	8000	<1965	John von Tunzelman	1975	Shooting & poison	Failed[3]	Mark & Baylis 1982
GOAT							
Auckland (Part)	45 975	1865	Kingsley Timpson	1989	Shooting & poison	Incomplete[1]	K Timpson pers. comm.
SHEEP							
Campbell	11400	1895	Brian Bell	1970	Shooting	Incomplete[4]	Brian Bell
WEKA							
Allports	16	1974	Warwick Brown	1976	Trap & shoot	Failed	Derek Brown pers. comm
Allports	16	1974	Derek Brown	1989	Poison	Incomplete[1]	Derek Brown pers. comm
Motutapu (by Allports)	2	c1974	Derek Brown	1989	Poison	Incomplete[1]	Derek Brown pers. comm.
Blumine	377	1972	Bill Cash & Allan Munn	1982	Trap & shoot	Failed	Bill Cash pers. comm.
Inner Chetwode	194	1928	Wildlife Service	1970	Trap & shoot	Stopped	Brian Bell
Maud	309	1950s	Warwick Brown, Bill Cash	1974	Trap & shoot	Failed[3,5]	Buck Bucknell pers. comm

[1] All animals may be gone - checks continuing.

[2] Few animals remain.

[3] Re-invaded by swimming.

[4] Remaining animals are within a fenced area.

[5] Re-introduced by humans is likely

Pp. 147-149 in Towns, D.R, Daugherty, CH., and Atkinson, LA-E. (Eds), ***Ecological restoration of New Zealand islands*****.**
Conservation Sciences Publication No. 2 Department of Conservation, Wellington.

MAPARA: ISLAND MANAGEMENT "MAINLAND" STYLE

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ABSTRACT

Because they are generally isolated from other terrestrial habitats, offshore islands offer distinct advantages to the conservation manager over mainland habitats. While significant progress has been made in managing islands for endangered species, it is neither feasible nor desirable to contemplate island transfers for the full range of threatened plants and animals. It is timely to attempt "island style" management programmes in important mainland habitats where effective control of pests is the objective, rather than eradication.

In order to increase numbers of kokako (*Callaeas cinerea wilsoni*) in the Mapara reserve in the northern King Country, an intensive five-year programme to control mammalian herbivores and predators has been initiated. As well as being relatively accessible, conveniently sized, and a previous site for intensive study of kokako and their use of habitats, Mapara reserve is surrounded by farmland - in effect, it is an island of forest in a sea of pasture. While the risk of reinvasion of pests to Mapara is likely to be much greater than it would be on a true island, the isolated nature of the forest provides an opportunity to undertake and refine island-type techniques and to monitor results. Since the conservation of kokako populations on the mainland is a primary goal identified in the draft Species Recovery Plan, the lessons learned at Mapara will have an important bearing on the long-term survival of the species.

INTRODUCTION

Natural resource managers in New Zealand are fortunate in that a large number of offshore islands are available for conservation management programmes. Isolated from other terrestrial habitats, many offshore islands have not been exposed to the same modifying influences evident in mainland habitats. As a result, islands provide habitats for plants and animals which have either disappeared or have declined significantly on the mainland. Such isolation also provides distinct advantages to the conservation manager in that pest species may be eradicated from islands for the benefit of favoured species, while others may be subsequently liberated to establish new populations. Given the range of native plants and animals which are now confined to one or a few offshore islands, and the successful island restoration and species transfer programmes that have contributed significantly to the conservation of several species, there is little doubt that island conservation programmes will continue to feature prominently in New Zealand for some time to come.

Since more and more plants and animals on the main islands are declining in both distribution and abundance it is important to maintain priorities for the development and refinement of island conservation programmes. In recent years some important successes have been achieved in eradicating mammalian pests from islands. Increasingly sophisticated techniques are being developed which allow us to contemplate intensive control or eradication programmes in quite large habitats. Because it is generally preferable to conserve plants and animals in the habitats where they naturally occur, it is important to apply management techniques developed on islands to mainland habitats.

THE MAPARA PROJECT

An example of a project which has been designed to capitalise on recently developed animal control techniques is to be found at Mapara in the Central North Island. About 65 of the endangered wattlebird, kokako (*Calleas cinerea wilsoni*) are to be found in 1400 ha of cutover podocarp/hardwood forest here. Surveys over the last fifteen years or so indicate that while a number of relatively large kokako populations remain in the northern North Island, their distribution and abundance is declining (O'Donnell 1982). Research over the last decade has shown that the kokako's recorded decline in the North Island can be attributed to one or a combination of three main factors: habitat loss, predation, and competition for preferred foods (Hay 1981). As a result of the preparation of a draft kokako recovery plan in 1989, Mapara was chosen as a site where management could be undertaken to increase kokako numbers through the control of these factors. Apart from the presence of a relatively dense population of kokako which has been intensively studied over a number of years, an important consideration in selecting Mapara was that it is completely surrounded by an extensive area of pastureland - in effect an island of forest in a sea of pasture.

From a management perspective there are advantages in treating discrete habitats such as this rather than large, contiguous forest tracts.

Other factors were also taken into account in selecting Mapara:

> Virtually the entire forest block has been reserved specifically for wildlife management purposes. This means in effect that a range of habitat manipulation techniques can be tried which may be impractical or unacceptable in other habitats, or on offshore islands. (For example, we are currently considering the planting of plum trees in selected kokako territories.)
>
> The reserve (about 1400 ha) is large enough to allow for any increase in kokako numbers, but not so large that effective animal control is not feasible.
>
> The reserve is accessible by road, is well tracked and has a relatively gentle topography.
>
> The Mapara kokako population has been monitored longer than and studied as intensively as any other kokako population. An intensive programme of territory mapping and roll calling will be maintained throughout the five-year period of the project to detect any changes in kokako abundance.
>
> In conjunction with earlier kokako studies, information relating to forest composition, structure and phenology within the reserve has already been collected and will continue to be monitored.
>
> A full range of introduced mammals likely to prey on or compete with kokako was (until recently) to be found within the reserve.
>
> There has been a long history of public interest and involvement with kokako.

The Department of Conservation's aim for the Mapara project is, through intensive animal control, to increase the numbers of kokako in the reserve within five years. Apart from the obvious benefits to the kokako here if the project is successful, there are also important lessons to be learned about the application of island-type control programmes in what is not a truly isolated island ecosystem.

Since reinvasion of target animals is inevitable, the objective here is to achieve control at the lowest practicable level, rather than eradication. This implies that any effective management must necessarily be long term - if not eternal!

Animals to be controlled at Mapara include:

Domestic stock: Cattle and, to a lesser extent, sheep have had ready access to the Mapara forest in the past. Boundary fence upgrading and maintenance over the last few years has resulted in stock now being virtually absent from the reserve. It is planned to complete boundary fence upgrading within the next few months.

Feral goats: Goat control programmes have been undertaken intermittently at Mapara and its environs over the last ten years. The current project provides a focus for intensive hunting within the reserve in conjunction with the completion of the boundary fence and in close collaboration with adjacent landowners.

Possums: While commercial possum hunting has been undertaken intermittently at Mapara in the past, recent vegetation assessments, pellet counts and trap surveys suggested that a relatively dense population of possums is present. Hunters from the Fur Producers Association and the Department of Conservation intensively hunted Mapara with the objective of reducing possum numbers to the lowest practicable level. Cyanide poison, traps and, subsequently, trained dog teams were used over a four-month period last winter to carry out what was probably the most intensive possum control programme on this scale to be undertaken on the mainland. Recent assessments suggest that an 80-90% reduction in possum numbers was achieved. Possum hunting pressure will be maintained throughout the course of the project.

Ship rats: As they are proficient tree climbers, ship rats are likely to be major predators of kokako eggs and chicks. Poisoning of ship rats is currently being undertaken within selected kokako territories at Mapara. The objective is to reduce the likelihood of rats encountering kokako nests by significantly reducing rat numbers during the kokako breeding season. TALON 50 WB baits have been laid within protective novapipe tunnels on a 50-m grid and replenished weekly. Tracking tunnels are being monitored to determine changes in rat abundance in both the poison block and in an adjacent uncontrolled area.

Mustelids: A network of Fenn kill traps has been established in areas adjacent to rat control lines. Stoats, in particular, are competent tree climbers and pose a threat to nesting kokako. A few weasels and ferrets have also been caught in traps around the reserve. Feral cats are also present. As with rats, the objective of the mustelid trapping programme is to reduce mustelid numbers over the kokako breeding season so there is less chance of their invading kokako nests.

Once it is determined that controlling these animals is feasible at Mapara and that this increases kokako numbers, the next challenge will be to identify which particular control programme was the most effective. These questions are already being addressed in other kokako management projects.

INVOLVEMENT OF THE COMMUNITY

In addition to intensive animal control operations, emphasis has been given at Mapara to enlist the support and co-operation of adjacent landowners, local residents and the wider community. The appointment of a reserve manager (or gamekeeper) who lives adjacent to the reserve, oversees daily operations and provides a contact point for visitors to the reserve. Prospects for success of this project in the longer term are remote if community support is not forthcoming. To date conservation groups such the Royal Forest and Bird Protection Society and the Native Forests Restoration Trust as well as schools and other organisations with a general interest in the outdoors have visited Mapara and, in some cases, have assisted in the current project.

It's essential to remember that the success of this and any similar projects in the future is dependent on the support and understanding of the community. Every effort will be made to advocate the philosophy of Mapara and to promote active community support and involvement. Already Mapara is providing a focus for wildlife and forest conservation in the Central North Island. While the stimulus, in this case, is a rare and ancient New Zealander, the kokako, there is no reason, in my view, why such intensive management and collaborative involvement should not be effective in a much wider setting.

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KEY ARCHAEOLOGICAL FEATURES OF THE OFFSHORE ISLANDS OF NEW ZEALAND

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ABSTRACT

Archaeological features on New Zealand's smaller islands reflect the many different ways these islands have been used by people in the past. The majority of recorded sites are the remains of former Maori occupation; however, some result from European activities such as whaling and mining. Because of the relative isolation of many islands in recent times, archaeological sites have been little affected by modern development. They are therefore an important historical resource. The archaeological record covers about 1,000 years of human impact on indigenous flora and fauna and can be of great assistance in developing restoration and management plans. Many of the sites are fragile and require careful management; these are often on islands which for other reasons also are not suitable for uncontrolled public access and recreation. There are, however, some sites on more accessible islands which are well suited to interpretation and visitor use.

INTRODUCTION

Aotearoa/New Zealand has been inhabited by humans for about 1000 years. First the Maori and then the Pakeha occupied, exploited and modified not only the main islands but the smaller ones, leaving a variety of traces of their activities on the land.

Human presence on the remoter islands that are part of modern New Zealand has been briefer or less continuous. Polynesian voyagers touched the Kermadecs at various times; the ancestors of the Moriori probably reached the Chatham Islands after the settlement of Aotearoa proper. The subantarctic islands were apparently unvisited by people until the European era.

It is important to understand that no island, no matter how small and inaccessible, has been unaffected by human activity. In some respects, the effects of this activity are irreversible - we cannot fully restore islands to their pristine pre-human state; nor should we want to. The cultural remains on islands are part of our human heritage; they are also repositories of archaeological evidence that can help us to understand past ecological processes and thus more wisely manage the islands for the future.

Just as many islands are sanctuaries for wildlife, so they can be considered sanctuaries of archaeological evidence. Some have not been occupied to any significant extent since Maori occupation ceased some time in the nineteenth century. The Three Kings, Poor Knights, and Hen and Chickens are examples. Other islands have a long history of pastoral use which has preserved archaeological features far more satisfactorily than has happened on the adjacent mainland. Examples include Motutapu and Tiritiri Matangi adjacent to metropolitan Auckland; islands in the Bay of Islands compared with the Bay's coastline; islands off the Coromandel compared with its coast; and Mana adjacent to Porirua (see pp. 214, 288). Inconvenient though it may sometimes be for management of natural resources, the archaeological features are an important part of the heritage of the islands.

MAORI USE OF ISLANDS

Maori use of the smaller islands varied considerably. The importance of an island was influenced by many factors, including size, accessibility, climate, soil fertility, terrestrial and marine foods, and the presence of other important resources, particularly stone for tool-making, but also timber, fibre-bearing plants and feathers.

To the Maori, whose principal means of transport was the canoe, most offshore islands were not a separate category of land, as they may appear to us today. They were normally part of a tribal territory which included the adjacent mainland; bad weather was the only barrier to travel between the two. Thus, although some of the remoter islands have unusual archaeological features, the archaeological landscape of the larger or closer islands is often simply a better preserved version of that on the adjacent mainland. For example, Great Barrier, the Mercuries and Slipper Island can be seen as extensions of the Coromandel Peninsula; the islands of the Bay of Islands or the Marlborough Sounds fit into the surrounding mainland setting; the inner islands of the Hauraki Gulf are part of the wider Auckland archaeological scene. Some of these islands happen to have special features, such as the climate of Great Mercury and the fertile soils of Motutapu. So too there are areas of favourable microclimate and pockets of particularly good soils on the mainland.

Maori in the northern parts of the North Island were gardeners, and land that was suitable for their principal crop, the sweet potato, was highly attractive. Thus the density of occupation on the northern off-shore islands seems to be correlated with the suitability of these islands for gardening (Edson 1973). Islands were also attractive for fishing and "mutton birding". The so-called mutton bird islands of Foveaux Strait were not the only places where burrow-nesting sea birds were found in quantities.

Islands were often important as human refuges. Some of the most important modern sanctuaries come into this category, including the Poor Knights and the Hen and Chickens. People here could be safer from attack. Even tiny islets around the coasts of the North Island were occupied for this reason. James Cook described examples on the coast of the Coromandel as "very small and more fit for birds to inhabit than men yet there are house[s] and places of defence on each of them" (Beaglehole 1968: 199).

Some islands were strategically important. For example, both Kapiti and Mana were well placed to control traffic across Cook Strait, and both were occupied by the northern tubes under Te Rauparaha who invaded the Wellington-Horowhenua region in the 1820s.

The significance of archaeological features is sometimes enhanced by traditional or historical information about them. The rather undistinguished *pā* (fortification) on the eastern tip of Motuarohia was the subject of an invaluable sketch by Parkinson, the artist on Cook's first voyage (Beaglehole 1968: figure 40), while Paeroa Pa on nearby Moturua was mapped in detail by the French in 1772 after they sacked it in retaliation for the death of Marion Du Fresne.

Some of the most important stone resources used for tools by the pre-European Maori are found on small islands. Mayor Island in the Bay of Plenty was the pre-eminent (although by no means the only) source of obsidian, the black volcanic glass which was indispensable for small flake tools (Seelenfreund-Hirsch 1985). D'Urville Island, off the northern tip of the South Island, has some of the most important sources of *pakohe* (metasomatised argillites and mudstones), used for stone adze blades, particularly during earlier centuries (Keyes 1975). Raw material from Mayor Island and products from the adze manufacturing centres on D'Urville Island were traded throughout Aotearoa. Some other northern islands had sources of obsidian or adze making stone of more local significance (Davidson 1984: 33, 195-200).

It will be evident from the foregoing that a full range of prehistoric archaeological sites can be found on small islands. These include fortifications and unfortified living sites, kumara storage pits, rock shelters, and stone working sites. Gardens, indicated by terraces, stone heaps, stone walls, and shallow ditch boundaries are among the most common archaeological features on the northern islands (see, for example, Hayward 1987). However, archaeological evidence of gardening is also found on islands as far south as D'Urville (Prickett and Prickett 1975). Sometimes, archaeological features on islands are obvious, even to those untrained in this field; sometimes they are insignificant or obscure, although they may be no less important. A sign of former occupation may be as slight as a typical Maori hearth consisting only of four stones; it may even be most apparent in a vegetation change, rather than in any structural or depositional features.

There are also sacred sites on islands: burial places, and perhaps ***wāhi tapu*** of other kinds as well. These must be respected by those who visit and manage the islands.

POST-EUROPEAN USE OF ISLANDS

The majority of recorded archaeological sites on islands are Maori sites, and it is these which contain scientific evidence of human impact in the period before written accounts. However, there is now rapidly growing interest in historical archaeology in this country, and the small islands also have their share of important historic archaeological sites.

Some islands were locations of early industrial and farming activity. The copper mining industry on Kawau in the 1840s and 1850s has been the focus of recent archaeological investigations (Clough in press; see also Thornton 1989). Kapiti and its small islets have what is probably the most important surviving archaeological landscape of the shore based whaling industry (Prickett 1983). Mana was the scene of one of New Zealand's earliest pastoral enterprises, and there are important archaeological features dating to this period (Jones 1987). The lighthouses, which are such an important feature of many of the islands, have given rise to archaeological features. Even the much more recent remains of 20th century military occupation on Motutapu, for instance, can be considered part of the archaeological landscape, and a part that has a great attraction for some sections of the public.

CONTINUITY IN HUMAN USE OF ISLANDS

I have spoken as if pre-European and historical archaeological sites can easily be distinguished and often, of course, this is so. But there are places where pre-European and nineteenth century archaeological evidence are inextricably intermixed, and where nineteenth century sites reflect occupation by both Maori and Pakeha. Because of the inaccessibility of many small islands, the same landing places have been used for centuries and sometimes much of the history of an island may be buried in a site or sites near the landing place.

Mana is an example of a relatively small island where much of the human activity has taken place on the coastal flat behind the beach and present wharf. George French Angas painted Te Rangihaeata's house there in the early 1840s (Angas 1847); an early survey plan shows fairly precisely the location of the settlement where this house stood (Mantell 1865). Over the years, farming has turned up stone adze blades representative of all styles and periods on this same coastal flat (Michelle Horwood pers. comm.); European activities have also been centred here, probably causing serious damage and destruction to earlier features. Although there are other significant archaeological sites on Mana, as mentioned above, the heart of the island's history is waiting to be explored on the flat behind the wharf.

THE OUTLYING ISLANDS

The subantarctic islands have no prehistoric sites as far as is known but they do have important post-European sites (Ritchie 1987). Considerable attention has already been giving to recording and preserving these.

The Chatham Islands were inhabited at European contact by the Moriori, a group who had developed a distinctive variant of Polynesian culture in isolation. There is disagreement about when the Chathams were first settled, but it may have been significantly later than the settlement of the mainland (B.G. McFadgen pers. comm.; cf. Sutton 1980). The Moriori probably came from Aotearoa originally, and in many ways their culture and economy were similar to those of South Island Maori, but until their islands were rediscovered by Broughton in 1791 they were completely cut off from the mainland. The Moriori visited their own rugged small offshore islands to fish and take birds. The middens of the Chathams islands are an important repository of knowledge about the fauna of the Chathams and the human impact upon it.

The Kermadecs have a different kind of history again. Uninhabited at first European contact, they had been occupied in the past by Polynesian voyagers from various sources including New Zealand, who had stayed long enough to leave recognisable archaeological deposits, at least on Raoul Island (Anderson 1980; Leach *et al.* 1986). Further exploration of the archaeological record there should reveal something of the effects of intermittent human presence over the past millennium.

HUMAN IMPACT

The small islands of Aotearoa proper have a history of about 1000 years of human occupation and modification. In pre-European times people cleared vegetation, introduced cultivated plants and probably weeds, transferred indigenous plants such as flax and quite probably indigenous fauna such as land snails (Hayward 1986), introduced *Rattus exulans* and domestic dogs, killed and ate burrow-nesting and other birds in large numbers, wiped out sea mammal breeding colonies and severely reduced non-breeding colonies (Smith 1989), killed and probably ate tuatara, made heavy inroads on shellfish, particularly rocky shore species, and quite possibly caused the extinction of a number of endemic plants and invertebrates on islands such as the Three Kings (Hayward 1987).

As we know, the impact has continued more recently with further forest destruction and the introduction of a variety of animals, including such oddities as wallabies on Motutapu and Kawau. For many years we have been aware of the threats posed by many of these introductions. Yet few people seem to have appreciated the truly catastrophic impact that the recent infestation of rabbits on Motukorea (Brown's Island) has had on pre-European archaeological sites, which have been literally totally undermined. This was a very recent introduction that need never have taken place.

THE SCIENTIFIC IMPORTANCE OF THE ARCHAEOLOGICAL RECORD

Because there have been relatively few excavations on islands, we are not yet in a position to take full advantage of the archaeological record, but a few examples of its value can be given. As a starting point, the actual distribution of archaeological sites can provide an indication of the extent to which the effects of former human modification have already been reversed (Hayward 1987). Many archaeological sites on small islands are now covered in established forest; on the Poor Knights, for example, significant areas of former human occupation and gardening have been reclaimed by burrowing sea birds. Dating of such sites would provide a clearer indication of rates of recolonisation.

Archaeological excavations, particularly of midden deposits, can reveal a great deal about the former distributions of animals of various kinds and about the changing environment in which people lived on various islands. The best examples so far are from islands now farmed. On Motutapu Island, excavations at the Sunde Site, a stratified coastal occupation site, have shown that people were on the island before the eruption of Rangitoto, returning immediately afterwards, and on successive occasions subsequently (Davidson 1978; R.K. Nichol pers. comm.). The eruption appears to have destroyed much of the vegetation and natural recolonisation by forest was inhibited by Maori gardening. There was a sharp decline in bird species in the middens immediately after the eruption and a slower continuing decline throughout the pre-European period. Not only forest birds but sea birds declined here as elsewhere, reflecting the increasing impact of people on the coasts. The Sunde Site has also provided remains of a previously undescribed lizard species from the lowest layers (Gill 1985).

There are many other ways that archaeological work can contribute to reconstructions of former environments. Land snails can be recovered from midden samples and some are habitat-specific, providing information about adjacent vegetation at the time the site was occupied. Burnt wood and seeds can be identified, adding to information about vegetation in the vicinity. As far as I am aware, no work has been done in New Zealand on insect remains in archaeological sites, but there has been considerable success in Britain in recovering insect remains from waterlogged deposits. This line of enquiry might eventually be very important in studying island ecology.

THE ARCHAEOLOGICAL RESOURCE IN ADVOCACY

There is considerable public interest in, and support for archaeology and history in this country, and the historical resource should be regarded as an asset. Information on the human history of the islands can be used to advantage in educational and popular publications. Whether the story is the Maori occupation of the Three Kings or one of New Zealand's first copper mines on Kawau; whether it is Te Rauparaha's conquest of Kapiti or the whaling stations there, and whether the public can see the physical remains or not, there are good stories to be told.

There is also great public interest in the success stories in wildlife preservation. The extent to which birds, plants and tuatara have reclaimed some of the remoter islands will also have great public appeal.

Archaeologists would not want many of the important sanctuaries opened up to the public any more than other scientists would. Fortunately, there are opportunities for public access to and interpretation of sites on some of the more accessible islands. It is important, however, not to spoil such opportunities by unthinkingly obscuring important and highly visible sites through replanting programmes.

CONFLICTING VALUES IN MANAGEMENT

Conflict can arise between optimum management of archaeological sites and other values on islands. Generally, however, there is ample scope for accommodating both. Many of the problems that have arisen in the past have been due to ignorance about archaeological sites and their significance. There have been instances of scientists turning over and dismantling stone walls looking for things that live under stones. There have been examples of unsympathetic tree planting, and thoughtless placing of fences, helicopter landing pads, and boat sheds. Such actions can destroy valuable parts of the archaeological record, as well as detracting from future interpretative possibilities.

Pastoral farming can be damaging but it can also be one of the forms of land use most compatible with the preservation of archaeological sites. The surface features of fortified and unfortified settlements and garden areas are best seen in pasture that is well maintained but not over grazed. Even the most insignificant sites can be recorded under optimum conditions at certain times of year. Reversion to a natural succession or deliberate replanting quickly render archaeological sites invisible. Eventually the roots of forest trees cause disturbance to archaeological deposits. Earthworks or stone structures in mature bush have a romantic appeal which may make them very attractive to the public but they are no longer so attractive to archaeologists as sites to excavate in search of knowledge about the human impact on the landscape.

Where an island has a relatively small number of important archaeological sites, it should not be difficult to give fair recognition to historic values within an overall restoration programme. Mana Island is a case in point. The nineteenth century archaeological features in the vicinity of the former lighthouse and the concentration of historic features around the landing area do not occupy an enormous area. While one may fantasise about the possibility of using a ditch and bank fence to enclose or exclude takahe, there is clearly room both for historic sites, and for restoration of vegetation and relocation of birds. Where an island is covered in archaeological sites, it may be necessary to develop different management strategies for different categories or groupings of sites.

However, archaeological features may have to give way to other values when serious damage is being done to them not by careless people, but by other creatures. Burrowing petrels totally churn up any cultural deposits that may exist in their nesting areas. It is probably not possible to educate petrels about archaeological sites; indeed, culturally modified soils almost certainly have positive attractions for them. On the Poor Knights, for example, this kind of damage has already been done. There are good reasons, however, to take account of archaeological features when planning to establish new petrel colonies and avoid siting such colonies in the middle of archaeological sites, which may contain important scientific information as well as being of historical significance.

To achieve the best management of islands, it is vital to ensure that archaeological features are properly recorded, and considered in all aspects of planning. In any restoration programme the question must be asked: are there areas which require special management to protect their historic features? For almost all islands, the answer is almost certainly yes.

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POTENTIAL FOR ECOLOGICAL RESTORATION OF ISLANDS FOR INDIGENOUS FAUNA AND FLORA

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ABSTRACT

The refuge offered by islands is a pivotal part of the effort to conserve New Zealand's distinctive fauna and flora. Many islands have been greatly modified; overall there is considerable potential to develop islands for the protection of plants and animals. Scientists and managers are urged to acknowledge past bias in their approach to conservation when formulating plans for island development (including restoration). Integration of plans with clear goals and priorities that fully embody the mission and goals of the Department of Conservation are required. People are part of conservation, and unless they are included in meaningful programmes, the full potential of conservation on islands will never be reached. General plans for five island groups are offered to demonstrate a spectrum of potential and complementary development on islands. The plans also represent a spectrum of likely public accessibility and participation as well as revenue generation. The islands were chosen near Auckland to ensure that participation and awareness of conservation is available to as many people as possible and as soon as possible. These extend management philosophy to include protection, public participation and cost recovery.

INTRODUCTION

The importation of many animals and plants into New Zealand has meant that islands offer the most certain and cost-effective way of maintaining populations of much of our native biota. Conservation of New Zealand's indigenous fauna and flora is ultimately for the benefit of the people of New Zealand (Department of Conservation 1989). Our spectacular animals and plants are part of our national identity (Nature Conservation Council 1981). Unfortunately past conservation management has been conservative and reactive - concentrating at the important protection end of the scale of conservation activities. An increasing world-wide interest in conservation is welcome, and we must take the initiative and extend the New Zealand public's perception of their country's animals and plants as well as reinforce our international presence in conservation. To achieve these aims, those of us involved in policy, management or scientific advice must stand back from our tasks and ask, what are we trying to achieve, for whom, and why? This will ensure that we have clear goals and directions and that the speed of achievement for conservation matches the potential.

The way all people, including managers and scientists, approach issues appears heavily biased by both their present and past environment (cultural, social and physical). Any approach adopted implicitly includes some bias, and it is frequently difficult to be objective, to make the assumptions explicit and so allow debate with others. For example, before the Department of Conservation was established, control of our fauna and flora was placed either with agencies that championed protection or with those who championed exploitation solely for money. Such polarisation is no longer necessary, and it is important to extend the protective end of conservation. To achieve this, we must discuss the priority and validity of past biases and goals. Janzen (1989) clearly articulates the problems of national parks that champion protection by locking up resources rather than working with the local public to achieve a park that works for all interests.

Custody of New Zealand's indigenous fauna and flora is entrusted to the Department of Conservation. This department has a clearly defined mission statement within its corporate plan, and this has been divided into three goals. These goals arise from a multifaceted approach to conservation that includes not only protection but also education and public involvement (see below). Moreover, they extend the meaning of conservation beyond the typically accepted botanical and zoological components that dominated past conservation planning. It is important that all restoration or associated development be planned as part of programmes that address all of these goals. We must accept that the public are included in these goals. Scientific justification and aims will need to provide broad principles with which managers can meet the necessary day-to-day implementation of plans.

The public are not only the indirect providers of conservation resources (as taxpayers) but are also the direct users (clients) of the conservation estate. How they impact on their environment and how they respond to proposed usage of conservation money will relate directly to their opportunities for participation (O'Connor and Simmons, this volume). When we advocate restoration for the ensured preservation of New Zealand's fauna and flora (cf. Daugherty *et al*. and Atkinson in this volume), we must ensure a broad spectrum of potential participation in conservation. Such an opportunity spectrum is widely used in recreation management (e.g. Stankey 1982, US Department of Agriculture 1982, O'Connor and Simmons, this volume) but is only in the early stages of development within the conservation end of New Zealand's recreation.

This paper attempts to justify a continuum of conservation developments for the protection of New Zealand's fauna and flora. Suggested planning will of necessity meld the scientific ideals with the pragmatic goals of the Department of Conservation. More specifically a range of potential island developments is proposed for the Auckland region. This region was chosen specifically because it has half the users, providers and potential supporters of conservation. The image of conservation clearly rests on getting the message to as many New Zealanders as quickly and as easily as possible, so this makes the Auckland region an important starting point.

RESTORATION OR DEVELOPMENT?

When planning habitat modification, restoration is an inappropriate term in all but the most general sense. While it is true that a change of habitat on islands may be necessary to protect existing values or provide a suitable environment for selected fauna or flora, it is important that the potential is not constrained solely to ideas of past environments.

Furthermore, as few islands escaped Maori or Pakeha influences in the past, debates on what constituted past communities are potentially time consuming and subjective. Biological values are not the sole justification for conservation; when historical values are included in plans (as on Tiritiri Matangi Island), complete restoration, even where full past documentation occurs, becomes inappropriate.

Ecologically conscious development of islands is a more appropriate phrase, as it allows a range of conservation activities that includes restoration. The approach expressed by this term will concentrate management and scientific skills to achieve clearly stated goals. Given the broad goals of the Department of Conservation (see below) it is important to plan for some level of human use of islands; it is also important that our language reflects this (see also Atkinson, this volume).

POTENTIAL SCOPE FOR DEVELOPMENT

The potential for developing habitat for fauna and flora on offshore islands is considerable. It certainly exceeds the likely budget for decades to come. The immediate cost of development will be higher for larger and for more modified and isolated islands. However, future benefits in terms of protection value will often increase across the same continuum. Realistic short and long-term goals must be set to ensure that the maximum support for conservation will be achieved in the shortest time.

Recreational conservation by a committed and interested public can greatly reduce the costs of protection of fauna and flora. For example, the most conservative estimate of input by public, trade and professional services and from donations during the first five years to Tiritiri Matangi Island exceeds $1 million (J.L. Craig, N.D. Mitchell, R. Walter and B. Walter unpublished data). Development of inshore islands that are readily accessible to as many people as possible and with considerable existing habitat must be included in early priorities as a way of reducing costs but maximising impact for conservation.

Ideally, a coordinated spectrum of complementary development across a number of islands will increase its value for fauna and flora as well as its impact on education for conservation. The full range of goals of island development for fauna and flora must include the biological, the historical, the educational and the revenue generating potentials. Conservation has the potential of generating considerable revenue and there is no doubt that finance additional to the current government grant is needed to ensure the long-term survival of our fauna and flora. Only through participation and education will the public understand the value of native ecosystems. We must appreciate the following links.

PARTICIPATION / EDUCATION ⟷ VALUE ⟷ REVENUE / SUPPORT

SETTING PRIORITIES FOR DEVELOPMENT

Setting priorities for development of islands for fauna and flora must start with the declared mission and goals of the controlling agency. The mission of the Department of Conservation (DoC 1989) is to conserve the natural and historical heritage of New Zealand for the benefit of present and future generations. This general principle is further expanded to include the three following goals:

1. Protect the country's natural and historic resources.
2. Promote enjoyment by the public and provide sensitive use of the natural and historic resources.
3. Promote public understanding and foster support for the protection of natural and historic heritage of New Zealand.

It is important, given the past emphasis on a lock-up type of protection, to realise that public enjoyment and use both now and in the future are the justification for conservation activities. We must move from trying to defend the total priority of the first goal and ensure that we amalgamate all three goals in our conservation plans. Allowing a few TV programmes, limited press reports and a number of little-read reports and scientific papers will rarely meet the intent of the second and third goals.

Moreover, we have long emphasised the need to protect fauna and flora (unfortunately synonymised with just part of conservation, the conservation of genetic diversity). This approach has stressed the roles of introduced mammals and habitat loss. As a student suggested in an exam script, "public apathy and a lack of resources may well be the most serious threat - to New Zealand conservation". The public are the source of resources, so it is time we marketed the values of conservation to them.

It is interesting to consider the reasons for minimising the public's involvement in past conservation. Reasons include the polarisation towards protection and the necessary diversion of very limited funds toward protection especially in more isolated localities. The often demonstrated link between members of the public and habitat destruction or the unintentional and intentional introductionof unwanted animals meant all of the public were suspect. Also, as the proposed New Zealand Conservation Strategy (Nature Conservation Council 1981) states "many conservation professionals feel threatened by public participation or do not see its benefits." This cry of elitism is increasingly voiced by public groups despite the fact that, as the Department of Conservation goals state, the public are part of conservation. When we attempt to reach the public we must remember that the public includes more than the five per cent of New Zealanders already committed through membership of professional and amateur conservation related societies.

Participation by the public will reduce apathy, will increase resources, and if charged will reduce vandalism (Aukerman 1986). All future plans require specifically stated levels of public usage as well as a declaration of what the public will be able to see and how much interpretation will be given. These must become reciprocal obligations.

The public will accept responsibility for the natural resources to which they have access and will pay or work to ensure success of the conservation programme. (This has already happened on Tiritiri Matangi).

The Department of Conservation has a reciprocal obligation to ensure access to real conservation programmes. Inclusion of translocations of rare and threatened species is likely to be an important part of such programmes and should be at least foreshadowed in species recovery plans. We can hardly expect major inputs from the public for programmes of revegetation or predator removal if their future gains appear trivial or indirect. Effective public involvement in the planning, including marketing, will foster success.

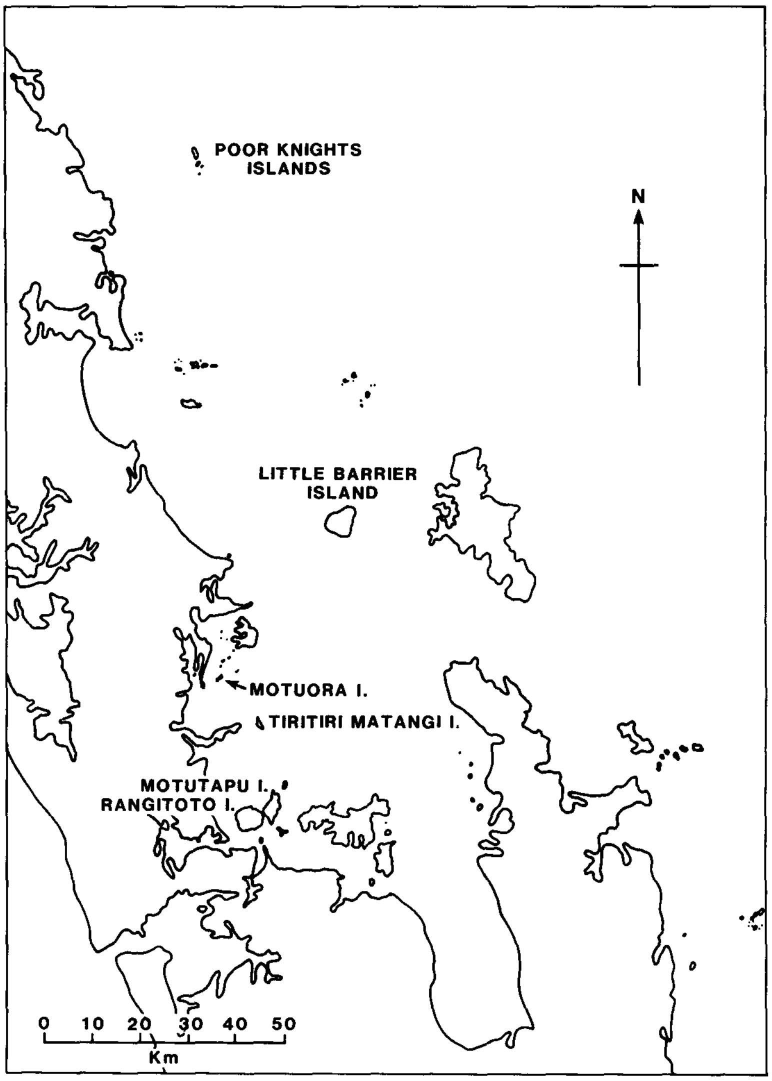

Fig.1. Islands of the Hauraki Gulf that may be developed as a spectrum of conservation potentials.

SPECTRUM OF ISLAND DEVELOPMENTS FOR THE CONSERVATION OF NEW ZEALAND'S FAUNA AND FLORA

Five islands or groups of islands are discussed to give examples of a range of development most able to foster the long-term conservation of our plants and animals (Fig. 1). Examples include the extremes of more remote islands that will most benefit from minimal or zero development and hence maximal protection through to islands that are highly modified but easily accessible to people. Public involvement and education on these islands can provide protection for selected species and have the potential of generating revenue. Each island group will be discussed with respect to likely goals, extent of development and human access, as well as likely budgets.

Poor Knights Islands

GOALS:

(i) Protection of fauna, flora, history and landforms

(ii) Education via media, scientific and popular publications
Cost recovery

These islands should be maintained as at present through minimal human impact (see also Atkinson this volume). Eradication of weeds such as pampas grass (*Cortaderia jubata*; Wright and Cameron this volume), with annual monitoring of such problems, should represent the maximum development. Tightly controlled access by conservation professionals and supervised media personnel will allow feedback to the public and scientific community. Access is a privilege, and charging should be aimed at cost recovery only.

Hauturu/Little Barrier Island

GOALS:
(i) Protection of fauna, flora, history and landforms
(ii) Education via media and restricted public involvement
(iii) Cost recovery

Hauturu was much modified last century before it was purchased for a nature reserve (Hamilton 1961). Natural regeneration of forest and the removal of cats (Veitch 1983) has ensured that this island is one of the largest tracts of forest in New Zealand free of European-introduced mammalian predators and herbivores. As such, it is an important preserve for fauna and flora. Limited numbers (1500 as in 1990) of public with a declared interest in conservation/environment are allowed to visit. Administrative and accommodation expenses are recovered.

In addition to the vegetation values associated with the lack of browsing mammals, the island has high conservation importance because it holds the only large self-sustaining population of stitchbird (*Notiomistis cincta*), over half of the existing kakapo (*Strigops habroptilus*) and the only population of kokako (*Callaeas cinerea*) not threatened by introduced mammals. The effect of translocations of saddleback (*Philesturnus carunculatus*) on giant weta (M. Meads and A. Balance unpublished report) suggests that future development should be more fully debated. (See also Atkinson in this volume for discussion on similar problems encountered for Mana Island.)

Development should include the phasing out of farming and the return of the rich flats to native fauna and flora. Planting of locally reared species by the public may be the most successful approach. No plants should be moved to the island, future translocations of fauna need to be carefully assessed and preservation of archaeological sites should be considered.

Hauturu in its present state is a most exciting and valued experience for the conservation-minded person. Much of the attraction results directly from past planning and expenditure, yet current users obtain these benefits at minimal cost. Policies of public involvement need urgent formulation to ensure that the prestige of the island is used in the best way for furthering the aims of conservation. If existing visitor levels continue, there will be a need for upgrading accommodation and providing some interpretive material (and thus a concomitant increase in visiting fees).

Tiritiri Matangi Island

GOALS:
(i) Provision of selected habitats
(ii) Translocation of selected rare and threatened fauna
(iii) Protection of fauna, flora, landforms, and history
(iv) Education by public involvement and open but controlled access
(v) Full cost recovery.

Tiritiri Matangi Island is the fast large-scale island development involving a joint programme between the Department of Conservation (through the Hauraki Gulf Maritime Park Board) and the public. This ambitious plan will result in the provision of forest and open grass habitat for the protection of selected rare and endangered fauna. In addition historical aspects have been preserved and provision has been made for long-term public access. The island has been named an open sanctuary, a concept which entails the joint and equal goals of providing a sanctuary for fauna as well as open but controlled access by the public.

In the first five years up to this conference, a conservative estimate of public input in labour, materials and planning is over $1 million. All parts of the island destined for forest have been planted, and development work on walkways and buildings is progressing. Unfortunately public demand and usage is rapidly exceeding the provision of facilities. An eventual limit on access at 20-30,000 visitors per year may be necessary. The hesitancy of the Hauraki Gulf Maritime Park Board to charge for services and speed planning by the use of contracts has meant that the rate of development is not matching the increase in public demand.

Charging to experience the island and its features, especially the rare birds, is necessary to provide facilities such as elevated walkways and interpretive material. These facilities will not only assist in the protection of habitat but will greatly heighten the impact of the visit. The hesitancy of policy makers to charge for *access* to the public estate is laudable, but this must not be confused with charging for *service* in the form of a heightened conservation experience. Before development for an open sanctuary began, Tiritiri attracted only a few hundred visitors per year, and most of these stayed on the beach. There will be 8,000 visitors in 1990, with the majority motivated by the chance to experience conservation in action. Enhancing this experience by imaginative trails, interpretive signs and other facilities is a development most people are prepared to pay for. Statute currently precludes a direct charge for access, but this is overcome elsewhere through charges for permits or access over a wharf. Charging for access across the wharf by commercial parties seems the best solution for increasing revenue for the continued development of the island.

The value of Tiritiri for translocations of threatened or locally rare fauna is increasingly recognised. Public interest is high, and the extreme level of past modification means that the dangers of an unforeseen impact on existing fauna is unlikely. All birds so far placed on the island have bred extremely well. Most notable have been the consistent double brooding of brown teal (*Anas anas chlorotis*) and the productivity of saddleback. Some pairs produce four broods a year with a clutch of up to double that recorded elsewhere. Some already live in trees planted less than five years ago and the prospects for future liberations of takahe (*Porphyrio mantelli*), little spotted kiwi (*Apteryx owenii*), robin (*Petroica australis*) and fernbird (*Bowdleria punctata*) look equally promising. Continued movement on these releases will reward public expectations.

The attention paid to present planning delays and the establishment of a marine reserve around the north-eastern part of the island will ensure Tiritiri has the potential of being one of the most exciting conservation exercises of the 1990s.

Motuora

GOALS:

(i) Provision of selected habitats
(ii) Translocation of selected rare and threatened fauna
(iii) Protection of fauna, flora, landforms, and history
(iv) Education by public involvement and open but controlled access
(v) Full cost recovery.

Motuora is a denuded island without rodents but also without a habitat suitable for most native fauna. The island is currently farmed. Because of the lack of rodents and the fact that it is too far from the mainland for colonisation by mustelids, Motuora is an important potential reserve for fauna and flora.

Farming of islands has an important historical link with the Auckland region and could be retained to advantage on this island. Farmland could separate four 10-hectare islands of forest and maintain an open edge which could be advantageous for tuatara (*Sphenodon punctatus*) breeding (C. Daugherty pers. comm.). Developing four separate forest areas allows the potential for different plant associations and a more diverse reptilian and invertebrate fauna. Rare birds, including the black robin (*Petroica traversi*), shore plover (*Thinornis novaeseelandiae*) and stitchbird would benefit from having a protected habitat geographically separate from the rest of their range (see Craig and Veitch this volume).

This development need not exclude public participation, even though it involves high-profile endangered fauna. The island could be developed as an outer-island experience. It is these outer islands that offer protection for threatened species at present, and it is features such as a lack of a wharf and highly controlled landing that can be duplicated on Motuora.

The development should proceed much as on Tiritiri. Plants should be grown where possible from local seed sources and planted by the public. Because of the almost totally denuded state of the island, track development should precede planting. Each island of vegetation (Fig. 2) should be developed in a planned sequence starting with the "Chathams-type island". Suitable sponsorship for the early release of a high-profile species like shore plover could provide the initial funds for the project. Providing interpretive material and charging "permit" fees should also be done from the very beginning. It is also worth noting that the presence of unusual intertidal rock platforms argues strongly for an associated marine reserve.

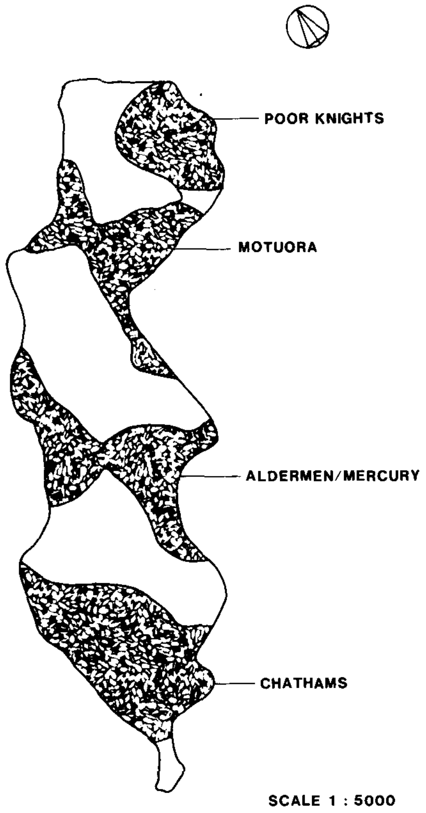

Fig. 2. Outline of Motuora Island showing "vegetation islands" and their likely identity.

Rangitoto-Motutapu

GOALS:

(i) Provision of selected habitats
(ii) Translocation of selected rare and threatened fauna
(iii) Protection of fauna, flora, landforms, and history
(iv) Education by public involvement and open but controlled access
(v) Full cost recovery.

These islands lie within the boundaries of an urban region containing over one million people. As such they offer the potential to educate people about the necessity and the recreational potential of conservation. "they will provide an example to the rest of the world that conservation of threatened habitats and species can occur in highly accessible places. The islands are sufficiently distant from mainland to preclude self-colonisation by mustelids and rats and so offer considerable potential as protection refuges. They already have considerable geological, historical and botanical values although the current lack of interpretive material means that these go unnoticed.

The value of these islands is heavily compromised by the presence of possum (*Trichosurus vulpecula*), rock wallaby (*Petrogale pencillata*) as well as unidentified rodents, cats (*Felis catus*) and mustelids. As we know from the recent success of removal programmes on offshore islands (Veitch this volume), all these animals can be removed. The costs of such a programme may seem high (see below), but they are offset by the potential benefits.

Upgrading visitor facilities, providing quality interpretive material, along with developing and replanting of parts of Motutapu (G. Campbell, pers. comm.) and translocating selected wildlife - stitchbird, saddleback, kakariki saddleback, kakariki (*Cyanoramphus auriceps*), robin (*Petroica australis*) and whitehead (*Mohoua albicilla*) - will offer people a highly accessible outdoor experience that would rival anything experienced in our larger National Parks.

FUNDING

A lack of funds is the single most important factor preventing the rapid development of these five islands or island groups. Where public are told the advantages that will accrue from development both for them and their natural heritage, they will be prepared to contribute. Current statutes allow potential charges for permits and access across a wharf. All projects will benefit from starting with a significant capital fund from donations or sponsorship. Sponsorship, sale of interpretive brochures, and wharf or permit charges will then fund continuing development.

Financial constraints preclude progress on all islands at once. Funding for protection must continue for all islands but development should proceed within clear priorities. Development of Tiritiri Matangi was begun in 1983, and it is important to foster the rapidly growing public perception of conservation that this island has generated. It is ironical that development on Tiritiri is now hampered more by planning inactivity than by finances, as the island has a public fund-raising group, the Supporters of Tiritiri Matangi (Inc). Motuora may need to be a long-term plan, to start after Tiritiri and Rangitoto-Motutapu have provided conservation recreation for large numbers of people.

Funding an ambitious programme like Rangitoto-Motutapu may appear problematical. Public usage of these islands is estimated as more than 150,000 visitors a year (J. Richie pers. comm.), but after development this should be nearer 300,000, once the enhanced experience is offered. Seeking a capital fund of $0.5 million via donations and then progressively taking a loan of up to $2.5 million will allow rapid provision of interpretive material and removal of mammalian pests (Table 1). Charging a wharf fee of $5.00 per adult with children free would easily meet interest payments and allow for repaying the loan over a period in the order of 10 years. The end result is exciting, accessible and meaningful conservation which should eventually provide revenue to further other conservation initiatives.

Table 1 - Likely costings for the development of Rangitoto and Motutapu Islands for the protection of native fauna and flora.

DEVELOPMENT	COST	
Removal of wallaby and possum	$0.5 million	
Removal of rats and mustelids	$0.5 million	
Develop roads and tracks	$1.2 million	
Provide interpretive material	$0.6 million	
Replant parts of Motutapu[1]	$2.0 million	
Provide visitor facilities[2]	$2.0 million	
Translocation of rare birds[2]	$0.1 million	
TOTAL	$6.9 million	
Less public and commercial input	$3.0 million	
FINAL AMOUNT REQUIRED		$3.9 million

[1] Estimate of public labour and donations.
[2] Raise by commercial sponsorship.

CONCLUSIONS

The potential for development of islands for native fauna and flora is immense. The importance of islands as a key to ensuring long-term survival of our fragile habitats is well understood. Islands facilitate a level of long-term management that is not possible on the mainland because of the threat of constant reinvasion of mammalian predators and grazers and weeds.

Conservation of fauna and flora is ultimately for the public and they must be offered access to the full range of conservation activities. Clearly protection of our most fragile island ecosystems means that participation in those areas must be via media coverage, but other equally meaningful island conservation programmes can include the public. The success of Tiritiri Matangi as an open sanctuary attests to this.

Increasing the public use of selected islands and the conservation awareness of those who participate in these activities must be supported by an increase in education of the remaining public. The Department of Conservation needs to further its education role; enlarging the public's perception that islands may be visited will intensify this need for education. Media coverage traditionally and correctly shows people that islands are wonderful and interesting places to visit. Public education needs to take two forms. First, we need to tell people why we need to conserve our natural heritage and hence why they shouldn't visit the most fragile environments. Second, we need to encourage sensitive use of the environment. Unfortunately there will be a need for staff in the field to enforce the law, and the level of this enforcement has to be seen both as a real deterrent against insensitive acts and also as necessary, consistent and fair.

This paper outlines briefly five island developments for native fauna and flora that include varying degrees of public participation. The islands discussed are all in the Auckland area, but similar spectra of development for other conservancies can be offered by people who know those areas well. The development of islands that offer minimal protection for fauna and flora in their undeveloped state (e.g. Tiritiri Matangi, Motuora, Rangitoto-Motutapu) costs money. Charging for commercial entry is a clear way of obtaining the funds necessary to meet the islands' full potential, both for preserving the fauna and flora and for enhancing the experience for the visiting public. The Tiritiri redevelopment programme has shown that people are prepared to support this type of conservation by paying a reasonable fee and by offering their labour. The reciprocal obligation on the Department of Conservation is to ensure that plans for island development are formulated with wide public input. Moreover, when the public achieve their set goals, the islands must be used by the department for previously agreed translocations. Such open and joint participation in conservation programmes will ensure an increasing national and worldwide profile for conservation and allow the potential of island development for the protection of fauna and flora to proceed at an ever-increasing pace.

ACKNOWLEDGEMENTS

The ideas presented in this paper have benefitted from long discussion with Anne Stewart, Dick Veitch, Neil Mitchell, Graeme Campbell, Barbara and Ray Walter, Ian Atkinson, Bob Drey, and Dave Simmons. I also wish to thank the conference organisers for the invitation to participate and to conference participants especially Dave Towns, Charlie Daugherty, and Ian Atkinson for such a free exchange of information and for their comments on the manuscript.

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PUBLIC INVOLVEMENT IN ISLAND RESTORATION

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ABSTRACT

The Royal Forest and Bird Protection Society was founded on the issue of island restoration, that of Kapiti Island in 1923. We are presently involved in New Zealand's most ambitious restoration project to date - eradication of mice and revegetation of the 217-ha Mana Island near Wellington.

Conservation groups and the New Zealand public have always played a major part in island restoration, in particular on large islands such as Little Barrier, Mangere, Tiritiri Matangi, Mana, Somes, and Limestone islands. Public involvement and support are critical elements of success in present and future island restoration projects.

INTRODUCTION

Public involvement in all facets of conservation has always been a feature of New Zealand. We have tended to regard this as the norm in forest conservation and the protection of threatened species, but conservation groups and the general public have also played a pivotal role in the conservation management and restoration of islands.

Public involvement in this has often centred on our larger offshore islands, which of course are most valuable for their greater diversity of plants, animals and habitats. For government officials these large islands have been difficult to tackle, with their local political problems and number of private landowners. Public groups are usually better equipped to overcome these problems, but it is pleasing to see the Department of Conservation fronting up to these issues with respect to Great Barrier, Kapiti and Pitt Islands.

This public involvement varies from general support through to tree planting and rat poisoning, and it can be described as being at five different levels:

1. Generally supporting government officials and park board initiatives.

2. Lobbying politicians, government officials and park board members to initiate island restoration projects or to continue with restoration projects.

3. Raising finance for purchase, management and/or restoration of islands.

4. Being involved in the on-the-ground island management work.

5. Initiating, financing and implementing island restoration projects.

Every island restoration project in New Zealand has involved the public at least to level two (lobbying). Several projects have been possible only because of separate public funding, and for others this extra funding has sped the project along.

A few projects have had volunteer involvement, and this important contribution is becoming increasingly common. A couple of island projects to date have come close to level five, although the advice, support and back-up finance of the Department of Conservation have been crucial to the projects' success.

EXAMPLES OF PUBLIC INVOLVEMENT

The following unselective representation of cases from the past hundred years shows how important public involvement has been in securing island reserves and their restoration. It also illustrates the increasing involvement of the public in conservation and island restoration.

Resolution Island

In the 1880s and 1890s the public and scientific bodies were advocating island reserves for our unique birdlife, which was rapidly declining as a result of habitat loss and introduced predators. In January 1891 the Australasian Association for the Advancement of Science set up a fund for an island reserve, and in September of that year the government gazetted Resolution Island, Fiordland, for the preservation of native flora and fauna. In 1893 the Otago Acclimatisation Society eventually persuaded the government to appoint a curator, Richard Henry, whose restoration work is now legendary. Henry transferred kakapo and great spotted kiwi between islands in Dusky Sound until stoats finally arrived on Resolution Island (Hill and Hill 1987).

Little Barrier Island (Hauturu)

The call for island reserves for flora and fauna was also strong in northern New Zealand. So, in 1892 when the Maori owners of Hauturu (p. 214) began felling kauri forest on the island, the Auckland Institute and Museum Council urged the government to honour their commitment to conservation by buying Hauturu as soon as possible. There was wide public support for this, especially from leading ornithologists Walter Buller and Andreas Reischek (Hill and Hill 1987, Galbreath 1989).

Kapiti Island

Public pressure resulted in the government passing the 1897 Kapiti Island Public Reserve Act, making most of Kapiti (p. 288) a reserve and ensuring that the balance would be eventually sold to the crown. But by 1922, the Kapiti sanctuary was being devastated by 5,000 sheep and goats. The public campaign to restore Kapiti, led by Val Sanderson, forced the government to appoint a new manager and to eradicate the stock. From this campaign, Sanderson went on to form the Native Bird Protection Society (later Forest and Bird Protection Society) with Sir Thomas McKenzie, the former prime minister who had protected Resolution Island, as its first president (Dalmer 1983). The society has played a prominent role in most island management and restoration issues since.

Mangere Island

The demise of the Chatham Islands' plants and animals has been a matter of public concern for a century. In 1966, when an opportunity arose, the Forest and Bird Protection Society helped pay for the purchase of Mangere Island for a nature reserve. In the 1970s the society helped with the revegetation project there. This was in an attempt to increase the forest area for the black robins moved there from Little Mangere (p. 304 and frontispiece), where the building of a helicopter pad, and then a storm, had destroyed most of their forest home.

Tiritiri Matangi Island

In more recent times, both conservation groups and the public have played a wider role in island restoration projects. In Auckland, the Hauraki Gulf Maritime Park Board, in association with Auckland University, Forest and Bird and World Wildlife Fund, have lead the way in island restoration in New Zealand with their Tiritiri Matangi project (p. 214). Thousands of volunteers have travelled to the island to plant trees. This revegetation project has involved people from all walks of life in conservation; not only conservation and service groups were involved, but local radio stations organised boatloads of people to come and plant (Lee 1987).

Now, with saddlebacks and whiteheads reintroduced and forest and shrubland regenerating, the island's attractions are becoming greater. Thousands of Aucklanders are keen to go back to see how their trees are growing - they have an investment in Tiritiri Matangi.

CURRENT PROJECTS

Three current island projects are also worth mentioning. These concern Mana, Somes and Limestone islands (pp. 214, 218), where the Royal Forest and Bird Protection Society, along with local bodies, the Department of Conservation, and the Ministry of Agriculture and Fisheries, are working on island restoration. The assistance of Porirua City's Parks Department has been invaluable in raising seedlings for Mana. The Wellington branch of Forest and Bird financed the growing-on nursery on the island and, as with Tiritiri Matangi, people flock over to Mana to tend the nursery and plant trees in the grassland gullies. But the most ambitious restoration effort yet must be the mouse eradication on Mana. This has been largely organised by Colin Rider from the Wellington branch of Forest and Bird and mainly staffed by Forest and Bird's Conservation Corps and volunteers. Essential advice and logistic support have come from the Department of Conservation's Mana ranger, Trevor Hook, and the department's Wellington conservancy.

It was an unemployment and youth training project, the Conservation Corps, which provided essential labour for the mouse poisoning and some finance for the bait. But involvement of Forest and Bird was essential in getting special discount rates for poison bait from the supplier.

Forest and Bird's network of volunteers turned out on weekdays with DoC staff to lay out thousands of bait stations, 50 m apart over the entire island, and to later replace and check the baits. The poisoning started in July 1989 and was repeated in August; since then, no mice have been trapped, apart from one barren female found in November 1989. The mouse eradication appears to have been successful.

In Wellington Harbour, the Lower Hutt branch of Forest and Bird has been working for a number of years with the Ministry of Agriculture and Fisheries to revegetate part of Somes Island, the quarantine station in Wellington Harbour. Last year, with the ministry's assistance and with Department of Conservation advice, they appear to have eradicated Norway rats from Somes Island and two small adjacent islets. (Rats had only arrived there in the 1970s and were kept to low numbers by quarantine station staff.)

In Whangarei, Forest and Bird persuaded the harbour board to retire Limestone Island from grazing and hand it over to the Whangarei City Council for a reserve. In association with the local Maori people, the Historic Places Trust, and the city council, they have a proposal for revegetating much of the island, wiping out rats and protecting the historical and archaeological features on the island.

Island restoration, like other facets of New Zealand society, is going through the devolution process. Up until 30 years ago people were mainly lobbying government and local officials to take action. Now the public are lobbying, planning, financing and managing island projects.

Forest and Bird's latest initiative is the Chatham Islands Heritage Project. This involves the county council, the Moriori Association, the runanga (Maori management collective), local landowners and the Department of Conservation. We have funding from the Lottery Board's Heritage Fund for fencing stock out of 400 ha of outstanding duneland forest and *Sporodanthus* wetland, for interpretation of the Moriori dendroglyphs at Hapupu and for nature interpretation at other sites. The participants in the programme are now working on proposals for funding for next year. Our approach surprised the locals, since up until now nobody had either asked them what they wanted or had been prepared to find finance for their conservation proposals.

The survival of the Chatham Island pigeon and a number of rare invertebrates relies both on the protection of virtually all remaining forest remnants on Chatham Island (p. 304) and restoration of a considerable area of forest cover. There now appears to be insufficient forest cover to support a viable pigeon population. As most of Chatham Island is privately owned, restoration of its forest ecosystems can only proceed with the support and cooperation of local landowners.

A similar approach would probably meet with success on two other key offshore islands:

> D'Urville Island, which has no possums, rabbits, or hedgehogs and no Norway or ship rats, but which has six mistletoe species and possibly a few surviving little spotted kiwi (see p. 288).

Great Barrier Island, which has with no possums, mustelids, rabbits, hedgehogs, Norway rats or deer, but which has kokako, kaka, black petrel, brown teal, ten reptile species and many more attractions (see p. 214).

Working with private landowners and the public is equally essential on many other islands with high values or great potential, such as Stephenson, Mayor, Great Mercury, Stephens, and the muttonbird islands around Stewart Island (pp. 214, 288). In some cases it may be necessary for the Department of Conservation to play a back-seat role, with a local council, runanga or Forest and Bird gaining the confidence of different community interests so that all can work together for conservation.

Non-government groups should be recognised for the wide role they have in island restoration. They have the capacity to develop island strategies, to plan, consult and organise, to develop restoration proposals, to organise finance for projects through appeals, sponsorship or trusts, as well as the ability to turn out with volunteers on the day to plant trees, transfer birds, or poison rats and mice.

CONCLUSIONS

There are many lessons in island restoration we have learnt over the past hundred years. But to maintain our current impetus, there must be more effort on some of the key ingredients in restoring New Zealand's islands, and each of these ingredients needs urgent attention.

We need a national strategy for threatened species ecosystems and for islands, a strategy that sets national priorities, objectives and goals so that the Department of Conservation and public groups can plan more effectively.

We need national oversight and coordination of island restoration efforts throughout New Zealand.

We need to recognise that public groups may be the lead agency in island restoration projects.

We need, in all projects, some level of public involvement.

The future of many unique native species and ecosystems hinges on the most effective use of all available resources. Coordination and cooperation are the most powerful tools for bringing public groups, private landowners and Department of Conservation efforts together. We have worked away on island restoration of small islands around New Zealand, and we have a number of successes. All of these will be valuable lessons for ecological problems on the North Island, the South Island, and Stewart Island - where our greatest island restoration challenges lie.

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VOLUNTEERS' VIEW OF THE ECOLOGICAL RESTORATION OF AN OFFSHORE ISLAND

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SUPPORTERS OF TIRITIRI MATANGI (INC), P.O. BOX 34-229, BIRKENHEAD, AUCKLAND 10

ABSTRACT

Volunteer workers have played a significant role in the ecological restoration of New Zealand's conservation estates over the last century. They have been involved in the reafforestation of Tiritiri Matangi Island since the start of the development programme in 1983. The Supporters of Tiritiri Matangi (Inc) was founded in 1988 by volunteers to ensure the continuation of the programme and to assist the further development of this open sanctuary.

Projects undertaken must fall within the management plan for the island and have the approval of the appropriate authority. Sources of funds for projects are subscriptions, donations and grants. Grants have the potential for substantial capital input, but also pose significant problems since the applications are essentially in support of a government department.

In fulfilling its aims, the Supporters of Tiritiri Matangi (Inc) will facilitate conservation education and contribute to the management philosophies of the island. Subsequent monitoring of the management practices will ensure that the developmental potential of Tiritiri Matangi is achieved. Given the present economic climate of New Zealand, and the pressure being brought on government departments to be self financing, volunteers will continue to play an increasingly important role in restoration and other conservation projects.

INTRODUCTION

Volunteers (i.e., unpaid enthusiasts) have played a significant role in New Zealand conservation since the 1890s, when Richard Henry first transferred rare birds from the mainland South Island to Resolution Island (Bellingham this volume). Much of the data on the biology of New Zealand's biota have been accumulated by volunteers pursuing their own interests; examples are the Next Records and Beach Patrol Records available through the Ornithological Society of New Zealand (Inc). The collection of data between 1965 and 1975 (by more than 800 volunteers), leading to the publication of *The atlas of bird distribution in New Zealand* (Bull, Gaze and Robertson 1985), represents a very significant contribution to New Zealand biological knowledge.

Volunteers contribute labour and funds to many conservation projects, often developing a strong sense of personal identification with a project. Many are involved in non-governmental conservation organisations that target conservation needs and use members as a resource for implementing such projects. Given the financial restraints presently placed on the governmental conservation agencies, volunteers will continue to have a significant and necessary input into conservation projects.

TIRITIRI MATANGI ISLAND

Volunteers have played a critical role in the reafforestation of Tiritiri Matangi Island in the Hauraki Gulf, New Zealand (see p. 214), following the commencement of the restoration programme in 1983 (James 1990, Mitchell and Walter this volume). Local branches of national conservation organisations (for example, the Royal Forest and Bird Protection Society and Ornithological Society of New Zealand), local service and interest groups (for example, Lions International and tramping clubs) and school groups have been the prime sources of these volunteers.

Since the launch of the programme, 180 000 trees have been propagated from seed and planted by volunteers of all ages from across the social spectrum. The number of visitors to the island each year is in excess of 5000, the majority of these being volunteers on organised planting trips. To join one of these trips, participants pay a fare to cover the cost of boat charter. Other activities that have been undertaken by volunteers on the island are sign painting and installation, nest and roost box construction and installation, track and boardwalk construction, noxious weed control, beach litter removal, nursery propagation work and annual bird surveys.

Tiritiri Matangi Island is a familiar distant landmark; it is visible from many parts of the Hauraki Gulf coastline, and the lighthouse was once renowned for its powerful light beams. Volunteers involved in the restoration of the island identify personally with the island because of its familiarity and their commitment to its future quality.

SUPPORTERS OF TIRITIRI MATANGI (INC)

The Supporters of Tiritiri Matangi (Inc) was founded in October 1988 by a group of volunteers who, aware of the restructuring that the Department of Conservation had to implement, were determined to ensure that the development of Tiritiri Matangi as an open sanctuary was not restricted in any way and that their prior efforts were not in vain.

The main objectives of the Supporters are (1) to promote and enhance the open sanctuary at Tiritiri Matangi and to ensure the continuation of the project; (2) to provide financial, material and physical support for the work at Tiritiri Matangi; and (3) to heighten public awareness of the existence and role of Tiritiri Matangi as an open sanctuary (Extract from the constitution).

Projects undertaken by the Supporters must be consistent with the management plan for the island and have the approval of the Department of Conservation or other authorities involved (such as the Ministry of Transport). The Supporters role, however, is precisely one of support, primarily supplementing the administering authority's input to the island's management and development.

Projects and Funding

In the first year of operation, the Supporters assisted the island's programme primarily through material contributions funded by subscriptions and donations. These included timber and associated hardware for tracks and boardwalks, spraying equipment and herbicide for the control of Japanese honeysuckle, a clothes dryer for the use of research students and volunteer workers, timber for signs at the island's access points, a water pump for automatic irrigation of the nursery, polythene bags for seedling propagation, food for whiteheads (*Mohoua albicilla*) during translocation from Little Barrier Island (Hauturu). Many projects were funded jointly with the Department of Conservation.

An additional source of funds available was that of grants. With a $9000 grant from the New Zealand Lottery Grants Board, the Supporters have provided a four-wheel-drive (FWD) all-terrain vehicle and helped the Department of Conservation buy a 3.8 kW portable generator, for use on the island. Before this, the sole vehicle on the island was a large FWD tractor - slow, heavy, expensive to run, and restricted to tracks, to which it caused considerable damage. The FWD all-terrain vehicle has proved its worth as a versatile form of transport; it has minimal running costs and reduced impact on the environment, and it gives the resident ranger fast access to all parts of the island. The portable generator allows use of power tools on construction projects away from the island's mains power supply, which makes volunteer work on such projects easier and more efficient.

Grants have the potential for substantial capital input into the island project. Complications can arise, however, since any application by the Supporters for a grant is in support of a government-administered estate and often is for a government departmental function. Some grants specifically exclude government agencies from eligibility, and in others the question of legal ownership of the object of a successful grant may pose problems. This was evident from the conditions set by the New Zealand Lottery Board in approving the grant for the FWD all-terrain vehicle. These conditions were that the vehicle and accessories remain in the ownership of the Supporters of Tiritiri Matangi (Inc) and that the Hauraki Gulf Maritime Park Board undertake to provide for ongoing maintenance and cost of upkeep of the vehicle. Although the Hauraki Gulf Maritime Park Board accepted these conditions, their policy on legal ownership of facilities (particularly buildings) provided under grant schemes is still subject to clarification.

Corporate sponsorship is seen as an additional source of funds and/or materials. Many corporations must fulfil environment-friendly mission statements in their management strategies. Du Pont (NZ) have already donated herbicide to control Japanese honeysuckle on the island, and they have publicised this involvement in both New Zealand and Australia. It is well recognised that care must be exercised in the seeking and accepting of corporate sponsorship to avoid exploitation of the island. Control of co mmercial interests can be achieved by all corporate involvement being channelled through, and controlled by, the committee of the Supporters of Tiritiri Matangi.

Involvement in Management

In addition to the seven elected members, a Department of Conservation representative is appointed to the committee of the Supporters of Tiritiri Matangi as a liaison officer. This allows for direct and immediate consultation on events and activities involving management policy and projects, thus ensuring that the management plan is adhered to and that the Supporters views are represented at the management decision-making level. At present, the Supporters do not have a representative on the Tiritiri Island Management Committee or observer status at meetings of this committee, although this situation is under review. The Supporters have been invited to contribute to the drafting of the new management plan for the island.

Involvement in projects on Tiritiri Matangi allows the Supporters to monitor the effectiveness of current management policies at both regional and national levels. Endorsements and criticisms of management policies can then be communicated through the appropriate channels. For example, in August 1989, the Supporters expressed concern about the effects of the America's Cup (Planning) Bill in a submission to the Planning and Development Select Committee, New Zealand House of Representatives. This bill had the potential to fast-track planning procedures and to override established management processes for reserves, both of which could have had a detrimental effect on the value of Tiritiri Matangi as a sanctuary. This exercise highlighted the potential that non-governmental organisations have for exerting political pressure. In the case of the America's Cup Bill, government employees and departments were unable to present submissions. Without the Supporters submission, the specific effects of the bill on the island would not have been represented to the select committee.

Future Projects

Future projects on Tiritiri Matangi will serve to fulfil two aims - protection and education. As a tool for conservation education, Tiritiri Matangi is unsurpassed. Many visitors to the island gain a greater awareness and appreciation of New Zealand's flora and fauna and their conservation. The Supporters will continue to promote and help fund any projects that enhance the island's value as a conservation estate and as a site for conservation education. Interpretive signs and publications are being considered as a means of increasing the educational value of a visit to the island.

Members have indicated that they are willing to present illustrated addresses about the island to interested groups. This is seen as a means of educating groups (such as local boating clubs) whose members do not usually join conservation organisations but may form a significant proportion of the visitors to the island. Considering the dramatic increase in recreational boating activities over the past decade (O'Connor and Simmons this volume), such an approach may prove to be imperative. This form of presentation may also be used to convey information to groups such as service clubs which are being approached to contribute funds to current projects.

Encouraging more visitors to the island necessitates its protection from their physical impact. This can be achieved through a system of well defined tracks, boardwalks and bridges that encourage visitors to follow particular routes. The Supporters have assisted in funding such construction projects to date and see them as a priority for funding.

ATTITUDES TO VOLUNTEERS

The involvement of volunteers in conservation activities can be considered as participative recreation. There is no doubt that volunteers are interested in the activities, and derive enjoyment from their involvement. Most, however, are motivated by a genuine concern for the local (and global) environment, with their involvement providing a sense of satisfaction that they can achieve something positive and lasting for our ailing environment (James 1990). The development of a sense of personal identification increases the commitment that volunteers have to ensuring the success of a project. Many conservation projects would be limited considerably without volunteer assistance.

The reafforestation of Tiritiri Matangi Island is an example of a project where the input of volunteer assistance has been of considerable magnitude - the value of this input to date has been estimated at $1 million (Craig this volume). In accepting such highly valued volunteer input to ecological restoration projects, the Department of Conservation must exercise a reciprocal obligation (Craig this volume) towards the volunteers in ensuring that their work is recognised and valued.

The following points (based on actual experiences of volunteers) should be considered by authorities carrying out ecological restoration projects that involve volunteers:

1. Assistance by volunteers should be acknowledged in an appropriate and timely manner. Failure to do so may undermine goodwill.

2. Being a volunteer means a commitment of time and usually money (e.g., transport costs). The contribution of volunteers, therefore, should be acknowledged as a valued input to conservation activities.

3. Some volunteers have qualifications in conservation-related sciences. Even if conservation employees don't know the background of the volunteers, they should treat them as fellow workers in a common cause.

The above points are logical components of advocacy; volunteer assistance cannot be assumed always to be available, so all possible steps must be taken to ensure that the volunteers' support, interest and input are maintained.

Occasional conflict between volunteers and employed conservation workers is inevitable since interests, opinions, values and qualifications vary (James 1990). Most conflicts can be reduced or avoided if volunteers are encouraged to channel their input through recognised conservation-orientated organisations. Organisations tend to have a degree of control over their own members, a means by which management requirements for the estate can be communicated (e.g., newsletters, meetings), and an elected committee whose members may have appropriate qualifications or skills.

There is no doubt that the formation of the Supporters of Tiritiri Matangi (Inc) has provided a means of increasing the effectiveness of the involvement of the many volunteers contributing to the Tiritiri Matangi project.

SUMMARY

The success of the reafforestation programme on Tiritiri Matangi Island clearly reaffirms the importance of the contributions of volunteers to ecological restoration projects.

The formation of the Supporters of Tiritiri Matangi (Inc) was precipitated by the threat to the future of the Tiritiri Matangi Open Sanctuary revegetation project. Its first year of operation saw the project safeguarded through substantial capital input and revealed a wider and more effective role in volunteer advocacy in conservation management through the provision of an organised focus for the many disparate volunteer groups involved.

Volunteers have played a significant role in past conservation projects, including island restoration, and will perhaps take on a role of even greater importance in the future. Umbrella organisations for volunteers may well enhance the values of volunteer support as has been the case for Tiritiri Matangi Island. Administering authorities should ensure that the volunteer is considered favourably when management strategies and advocacy guidelines are being formulated for conservation estates.

ACKNOWLEDGEMENTS

I am grateful to fellow committee members of the Supporters of Tiritiri Matangi (Inc) for their assistance in preparing this paper.

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PLANNING FOR SUSTAINABLE DEVELOPMENT ON SEABIRD ISLANDS: THE ROLE OF SCIENTISTS IN GENERATING INFORMATION

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ABSTRACT

Further exploitation of New Zealand's seabird islands for such uses as tourism and recreation should not be considered without detailed planning analysis, including physical planning. Successful application of planning methods requires an information base sufficient to provide answers to management questions.

The paper indicates the kind of information planners need and examines how scientists can fulfil scientific objectives while at the same time providing information needed by planners. Examples are taken from research done on breeding populations of wedgetailed shearwater (*Puffinus pacificus*) and black noddies (*Anous minitus*) in the Capricorn Group of islands, Great Barrier Reef Marine Park, Queensland, Australia.

INTRODUCTION

One of the traditional concerns of planning has been assessing the impact of development on space. At present, there are deficiencies in knowledge of the longterm impact of tourism and recreation on natural resources already identified as being worthy of conservation (Australian Parks and Recreation 1982). Scientists are generally reluctant to commit themselves to a spatial delineation of habitats. They correctly refer to physical and temporal change of communities and the varying effects of those changes on different species. However, at a local and regional level, one of the main planning problems still is locating development in places where it is appropriate and sustainable.

A number of authors have approached the problem from various perspectives. McHarg (1969) generated the sieving process, which has been a useful tool where information is limited. It analyses the spatial implications of development by using a composite mapping (layering) technique in which each map layer shows one particular type of restraint or opportunity. Sieve mapping also forms the basis of various numeric techniques. While these can also deal with more complex data, they can be used to indicate constraints to development (areas of high conservation value, earthquake risk areas, unstable slopes, for example) and to highlight opportunities for development, particularly of urban land use considerations such as fertile land or views (Booth 1986, McDonald 1983, Betters and Rubingh 1978). Scientists have criticised such planning techniques as sieving on the basis that interdependences between ecological factors are either ignored or misunderstood, that the weighting of natural values is usually an arbitrary process, and that ecological interactions between subunits (often artificially defined) are ignored (Westman 1985).

The need to ensure that development in natural areas is sustainable also requires consideration of the long term implications of development on the structure and functioning of ecosystems. The conservation of species within their chosen habitats and the protection of rare or threatened species means that habitats, in particular critical habitats, must be identified and either used under controlled conditions or preserved in a pristine state if necessary.

The problem of deciding which spaces are suitable for development is exacerbated dealing with development on small islands, which may have simple ecosystems and lack detailed research into their resources. Spatial analysis is also of special importance on islands because the full implications of the activities (specifically tourism and recreation), relying on the natural resource may be monitored. Segnestam (1975) comments that physical planning, as part of a long term management programme offers the best bird protection in the long run as it protects biotypes.

The aim of this paper is to further examine these problems. By way of illustration the status of current knowledge of the wedgetailed shearwaters in the Capricorn Group will be discussed in relation to the level of knowledge required to effectively plan long-term environmental objectives. While New Zealand islands may have a different character and different problems concerning their possible development, the principles concerning the generation of scientific information for planning purposes are similar.

The topic is developed within the framework of the Ultimate Environmental Threshold (UET) method, which was applied to Heron Island and the others in the Capricorn Group (Kozlowski 1985, Rosier *et al.* 1986, Hill *et al* 1987, Kozlowski *et al.* 1988, Hill and Rosier 1989). In brief, this method attempts to define areas from which development should be excluded because human use may place a given ecosystem beyond the point of no return. The method considers three aspects of environmental quality -uniqueness, resistance and transformation - the possible consequences of development. In association, a research programme has been initiated on Heron to monitor breeding populations of wedgetailed shearwaters (*Puffinus pacificus*) and Black Noddies (*Anous minutus*), which dominate the ecology of the three largest islands, North West, Masthead and Heron (Hill and Barnes in press, Barnes and Hill in press). This work has produced some useful and controversial results, but the greater understanding gained has raised as many questions about the type of scientific information generated as it has resolved.

STUDY AREA

The Capricorn Group is a group of islands, tidal reefs, and shoals at the southern end of the Great Barrier Reef, off Queensland, Australia (Fig. 1). Heron Island (the third largest in the group) currently supports a tourist resort, university research station and the national park headquarters. More than forty percent of the surface area has been cleared of vegetation, mainly *Pisonia grandis* forest, to make way for buildings and associated facilities. Given this situation it is perhaps unusual to find that Heron Island is still an important nesting site for seabirds and turtles and that the remaining *Pisonia* forest is also rare because of its size. The *Pisonia* tree is traditionally associated with seabird islands and guano deposits (Hatheway 1953). Although a number of islands may support isolated clumps of *Pisonia*, there are only five islands (cays) on the Great Barrier Reef with *Pisonia* forests, and four of these are in the Capricorn Group. North West, Masthead and Tryon Islands are uninhabited but are used by campers. Wilson Island is used as a camping and picnic island by the Heron Island resort. Peak periods of demand occur in the summer holiday period (December/January), which coincides with the seabird breeding season.

Proposals in the past to develop the other larger islands have been accompanied by government reports about the suitability of the islands for tourist resorts and the feasibility of constructing airports. Current development consists mainly of toilet blocks being built on islands and structures being built on the reefs surrounding the islands for the purpose of coral reef observation platforms etc. However increasing numbers of day visitors are travelling to the uninhabited islands either in private boats or with tour operators. The nearness of the island group to Brisbane, Queensland's capital city, will result in inevitable development proposals in the future.

North West and Masthead Islands are principal breeding colonies for species of seabirds and turtles and the smaller islands in the group support several breeding colonies of various tern species. In planning for the development and management of the group, particularly Heron Island with its intense development, attention must be paid to the conservation of the key natural elements because of their recognised ecological significance as principal nesting islands for turtles and seabirds (Claridge 1986, GRBRMPA 1978). Those natural attributes also make them desirable tourist destinations and a base for scientific research, but these will be lost if ecological considerations are ignored or dealt with superficially and if sustainable development is not adopted as the major focus. Sustainable development is used in the same context as outlined in the World Conservation Strategy (IUCN 1980).

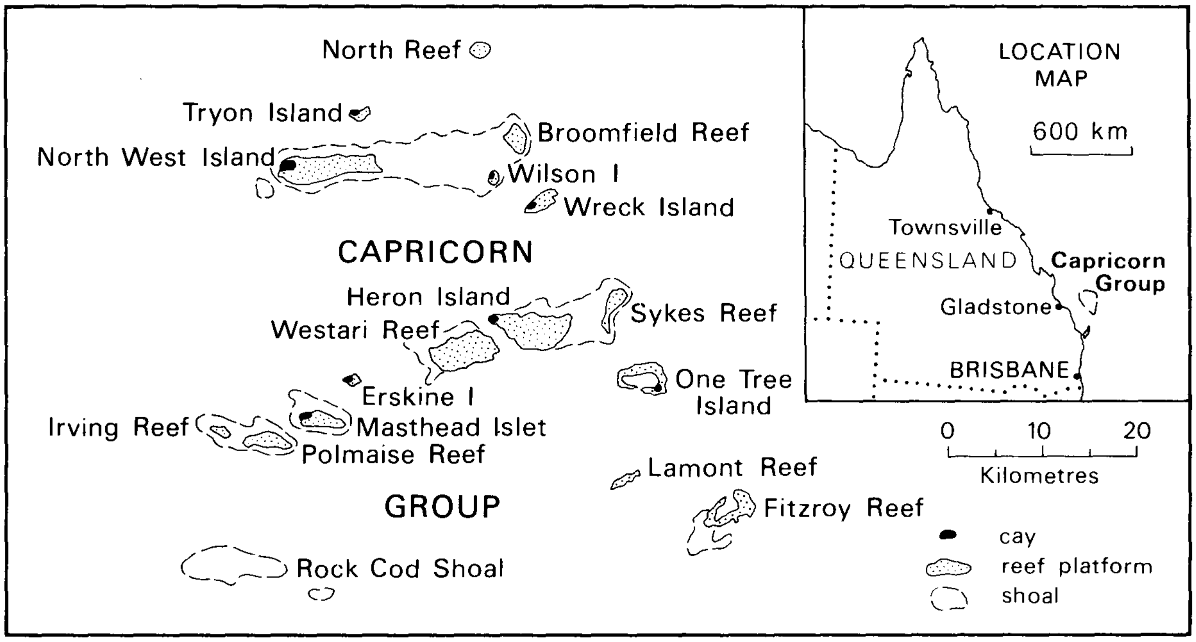

Fig. 1. **Location map of the Capricorn Group.**

INFORMATION NEEDS

The various applications of the UET method in the Capricorn Group have led to defining territorial thresholds for areas in which development of various types is excluded. To define the thresholds, relevant elements (in this study, geomorphologicalstructure, vegetation, seabirds and turtles) are assessed according to their uniqueness or ecological significance, their resistance or ability to cope with human disturbance, and their transformation or degree of change (by humans) from pristine state. The data sets required to provide quantitative assessments of uniqueness, resistance and transformation are extensive and involve in-depth understanding of total ecosystems (worldwide distribution of a species) as well as its component parts (local distribution and ecology of a species).

Ecological significance

Ecological significance is the overriding consideration in an environmentally based approach to planning. A number of problems arise when an attempt is made to analyse a place in terms of its significance to a species. Generally it has been agreed that significance is a subjective value judgement referring both to biological importance and to the significance of the place or species to humans (Cooper and Zedler 1980, Wathern and Young 1986). Consequently authors have approached the analysis in a variety of ways. For example sites which support a critical percentage, as determined by the scientist, of the national or international populations of a bird species may be set aside as significant sites (Lloyd 1984, Ogle 1981). Another approach requires that sites be evaluated by ornithologists using words such as 'principal', 'important' or 'good' when gauging importance (Wright 1977, Adamus and Clough 1978, Williams 1980, Fuller 1980). The UET method bases an estimation of uniqueness or significance of a site on whether it is 'unique', 'rare' or 'common' to a species as a habitat, breeding place, feeding ground etc. Significance is generally measured on a regional and world scale. The ecological significance of a site may also be combined with an evaluation of the viability of conserving the site and the possible scientific and educational values (Tans 1974, Gehlbach 1975, Wright 1977, Adamus and Clough 1978). This type of approach is not favoured by planners, as it introduces a set of variables which alters the emphasis from simply determining the status of a species or of a habitat to deciding whether people want the site preserved and, if so, whether this is possible. Both of the latter issues should be appraised separately at a later stage in the planning process.

In the Capricorn Group, a Great Barrier Reef Marine Park Authority (GBRMPA) report (Claridge 1986) adopted Heatwole's criteria (1984) and ranked islands as principal, major or minor according to their importance as breeding sites for seabirds generally. However, his conclusions differ from earlier studies (e.g. Lavery and Grimes 1971) that indicate a different ranking order. (There is no clear indication of why ranking is different.) Such anomalies pose planning problems, as they suggest, for example, that the status of islands with respect to conservation assessments changes or has changed over time. Since a number of species are involved, it may also be that the importance of some species has altered in relation to others.

Other GBRMPA reports (Hulsman 1983, 1984) provide population estimates for wedgetailed shear waters in the Capricorn Group, and Donahoe (1986) has addressed the international aspects of their distribution. These data highlight the importance of the Capricorn Group (particularly North West Island) as a nesting site for the wedgetailed shearwater. No indication is given, however, of critical issues such as the level of protection afforded other nesting sites or whether the populations are increasing, stable or declining. While general evidence suggests that the wedgetailed shearwater is secure internationally (Nelson 1980), detailed studies are lacking.

The overall level of information available on ecological significance of the Capricorn Group Shearwater population and the individual island sites is certainly inadequate from a planning point of view. As Hulsman (1983) points out, it may take up to ten years to gather relevant data, and this is conditional on a decision to do so being made by management authorities.

Resistance

The resistance of a species is evidence of its resilience, but the measurement of resilience is difficult. Researchers have developed various indexes, using one or more factors to arrive at an estimate of a species' resilience. Westman (1985) identifies several factors that need to be taken into account including restoration time, the threshold beyond which repair to the system can no longer occur, the comparison of change caused by chronic stress to stress associated with normal succession and the degree to which the final altered state differs from the original state before impact.

The reactions of seabirds also depends on the duration of contact with humans and may range from diminished sensitivity to humans, avoidance of humans (e.g., through migration) through to the collapse of the population, depending on the species. The effects of human activities on groundnesting seabirds are particularly difficult to evaluate (Anderson and Keith 1980). Resistance of wedgetailed shearwaters may only be gauged superficially due to a lack of research into this aspect of their ecology. Nelson (1980) records that disturbed sites are less attractive as nesting areas although this does not appear to be a universal phenomenon (Hill and Barnes in press). Since shearwaters lay only one egg per season, any damage to the nesting burrow during the nesting season will affect success. The physical layout of burrows is such that severe damage occurs if humans enter an area with high burrow densities. This applies to non-breeding and breeding seasons (Nelson 1980). The degree of impact is difficult to gauge without understanding the optimum levels of breeding populations, but research into this takes years of work.

Wedgetailed shearwaters in the Capricorn Group appear to have accepted the presence of humans insofar as they nest around buildings in the developed area of Heron Island and apparently take little notice of humans.

A secondary issue is the effects of any damage to the island vegetation, which is ultimately sustained by the breeding population of seabirds. It has been historically accepted that the guano deposited by seabird populations is necessary for the continued survival of the *Pisonia* forest and that if the forest is substantially destroyed, the soil becomes severely degraded so that sustaining other vegetation is difficult (Hatheway 1953, Stoddart 1984).

Recent research on Heron Island (Hill and Barnes in press) also indicates that the highest nesting densities are found in habitats modified or created by development activities on the Island. However nesting densities on Heron Island are consistently lower than in corresponding areas on North West and Masthead Islands. There has been little research into the patterns of nesting, an aspect which appears to be significant for birds nesting synchronously. For example, distribution of pairs may be partitioned within the colony with older successful breeders choosing the key locations (Nelson 1980).

No research has been conducted into nesting patterns for the Capricorn Group populations or the impact of buildings and pathways in splitting natural groupings in the colonies. Existing data also relate to nesting activity, not actual breeding success, so the existence of nesting activity may not necessarily indicate a high resistance. Obviously, the resistance of the shearwater colonies on the Great Barrier Reef is not fully understood. Many reports, largely anecdotal, suggest a 'nil/minimal' resistance to disturbance and stress the importance of pristine *Pisonia* forest to the maintenance of the Capricorn population. On the other hand, systematic research into the problem (Hill and Barnes in press) suggests that this may not be the case, and the issue is not yet resolved. Researchers have not formulated findings in a manner that lets information be used in the application of a planning method, and anecdotal accounts don't allow even superficial judgements to be made about any of the factors which could be used to measure resilience so that satisfactory planning recommendations may be made to developers.

Transformation

In UET terminology, 'transformation' is the degree to which an element has changed from its original state, where self-regulating mechanisms were working and a balance was maintained between biotic and abiotic factors. Transformation and resistance are analysed separately to allow more scope for describing possible rehabilitation or further exploitation. Either option can vary by the degree to which transformation is irreversible or to which a given species is resistant to change.

Obviously management of human usage can substantially affect the degree to which transformation is detrimental to the whole ecosystem. (For example, pathways may be built over nesting areas.) Transformation, described by using a rating scheme (total, partial or nil/minimal), may be either reversible or irreversible. The significance of transformation is realised through an assessment of the target organism's resistance or its ability to cope with changes induced by human interference to the ecosystem.

The information available to gauge transformation to seabird colonies is difficult to use with any accuracy. The mere presence of humans (even doing research fieldwork!), predation by introduced species, human exploitation of eggs, fledglings and adults, destruction of habitat along with accidental deaths at sea resulting from oil pollution, ingestion of plastics and being drowned in fishery nets are all impacts which may transform seabird systems The difficulty of isolating specific effects of human impact on land portions of reef/cay systems (Fosberg 1961) from the natural impact caused by cyclones, nesting turtles and inadequate food supply in the breeding area also causes research problems. Different species are affected in different ways and to varying degrees (Nelson 1980, Croxall 1987, Furness and Monaghan 1987). Although the wedgetailed shearwater is relatively common, it is virtually a mystery bird along with other species of Shearwater, as the migration and feeding habits of all of them are so difficult to research (King 1974).

Literature dealing with the Capricorn Group lists many transformations to the environments used by the wedgetailed shearwaters. These include destruction of habitat, tree removal, compaction of soil, construction of buildings and paved areas, irresponsible disposal of garbage, feeding of seagulls and the introduction of exotic fauna and flora (Hulsman 1983, 1984, QNPWS 1983, Heatwole 1984). However, observations are general and, again, impacts are described in an anecdotal fashion. While these impacts are recorded on highly developed Heron Island, most can be found in some form on all islands in the Capricorn Group.

CONCLUSIONS

Some applications of planning methods may result in inadequate generalisations, incorrect assumptions and possible misuse of ecological information if the members of planning teams are not selected from the necessary range of disciplines and if working guidelines are not explicitly stated. However, it is also important for scientists doing work in the field to realise that an adequate data base must be able to contribute to planning objectives as well as scientific ones. This is especially relevant in ecologically sensitive places where the information is inadequate or difficult to gather and where developmental pressures require immediate decisions about the allocation of space. In the Capricorn Group, for example, the seabird research has been carried out with little understanding of the planning context in which it may be used. Information has been gathered with scant regard for the problems of using data on the environment along with the planning methods used to allocate development of specific spaces.

Limitations of current research and priorities for further research should be stated if data are to be useful to planners. For the Capricorn Group, seabird researchers have neither stated where evaluations are subjective nor have they alluded to research priorities until recently (Hulsman 1983, Hill and Barnes in press). And even in recent work, the objectives still reflect the priorities of individual researchers, not of the management agencies.

Finally, information must be documented in a form which lets future research build accurately on previous work. Assumptions should be stated and anecdotal accounts must be noted as such, because of their influence on the assumptions of future researchers. The acknowledgement of the degree to which information is based on conjecture assists the planning team in weighting the importance or relevance of information used in the planning process.

Planners acknowledge that the gathering of ecological data in remote places, such as islands, is difficult expensive and time consuming. It is also accepted that personal experience, expert opinion and conjecture are all valid sources of information in situations where scientific research is incomplete. However - where scientific research has been carried out - the information gained can only be effectively used in the planning process as a basis for considered estimates and guesses about the future if scientists consult with planners about the design of, and assumptions made in, applied ecological research. To complement this, management authorities who are responsible for developing research guidelines and for allocating priorities in research programmes have a responsibility to foster research which is specifically oriented towards planning requirements.

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THE VALUE OF PRISTINE ENVIRONMENTS

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ABSTRACT

The impact of human and environmental changes on the many islands in the New Zealand region ranges from massive ecological upheaval on some islands to a state close to pristine wilderness on others. To date, conservation effort has tended to focus on restoration and management of endangered species on affected islands; islands in a pristine state have received scant attention. Yet such islands offer a range of scientific and cultural values which are rarely defined explicitly. We explore the value of islands in a pristine state and suggest that such places deserve and need more attention than they receive. They may operate as a control or reference for restoration work on more severely changed islands, they may serve as biological indicators for general environmental trends, and they have a great potential value for future generations.

INTRODUCTION

Human impact on the many islands in the New Zealand region has subjected some areas to massive ecological upheaval and left others in a state close to pristine wilderness. In many cases the extent of change is unknown, because introduced animals such as goats or cats may have removed all trace of some species from the island, even endemic ones. It would be difficult, therefore, to assign any one island a calculated "level of impact" based on such criteria as number of species that have disappeared, number of years of human habitation, or number of introduced species. Such measures would probably be meaningless anyway, because the costs associated with (for example) extinction of a species or an environment changed by the presence of grazers are unlikely to be measurable in equivalent terms.

With a few notable exceptions (e.g. Waiheke), New Zealand islands tend to be relatively undeveloped environments that provide qualities important to individuals and society, such as beauty and peace. In addition, they provide a wide array of benefits, by being places for recreation, natural laboratories, or sources of knowledge (of genetic diversity, for example). People can derive these benefits either directly, by visiting the island, or vicariously through television or by growing an unusual island variant in their garden. Some might benefit simply from knowing that these places exist and that policy is aimed at preserving them for future generations.

Over time, benefits can be said to "flow" from the island, because people are gaining by its existence. Benefit flows depend on information, including information that the island exists, information about what is on that island, and information that the state of the island is being maintained (or enhanced). Information is therefore a necessary precursor to benefits. Also, the best way to recruit people who will appreciate the benefit and help maintain it (e.g. funding supporters for island management) is to provide information; otherwise, support may disappear (Meter 1980).

Here, we investigate the value of pristine islands, those unused or unspoiled in the sense of being unmodified by human activities. We ask what pristine environments have to offer humankind, and whether they require something other than to be left alone in order to maintain their pristine state. We acknowledge that any environment may have existence values independent of human awareness, but in this paper we restrict ourselves to a human perspective, because this is of primary relevance to the conference theme.

DO PRISTINE ENVIRONMENTS EXIST?

Truly pristine environments presumably no longer exist anywhere on the planet. Environmental pollutants such as acid rain, dioxins, CFCs, radioactive materials, and discarded plastics constantly reach every land surface on the globe. New Zealand's subantarctic islands are extremely remote, yet most are visited by tourists nearly every year. Islands are therefore subject to a continuous (and increasing) impact generated by human activities.

There are two senses of impact relevant here. The first is like a chronic disease, where impact is at a sustained low level and may be impossible to control (examples are listed above). The second is like an acute illness, where sudden and drastic changes are wrought by a change of state (human residency and the creation of farmland, or the introduction of exotic plants and animals).

Islands subject to acute impact will presumably eventually attain a dramatically different state of equilibrium; this invariably involves extinctions or restrictions of range of some plants and animals, invasion and expansion of others, and often involves ecological upheaval on a grand scale. Although virtually all New Zealand's islands have experienced a sustained human presence, on a few (e.g. Aldermen, Snares) this has been limited to short stays (a few years at most) with little gross modification. Some others - Little Barrier, Codfish, Mana, Allports - are being restored to a more original state.

Islands subject to chronic impact may stay virtually unchanged for long periods. However, subtle, widespread, and unsuspected damage may occur, such as the impact of DDT on breeding success of many bird species. All islands probably experience chronic impact in relatively similar ways. Our lack of knowledge of what these might be is one of the core themes of this paper.

Pristine islands do not exist. However, islands do exist which have not been subjected to the acute impact of humans or our commensals (camp followers such as rats and weeds, food or farm animals such as weka or sheep); their ecology may be little different from what it was before the arrival of humans in New Zealand. Such islands can be regarded as close to pristine, and we suggest that they are a valuable resource for assessing the effects of chronic impact on those other islands (including the mainland) which are of more immediate value to the current human population. We are, in a sense, without a baseline for investigating the value of pristine islands because all are subject to some level of impact; for present purposes, we will consider as pristine those islands subject only to chronic impact.

WHAT ARE THE BENEFITS OF PRISTINE ISLANDS?

Numerous maintenance and restoration options confront legislators and official decision makers. A meaningful analysis of the alternatives would compare the total benefits individuals attach to restoration or maintenance of the natural environment with the costs of management. If benefits exceed costs, then that management option can increase the welfare of New Zealanders now and in the future.

To the economist, value arises from a preference relationship. Preference for state A (pristine island) over state B (degraded island) derives from one's assigning a higher value to state A (Brown 1984). The benefits of island management derive from the value of the existing quality of island resources. Because of continued chronic impact on islands, it is possible (even likely) that a policy of "doing nothing" will eventually reduce the flow of values associated with a given island. Since benefits and damages are mirror images, diminishing benefits must be regarded as damages and a measure of the value of what is lost when island quality is degraded.

An essential component of this argument is that damages (which may be measured retrospectively) are usually easier to measure than benefits (which are often analysed prospectively). However, without an analysis of benefit values it may be impossible to determine the level of justifiable cost to attach to maintenance of those benefits. Also, restoration cost after degradation may be massively higher than the cost of preventive maintenance.

Where resources are limited, decision making has to include an examination of opportunity costs. Opportunity costs are the maximum net benefits foregone by not using a resource in its next best alternative use. Information on opportunity costs is of central importance in allocating scarce resources among competing ends. In island management projects, market institutions can supply information on the opportunity cost of using labour and capital as inputs. Current island management policy has two types of opportunity costs. First, tax money has alternative uses within the economy. Second, scarcity of money means that some projects cannot be undertaken, so the benefits associated with those projects are foregone.

Unless adequate information is provided, projects which could benefit the community may not get funded. Such a situation would not last for long in a competitive market because entrepreneurs would redefine their needs to take advantage of available finance. However, non-market institutions tend not to continually update information on costs and benefits, in part because the values associated with their product are either poorly defined or difficult to measure.

The amount of benefit received will vary across the spectrum of islands within New Zealand's jurisdiction. The amount associated with pristine environments in particular, is likely to be uncertain at best. This uncertainty stems from a lack of information about people's existing and future preferences, but it also stems from a lack of scientific knowledge about the island systems. It is difficult to imagine how individuals can assign values to pristine environments, and then decide which they prefer, without baseline scientific knowledge of the areas concerned, especially as the acquisition of such knowledge is usually one of the primary justifications for maintenance of the pristine state in the first place.

The total benefits of an island can be broken down into two components (Kerr and Sharp 1987). First, use benefits are those we typically associate with visiting an island, for active recreation or for enjoying its natural beauty. Some use benefits (e.g. forestry) necessarily change the character of the environment and may impinge on benefit requirements of other users (e.g. recreation). Visiting may also be indirect (via TV, books, or by studying scientific reports) and may enhance immediate conservation benefits with minimal direct impact. Recreation and commercial use are obvious use benefits; we can also include scientific use (including active conservation efforts) and the need for islands as a source of knowledge and for cultural use.

Great uncertainty attends the future use and availability of any island's resources. Even though resources are not used now, it may be quite rational for current non-users to pay for an option that offers a future use.

Second, existence benefits are those derived from the knowledge that island environments continue to exist. They include simply pleasure, the potential knowledge that can be derived from the island, passive conservation (that is, the preservation of the original state), both spiritual and cultural value to future generations, and the possibility of deriving information on genetic resources. Existence benefits are non-depletable, and many individuals can profit from them simultaneously. People not using the islands now, and also unlikely to do so in the future, can nevertheless be affected by policy, and might be willing to pay something just to know that the island exists and is being preserved. For example, many New Zealanders do not expect to see a kakapo in the wild but are quite happy to see their tax dollars spent on the preservation of this animal.

Clearly, different distributions of total benefits will exist for different islands. Use benefits will probably dominate estimates of total benefits in accessible northern islands, while existence benefits are more likely to predominate in the remote southern islands. Use benefits can generally have a monetary value placed upon them, although some less easily valued benefits may also be involved. However, we believe that existence benefits of islands are currently rather poorly defined and the benefits are probably undervalued. Unfortunately, without such valuation it becomes increasingly difficult to assess cost/benefit equations to ensure that existence benefits are maintained. In a situation of limited resources, it is likely that those benefits that can be given immediate cost assessment will be considered first.

In general, use benefits are likely to be incompatible with the maintenance of a pristine state, although it may be possible to achieve some of these benefits with minimal impact Existence benefits are compatible with pristine environments, but they do not allow for monitoring to determine if the pristine state is being maintained. Given chronic human impact on environments at a global level it is probably impossible to maintain a pristine state without some level of monitoring or interference. Some 'use' will be required in order to maximise existence benefits. See Ehrenfeld (1976) for a more detailed analysis of existence benefits.

Although existence benefits should be emphasised for pristine islands, we suggest that current global levels of chronic impact make some "use" of any island inevitable. In order to keep existence benefits, information about the state of those islands is necessary. Obtaining that information will necessarily involve visiting, some impact, and some costs. Given that environmental monitoring is required, there are at least three potential benefits of pristine environments that may involve little or no impact additional to a monitoring program (Ehrenfeld 1976).

First, pristine environments are a place where chronic impact on other, more immediately important human environments can be assessed. Essentially, they may be the best location for monitoring what amounts to a huge experiment in environmental modification. A process such as the greenhouse effect is not usually regarded as an experiment, but it does represent a manipulation of the environment, and we should consider it - among other things - as an experiment that gives us valuable data.

Second, a primary and laudable objective of conservation organisations is restoration of a pristine state for its own sake. Pristine environments can provide information on just what constitutes a pristine state elsewhere, allowing assessment of whether such a state is achievable in other areas within their resource constraints.

Third, pristine environments may provide a laboratory for testing management procedures proposed for restoring environments to their original state. The cost of such tests may be considerably lower than either the cost of implementing the proposal without testing first, or the cost of impact on the pristine island; it may be far outweighed by the benefits obtained from refining one's proposal.

CONCLUSION

We have said that baseline information is necessary to sustain the benefit flows from pristine islands. Additionally, we suggest that pristine environments could be used with little additional impact to gather important information relevant to management and environmental monitoring. If this is accepted, then research on at least some pristine islands must be regarded as a necessity. We do not believe that there are currently in New Zealand any research projects under way which have been designed to maximise the benefit flows from pristine islands.

The main reason for this lack appears to be that pristine islands have not been adequately represented in analyses designed to distribute the limited resources available for conservation activities. This lack of representation, in turn, is because the benefit flows from these islands are underassessed. We suggest that pristine islands are an endangered species, and that attention to their needs may already be overdue.

ACKNOWLEDGEMENTS

We thank F. Proffitt for discussion and Colleen Cassady St Clair for comments on the manuscript. Our research is funded by the New Zealand Lotteries Board, the Department of Lands and Survey, the Department of Conservation, and the University Grants Committee.

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THE USE OF ISLANDS FOR RECREATION AND TOURISM: CHANGING SIGNIFICANCE FOR NATURE CONSERVATION

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ABSTRACT

Restoration of islands for nature conservation is challenged continuously by changes in recreational and touristic behaviour. This paper explores the three key elements in recreation and tourism planning - the user, the environment, and potential management responses - and examines their significance to island restoration for conservation. Recent trends in New Zealand and elsewhere demonstrate increases in island-related recreation. Illustrations are given for both northern and southern parts of New Zealand. Use of islands is affected significantly in volume and character by the nature of the islands and means of access to them.

Conservation objectives for natural environments must be clear in order to formulate management objectives for compatible recreational use. Management solutions need to continue both preservation and recreational use. If people do not use these island areas and do not learn to feel strongly about them, preservation may ultimately lack essential support. The dispersed nature of the resource base, the management of recreation access and ongoing visitor education are key considerations.

ECOLOGICAL PERSPECTIVE

We have both worked for some years in the study of recreation in different settings. One of us has concentrated on tourism studies in recent years, the other on interpretation of ecological principles in resource management, especially for different land uses, including nature conservation. Neither of us has made a speciality of marine recreation but both of us are aware of the significance and limitations of islands for recreation and for nature conservation. We are conscious of the great potential for nature conservation which islands present - as refuges for rare and endangered species, as sites in some degree isolated to allow evolutionary processes to continue in their own expression, and as sites preserved from particular forms of disturbance. We are conscious too of their value as nature reserves in a sea of changing landscape, even though we often recognise this only indirectly. These values have been expounded and examined by MacArthur and Wilson (1967), Diamond (1972, 1975), Diamond and May (1976), Cody and Diamond (1975), Simberloff and Abele (1976) and Gorman (1979). For New Zealand in particular, rigorous expositions and examinations have been presented by Knox (1973), Crisp (1985), Williams (1984) King (1984), East and Williams (1984) and Diamond (1984).

Neither of these lists is in any way complete; they just show that we also care. Because we care, we invite you to examine the potentially large significance of recreation and tourism for the restoration and maintenance of islands as part of nature and culture heritage. In proposing such an examination, we suggest you continue in the mode of island ecology in which you have been so well led from the beginning of this conference. We suggest that you consider *Homo sapiens* subspecies *recreationalis* var. *aquaticus* or *H. sapiens* subspecies *turisticus* as including particular forms of what Jared Diamond, from his observations on Long Island in the New Britain group, dubbed "super tramps". These are species which have been selected by their ability to disperse across open water and for their rapid powers of reproduction, species which specialise in occupying islands too small to maintain stable long-lasting populations or islands newly exposed by some traumatic event.

We propose as a hypothesis for your later testing that some current aquatic recreational behaviour in the setting of New Zealand inshore and offshore islands conforms with these characteristic attributes of super tramps where dispersal is a way of life. We propose as a further hypothesis for your later testing that these people, being *Homo sapiens*, can be persuaded to modify their behaviour to avert the potentially disastrous fate for island nature conservation that the current way of life could bring.

We also propose for your examination the hypothesis that the mode of behaviour of *Homo sapiens* subspecies *turisticus* in the recreational setting of New Zealand outlying islands is also characteristic of that of a super tramp. We suggest that in the Southern Ocean this particular super tramp may not be so amenable to self correction and may soon make its way of life unsustainable. We fear that its self-willed extinction could be accompanied by the loss or transformation of several systems with consequential extinction for many island species.

It is ironic that the once famous rock group Super Tramp should have used as an album cover a picture of a well-shielded, obviously opulent, passive recreationist failing to observe the destruction about him, to the phrase "Crisis! What crisis?"

The main facts (and their implications) to which we want to call your attention are:

Boat use and numbers are high and rising rapidly.

Inshore and closer offshore islands are favoured boating recreational settings.

Boats show increasing variety, including an increasing capability to disperse across open water; boat users with such capability increasingly make use of it, bringing further offshore islands into the recreational ambit.

Boat visits, with or without regular landing rights, increase the risk of disturbance to islands.

Public education for conservation responsibility in maritime recreation is essential for nature conservation on islands.

Recreational opportunity spectrum planning for maritime resources is essential for nature conservation to be possible on islands.

With respect to conservation uses, commercial recreation boat uses will have to receive special attention.

OWNERSHIP AND USE OF BOATS IN NEW ZEALAND

Tables 1 and 2 give basic information from the New Zealand Department of Statistics (1971, 1981) on the numbers and general types of pleasure boat used in New Zealand. In response to our enquiries, J.M. Terry, Executive Officer of the Auckland Volunteer Coast Guard Service, said "We are aware of the steady increase in boat anchorages and strain on the island anchorages and beaches, and would not doubt that the boating population of the Auckland district was double that of the 1981 census." Growth seems fast, although imprecisely known.

Table 1. Pleasure Boat Ownership, National Figures

Year	Households	Boats	%
1971	801 686	77 529	9.7
1981	1 003 113	171 690	17.1

The increase in ten years in proportion of households with boats was 76%. The increase in number of boats was 122%. No more recent data are available.

Table 2. Pleasure Boat Types

Year	Boat numbers	Outboard %	Inboard %	Sail %	Paddle %
1971	77 529	48.9	24.4	12.9	14.8
1981	171 690	40.8	19.5	15.8	24.1

In 1971, 91% of boats were less than six metres long. While data on boat length are no longer collected by the Department of Statistics, sources in the boat building and retail industry confirm that the number of larger boats is increasing, as is the range of smaller craft (owing to more powerful, fuel-efficient engines).

Boat ownership is unevenly distributed in New Zealand. Highest proportional boat ownership is centred on Whangarei (19.5% in 1971). Auckland (12.1%) and Nelson (14.8%) were also above the national average of 9.7%, and Christchurch (6.9%) was below. Similar relationships persisted in 1981 census. (The situation is less clear from a 1988 sample consumer survey of 3400 households.)

In his *Boat Safety Report of 1988*, published in 1989, Michael Foster examined boat populations of various areas in the context of the ratio of pleasure boats to police boats. He conservatively estimated Auckland boat numbers at 70 000 for 1989, demonstrating a very wide pleasure boat to police vessel ratio, in comparison with Perth/Fremantle and Brisbane/Gold Coast in Australia, Thames in England, and Toronto in Canada. (He also suggested (from 1981 data) that Northland with 11 556 boats, Tauranga with 12 777 and Canterbury with 14 526 boats could also benefit from the presence of a purpose-built sea rescue/police boat. Wellington (10 437) now has a new police boat.) Nelson/Marlborough, which has a combined boat population of more than 9 000, shouldn't be overlooked, as it is periodically enriched by boats from other centres.

Favoured areas for moorings in summer months, especially for larger craft from other centres, are the Bay of Islands, the Hauraki Gulf, Nelson and the Marlborough Sounds, all areas characterised by varied shorelines and many islands. At the same time as an increasing amount and variety of activities associated with boats of different kinds affects inner waters, there are more craft which can (and do) cross more open water, as documented by Book (1982) in a visitor survey of the inner islands of the Hauraki Gulf. Foster's 1989 assessment of most popular boating locations identified (1) the inner harbour and surrounds of Rangitoto, Motutapu, Waiheke, Pakatoa, and Ponui islands to Orere Point, (2) Thames shore, (3) western Coromandel from Te Kouma northward, (4) western waters off Great Barrier Island, (5) small area of eastern waters off Great Barrier, and (6) Leigh to Whangaparoa, including Kawau Island and Tiritiri Matangi Island (see p. 214).

It is important to note that, apart from the minority engaged in racing, cruising boats often demonstrate important features of flocking behaviour in favoured sites, accompanied by basking and loafing behaviour. For many relatively fast boats this loafing time may exceed 80% of experience time. In some areas, rather than gregarious behaviour, boats display solitary behaviour, often loafing in the lee of more remote islands.

Book's (1982) observations at close offshore islands - Rangitoto, Motutapu and Motuihe - indicate some boat species aggregations as striking as an aggregation of shags, oyster catchers and dotterels on an estuary.

VISITOR BEHAVIOUR

Where visitors ashore were concerned, ferry transport dominated over private transport on Rangitoto-Motutapu; this situation was reversed on Motuihe Island. Distribution of party size was similar for all four conveyance-destinationgroups. Length of stay, frequency of visits and concentration on aquatic recreation were higher for private boat travellers (Book 1982).

Recreational behaviour is greatly influenced by preference and opportunity for participation. Water and water-based settings and activities are a major focus for outdoor recreation in New Zealand. The *Policy for outdoor recreation in New Zealand* (NZCRS 1985) summarised national recreational trends and concluded, "When the three most favoured activities of each individual are reviewed, active outdoor recreation is significant to almost half of the population. The most popular of these activities are swimming (11%), fishing (9.2%), short walks (8%), tramping (4%)...."

Activities related to outdoor conveyances, among the top three favoured activities for 17% of the population, include boating (7%) and driving (4%) as major activities.

Two population-based studies, one in Auckland (ARA 1973) and one in Christchurch (Murphy 1981), recorded any participation (from one to more than 15 occasions) in the most popular activities over the previous year. Casual activities were the most popular, with participation decreasing as activities become more specialised and more physically demanding. Among the 16 most popular activities listed, water-based recreations are well represented.

Table 3. Participation in Water-based Activities

Activity	Rank	% Participation (Auckland)	% Participation (Christchurch)
Visit beach	2	85	77
Swimming	4	65	52
Sea fishing	7	35	20
Pleasure boating	9	22	28
Power boating	12	12	10
Sailing	13	11	5

Source: NZCRS (1985)

Murphy's 1981 study for the New Zealand Forest Service also reported that beaches and oceans were the most favoured out-of-city locations for recreation, attracting 79% of the population for an average number of 14 visits during the previous year. The next most popular natural setting was lakes and rivers, with 50% of the population visiting an average of seven times during the same period. Forests and mountains attracted about one-third and one-quarter of the population respectively, with slightly fewer visits on average.

Environmental and cultural conditions may greatly influence boat visitor behaviour. This is illustrated for the Bay of Islands and the Marlborough Sounds. The Department of Lands and Survey sponsored major studies in both the Bay of Islands (Department of Lands and Survey 1980) and the Marlborough Sounds (Schellhorn 1984). These provide insight into recreation patterns and expectations in major island parks. Even given the recognisable differences between the two geographical areas, the Bay of Islands and the Marlborough Sounds are comparable in recreational features. Both parks are popular recreation environments with outstanding coastal scenery, and both feature important sites of Polynesian and early European history. The methodological bases for both studies were similar, with an anlysis of self-administered questionnaires for visitors and residents as the primary research method. Both studies were undertaken throughout the peak summer holiday period. The Marlborough Sounds study, building on the experience of the Bay of Islands study, was supplemented by interviews at four reserve sites, representing a range of recreational and access attributes, as well as by an aerial boat-counting programme. While some differences in the specific items questioned exist, the studies provide a reasonable basis for comparison.

In the Marlborough Sounds, the three most popular activities are water-based, while visiting historic and scenic sites predominates in the Bay of Islands (Table 4). In both studies, access to private boats is usually prerequisite to other water-based activities. Commercial cruises are an important activity for close to one-third of each sample. Schellhorn (1984) noted the significance of this service to those who do not have access to private boats, and their importance to the first-time visitor. He reported, "More than half of first-time visitors go on a cruise (51.9%). This figure is slightly lower for holiday makers with few previous visit experiences (33.9%) and drops significantly for the regular holiday makers (12.7%)."

This trend demonstrates the importance of commercial boat services as an initial information and orientation base.

Table 4. Comparison of Water- and Land-based Activities, Bay of Islands and Marlborough Sounds

Activity	Bay of Islands %	Marlborough Sounds %
	Water-based	
Fishing	N/A	61.6
Swimming	N/A	60.5
Sunbathing	51.4	57.7
Organised cruise	26.4	31.3
Boat fishing	24.9	N/A
Cruising boat	21.6	N/A
Shore fishing	13.6	N/A
Snorkelling	11.5	16.3
Power boating	10.8	27.8
Sailing	9.8	13.2
Water-skiing	5.0	9.0
Scuba diving	4.3	9.0
Windsurfing	-	4.3
	Land-based (three major activities)	
Scenic/historic visits	64.7	N/A
Picnicking	29.6	39.8
Short walks	27.7	57.3
Driving	N/A	36.4

Sources: New Zealand Department of Lands and Survey (1980); Schellhorn (1984).

Schellhorn noted the changing mix of visitor activities, which was attributed to the Marlborough Sounds' physical attributes and the ease and means of access. For example, in the Sounds, sailing reached its highest user frequency in Ship Cove (50%), while motor boating was highest among users of Mistletoe Bay (54%), where there is road access and a jetty.

Apart from Book's (1982) short survey and the similarly short survey of visitors to Kawau Island (Department of Lands and Survey, 1983) little is known of how visitors use specific islands once they have gained access. It seems fair to postulate that users of private boats, while more difficult to monitor and manage, are less likely to travel far from their boats if they must leave them unattended (Rex Mossman, Department of Conservation, pers. comm., October, 1989). In contrast users of commercial services have the capacity, and relative freedom from immediate responsibility, to allow large numbers of visitors to penetrate further into island environs. Regulatory responsibilities for commercial operations make it possible to determine and monitor where specific impacts are likely to occur and to manage for them (e.g. requirements for rodent baiting to allow anchorage or mooring to be more safely made near vulnerable islands).

Since the quality of impact results from the behaviour of individuals, numerous authors have suggested that visitors may be educated to behaviour consistent with conservation objectives. Part of this is a clear recognition of the status and significance of the resources that they visit. An interesting aspect of Schellhorn's study concerned itself with visitors' use of reserves, which in the Marlborough Sounds cover about one-third of the land area. In his study, two-thirds (64.2%) of visitors reported that they had visited one or more reserves during their holidays in the Sounds. However, when this was compared with data on interview locations some 6% of the visitors were unaware that they were actually present in a reserve while being interviewed, and up to 20% of campers were similarly unaware that they were camping on land designated as a reserve. Mode of transport was a significant factor influencing reserve visitation. Of sail boaters 86% visited reserves, compared with 74% of motor boaters, 49% of those travelling by commercial boat and 67 % of those travelling by car.

As would be expected from the situation described earlier for Hauraki Gulf, there is a distance decay in visitation from urban oriented mooring sites toward the more remote and exposed islands. Choice of destination is dependent not only on kind of vessel but upon local conditions, especially for sailing, and presumably on the length of time needed to explore the outer reaches of the park. What has also to be recognised for Marlborough Sounds is the considerable dispersion of holiday and permanent homes. The sociological carrying capacity for recreation by quick craft is probably enormous. The risks of influence on natural conditions may also be enormous.

Examination of this hypothesis has only just begun. Critical study of boating behaviour has not yet started. There is no cause for rejecting our hypothetical sequence, but there is insufficient hard evidence to espouse it wholeheartedly. What seems clear is that the processes of boat dispersal, analogous to super-tramp behaviour, help explain the expanding recreation intrusion, voluntary and involuntary, into the remote or isolated offshore islands. Planning for both is essential, as education rather than more policing is vital for securing island restoration and maintenance within the limits of acceptable change.

In response to the kind of conditions described, Mossman and Millar (1986) outlined a management planning approach to ensure conservation of those island reserves more especially valued for nature conservation. They mentioned three special categories: Inviolable reserves (for example, Poor Knights, Hen and Chicken, Mercury, Aldermen islands), sanctuaries with restricted access (Cuvier, Bream islands (outer), Mokohinau), and sanctuaries with controlled access (Little Barrier Island).

To sustain this categorisation, practical management principles for the board room and management office were outlined. These principles are mainly dependent on public education of boat users for success, as they are difficult to police. As Devlin and O'Connor (1989) have pointed out for visitors to mountain national parks, such public education depends on what can be done at amenity or development areas. The promotion of nature conservation on predominantly recreational islands is required for educational purposes. It must be achieved while providing an opportunity for acceptable recreation, both terrestrial and aquatic. Island ecological restoration and ROSLAC planning (that is, balancing the recreation opportunity spectrum against limits of acceptable change) seem to us interdependent. Uncertainty and risk must be integral parts of conservation and recreation planning. Crisp (1985) reminds us that Moturua Island in the Bay of Islands was burned in the course of feature filming. The bush on southern Kapiti Island burned in 1976 in a fire started from a boat's distress flare!

TOURISM AND ISLAND CONSERVATION

There is some connection between requirements posed by the recreational use of islands as we have outlined them and the requirements posed by tourism. There are also some divergences. We will attempt to summarise some of the principal features of tourism that have significance for conservation of islands:

Tourism, like boating, is growing. We have gone from 241000 international visitors in 1970 to 445 000 in 1980 and 868 000 by March 1989; the current target for the year 2000 is three million.

Tourist appetites are changing and are being differently nourished. Freer, more adventurous, more active visits result in considerable shifts in location of tourist business. For example, a three-fold increase from

1975-1976 in proportion of overseas tourists visiting Northland is illustrated by its current tourist load of 4.2 million bed nights.

Commercial ventures into provision of tourist service include not only increased passenger services, but boat hire, with and without crew. The quality range of this last group is enormous and difficult to assess, particularly with respect to such intangibles as policing for safety (Foster 1989) or for island conservation.

As Keller (1984) pointed out, tourism growth at any locality makes demands for capital investment. This is soon sought from outside the locality and, if the needs are large enough, eventually sought offshore. This leads to conflicts of interest and loss of local control. Loss of local control may also affect local involvement in nature conservation. Offshore investment in tourism could also result in reduction in effective national responsibility for nature conservation. National expenditure in touristic investment may be at odds with expenditure on nature conservation.

In itself, the image of the last islands of nature in a spoiled world promotes a nature tourism use. Conservation standards for outlying islands in a place like the Southern Ocean are likely to be but tenuously maintained in such a combination of circumstances.

The management of tourism in the global commons of Antarctica poses special challenges (IUCN 1987, Mussack 1988), and this also holds true for the islands of the Southern Ocean. There will be no more second chances. Mistakes will be paid for in accelerated loss of species.

There is nothing pejorative in the concept of super-tramp. We should recognise that such species have not a limitless habitat. Acceptance of the finite should be a mark of the sapient. Adjustment to the demands of potentially conflicting goals of nature conservation and nature enjoyment must be made in conditions of dispersed but very finite island resources.

In order to formulate management objectives for recreational use, conservation objectives for natural environments must be clear. Management solutions to dual-purpose conservation and recreation problems are made more difficult by the paradoxical relationship between preservation and recreation use. If people do not enjoy these island areas and learn to feel strongly about them, the preservation system may ultimately lack the support which is essential for its functioning.

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WORLD HERITAGE VALUES OF NEW ZEALAND ISLANDS

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ABSTRACT

New Zealand's national parks and other protected areas are widely acknowledged to contain landscapes, plants, animals and cultural features which are of such outstanding scientific and conservation value that they have international significance. The World Heritage Convention, adopted under the auspices of UNESCO in 1972, gives the opportunity for international recognition of these values through designation of World Heritage status for areas of outstanding natural, scenic and cultural significance.

While New Zealand has several mainland sites listed or proposed for designation as World Heritage Sites, no entirely island sites have been listed to date. In this essay, an evaluation against the criteria for World Heritage Site designation of the conservation values of the important island reserves in New Zealand is presented. Two preliminary proposals for World Heritage sites are advanced from among these islands - the Kermadec to White Island chain, and the cool-temperate islands of the Australasian sector of the Southern Ocean.

WORLD HERITAGE PROTECTION

World Heritage Sites designated under the UNESCO World Heritage Convention are regarded as being outstanding representatives of the world's natural and cultural heritage (UNESCO 1988). They are considered to be of such universal value that they should be included within a global network of sites and monuments whose protection is the responsibility of all the societies of the world. While it is accepted that the tasks of identification of sites, and their protection and transmission to future generations, are those of individual sovereign states, it is also acknowledged that the international community has a duty to cooperate in these roles. Thus, the World Heritage Convention complements heritage conservation undertaken at the national level.

To conduct and support its work the Convention establishes the World Heritage Committee, which meets each year to:

(i) identify and list World Heritage properties based on nominations submitted;

(ii) decide which properties should be listed as being "in danger"; and

(iii) determine how resources of a special fund should be used to assist parties in their protection activities.

This special fund, known as the World Heritage Fund, is available for general aid grants, for acquiring expert management advice and research, for training management staff, and for purchase of essential equipment.

At April 1989, the World Heritage Convention had 109 State Members, which makes it the largest of all international conservation conventions. At the same time, the World Heritage Site network consisted of a total of 315 sites, as follows:

226 Cultural Properties: e.g. Great Wall of China, the Old City of Jerusalem, Carthage, Stonehenge, Auschwitz and Timbuktu.

70 Natural Properties: e.g. Grand Canyon National Park, Yellowstone National Park, Kluane/Wrangell-St Elias National Parks, Sagarmatha (Mt Everest) National Park, Kilimanjaro, and the Great Barrier Reef Marine Park.

19 Joint Cultural/Natural Properties: e.g. Ngorogoro Crater; Kakadu National Park, and Western Tasmania.

New Zealand has two sites listed under the Convention as natural properties, viz. Fiordland National Park and the combined Westland/Mount Cook National Parks, each designated in 1986. Two other New Zealand sites are currently under investigation by UNESCO for addition to the list: Tongariro National Park (nominated as cultural/natural property) and South-West New Zealand (Te Wahi Pounamu). The latter has been nominated as a natural property and covers a total of 2.6 million ha, incorporating the formerly listed Fiordland, Westland and Mount Cook National Parks (Department of Conservation 1989).

LISTED WORLD HERITAGE ISLANDS

Oceanic islands are scarce among designated World Heritage sites. Only five complete island sites are currently listed:

- St Kilda (Atlantic Ocean, 58°N latitude);
- Galápagos Islands (Pacific Ocean, equatorial);
- Henderson Island (Pacific Ocean, 24°S);
- Aldabra Atoll (Indian Ocean, 10°S); and
- Lord Howe Island (Tasman Sea, 32°S).

Parts of some important island groups are also listed. These include:

- Hawaii Volcanoes National Park, Hawaii (Pacific Ocean, 20°N);
- Garajonay National Park, Canary Islands (Atlantic Ocean, 28°N); and
- Vallee de Mai Nature Reserve, Seychelles Islands (Indian Ocean, 4°S).

CONSERVATION IMPORTANCE OF NEW ZEALAND ISLANDS

The New Zealand island assemblage

The New Zealand archipelago includes, in addition to the three main islands, about 600 offshore and outlying islands and islets. These are arranged among six major groupings (see pp. v, 2, 214, 288, 304):

- Subtropical Kermadec and Three Kings,
- Northland/Hauraki/Coromandel,
- Central New Zealand straits and sounds,
- Fiordland/Stewart Island,
- Chatham group, and
- Cool-temperate island groups.

Some 300 of these islands (i.e., about 50%) are contained within 102 protected natural areas of various categories (Dingwall and Penniket 1986), currently managed by the Department of Conservation under the Reserves Act 1977, Wildlife Act 1953 and National Parks Act 1980. (Protected areas legislation is undergoing review at present) About half of all the protected islands are nature reserves, which is the strictest form of protection under the Reserves Act and a status accorded only to areas whose natural ecosystems are of outstanding scientific value. Most other island protected areas are scenic reserves within New Zealand's three Maritime Parks, while two islands are Specially Protected Areas within Fiordland National Park and so have very secure legal protection. The cool-temperate groups are National

Reserves, giving them in effect the legal status and security equivalent to national parks and signifying their national importance.

Most protected islands are managed to preserve their intrinsic natural values such as unique, rare and threatened plants and animals and their habitats. Few islands are protected solely for their cultural values, but many are of great cultural significance for the Maori as former dwelling sites, quarries for precious stone, burial grounds and food sources. Only one island protected natural area is privately owned - all others being managed as part of the public domain. Island protected areas extend throughout the length and breadth of New Zealand territory, from the subtropical Kermadec group in the north to cool-temperate Campbell Island in the south, and the Chatham group in the east.

New Zealand's existing World Heritage islands

New Zealand already has some 40 offshore islands larger than five hectares (i.e., 7% of the total), with World Heritage status, by virtue of their inclusion in the Fiordland National Park World Heritage site. There are 16 lacustine islands also included in this site. The more unmodified and important of these are the rat-free Breaksea Island and the Outer Gilbert Islands, and isolated Solander Island west of Foveaux Strait. Other significant islands are the much larger Secretary and Resolution Islands.

Stewart Island has undergone preliminary assessment for World Heritage status and is probably unlikely to meet the required standard. While parts of Stewart Island and its outliers are of undoubted ecological importance and have a high conservation status as nature reserves, the group lacks overall 'outstanding universal value'. The island also lacks ecological integrity on account of the widespread destructive impacts of introduced alien predators and browsing animals - notably rats, cats, possum and deer.

Protection through World Heritage listing

Mainland New Zealand biota and landscapes are well-represented in existing and proposed World Heritage Sites. A great diversity of ecosystems characteristic of much of natural indigenous New Zealand is included, extending over a wide latitudinal range and through altitudes ranging from the seacoast to mountaintops. But offshore and outlying islands also play a vital role in New Zealand's conservation story and reflect some of the country's most distinctive ecosystems and landscapes.

Other papers at this symposium have outlined how islands are special environments for conservation and are very different from mainland areas. Island ecosystems strongly reflect an oceanic influence; they have limited space, restricted habitats, impoverished floras and faunas relative to comparable mainland areas, and a high degree of species endemism, reflecting their isolation. Consequently, islands can have extremely important conservation values, particularly as refuges for rare and threatened species, especially those lost from the mainland. But islands are also very vulnerable to disturbance and loss, and they are difficult to restore. New Zealand has some of the best and worst examples of island conservation, yet we are also widely acknowledged as leaders in island species protection and restoration, particularly through species translocation programmes and predator eradication and control techniques (e.g. Moors, Atkinson and Sherley 1989). World Heritage designation for New Zealand islands would, therefore, not only further promote protection of our islands but would also add international prestige to this conservation work and serve as an influential force for island protection elsewhere in the world.

To date, assessment of the international significance of New Zealand's protected area network as potential World Heritage sites has been far from comprehensive. In fact it has been rather *ad hoc*, with no clear procedural process for *formulating* and *evaluating* candidate areas. The process is much clearer for *securing* nomination once the State member (i.e., the New Zealand government) has accepted the worth of any preliminary proposal. In our view, an important challenge awaiting the New Zealand Conservation Authority and the Department of Conservation is a comprehensive assessment of the Neozealandia and Insulantarctica biogeographical provinces (Udvardy 1975) for those units which are of World Heritage value. Any such exercise must include the islands of both provinces, as well as their surrounding marine environment.

Advantages and disadvantages of World Heritage status

Conferring World Heritage status on monuments and sites can produce several real benefits. Inclusion on the World Heritage List brings international prestige to areas so inscribed. It confers international recognition on their value to global conservation, to science and to society. At home, it allows a nation to take pride in the finest elements of its natural and cultural heritage. For the host government, while the greater exposure increases the obligation for environmental protection, it can also generate considerable economic activity through increased tourist interest and activity (necessitating, of course, careful management according to conservation principles). World Heritage status can also be used to promote the cause of conservation generally, through increased public awareness and sponsorship of protected areas. There is also the added opportunity of sharing financial and technical resources internationally through the World Heritage Fund.

There are also some potential disadvantages, particularly for fragile island ecosystems. The increase in pressure for public visits (already a significant factor in our cool-temperate islands), can hold the allure of an additional source of revenue for managers who always seem hard-pressed for operational budgets. The desirability of fees from entry permits must be carefully balanced against the need to hold visitor numbers to a level and frequency which does not place the island ecosystem at risk. Another potential drawback with some of our most important island sanctuaries is the restriction that World Heritage status could place on options for translocating endangered species outside their historic habitat range.

APPLICATION OF THE WORLD HERITAGE CRITERIA TO NEW ZEALAND'S ISLANDS

Criterion 1: SITES NOMINATED SHOULD BE OUTSTANDING EXAMPLES REPRESENTING MAJOR STAGES OF THE EARTH'S EVOLUTIONARY HISTORY.

As New Zealand straddles the boundary between the Pacific and Indian-Australian plates, its shape and landforms reflect the enormous tectonic forces generated by the movement and contact of these two major segments of the earth's crust. To date, two major features of this plate boundary have featured in two of New Zealand's terrestrial nominations for World Heritage - the Alpine Fault in South-West New Zealand (Te Wahi Pounamu) and the Tongariro Volcanic Centre at the southern end of the Rotorua-Taupo Volcanic Zone.

The active volcanoes that ring the Pacific Ocean - the so-called "Pacific Ring of Fire" - virtually all lie on plate boundaries. One significant section of this volcanic archipelago, the Tonga-Kermadec Island arc, lies along the Pacific/Indian-Australian plate boundary to the north-east of the North Island of New Zealand. These islands, and the 10,000-m deep Tonga-Kermadec Trench lying parallel to the east, are a classic example of a subduction zone (where the oceanic crust of the Pacific Plate is being forced down into the mantle underneath the more continental Indian-Australian plate). The resulting chain of volcanic islands is andesitic in composition, its 'intermediate' rocks reflecting the mixing of the oceanic basalt with the continental sedimentary rocks in the magma.

The part of the Tonga-Kermadec island arc under New Zealand jurisdiction extends as a chain from Raoul Island (an active volcano, the northernmost of the Kermadec group), southwards through Macaulay, Curtis (thermal areas), Havre Rock, L'Esperance Rock, and the Star of Bengal Shoal, to White Island, the active volcano 50 km north-north-east of Whakatane in the Bay of Plenty (Fig. 1). Not all of these volcanoes marking the plate boundary have risen above the sea surface as islands; some (such as the active Rumble group) are seamounts, volcanoes rising up to 2500 m from the ocean floor.

The other oceanic subduction zone featuring an island is the Macquarie Ridge, extending to the south-west of Fiordland. In contrast to the Kermadec-White Island ridge, the Macquarie system has resulted from a reversal of the plate relationships, since here the Pacific Plate is being pushed over the Indian-Australian Plate. In addition, Macquarie Island is not volcanic in origin (its basalt and serpentine are considered to be an uplifted piece of oceanic crust) and the whole system is considered to be waning in activity since its peak in the mid-Tertiary (Stevens 1980).

There are a number of volcanic archipelagos strung out along plate boundaries around the Pacific basin. The Aleutian Islands, the Kuril and Ryukyu chains, and the Philippines-Sulawesi-Sunda archipelago all portray many of the major features in the evolutionary history of the plates making up the earth's crust. The Kermadec group, however, has a high level of protection. In addition, a case is made elsewhere in

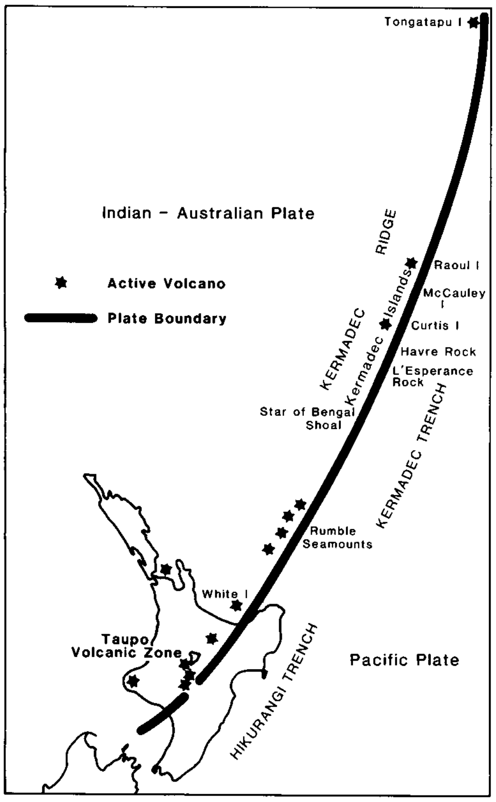

Fig. 1. Map of Kermadec - White Island chain, showing location of plate boundary.

this conference proceedings for the strict protection of their surrounding waters and outstanding marine life within a marine reserve (Ballantine this volume). While we are not qualified to comment on the international significance of this marine life, it could contribute to the overall argument supporting world heritage status (cf. criterion 2 or 4).

The need for integrity is also a necessary condition in assessing World Heritage value.[1] The Kermadec-White Island chain, if proposed in its entirety, has a high degree of tectonic and geological integrity. It is a classic subduction zone, and the area of most intense earthquake activity in the New Zealand biogeographical province. It is an interesting contrast to the other plate boundary contact proposal of high integrity - the Alpine Fault of South Westland/Fiordland, a transform fault which allows the plates to slip sideways thereby reducing the intensity of earthquake activity.

Criterion 2: SITES NOMINATED SHOULD BE OUTSTANDING EXAMPLES REPRESENTING SIGNIFICANT ONGOING GEOLOGICAL PROCESSES, BIOLOGICAL EVOLUTION, AND MANS INTERACTION WITH HIS NATURAL ENVIRONMENT; AS DISTINCT FROM THE PERIODS OF THE EARTH'S DEVELOPMENT, THIS FOCUSES UPON ON-GOING PROCESSES IN THE DEVELOPMENT OF COMMUNITIES OF PLANTS AND ANIMALS, LANDFORMS, AND MARINE AREAS AND FRESHWATER BODIES.

The outlying island groups all exhibit important examples of biological evolution. Not only are they important centres of endemism for plants (and invertebrates and birds) but the limited number that are still free of introduced mammalian herbivores and predators are almost axiomatically of international importance. Only here, in these few pristine islands, has the ongoing evolution of communities of plants and animals continued in the absence of introduced continental flora and fauna. Whereas most of the offshore islands (with the exception of the Poor Knights group) tend to have vegetation similar to that of

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[1]The key elements of integrity are: containing most key interrelated elements, sufficient size to be self-perpetuating, ecosystem integrity, necessary habitat requirements (for species survival), and adequate legal protection and management. [Summarised from UNESCO operational guidelines for implementation of the World Heritage Convention.]

the mainland, the outlying islands have been isolated since before the last glacial period, and their high degree of endemism reflects this longer isolation.

The Chatham Islands are probably the outstanding group in terms of the endemism in their flora and fauna. For example, 11% of their total vascular flora is endemic, 11 of the 12 species dominating their forests are endemic, and 42% of the species/subspecies of their indigenous birds (including 11 of the 12 forest-dwelling birds) are endemic (Atkinson 1989, Atkinson and Bell 1973). Yet the Chathams are probably the worst example among New Zealand's outlying islands of the loss of indigenous biota through human impact. Overall, only 0.3% of the Chatham group is protected as nature or scientific reserve, and until this improves it would be difficult to advance the islands as a serious contender for World Heritage nomination.

The Three Kings and Kermadec groups each have high levels of endemism in their biota, but they have also been severely modified in the past by fires and introduced animals.

The cool temperate/sub-antarctic islands group are probably the least modified and there is a high level of endemism in their flora, including an ancient element that could represent a link with pre-Quaternary Antarctica. The case for nominating these islands for World Heritage status is developed later in this paper.

Do any of our islands represent outstanding examples of "man's interaction with his natural environment"? The northern and eastern islands sustained 1000 years of Polynesian occupation; some of them like Tawhiti Rahi in the Poor Knights group carried a large population, who probably removed virtually all the original vegetation during their occupation in pre-European times (Hayward 1986).

The Titi island group in Foveaux Strait has sustained Maori populations for hundreds of years with its annual yield of 'muttonbirds'. Other islands have been important sources of stone (such as the obsidian of Mayor Island and the argillite of D'Urville Island) and other raw materials which were items of inter-tribal trade. Despite their tragic fate, is World Heritage status an appropriate way to recognise the significant achievements of the Moriori people of the Chatham Islands in their attempts to live in harmony with a remote and climatically hostile island ecosystem?

Overall, this criterion seems to emphasise the *representativeness* of the on-going processes. There is limited diversity within the flora and fauna in the groups discussed above, and this could limit their "outstanding significance" required to satisfy this criterion.

Criterion 3: SITES NOMINATED SHOULD CONTAIN SUPERLATIVE NATURAL PHENOMENA, FORMATIONS OR FEATURES; FOR INSTANCE, OUTSTANDING EXAMPLES OF THE MOST IMPORTANT ECOSYSTEMS, AREAS OF EXCEPTIONAL NATURAL BEAUTY, OR EXCEPTIONAL COMBINATIONS OF NATURAL AND CULTURAL ELEMENTS.

This criterion does allow us as authors to express our personal views on "exceptional natural beauty" and scenery inasmuch as "beauty is in the eye of the beholder". New Zealand's islands may not be as 'superlative natural phenomena' as the mountains and glaciers of South Georgia, or have either the eruptive power of a Krakatoa, or the scale of Mauna Kea in Hawaii - the highest (10,000 m) base to summit mountain in the world. Nevertheless, many of our islands individually have some outstanding landscape features:

- Rangitoto, a youthful, miniature 'Mauna Kea',
- the Aldermen Islands, their jagged spires all that remain of a former rhyolitic dome,
- Mayor Island, with its impressive central lava dome,
- the myriad forested-covered, ice-planed islands in Dusky Sound,
- the sheer cliffs of Solander Island, the eroded trunk of an ancient andesitic volcano lying isolated at the western end of Foveaux Strait.

(The last two examples already have World Heritage status as part of Fiordland National Park world heritage site.) The obvious weakness in the above list is that each on its own is hardly of international significance, and together they lack any sort of thematic integrity.

Similarly, our best examples of pristine island ecosystems, communities free of any significant introduced plant, animal or human influence, would be expected to fail the integrity requirement. Collectively, Meyer Island in the Kermadecs, Middle and Green in the Mercury group, the Snares, and Adams Island in the Auckland group are among the least modified islands in the world, but that is all they have in common.

There may be a case for some of our island groups being of international significance because of the sheer density of their breeding populations of seabirds and marine mammals. This particularly applies to the cool-temperate (subantarctic) islands, and this argument is developed further below.

Criterion 4: SITES NOMINATED SHOULD CONTAIN THE MOST IMPORTANT AND SIGNIFICANT NATURAL HABITATS WHERE THREATENED SPECIES OF ANIMALS OR PLANTS OF OUTSTANDING UNIVERSAL VALUE FROM THE POINT OF VIEW OF SCIENCE OR CONSERVATION STILL SURVIVE.

This criterion immediately begs a number of questions when we try to apply it to New Zealand's islands. First, consider some of those islands of the highest importance as sanctuaries for rare and endangered animals - say, Codfish, Little Barrier and Kapiti. Each contains translocated populations of animals under serious threat in their original habitat on the mainland or other islands. In some cases, the high degree of management required to ensure the survival of these species has significantly diminished the 'natural' value of the island. This in no way diminishes the conservation importance of the sanctuary island, but it certainly seems to weaken its relevance to this criterion.

Second, it is very difficult to decide which of our rare and endangered species are of 'outstanding universal value'. Ornithologists might opt for Little Barrier or Taranga Island, herpetologists for Stephens Island or the Brothers, and entomologists for Middle Island in the Mercury group. Most of us would probably agree that the kakapo is a bird of 'outstanding universal value', but few of us would agree that it therefore follows that Codfish, Little Barrier and Maud Islands should have World Heritage status.

There is one distinctive New Zealand animal which truly has international recognition, with a reptilian suborder all to itself - the tuatara. We are not well qualified (or certain of the value) for developing a detailed case for the designation of our 'tuatara islands' as a group worthy of World Heritage status. However, we believe that it is an idea warranting further consideration.

WORLD HERITAGE - A PRELIMINARY CASE FOR THE NEW ZEALAND COOL-TEMPERATE ISLANDS

At Paimpont, France, in 1986, a meeting of representatives of scientific and conservation organisations from all countries administering cool-temperate and subantarctic islands urged, among other things, that national authorities consider which islands might be proposed for international designation such as World Heritage Sites (SCAR/IUCN 1987).

Biogeographically, the New Zealand 'subantarctic' islands[2] fall within the province of Insulantarctica, one of the 227 provinces identified in a classification scheme to encompass the world's biogeographical diversity (Udvardy 1984). Insulantarctica includes 22 major oceanic island groups in the Southern Ocean (Clark and Dingwall 1985), covering a wide latitudinal range from Tristan da Cunha at 37°S near the Subtropical Convergence, to the South Shetland Islands at 62°S in the zone of almost permanent pack ice. New Zealand territory includes five southern island groups within the cool-temperate zone: Snares, Aucklands, Campbell, Bounties and Antipodes.

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[2] Although commonly referred to as 'subantarctic', the southern New Zealand islands are more appropriately considered as representative of a cool-temperate zone, characterised by a mean annual air temperature generally above 5°C, supporting vegetation, including trees and woody plants, and lying generally between the Subtropical and Antarctic convergences. For the rest of this paper we will use the more accurate term 'cool-temperate' to describe these southern islands (Clark and Dingwall 1985). The islands of Insulantarctica fall into three biogeographic zones: *Maritime Antarctic* (e.g., South Shetlands, South Orkneys) well south of the Antarctic Convergence, *Subantarctic* (e.g., South Georgia, Macquarie Island) in the vicinity of the Antarctic Convergence, and *Cool-temperate,* situated between the Antarctic and Subtropical convergences (Fig. 2).

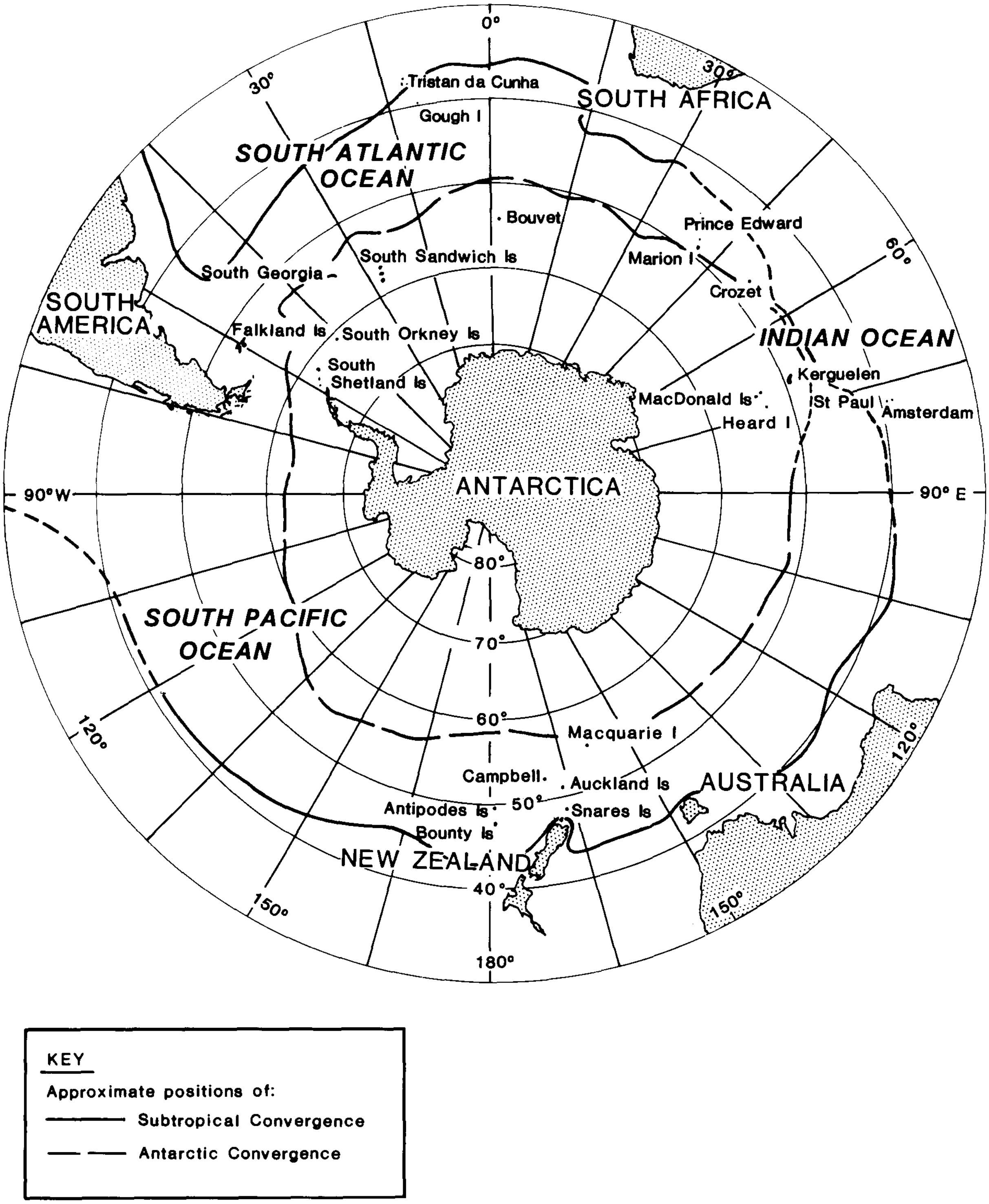

Fig. 2 The southern hemisphere south of latitude 30°S, showing the Antarctic continent, southern islands, and the Subtropical and Antarctic convergences. The cool-temperate islands are those lying between the two convergences.

The following outline of a case for World Heritage Site status for New Zealand's cool-temperate islands is only indicative. The conservation values of the islands are considered in terms of the four criteria just outlined, with information drawn principally from the reserve management plans published by the Department of Lands and Survey between 1982 and 1986.

Representation of the earth's evolutionary history

New Zealand's cool-temperate islands all lie on a well-defined, relatively shallow submarine platform, the Campbell Plateau, between latitudes **48°** and **55°S.** The Auckland Islands, Campbell Island and the Antipodes are all volcanic in origin, but they vary in age. Recent dating of the volcanics (Adams 1981) has revealed that these islands are all linked together, and to the volcanoes of the eastern South Island, by a pattern of migrating volcanism in the late Cenozoic. This pattern was probably generated by the passage of a continental crustal plate carrying the South Island and Campbell Plateau over a north-south-trending hot zone of upwelling in the mantle. This produced an eastward-progressing zone of volcanism, between 25 million years ago at the Auckland Islands and one million years ago at the Antipodes. These islands therefore play a significant role in unravelling the volcanic history of the South-West Pacific Basin south of New Zealand. In contrast, the Snares and Bounties are granite masses forming part of the basement of the Campbell Plateau, the former being a remnant of an ancient batholith which also includes the southern part of Stewart Island.

Representation of significant ongoing ecological processes

The geological situation of the islands has been explained above. From a geomorphic viewpoint, the islands, particularly the high volcanic ones, illustrate markedly the tremendous forces of past glacial action (there is no permanent ice today), and ongoing marine erosion. At Auckland and Campbell islands recurrent episodes of Pleistocene glaciation, which must have favoured the development of icecaps and huge valley glaciers, have produced a remarkable series of radiating U-shaped valleys, many with cirques carved into their upper walls. Today, the lower reaches of these valleys have been infilled by the sea to create several large harbours and many precipitous fiords. The latter are most conspicuous along the eastern coast of the Auckland Islands. On the western coasts, which are more exposed to the prevailing wind and wave direction, the volcanoes have been severely eroded away by the sea, so that there is a distinct asymmetry in the plan shape of the volcanoes.

These island groups are the only land masses in a vast expanse of ocean; the Auckland Islands, more than 62,000 ha in size, are the largest landmass in the Pacific subantarctic. The island groups are of particular interest in that they lie near the limits of antarctic water yet are under the influence of warmer currents from the subtropics. This oceanic interchange apparently contributes to high productivity and an exceptional biomass in the seas surrounding the islands. Thus, the islands are globally important as the home not only of countless numbers of seabirds but also of marine mammals that feed throughout the Southern Ocean. These animals are mostly top carnivores in food chains and play a key role in the overall ecology of the Southern Ocean.

Long periods of isolation and the great distances separating the islands from neighbouring landmasses have resulted in the evolution of a distinctive flora and fauna which, although varying considerably among the island groups, are notable for the number of endemic species and subspecies and specialised forms. While the number of species is limited, absolute numbers of animals are huge and counted in millions. The Snares, for example, has the largest population of sooty shearwaters (almost 3 million pairs) in the world, while Campbell Island is the finest of all albatross islands, harbouring five breeding species - more than any other island in the world. Teeming colonies of penguins, other seabirds and seals are testimony to the biological richness of the surrounding seas and to the importance of these islands as breeding and resting places.

The distinctive island vegetation includes some of the southernmost forests in the world and many endemic species of vascular plants, some at their ecological tolerance limits. The Auckland Islands mark the world's southernmost limit of tree ferns, for example. The vegetation mantle varies widely from group to group: from almost continuous forest (Snares), through coastal fringing forest (Auckland), shrub-tussock cover (Campbell/Antipodes), to a rocky terrain with sparse lichen and algae (Bounties). The Auckland Islands, which have the richest flora of any of the islands in the Southern Ocean, include the pristine Adams and Disappointment islands. Adams Island supports an expanse of flowering shrubs and megaherbs unrivalled anywhere on southern oceanic islands, in an area which has been evocatively named 'Fairchild's Garden'.

Moreover, the islands contain some of the last remaining areas of the world's vegetation unmodified by humans and their associated animals. The Snares, for example, is one of the few forested island groups anywhere in the world without introduced mammals of any kind. As such, the island ecosystems are of immense value for scientific study. Their biota is the culmination of a long history of dispersal, climatic control, and community interactions without human interference. Internationally, the evolution of this biota is of great taxonomic, ecological and biogeographical interest.

Inclusion of superlative natural features

The cool-temperate islands include some impressive oceanic volcanic landscapes. Auckland, Campbell and Antipodes Islands are notable examples of Cenozoic volcanic activity associated with seafloor spreading and crustal plate movement in the South-West Pacific Basin. They display classic volcanic landforms of varying maturity, including domes, cones, primary and secondary volcanic formations, and erosional features such as calderas, which through post-glacial drowning by the sea have been transformed into landlocked harbours. Specifically, the Auckland Islands are the eroded remains of two coalesced volcanic domes (Ross and Camley volcanoes) up to 660 m high, 13-36 million years old, composed of a complex sequence of basaltic lavas and scoria, exposed dramatically in the bold sea cliffs. Campbell Island is the 560 m high remnant of a Miocene volcanic dome. Basaltic lavas overlie breccias and sedimentary rocks, which are exposed over a wide area and penetrated by an intensive network of dikes and sills. The Antipodes are the remnant of one large (402 m high) and several subsidiary Pleistocene volcanic cones, primarily composed of pyroclastic rocks but with several lava flows.

The scenic quality of the islands and their aesthetic appeal are such as to have an emotional impact on all who visit them. The exceptional natural beauty of the islands stems from their isolation, the stark grandeur of the terrain, the sometimes hostile and forbidding climatic environment, and the fascinating assemblage of wildlife and plants.

Presence of significant natural habitats with threatened species

Plant communities

Plant cover varies considerably from the Bounties with their sparse cover of algae and crustose lichens, to the Auckland Islands with 231 species of vascular plants, comprising one of the richest floral assemblages of all islands in the Southern Ocean. (Campbell Island has 218 species of vascular plants, Antipodes 63, and the Snares 20.) The Snares, with only two species of alien vascular plants, are among the least human-modified of all the world's forested oceanic islands. The natural forest canopy is dominated by just two species and the ground layer contains one endemic megaherb (*Anisotome acutifolia*) and another (*Stilbocarpa robusta*) which occurs on only one other island of Fiordland. The Auckland Island forests are notable for the presence of 44 species of fern, including the world's southernmost tree fern, *Cyathea smithii*; three species of the megaherb *Pleurophyllum*, a genus endemic to the New Zealand southern islands and Macquarie Island; and a coastal fringe of southern rata (*Metrosideros umbellata*) forest.

Campbell Island, south of the forest limit and with plant communities significantly modified by introduced grazing animals, is today dominated by *Poa* tussock and *Bulbinella rossii*. Recent eradication of cattle and restriction of the range of sheep are encouraging regeneration of the natural vegetation cover in which *Chionochloa* tussocks are predominant along with *Pleurophyllum* spp., *Anisotome* spp., and *Stilbocarpa polaris*. The main vegetation of the Antipodes is *Poa*-dominant maritime grassland, and the only woody plants are four species of *Coprosma*. All island groups with vascular vegetation have plant species considered to be rare, including 34 species at the Auckland Islands alone.

Animals

The Snares has 23 species of breeding birds, notable among which are the endemic Snares crested penguin (23,000 pairs in 125 colonies); Buller's mollymawk and Salvin's mollymawk, endemic to the region; and an estimated 2.75 million burrow-holding pairs of sooty shearwater. These islands are among the world's northernmost breeding grounds of the cape pigeon and Antarctic tem. Three landbirds are endemic - a tomtit, fembird and snipe. Some 70 species of birds have been recorded from the Auckland Islands, of which 48 breed there. Eight taxa are endemic, including a rare, flightless teal, a snipe (both now absent from the main island), and a banded dotterel with less than 200 individuals remaining (and regarded as endangered). The islands support the world's largest breeding populations of wandering albatross and shy albatross, and there are important breeding populations of rockhopper penguin and the rare yellow-eyed penguin (less than 250 pair). The island group is the principal breeding ground for one of the world's rarest seals, the Hooker's sea lion (about 5,000 animals).

Three species of seals and 29 species of bird breed on Campbell Island, including five species of albatross, which is more than on any other island in the world. This island is also the world's main breeding locality of the southern royal albatross. Twenty-four species of bird breed in the Antipodes, four of which are endemic - a snipe, pipit, red-crowned parakeet, and the rare Antipodes Island parakeet. Breeding seals include the Southern elephant seal and the New Zealand fur seal, which in 1985 recommenced breeding there, 140 years after being nearly wiped out by sealers. The Bounties support the largest known breeding population of New Zealand fur seals (about 16,000 individuals), and there are seven species of breeding bird, the most abundant of which are the erect-crested penguin and Salvin's mollymawk. An endemic shag, the world's rarest, has a breeding population of only 550 pairs.

Ecological integrity

Alien plants

Both Campbell and Auckland Islands have a considerable number of alien plants (81 species and 41 species, respectively), but none of these presents a threat to indigenous vegetation communities at present. Control of widespread naturalised alien plants is impractical. Experience shows that introduced plants are usually successful only on artificially disturbed ground and eventually succumb to competition from indigenous plants. Vigilance is necessary to reduce the chance of new introductions and spread among the islands in the group, and strict quarantine/inspection requirements are now imposed among the conditions of entry by people to the islands.

Alien animals

Snares, Bounties and some offshore islands in other groups are without introduced animals of any kind, and the Antipodes has only the house mouse. Alien mammals are a cause for concern elsewhere. The Aucklands group has rabbits, goats, pigs, cats, and mice, while Campbell Island has sheep, cats and Norway rats. A comprehensive approach to alien animal control within the island groups is being developed.[3] With currently available methods, eradication of mice is impossible and total elimination of cats is not feasible either, given their low numbers and wide distribution on rugged terrain. Elaborate quarantine measures are in place to prevent new introductions of rodents and cats and their spread to alien-free islands. Control of rabbits on Enderby Island (Aucklands) and pigs on the main Auckland Island is currently under active consideration. The removal of pigs, which have ravaged large-leaved herbs and are implicated in the decline of several species of burrowing petrel, presents a considerable challenge.

The islands are without permanent human settlement, though the small meteorological base on Campbell Island is attended all year round. Reserve management staff and tourists, the latter arriving in limited numbers aboard cruise ships and some private yachts, are occasional visitors but are subject to strict conditions of entry and surveillance.

COMPARISONS WITH OTHER SOUTHERN COOL-TEMPERATE (SUBANTARCTIC) ISLANDS

New Zealand's southern islands are not alone in the Southern Ocean. Scattered throughout the vast expanse of ocean surrounding the Antarctic continent, the 22 major islands or island groups include more than 800 individual islands encompassing more than double the area of the Hawaiian Islands (Clark and Dingwall 1985). Any comprehensive evaluation of the World Heritage prospects of the islands of the Southern Ocean would need to consider candidates within all three zones of the Insulantarctica province (Fig. 2). For the purposes of this discussion, however, it is appropriate that we limit our evaluation to only the other cool-temperate islands, which have a biogeographic affinity with New Zealand's cool-temperate islands. The cool-temperate island zone includes five main groups: the New Zealand islands, the Falklands (Islas Malvinas), Tristan da Cunha, Gough Island, and Ile Amsterdam and Ile St Paul (Fig. 2).

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[3] Goats on the Auckland Islands have been reduced by shooting and live capture for removal to the mainland, and their elimination is imminent.

With the exception of the New Zealand islands, all the other cool-temperate islands in the zone would probably fail to comply with the criteria for World Heritage status. The Falklands and Tristan da Cunha have permanent human settlement and are highly modified, thus lacking the ecological integrity required for World Heritage natural properties. While there are many reserves and wildlife sanctuaries on the Falklands, in both government and private ownership, they cover less than 0.01% of the total area. Widespread and increasing farming activities, particularly sheep farming, have transformed the native plant cover, and the added impacts of introduced rodents, cats, dogs and foxes have dramatically reduced the numbers of seabirds. Fisheries also pose a significant threat to island wildlife. The outlying islands of the Tristan group are strictly protected, but the main island has only one wildlife sanctuary. There is a long history of human modification from farming and settlement, and several species of birds are either extinct or greatly reduced through predation by rats and cats in particular.

Ile Amsterdam and Ile St Paul, while unihabited, lack formal protection and are extensively modified by human activity. Sheep and cattle grazing, along with repeated fires, have destroyed vegetation cover, contributed to excessive soil erosion and reduced the extent of bird habitats. Introduced cats, rats and mice (and rabbits at St Paul) are implicated in the severe depletion of birds, particularly small, burrowing petrels, and most birds remain threatened.

Gough Island, 6500 ha in size, is protected as a wildlife reserve. It is without permanent human settlement and is largely unaffected by human activity. Tussock and scattered shrubs dominate the vegetation cover, which includes several alien species that are widespread but not abundant. There are large seabird populations and two endemic landbirds - a rail and a bunting. The house mouse is the only alien vertebrate. Gough Island, therefore, has a degree of ecological integrity not present at other islands, but it lacks outstanding elements in its natural flora and fauna and thus, in isolation, probably falls short of the qualities required for World Heritage designation.

The New Zealand cool-temperate island groups, which are all strictly protected and are managed to preserve or enhance a wide range of conservation values, and which collectively represent the diversity of landscapes and biota present in their biogeographical zone, are therefore the principal candidates for World Heritage status from among the cool-temperate islands of the Southern Ocean.

Possible inclusion of Macquarie Island

Macquarie Island warrants special mention in this analysis, even though the biogeographic zonation used here distinguishes it as 'subantarctic' compared with the New Zealand cool-temperate islands. However, some biogeographers include Macquarie Island within the greater New Zealand biogeographic region (Meurk 1984, Meurk and Blaschke this volume), although it is characterised as 'Low Antarctic' as opposed to 'Subantarctic'.

Macquarie Island experiences a somewhat cooler and drier climate than Campbell Island, its nearest neighbour among the New Zealand islands. Nevertheless, the two islands have many biological affinities - they are both treeless, with extensive Poa-dominant grassland and herbfields, many breeding seabirds in common, and breeding populations of Southern elephant seal and New Zealand fur seal. They also have a common history of human contact, with an early exploitation phase followed by scientific exploration, on-going meteorological observation, and eventual protection as nature reserve. Both share the legacy of a diverse group of introduced animals, which have induced extensive vegetation modification and severely depleted bird populations, but are now subjected to active control measures.

As a horst block, Macquarie Island has a different geological origin and character from the New Zealand islands, but it shares with Campbell and Auckland islands the distinctive imprint of Pleistocene glaciers on the terrain, though all are without permanent snow and ice today.

Given the degree to which Macquarie Island shares biological, historical and conservation management elements with the five New Zealand island groups, a convincing case could probably be made for linking the six within a World Heritage site made up of the oceanic islands in the Australasian sector of the Southern Ocean. This interesting prospect is left for further detailed consideration.

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WORST-CASE SCENARIOS FOR ISLAND CONSERVATION: THE ENDEMIC BIOTA OF HAWAII

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ABSTRACT

Hawaii offers unexpected lessons, and although the conditions in Hawaii are more extreme than on islands elsewhere in the world, the Hawaiian experience is globally applicable. Although plants and animals of the offshore Californian islands have recovered with ordinary exclosure techniques, Hawaiian plants and animals respond to this technique only in a few areas. The number of weedy entrants more successful than the native is almost infinitely large. The Hawaiian public, and the American public at large, are not well informed about the nature of Hawaiian biota; this failure and its consequences are examined. What is the role of research in a situation where conservation problems are extreme? Unexpectedly, this is the bright spot in the Hawaiian situation; reasons for this and comments on how research is related to conservation efforts are offered.

INTRODUCTION

Initially I was invited to talk about a campaign plan for the restoration of islands. This conference has demonstrated that I really cannot fulfil the title I was given. I cannot advise those involved in conservation in New Zealand: they are obviously experts in this field. I am not involved in management. As an academic, I am not a general; I am a witness or reporter. You are the people who make natural areas available to scientists. We often do little or nothing to help you; in fact, we may be the people who make demands of you or get in your way. What I can do is lend perspective to the conservation picture in New Zealand. I am going to talk largely about Hawaii and largely about plants, because these are fields with which I am better acquainted. In talking about Hawaii, I may make New Zealanders feel better about New Zealand, because Hawaii is a series of worst-case scenarios. However, I mainly wish to lend a global perspective to New Zealand's picture. In New Zealand your efforts are devoted to increasing the abundance of rare species, or returning areas to a more nearly natural state. In Hawaii, the task may rather be how to slow extinctions, or what to do while extinction is occurring.

New Zealand's problems are markedly different from those in other areas. For example, this conference has been, in essence, about offshore islands. In my home state of California, offshore islands are so rich in endemics that one cannot translocate mainland species onto them. One would be introducing alien species that would compete with the endemics. Similarly, Hawaii in effect has no offshore islands to which one could translocate species. What few offshore cinder cones there are prove to be so dry that the bulk of flora and fauna species could not live on them. California's flowering plant flora is about five times that of New Zealand. One in five California flowering plants is an annual. Another one in five Californian flowering plants is a short-lived perennial. Most of the threatened and endangered species are annuals or short-lived perennials. How could one manage a flora the size of New Zealand's, but composed entirely of annuals? Would one have to have a small farm for each species, harvesting seeds each year and replanting them the following year? How could one arrange for pollination of the species, not all of which are autogamous, and for most of which occasional outcrossing is characteristic? New Zealand's management problems may seem relatively simple in comparison with situations like these.

ORIGINS OF THE HAWAIIAN BIOTA

First, let's see what is so special about Hawaii. The Hawaiian biota is an oceanic island biota. Among oceanic island biotas, it is the oldest and most highly evolved in the world. New Zealand, by contrast, is a continental island that has inherited continental plants such as conifers and *Nothofagus.* If we look at a map of the Hawaiian Islands, we see the five major islands. Of these, Hawaii is the youngest. Its oldest rocks are less than a million years old. Kauai's oldest rocks are a little more than 5 million years old. However, the atolls and rocks that stretch from Kauai to Midway were once high islands, and Midway is about 10 million years old, thereby adding another five million years to the age of the biota. Wake Island is the last remnant of an even earlier segment. Stretching from Wake Island towards the Kamchatka Peninsula are the Emperor Seamounts, now-submerged remnants of high islands on which the Hawaiian biota first established (see p.vi). Thus by tracing the Hawaiian chain back to the Emperor Seamounts, one has a series of stepping-stone islands on which Hawaiian plants and animals have had perhaps 50 million years in which to colonise and evolve. New Zealand acquired its older elements from the Gondwanaland continent and retained them after that continent broke into pieces. On the contrary, Hawaiian organisms dispersed across stretches of sea water. To imagine which plants and animals can get to an oceanic island, one can imagine a list of plants and animals suited for dispersal across sea water followed by establishment on lava surfaces. One doesn't have to imagine such a list; one can see it in Auckland Harbour. Rangitoto Island's flora is entirely composed of plants adapted to long-distance dispersal followed by establishment on lava. The roster of plant genera on Rangitoto is virtually identical to that of the Hawaiian Islands, with the addition of only a couple of genera: the puka, *Griselinia,* and the rewarewa, *Knightia.* To walk from Motutapu to Rangitoto is literally like walking to Hawaii. A similar effect can be seen on the Bonin (Ogasawara) Islands, about 200 km from the Japanese mainland. The genera of plants on the Bonin Islands are nearly all also found on the Hawaiian Islands, and plants with seeds that are not suited to dispersal over water and establishment on lava are absent.

ADAPTIVE RADIATION IN HAWAII

What is interesting about this most ancient and highly evolved of oceanic island floras and faunas, the Hawaiian? Adaptive radiation, the tendency of a single group to fan out into various habitats, is exceptionally well represented in Hawaii because of the range from dry to wet and hot to cold. Among the most striking examples of adaptive radiation are the Hawaiian honeycreepers and the tarweeds. The tarweeds include *Argyroxiphium, Wilkesia,* and *Dubautia. Argyroxiphium* consists of the well-known silversword native to dry alpine areas, *A. sandwicense,* and also the bog greensword, *A. grayanum,* from a totally different kind of habitat. A close ally of *Argyroxiphium* is *Wilkesia. Wilkesia* looks like *Dracaena* or a New Zealand cabbage tree (*Cordyline*). Another close relative of *Argyroxiphium* is *Dubautia,* which includes trees, shrubs, subshrubs and a liana. Some of the smaller shrubby *Dubautia* species can be found in such diverse habitats as leeward slopes of the island of Hawaii (rainfall about 30 mm per year) and the summit of Mt Waialeale (15 000 mm per year). The differences in plant form and leaf size in these species are paralleled by differences in anatomy and physiology. When I studied the anatomy of these plants, my evidence showed that they were closely related to the tar weeds of the west coast of California although taxonomists had claimed otherwise. Anatomical evidence alone doesn't convince botanists, but DNA evidence does. At the national biological meetings at the University of California, Davis, in 1988, a symposium devoted to the tarweeds presented remarkable DNA evidence. This evidence showed that the Hawaiian tarweeds are tarweeds and that they are derived from the California tarweeds, which are annuals or short-lived perennials. More importantly, the source of the Hawaiian tarweeds is apparently the genus *Madia* in California. DNA evidence also shows that *Raillardella* and *Raillardiopsis* (which I transferred into the tarweeds from another part of the family Asteraceae) are Californian tarweeds closely related to *Madia* - perhaps part of *Madia.* If the Californian tarweeds are close to the Hawaiian tarweeds in their DNA, is there a possibility they can actually be hybridised? This dramatic possibility was realised in the summer of 1988, when a Hawaiian *Dubautia* and a California *Raillardella* (both endangered species) were hybridised and produced fertile seed. These studies showed that long-distance dispersal from California (or a very nearby area) occurred, perhaps about 5 million years ago or less. Also proved was that the ancestors of the Hawaiian tarweeds were not trees, but less woody plants like the California tarweeds. This is interesting, because European botanists (who are unfamiliar with the Pacific) believe that woody plants on islands are relicts rather than products of secondary woodiness, as was proved in this instance.

The other dramatic example of adaptive radiation in Hawaii is furnished by the Hawaiian honeycreepers, which can be said to represent about two and a quarter cycles of adaptive radiation, with the newer yellow-green honeycreepers replacing an older group of red and black honeycreepers. The yellow-green honeycreepers show an amazing range from parrot-billed to sickle-billed (like honeyeaters) to finchlike. Not only the bills, but the tongues, bill musculature, and diets of these birds show remarkable differentiation. Botanists familiar with the tarweed story that has emerged recently are saying that the most outstanding example of adaptive radiation on islands is not the Darwin's finches, but the Hawaiian tarweeds, followed by the Hawaiian honeycreepers. The very simplicity of the Galapagos flora and fauna permitted Darwin to see the story of the Darwin's finches. He would have agreed that the tarweeds and honeycreepers show evolutionary phenomena in greater dimension. Yet because of the threatened nature of the Hawaiian biota and the severe conservation problems, we may lose important portions of this story. However, recently Television New Zealand documented the stories of the tarweeds and honeycreepers, even showing details of i'iwi pollination of *Trematolobelia* that are not in the literature.

CONSERVATION OF ISLAND BIOTAS - THE HAWAIIAN EXPERIENCE

What has gone wrong in Hawaii - why are the conservation problems so severe there? One interesting answer is in the organisms themselves. They are more vulnerable than plants and animals elsewhere. Why should this be true? If we look, for example, at New Zealand, we see old continental elements. One factor in their ability to compete is in their chemical defences. Conifers have resins, tannins, and flavonoids that deter herbivores, whether mammals, birds, or insects. Such chemical defences may be less in New Zealand plants than in plants now on continents because mammalian herbivores were absent in pre-human times in New Zealand, although appreciable levels of plant predation may have been represented by moas. In contrast, Hawaiian plants are poor in chemical defences. There are only two poisonous species in the flora that I know, and both may be recent immigrants. About three genera and fifty species of the mint family are native to Hawaii, yet all of these are scentless. Mints on continents are strongly scented (e.g., sage, basil, oregano) as a means of deterring herbivores. Even the raspberries of the Hawaiian islands are thornless. All of these show a low level of defence against herbivores. One can imagine that an early plant arrival on the Hawaiian Islands, evolving in the absence of mammalian herbivores and big bird herbivores, may have lost defensive compounds. Chemical defences require energy for a plant to produce - they are expensive. Why produce expensive defences if there is no threat? (Even the American public has begun to agree to that.) Later immigrants, also confronted with an herbivore-free situation, adapted to the island defence-poor norm rather than the defence-rich continental pattern.

Chemical defences may represent only one aspect of vulnerability in Hawaiian plants. This vulnerability is also shown in the degree to which weeds can displace native species. In New Zealand, certain weeds are numerous and an undeniable problem. However, weeds in Hawaii are even more virulent. Such plants as strawberry guava, Brazilian pepper, lantana, and *Leucaena glauca* form impenetrable stands. There are even some weeds from New Zealand in Hawaii, such as the karaka (*Corynocarpus*), whereas no Hawaiian plants have become weeds in New Zealand.

What are other reasons for the extraordinary difficulty in conserving Hawaii's wildlife? One is the large number of introductions. The number of introduced species is about the same as the number of native species. Approximately 3,000 insect species have been introduced, and about 3,000 are native. The number of native and introduced passerine birds is similar - about 35. There are about 1,200 native plants, and at least as many have been introduced.

Many native Hawaiian species are very local. Many are confined to a single island; many to a small portion of a single island.

Hawaii has a very high proportion of land under private ownership. When the islands were ceded to the United States, a few individuals purchased most of the land. Relatively little land is under federal control. The most important federal holdings are the best conserved: Haleakala National Park, Hawaii Volcanoes National Park, and the Leeward Islands Wildlife Refuge. Nature Conservancy has acquired some large tracts. However, there are still large areas of wet forest in which pigs and other destructive herbivores are uncontrolled.

Hunters have been very influential in controlling the presence of the large herbivores. Although the total number of hunters in the Hawaiian Islands is not large, they tend to be moneyed people who constitute an effective lobby for continuing the presence of herbivores. The traditional policy of the US Fish and Wildlife Service has been "sustained yield" of the herbivores. This policy makes sense in the mainland US, where herbivores are native and where hunting reduces numbers to a level compatible with plant survival. However, in the Hawaiian Islands, where the herbivores are not native species, and where they constitute a major threat to the survival of native vegetation, a policy of sustained herbivore yield assures continued extermination of the native forest.

Public apathy has been a problem in preservation of Hawaiian plants and animals. Although the level of public awareness of conservation problems has improved, the apathy in past years has taken its toll. Reasons for this apathy are not immediately apparent, but one may suggest a number of possibilities. The destruction of the Polynesian culture in Hawaii has meant that those peoples, traditionally very knowledgeable about native flora and fauna have lost touch with them as they became plantation workers and urban dwellers. In parts of the mainland US, such as California, wealthy individuals often use the outdoors for summer recreation and after becoming interested in the natural history of these areas tend to belong to organisations such as the Sierra Club, devoted to preservation of wilderness areas. Hawaiian residents have used Hawaiian wilderness areas to a much lesser extent, and the moneyed residents of Hawaii seem to have favoured hunting over backpacking on nature trails. The national parks, because of their outstanding scenic and geological interest, may have been marketed primarily for those values, with plant and animal resources less mentioned. There have been failures in publicity at all levels. The average New Zealander is familiar not only with the names but also many facts concerning native birds and plants. The average Hawaiian, if asked to name a famous native plant and a famous native bird, might mention the silversword and the nene (Hawaiian goose), but many Hawaiian residents would not be able to name these, and very few would know about honeycreepers or lobeliads. Because there has been such little dissemination of information about Hawaiian wildlife, the audience of people interested in these organisms is accordingly small - a vicious circle.

What can be done to save Hawaii's biota? Herbivore eradication is highly desirable of course. Goat eradication has been undertaken in the two national parks. In Haleakala National Park, fencing in of the park boundaries followed by goat eradication has led to the return of the silversword both within the crater and on the outer slopes, and we may be able soon to see silverswords shimmering on Haleakala in large numbers, as they must once have been. Telling this success story is a pleasure, because so many areas are in much less good condition. Pigs still roam uncontrolled in many areas, and in particular the wet forests, where the majority of the endemic flora and fauna live, are still being degraded by pigs. The areas that most need preservation, therefore, are the ones receiving less attention.

Weed eradication has been undertaken in a few instances. One day I watched amazed as an attempt was made to control gorse on Haleakala by bulldozing it. If I had tried to tell these people that bulldozing would only widen the area of disturbance, result in a more weedy area, and do nothing about the store of gorse seeds left in the ground, I would probably have been ignored. In the American mythology, bulldozers solve problems rather than create them. Use of herbicides would be more effective, because less disturbance would have been created.

Biological controls for weeds could be used, and some have been tried. One of the best examples of use of biological controls occurred in Hawaii. Earlier in this century, both Australia and Hawaii were plagued by the prickly pear cactus (*Opuntia*). Introduction of the scale insect *Cactoblastus cactorum* led to the elimination of the prickly pear cactus from both localities. Biological controls have been tried for some other Hawaiian weeds, and some may be successful. The problem is that there are so many virulent weeds in Hawaii that biological controls may be available for only a fraction of them. In the case of weed extermination by biological controls or by other means, one is still left with the unsettling question as to how resilient Hawaiian native plants may be. The resilience seems greatest in alpine, dry forest, and beach areas, but these areas are much less rich than the wet forest habitats. We do not know how well wet forest would recover, or how soon, if weeds were removed.

Exclosures have been tried in two places: Haleakala National Park and Hawaii Volcanoes National Park. The Haleakala exclosure proved that areas protected from goats would produce silverswords, and led to fencing of the entire national park. In the exclosure in Hawaii Volcanoes National Park, vegetation returned, including a species new to science. Conceivably, if large mammalian herbivores cannot be eliminated soon enough, some Hawaiian plants may be rescuable only by use of exclosures. There is at present no impetus to build exclosures, however. Also, we do not know what damage to plants may be done by the omnipresent rat; flower and seed predation by rats might be almost as serious as predation by the large mammalian herbivores. Relocating plants or animals to offshore islands is a technique similar to use of exclosures, but as mentioned above, the few offshore islets in Hawaii are so small and dry that they are unsuitable for the vast bulk of Hawaiian plants and animals.

Artificial culture of Hawaiian species is always a possibility, but one that has not elicited much interest as yet. Although some native Hawaiian plants have been grown in the National Tropical Botanical Garden and in the Lyon Arboretum of the University of Hawaii, I have not yet seen Hawaiian native plants used in private gardens, whereas New Zealand gardens would be rather bare if the New Zealand native plants were removed from them. Long-term culture of flowering plants in botanical gardens is questionable in any case, because the numbers of individuals are small, loss of genetic identity by hybridisation is a serious problem, disease control rarely sufficient, and ongoing interest in the absence of good areas for re-release into the wild is often doubtful. There are no fewer than 500, perhaps as many as 900, endemic fruit flies in the Hawaiian Islands. But these cannot be cultured on standard *Drosophila* medium; they require media made from extracts of particular leaves. Can one seriously imagine that anyone would expend the money and effort required to keep these Hawaiian drosophilids in culture?

Seed storage is a theoretical possibility, but seed viability is short for plants of wet forest. This technique is a realistic one for plants of drier and cooler areas, such as California.

One of the most important activities in a place with so many threatened species is one that is obvious: research. When I wrote my book, *Hawaii, A Natural History*, I thought I might reach backpackers and similar natural history amateurs. Instead, the audience I seem to have reached most effectively is composed of graduate students. Graduate students discovered they could find very interesting, well-defined problems in Hawaii and enjoy a climate much more pleasant than Michigan in the winter. I found that a generation of graduate students was pursuing, much better than I could have, a series of studies that needed doing, so I returned to wood anatomy, in which most of my time has been spent in recent years. The best work done during the lifetime of a PhD is often their doctoral dissertation, so I felt positive about being displaced by a generation of talented youngsters. When a flora and fauna such as the Hawaiian are threatened with extinction, the most positive contribution of effort may be research. In future years, managers of areas may not be faulted for extinction, because the public will very likely conclude that extinctions were inevitable. However, academics like me very likely will be blamed for failing to study organisms while they were in existence, for failing to discover information obtainable only when these species were alive.

In connection with research, I would like to mention a possibility little considered at present, but a very real opportunity. One can freeze-dry plant portions and store them in vacuum packs. The technology for doing this is not expensive and is already in use in the food industry. This technique is also applicable to animal tissue. Freeze-dried plant or animal portions stored in this fashion should be good indefinitely. From such preparations one can recover intact DNA from which studies on genetic variability and relationships can proceed. Such stored DNA can give us phylogenetic trees involving extinct organisms. When one can see the last few individuals of a plant alive, surely that is the time to prepare material for future research. Herbarium material does not preserve DNA adequately. However, one should mention that herbarium specimens do preserve structure and can be used for studies in plant anatomy, so at the very least, herbarium specimens of a vanishing species should be prepared. Similar considerations apply to museum specimens of animals.

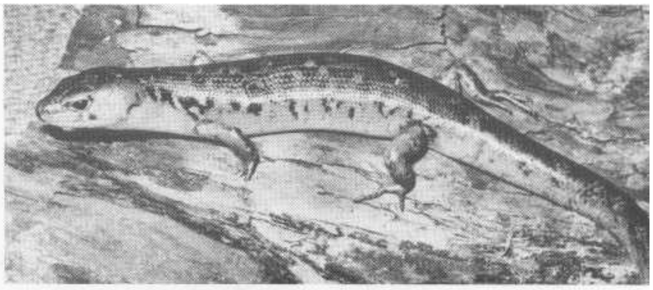
CONSERVATION MANAGEMENT AND ISLANDS

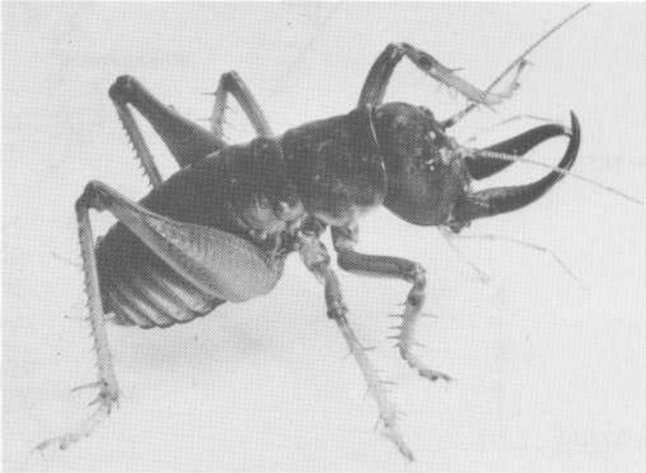
Finally, I as a scientist do have some requests to make of those of you who manage preserves and habitats. First, those of you who are constantly observing an area often can see important natural history details that elude scientists who make only short-term visits. If information you know is not recorded, or recorded only to remain in a filing cabinet, much of value is lost. I know you have other tasks, but please consider either publishing observations you think might be of value, or else communicating them to someone who may be interested in publishing them. There are worse fates than being a co-author. By being familiar with an area or a particular species, you may know of interesting questions that have not occurred to a scientist capable of applying specialised techniques of study. By suggesting a research problem to someone, you may well engineer an important contribution to our knowledge of wildlife.

With your responsibilities to care for an area or species, furthering publicity for what you do may seem a minor or excessive task, but again, a few words to the right person may have enormous effect. Making an area available to those in journalism or television can be a nuisance, but I think you will agree that it is an essential if we are to ask the public for help and support.

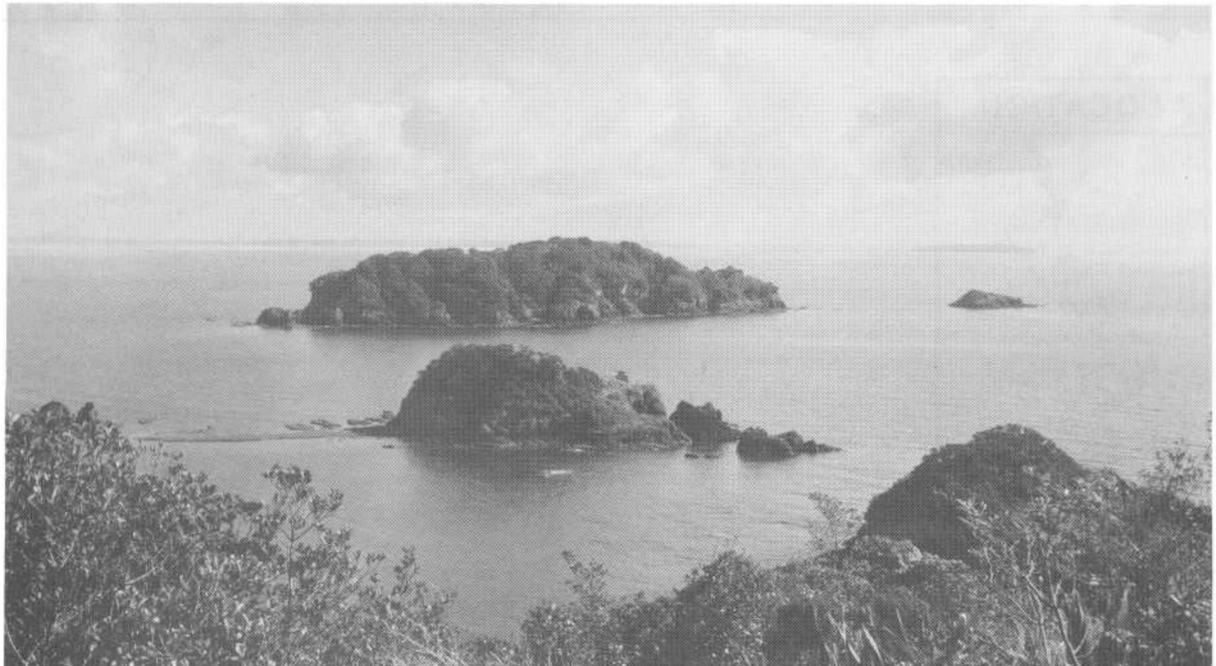
Making an area available to scientists is also very desirable if one happens to be a scientist needing access, as I frequently do, to an area of interest. Even if I am pleading my own case and that of my fellow researchers, I would like to ask your help in this regard. To those who are unfamiliar with other jurisdictions (as I am with New Zealand permission procedures), the help of a manager in aiding access often proves very valuable.

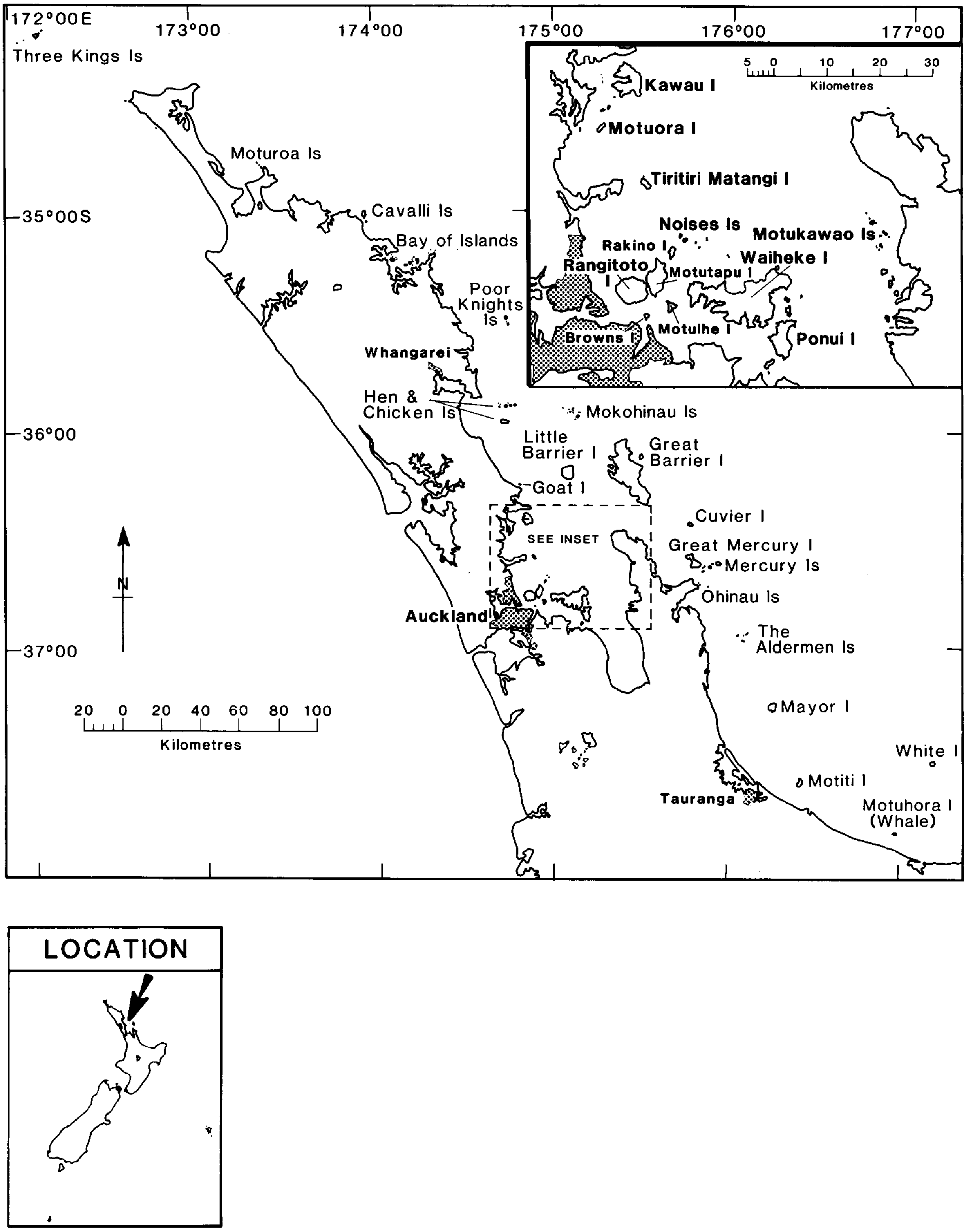
My last request to managers is that you not be discouraged. In the United States, we are currently fond of the saying that you can't solve a problem by throwing money at it. You will reply that problems aren't solved by withdrawing money from them, either. Causes in conservation are so worthy that there is never enough money to fund all that are deserving at an appropriate level. Likewise, administrative auspices are never as favourable as one might wish. Work in conservation tends to be, by its very nature, lonely, you are not likely to get the recognition you justifiably should have. However, during the talks at this conference, I have noticed the enthusiasm of each of you as you talk about your project, your work on your piece of the New Zealand heritage. Ultimately, it is the individual enterprise indicated by that enthusiasm that solves problems and gets work done, in conservation as elsewhere. An enthusiasm based on belief in what you're doing. I can't help noticing that New Zealand puts images of birds and plants on its money, rather than pictures of politicians, soldiers, and government buildings. New Zealand has its values right, and acts on them. That's why New Zealand is number one in the world in conservation. The United States recognises New Zealand's pre-eminent position in conservation, countries throughout the world do. So please, maintain your innovation and enterprise and show us the way.





SECTION 2: ISSUES AND DISCUSSIONS





Above: Islands of northeastern New Zealand.

Pages 215-216 in Towns, D.R, Daugherty, CH., and Atkinson, I.A.E. (Eds), 1990. *Ecological restoration of New Zealand islands*.
Conservation Sciences Publication No. 2. Department of Conservation, Wellington.

THE BOTANICAL VALUES OF THE NEW ZEALAND SUBANTARCTIC ISLANDS

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ABSTRACT

Subantarctic islands comprise an almost unlimited opportunity for understanding the dynamics of vegetation processes. Compared with northern islands, their vegetation is structurally intact, well documented, and without major adventive weed problems. Recent management plans for these islands incorporate the decision to eradicate feral mammals. Animals deemed necessary for genetic evaluation should be taken off immediately and the remaining populations eradicated according to plan.

I would like to begin by reminding managers of islands that the communities of plants found there, and the invertebrate populations associated with them, have the right to equal consideration under the Conservation Act. Furthermore, while there has been an emphasis on islands as locations for endangered species of vertebrates, I shall argue that the contributions to knowledge that would result from studies of the dynamics of the plant and invertebrate communities could be at least as great as those from the study of New Zealand's strange birds and reptiles.

If we seek to understand the full impact of humans and their domestic stock on vegetation, we need to go back a long way. Archaeological studies indicate that significant modification of natural vegetation can be observed as far back as the early Holocene. For example, treeless Dartmoor in south-western England appears to have been created by the overgrazing of a woodland habitat 3000 years BP. The builders of the Egyptian pyramids in the middle of the Holocene considerably modified the vegetation of northern Africa. The earliest presence of humans in Central America can be seen in the pollen record 8000 years BP.

For very logical reasons, the South West Pacific region was among the last areas of the world to be colonised by humans. The vegetation of Aotearoa (New Zealand) and its northern islands has suffered only 1000 years of human modification. But we can be reasonably certain that Polynesians never reached the subantarctic islands until after the arrival of the European in New Zealand. This makes the subantarctic islands very special in a global context. Their colonisation by humans has been within the last 200 years, within the period of detailed, written history, within the era of science and not much before the advent of photographic technology. The islands also lacked the selection pressures of moa browsing and grazing which occurred on the mainland.

In my opinion, the subantarctic islands are as yet still undervalued by both local and international custodians of natural systems. They comprise an almost unlimited opportunity for understanding the dynamics of vegetation processes in the absence of herbivorous vertebrates and with a mere 200 years of human interference. Earlier in the conference, Professor Diamond drew our attention to the distinctiveness of the New Zealand biota by likening it to that of another planet. If that analogy is accurate, then the plant and invertebrate communities of the subantarctic islands are like those of a moon to that other planet.

But as many of you will know, brief that the human presence has been, there is a legacy of that occupation. Feral domestic mammals from the northern hemisphere, introduced by early visitors and inhabitants, are present on some islands and consequently their vegetative communities are severely damaged. Furthermore, contrary to popular belief, the deterioration is continuing.

In considering the restoration of the subantarctic islands, I note that these islands have fewer problems than those outlined for the northern islands so far discussed at this conference.

1. The level of restoration needed is much less than that for the northern islands. On even the worst affected island, the vegetation is still structurally intact. If the feral mammal populations are removed, the vegetation will recover. Experiments on Campbell Island have shown that there are still sufficient refugia to supply the seeds of depauperate species.

2. There is no lack of knowledge about the composition of the original vegetation. There are stacks and islets which have never had browsing mammals or human occupancy. There are also good early records and photographs.

3. There are no major adventive weed problems.

4. The remoteness of the islands means that there is little likelihood of unauthorised re-releases after the feral animal populations are removed.

5. Finally, these islands already have recent management plans and, after much discussion, debate and canvassing of opinion, these plans incorporate the decision to eradicate the feral mammals.

There is, however, one problem in subantarctic island restoration which the managers of the northern islands do not face. It has been argued that the genotypes of some of the feral mammal population may include genes of use in mainland genetic improvement programmes. This possibility has delayed and inhibited the actioning of the eradications as called for by the management plans.

I do not propose to debate the potential genetic value of these populations. Dr M.R. Rudge will update the workshop on current thinking along those lines. But I can say that whatever the genetic merit of the animals, there is no need for any of them to remain on the subantarctic islands. Those deemed necessary for genetic evaluation should be removed forthwith and the remainder eradicated according to the management plans.

I have tried to convey the global distinctiveness of the communities of plants and invertebrates of the subantarctic islands which have evolved in the absence of vertebrate browsers and grazers and with an unusually short exposure to human interference. I hope the workshop accepts the values of that distinction and that the considerable expertise gathered here can be mobilised to examine the problem of how and therefore when the alien mammals can be removed.

Pages 217-220 in Towns, D.R, Daugherty, CH., and Atkinson, I.A.E. (Eds), 1990. *Ecological restoration of New Zealand islands.* Conservation Sciences Publication No. 2. Department of Conservation, Wellington.

THE IMPORTANCE OF FERAL ANIMALS ON NEW ZEALAND ISLANDS

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ABSTRACT

Feral mammals are important on New Zealand islands for two different and sometimes conflicting reasons: They reduce the value of the island for conserving indigenous flora and fauna, but they also have an intrinsic value in programmes of livestock genetic conservation. Sometimes these conflicts can be separated (Pitt Island, Arapawa Island); sometimes they cannot (Auckland Island). If they can, the interesting process of selection without domestication can be observed in the feral population. If the conflicts cannot be resolved in situ, management practices should allow for securing the genetic type before it is exterminated. The recent draft of the IUCN Feral Caprinae Position Statement offers a practical guide to issues and solutions for managers.

INTRODUCTION

There is no question that feral animals have had important effects on New Zealand islands; the question here is whether it is important to keep some of them on islands.

Feral animals for this purpose means livestock mammals - sheep, goats, cattle, and pigs. In the context of this particular conference their presence has to be set against restoration of islands as reserves. That immediately begs a conflict because, in both principle and New Zealand statute, alien organisms diminish the intrinsic value of an island. The issue then is to define what values these mammals have, why an island home is appropriate, and whether conflicting values can be accommodated. This is a sharp debate for New Zealand biologists because the country has an international reputation for clearing mammals from islands and is a model for other places, such as Hawaii and the Galapagos. Any tolerance towards animals with such destructive abilities strikes not only at practical management but also at the very philosophy of the importance of islands.

In this discussion paper I will show why people are interested in conserving feral mammals, show which New Zealand islands still have one or more resident species, and discuss the issues faced by managers.

GENETIC DIVERSITY

During the 1970s, FAO, other international bodies and rare breed societies drew attention to the worldwide decline in the number of breeds of livestock. This happened because market forces, fashion, and centralised breeding programmes drove locally adapted "old-fashioned" breeds into decline and extinction. For FAO, feral animals were considered part of the world's residual livestock diversity (Mason 1979). New Zealand feral mammals were examined from this fresh viewpoint at a wide-ranging seminar (Whitaker and Rudge 1976), and various populations were eventually given a tolerated or protected status. In 1988 New Zealand set up a Rare Breeds Conservation Society, which included feral livestock in its mandate (Blair 1989). Governments in Holland, France, Hungary, Brazil, Scandinavia and Greece have set up or supported livestock conservation programmes, and rare breed societies in many countries have a strong following.

At a conference in Warwick in 1989, an international coordinating body was established under the auspices of FAO to guide the varied activities scattered around the world (Alderson 1990). New Zealand's contribution to livestock genetic conservation was seen as very relevant to the overall effort, particularly with respect to feral forms.

Although the worldwide interest in conserving minority or superseded breeds has been active since the 1960s, it is only now that some of the benefits are becoming evident (Alderson 1990, Rudge 1990). This is because the commitment has been and still is an insurance for the future, and very rarely can a short-term commercial return be demonstrated. The philosophy is simple: Conserve diversity while it can be conserved so that posterity will still have choices. Philosophy without practical benefits means that the case to conserve seems flimsy and attracts negligible resources. For that reason alone it is simpler and cheaper to leave the animals where they are. If this were the only reason to keep them on islands, clearly challenging other priorities and values, the case would be rather shallow. A more worthy reason, at least scientifically, is that conserving in situ permits the natural selection process to continue. We know something of what this has done to feral sheep (Orwin and Whitaker 1984, Rudge 1986, Van Vuren and Hedrick 1989), but nothing about other species.

THE CONFLICTS

At the 1976 seminar, it was generally accepted that some remaining populations of feral mammals had a genetic value, especially those on islands, though the principle was hedged with necessary caveats about animal health and delicate unique ecosystems. The same perceptions and the same spirit were summed up at later discussion convened by IUCN to consider the status of introductions:

> In general there is little to suggest deviating from the rule that conservation of flora and fauna native to a place should always take precedence over conservation of introductions. Nevertheless the potential value of some feral animals should be recognised and conservation action taken where appropriate. (Munton 1984).

These relative priorities are also spelled out clearly as a hierarchy of management principles in the IUCN Position Statement for Feral Caprinae (Rudge in press):

> Indigenous biota takes precedence over alien.
> Truly wild animals take precedence over feral.
> Ancient types take precedence over modern.
> True breeds take precedence over hybrid forms.

Quite clearly, feral mammals have a conditional status. This means that in managing islands we have first to satisfy the priority of safeguarding intrinsic values before allowing the possibility of shared use.

WHO GOES, WHO STAYS?

If we consider in turn the few New Zealand islands which still have feral mammal populations, we find big differences in tenure, use, natural values, and risk level (Table 1). Some are populated, farmed, forested and greatly modified; others are in a wholly or relatively natural state. This suggests among other things that a doctrinaire position towards the feral mammals is not really appropriate, that multiple uses are already a fact, and - trite as it may sound - that each place and feral population has to be considered on its merits.

DISCUSSION

It has been said that islands valuable for conservation of native, often endemic, flora and fauna are being used as a free farmyard for animals which should not be there and which no-one is prepared to finance into a new home. Quite a few points arise from that broadside.

Without doubt the genetic value of feral animals is, or should be, of more interest to agro-scientists than to wildlife conservators or island managers. Yet it is a sad fact that since 1976 neither the agricultural agencies nor centres of learning in New Zealand have responded actively to the opportunities put before them. Exceptions are the Ministry of Agriculture and Fisheries' Ruakura unit, which has maintained study flocks of feral sheep, and LandCorp (formerly Fields Division of the Department of Lands and Survey), which has retrieved and bred flocks of Auckland Island goats.

Secondly, the islands have demonstrable values both nationally and internationally expressed in terms such as "unique", "exceptional", and "priceless". They are often priceless in both senses because their values are not commercial values. The feral mammals, at best, have only a potential commercial value. It is nevertheless surprising in a country so dependent on agriculture that so little support is forthcoming to guard against extinction, or even to evaluate characteristics. In the past, the costs of fencing off sheep on Campbell and Pitt Islands have been borne by the budget dedicated to conserving native ecosystems, not livestock genetic diversity. The Department of Conservation, while continuing to be sympathetic to the principle of conserving feral genetic types, cannot carry the cost of removing animals to the mainland. So long as other management costs are not thereby increased, leaving them where they are is a low-cost option for all concerned. This solution also carries the advantage of allowing natural selection to continue in animals freed from the selective and management practices of domestication.

The case for feral mammals on islands is not made out of perversity or to make the lives of island managers more difficult than they already are. It is motivated by a genuine belief that today's management decisions should not foreclose tomorrow's choices and that short-term uses may not be the best indicators of long-term value. It so happens that islands point up particularly strongly the conflicts in values and management choices. A corollary of this is that the decision, once made, is a much more visible expression of policy than it is elsewhere, where "policy" often exists by default. Whether or not any other people or bodies should be lending support, the fact is that the island managers hold the responsibility here and now. For many of the islands listed, it is not imperative to exterminate the feral animals. For those where it is then Management Plans should, at least, carry the obligation to canvass for expressions of interest.

ACKNOWLEDGEMENTS

John Parkes kindly supplied the latest information on the distribution of some island populations.

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Table 1. Islands with feral mammal populations, arranged from north to south, with their approximate areas.

Island	Species and status	Safe Management
Great Mercury (1860 ha) Inhabited	Small population of goats, could be semi-domestic.	Could stay.
Great Barrier (28 500 ha) Inhabited, farmed, forest in the northern end.	Local, light population of goats of large body size.	Local conflicts. Eradication to protect forest, in north. Could stay elsewhere.
	Scattered populations of pigs.	Nuisance value, could stay.
Rakitu (Arid I.) (400 ha) Private, farmed	Goats brought from Great Barrier.	No conflicts, could stay.
Kaikoura (1500 ha) Private, some forest	Goats brought from Great Barrier.	Valuable forest, eradication desirable.
Stephenson (100 ha) Farmed.	Semi-domestic goats.	No conflicts, could stay.
Mayor (1280 ha)	Pigs.	Low conflict, could stay.
D'Urville (16 800 ha) Inhabited, farmed. Much forest	Small scattered population of pigs.	
Arapawa (7780 ha) Inhabited, farmed. Forest remnants.	Possibly a rare breed of goats. Fenced out of prime part of nature reserve.	Reserve protected, could stay on private land.
	Scattered pigs which damage forest and invertebrates. Fenced out of reserves. Mixed strain.	Some recreational interest Eradication desirable.
	Sheep fenced out of nature reserves.	Retain in the fenced reserve.
Forsyth (770) Farmland and scrub.	Goats numerous. No reserves at risk	No conflict, could stay.
Chatham (90 000 ha) Inhabited, farmed.	Small scattered population of sheep in south.	No real hazard, could stay.
	Pigs scattered throughout Local recreational value.	Control. Eradication probably impossible because of local opinion.
Pitt (650 ha) Inhabited, farmed.	Sheep fenced into a feral sheep reserve.	Reserves protected, maintain sheep in special reserve.
	Light scattered pig population. Local recreational value. Threat to reserve.	Eradication desirable but local people object
Enderby (700 ha) Uninhabited, subantarctic reserve.	Shorthorn type cattle of late 19th century. Damage streams and forest	Eradication planned in 1990. Advertise information for expressions of interest in captive specimens.
Auckland (45 970 ha) Uninhabited, subantarctic reserve.	Small, local goat population with potential to spread. Damage to vegetation. Large body size, cashmere potential. Captive colony now on mainland (LandCorp).	To be eradicated November 1990.
	Pigs (1806). Light, scattered population. Damage to vegetation and seabirds.	Eradication but advertise for interest in captive specimens.
Campbell (11 300 ha) Uninhabited, subantarctic reserve.	Sheep flock fenced on to a peninsula.	Reserve protected, maintain sheep in fenced area.

Pages 221-239 in Towns, D.R, Daugherty, C.H., and Atkinson, I.A.E. (Eds), 1990. *Ecological restoration of New Zealand islands*.
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VEGETATION MANAGEMENT ON NORTHERN OFFSHORE ISLANDS

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ABSTRACT

Over the past 20 years, management of many New Zealand islands has been biased towards the well-being of animals rather than plants. The need exists for an equal emphasis on plant and animal ecology in island management - in fact for a single emphasis on the well-being of the whole biota. Island botanical values requiring preservation are reviewed. Differing levels of vegetation management possible are outlined, using examples from amongst northern offshore islands, and their consequences discussed. We propose a fundamental strategy of minimal interference for island management. Any departure from this principle should ensure that low impact management options are exhausted before higher impact options can be implemented. A scientific authority covering all facets of the biota to evaluate proposals for altering current flora and fauna of islands is essential.

INTRODUCTION

The northern New Zealand offshore islands (north of Cape Egmont and East Cape, Kermadec Islands excluded) vary in age from young volcanic islands less than 10,000 years old (White, Mayor, Browns and Rangitoto) to islands several million years old (Three Kings). Most northern New Zealand islands were formed in the last 500,000 years and include greywacke, sedimentary, rhyolite and Quaternary volcanic rock types (Hayward 1986a).

The majority of northern offshore islands were connected to the mainland by land bridges during the Pleistocene. Generally the length of time separated from the mainland, island size, and the degree of isolation are all reflected in the level of speciation in the island group (e.g., the number of endemic higher plant species on the Three Kings is 13 and on the Poor Knights is three).

Although most of New Zealand's offshore island biota have been significantly modified by prehistoric Maori (Hayward 1986b) the general paucity of browsing mammals and human activity on islands has meant that today most are less modified than comparable mainland areas. Island ecosystems are generally simpler, with fewer species and less habitat diversity than mainland systems, except for the very large islands such as Great Barrier Island that were once connected to the mainland. Exotic browsing mammals (goats, pigs, possums, sheep, rabbits, deer, wallabies, rats, etc.) have severely modified much of the mainland vegetation and are continuing to degrade it further. For example, possums are known to selectively browse certain plants, including prominent tree species (pohutukawa, northern tree rata, kohekohe - see Appendix 1 for scientific names of all plants mentioned in the text), and it is possible that these species will be eliminated from the mainland if present trends continue. Therefore islands are not only the home to a different genetic stock of plants, but they are likely to become the future stronghold for some present-day predominantly mainland species. Unfortunately, introduced mammals also exist on many New Zealand offshore islands, although recent eradication of rats, possums, goats and cats from quite large islands offers future hope that all New Zealand islands can one day be free of introduced mammals.

POTENTIAL NEGATIVE EFFECTS OF REVEGETATION OR RESTORATION

Atkinson (1988) defines ecological restoration as "active intervention and management to restore biotic communities that were formerly present at a particular place and time." He also gives examples of ecological restoration in New Zealand. Revegetation, on the other hand, simply involves recreating a vegetation cover without necessarily aiming to reproduce a previous community or assemblage. Exotic species might be used for revegetation but would be inappropriate for restoration of a natural community. This section concentrates on some of the more significant negative effects of revegetation or restoration as we believe the 'positive' effects are well-known and too well supported.

Restoration - A fallacy?

Restoration requires the knowledge that a species or community to be restored used to be present. Sometimes this is assumed because of the island's proximity to a known community or species. While this is probably correct in many cases, it is by no means guaranteed; Middle and Green Islands (Mercury Group) are less than one kilometre apart, both are near pristine, and they are the two least modified islands in the Mercury Group with no introduced mammals and no recent human disturbance. Yet Middle Island has a forest cover dominated by large-leaved milk tree and Green Island forest has no milk tree. There is no obvious explanation for this. On a larger scale, Little Barrier's closest neighbour is Great Barrier Island; both are large islands of predominantly volcanic origin lying only 18 km apart. There is no beech on Great Barrier, yet on Little Barrier hard beech is frequent and there is also a small area of black beech. Once again there is no obvious explanation.

The pollen record can be used for reconstructing past vegetation, but much pollen can be identified only to family or genus level. A suitable site for pollen accumulation and preservation is also required. However, pollen evidence is not very reliable for indicating local presence of a species on a particular site, and it should be remembered that the composition of vegetation is not static and what was present in the past may not be suitable for present-day conditions anyway. Plant fragments (including seeds) may offer more reliable evidence.

Many New Zealand plants exhibit disjunct distributions. These may be due to a variety of factors. Early Maori translocations are suspected in some cases, for instance, taking puka from the Three Kings to the Hen and Chickens Islands and the Poor Knights lily from the Poor Knights to Hen Island. Some appear natural, but are difficult to explain; *Metrosideros parkinsonii* is common in North-West Nelson but only known in the north from two high peaks, the summits of Little Barrier and Great Barrier. Other disjunct distributions are relict populations due to habitat destruction, selective browsing, or disease, e.g. large-leaved milk tree, Cook's scurvy grass, and *Euphorbia glauca*. Disjunct distributions make it hard to reconstruct past plant distributions with any degree of certainty.

Present revegetation or restoration goals often unclear

There is no doubt that most people experience a sense of satisfaction from planting, but some current revegetation and restoration practices on offshore islands may be doing more harm than good. The marvellous public enthusiasm and support of conservation issues that the Tiritiri Matangi Island revegetation programme has stimulated is well worthwhile, but it should be restricted to a small number of already heavily modified islands as the result is more akin to a biological park than a dynamic natural ecosystem. Although they may frequently be highly modified, close inshore islands are generally within the reach of birds and wind-dispersed seed which will naturally revegetate them in time. Most islands lying farther offshore are far too important biologically to even consider artificial revegetation.

In many cases islands are being revegetated or suggested for revegetation primarily to create animal habitat, and the plants themselves take second place. Low, open vegetation can contain rare plants, and planting tall vegetation for better animal habitat may decrease some of the present botanical values. *Ranunculus urvilleanus*, a threatened New Zealand endemic buttercup on Tiritiri Matangi Island, was known to be present before revegetation began (Esler 1978). The open habitat where this buttercup lives was proposed for planting until the possible consequences of this action were pointed out. Also, Tiritiri is the natural southern limit of the native morning glory *Ipomoea cairica*, which is locally common on the open north-eastern side of the island. This area should not be planted if this population is to survive.

In August 1989, 800 two-year-old pohutukawa were planted by the Department of Conservation on the lighthouse end of Cuvier Island. The seed was collected on Cuvier and raised on Tiritiri Matangi Island. This was done supposedly to increase the bird habitat on the island. Rather than plant a future canopy species here, a seral cover to attract birds would have been preferable. It was good to see Cuvier being used as the seed source, but why the rush to increase bird habitat when there is a large existing seed source adjacent to the replanted area? Revegetation of this area would have taken place naturally, though possibly more slowly, but it would have resulted in more diverse species and therefore a richer habitat for birds. If speedier regeneration were for some reason essential, lower-impact and (significantly) lower-cost options were available.

Rangitoto Island is unique in the New Zealand Botanical Region; this is recognised by its being placed in its own ecological district. Such an important flora must not be compromised by genetic pollution. Yet in October 1989 some 400 native plants were planted on the highly modified Motutapu Island which abuts Rangitoto. These plants came from a variety of sources including Tiritiri Matangi Island. The 250 karo plants donated by Manukau Polytechnic had an unknown provenance! Because of Motutapu's location immediately alongside Rangitoto, it is critical that stock from the two islands be used if replanting can be shown to be necessary. To make matters worse, possums and wallabies are common on Motutapu, and the Department of Conservation is currently considering a control or eradication operation on these browsing mammals. Surely any revegetation or restoration of Motutapu should take place after the animal threat is removed or reduced?

Plants should always be specifically grown for a revegetation or restoration project and not used just because a nursery has excess stock.

Increased human activity

Revegetation and restoration both mean an increase in human activity on the island which increases the likelihood of introductions of seed (attached to clothing, boots, camping equipment and the like) and soil-borne pathogens (in soil on boots, spades, camping equipment). Most weeds on conservation islands are present around the areas of greatest human activity.

The potential for unwanted introductions greatly increases if the nursery is not on site. Even though an island has had a past history of occupation or is frequently visited or is close to the mainland, it may still be free of certain plant pathogens, browsing animals and aggressive weed species of adjacent areas. Potential unwanted introductions from a mainland-based nursery would include:

(i) Pathogenic micro-organisms in the plant material or soil/potting mix or from the water. Thomson (1981) recorded cucumber mosaic virus in cultivated Chatham Island forget-me-not. The wild population would be threatened if diseased plants were ever transferred back to the Chatham Islands.

(ii) Invertebrate plant browsers - garden snails, chewing insects, etc.

Weeds - most nurseries themselves have a weed problem already.

(iv) Wrong plant material - illegible or mixed labels, for example.

(v) Genetic pollution - if the propagated material is not from the island to be revegetated then there is a risk of inappropriate plantings.

Godley (1972) pointed out that the scientific value of indigenous vegetation can be seriously reduced by planting species outside their natural geographical range (many plants are at their geographical limit on offshore islands); by planting species within their natural geographical range, but in unnatural habitats; and by planting species within their natural geographic range but not using the local race. Thus, the risks of unwanted introductions are minimised by propagating only plant material originating from that island and actually carrying out propagation on that island. The larger the project, the more important an on-site nursery is. Even small amenity plantings around buildings such as information centres and toilets should be derived from local plant stock. These ideas are particularly important in relation to islands with endemic biota and those offshore and outlying islands that are relatively little modified.

Genetic variation of northern offshore island plants

There are at least 127 native New Zealand higher plant species wholly restricted to offshore and outlying islands, and 110 of these are endemic to the islands. This includes 14 unnamed species (compiled from Druce 1989). If infraspecific taxa were included these totals would greatly increase. Some of these island endemics, such as *Tecomanthe speciosa* and the Poor Knights lily, are quite spectacular and add a very important dimension to our flora. There are many other plants that are predominantly island species but just manage a toehold onto the mainland - *Carmichaelia williamsii*, parapara, and coastal maire.

The chromosome numbers of only 50% of the New Zealand higher plants are known (Druce 1989). Some plant 'species' are known to have more than one chromosome number, e.g. *Pratia angulata* and *Hebe diosmifolia* (B.G. Murray pers. comm.) and these can be regarded as cryptic species until morphological differences are found to further differentiate them. Most New Zealand chromosome work has been done on very few individuals so cryptic species may be far more common than presently known.

Druce lists some 445 unnamed species in his 1989 *Indigenous higher plants of New Zealand*, which is almost 20% of the total New Zealand native higher plant flora. New species continue to be discovered, and these fall into two categories:

Previously undiscovered species: *Elingamita johnsonii* was discovered on the Three Kings in 1950 (Baylis 1951), and *Asplenium pauperequitum* was discovered on the Poor Knights in 1982 (Brownsey and Jackson 1984).

Species requiring splitting of existing taxa: Three recent coastal additions are *Einadia trigonos* (which means there are now three similar coastal *Einadia* species), a new species of *Crassula* (*C. tetramera*), which is very similar to and was previously included in *C. sieberiana*, and a new species of *Senecio* (*S. marotiri*), which was segregated from the *S. lautus* complex (Webb *et al.* 1988).

The large-leaved forms of many mainland plants on northern offshore island are well known. Taylor (1986) and Beever (1986) documented seven infrageneric and 19 infraspecific (13 unnamed) examples.

The large-leaved northern offshore island koromiko exhibit a wide range of genetic variability and are presumably in the midst of a burst of speciation. Currently there are thought to be at least six entities which look similar, and some even co-exist on islands.

Genetic variation is commonly exhibited by plants below varietal or sub-specific level but this has been poorly described for New Zealand plants. New Zealand taxonomists are still defining species levels for many native plants (ca. 20%), and microspecies have yet to be defined. For example, kawakawa (*Macropiper excelsum* s.l.) on the northern offshore islands has a large, shiny-leaved form which is formally recognised as f. *psittacorum*. Intermediate forms exist, but leaf size, leaf shininess and petiole colour appear to be consistent for each island group, which suggests different island races. These differences are maintained in cultivation. The 13 large-leaved infraspecific forms listed by Beever (1986) may also be examples of different races.

The high genetic variation exhibited in many New Zealand plants, combined with the relative infancy of plant taxonomy in New Zealand, points strongly to the need for the utmost caution in moving plant stock to islands for revegetation or restoration. At the very least the restraints mentioned by Godley (1972) and Timmins and Wassilieff (1984) should be followed if some sort of 'naturalness' with scientific value is desired, rather than a botanical park.

Risks to delicate genetic balance

Even assisting the regeneration on an island will alter the genetic expression of those species present; for example, taking cuttings greatly increases the phenotype of the selected individuals but does not increase the overall genetic variation of the species. Dioecism is common in New Zealand plants with some 12-13% of the species being dioecious (Godley 1979: 459). Natural ratios for dioecious plants should be determined and replicated as far as possible.

Interspecific hybrids are frequent in such plant genera as *Coprosma, Corokia, Fuchsia, Melicope, Olearia* and *Pseudopanax*. Intergeneric hybrids are seen in others, such as *Celmisia* and *Olearia*. The presence of hybrids means that the selection of cutting material or seed for propagation must be made very carefully. Unfortunately in many of the Auckland Regional Authority plantings in the Centennial Memorial Park (West Auckland), *Corokia* and *Pseudopanax* hybrids are frequent. Where possible, seed rather than cuttings should be used for propagation as this maximises genetic variation, and the seed should be collected from sites removed from potential hybrid situations (e.g., where species known to hybridise are found together).

Care must be taken with revegetation or restoration projects or rare plant transfers that closely related taxa which do not naturally overlap (including their pollen rain) are not brought into contact; otherwise, unnatural hybrids may occur.

Another risk lies in the planting of a closely related exotic species by mistake, such as Australian ngaio for New Zealand ngaio. This has already occurred on an Auckland mainland reserve (Tahuna Torea). Not only has an exotic been unknowingly introduced, but hybrids may occur between the two similar species.

Translocations vs natural island flora

Too often in the past the translocation of threatened animals to an offshore island has occurred without consideration of the full impact of the species on the island's existing biota. There are many examples of partially or totally herbivorous animals (landsnails, birds and reptiles) being placed on offshore islands with very high existing botanical values. Yet it appears that no environmental impact reports were carried out before these translocations. Many of these animals are capable of transporting seed in their gut, and Simpson (1971) has recorded the viability of seeds, both native and exotic, that have been ingested by birds. Have translocated species been quarantined before transfer to void plant seed?

Where possible we would prefer to see threatened flora and fauna protected within their natural range rather than seeing them shipped off to a "safe" offshore island and compromising that island's integrity.

ALTERNATIVE METHODS OF REVEGETATION OR RESTORATION

Evans (1983) provides widely accepted methods for revegetation. However, programmes for revegetation or regeneration require money, people, and time. Even when voluntary groups are involved, already scarce Department of Conservation funding and time will be committed. The reality therefore is that other DoC projects will be postponed or dropped.

Natural regeneration

The speed of natural regeneration on northern New Zealand islands is widely underestimated. When conditions are right it can be very rapid, even on isolated, exposed offshore islands, as long as there is a seed source close by. For example, Great Island in the Three Kings Group has undergone spectacular regeneration since the removal of goats in 1946. We would have predicted equally spectacular results for Whale Island in the Bay of Plenty following the removal of browsing mammals. However, natural regeneration was not given a chance, and a replanting programme was initiated (Smale and Owen this volume).

An alternative to revegetation on an island is to preserve natural vegetation close by (either on a neighbouring island or the mainland) so that together the two parts will be large enough to support and encourage bird movement between the two areas. If the pine planting in the early 1980s on Great Mercury Island had not taken place, the regenerating forest and scrub would be providing a seed source (instead of a weed source) for the natural revegetation of the modified smaller Mercury islands.

One of the great advantages of natural regeneration as opposed to planned revegetation is that it helps our understanding of natural regeneration pathways. The end result will be individual plants that are better suited genetically to their habitat, as they have undergone a strong selection process in order to survive, unlike the hand-propagated and nurtured plantings.

Although it may seem somewhat of a contradiction, exotic species may be involved in natural revegetation. Islands with bad infestations of gorse may be better off in the medium to long term if the weed is left rather than control attempted. Gorse is a good nurse crop for native species and can be overtopped and largely shaded out in 30-50 years. For islands without immediate or particular conservation requirements, natural regeneration through gorse would be preferable to the major interference caused by control and replanting.

Seral (native or exotic) species

The beauty of planting seral rather than canopy species is that, if there is a nearby seed source (as in Motutapu and Cuvier Islands), the final canopy will be natural rather than designed on a botanist's desk and planted in rows. Such a seral cover should be hardy and chosen to attract frugivorous birds, who will distribute the seed of future canopy trees. If native plants are preferred these should ideally come from the island to be revegetated. Examples would include flax, *Coprosma* spp., cabbage tree, *Pittosporum* spp., poroporo, New Zealand ngaio, and *Pseudopanax* spp.

Alternatively exotic species could be used in this way as long as marginal sites such as cliffs are small. Seral plants persisting in marginal habitats could be eradicated after the new canopy has shaded out the bulk of the seral crop. The advantages of using exotic species are that many are rapid growing and that they are obviously foreign to the island (unlike many unsuitable natives which have been planted). There are exotic nurse crops which are short lived and light-demanding. Legume species which will attract birds and increase soil nitrogen levels can be particularly beneficial in promoting regeneration. Exotic species which could be considered for northern islands include some wattle species, brush wattle, and tree lucerne. The latter is similar to kowhai, and both attract that great seed disperser, the New Zealand pigeon (*Hemiphaga novaeseelandiae*) to browse on the spring foliage and flowers. However, the effects of the introduction of exotic plant species into a more-or-less native community need careful evaluation (Simberloff this volume). Many members of the pea family have extremely long-lived seed, and dormant seed-banks in the soil may prove to be a problem when later wind-throw of the canopy occurs.

Monitoring and eradicating targeted species

In most cases we believe effort is better spent on monitoring and eradicating exotic flora and fauna, particularly aggressive weeds and browsing mammals, than on revegetation. Currently known problem weeds on northern islands, together with those we assess to have aggressive potential, are listed in Appendix 2. Motutapu Island is a case in point; eradication of the browsing mammals and aggressive weeds should occur before any revegetation or restoration.

On Rimariki Island the adventive century plant dominates a back-beach dune which would otherwise support silvery sand grass (Fig. 1). It is actively spreading by vegetative means, and eradication becomes more difficult year by year.

Fig. 1. Century plant visually and biologically dominates the upper beach on Rimariki Island, Mimiwhangata Farm Park, 25 November 1981.

On Tiritiri Matangi Island, Japanese honeysuckle was known on the island before revegetation took place (Esler 1978), yet control was not attempted until it had become a smothering weed during the revegetation programme. By this time it had greatly increased its range, and control is proving difficult and expensive. Also, with the increase in vegetation cover and hence bird numbers, the bird-dispersed fruit of Japanese honeysuckle is being spread far and wide. With the benefit of hindsight, the honeysuckle should have been removed first. Mile-a-minute and tree privet are also present on Tiritiri and may prove to be future problem weeds if not eliminated soon.

Tiritiri is fortunate to have a dedicated staff member (Ray Walter) resident on the island; most other island reserves lack live-in caretakers who might detect a new alien weed arriving and ensure its prompt removal. In his two highest management classes for northern offshore islands, Taylor (1989) suggested that these islands be visited at least once every two years to check for harmful introductions (rats, weeds, etc.) and that contingency plans be implemented when necessary. As the Tiritiri honeysuckle example has shown, early detection should have been followed by quick eradication; this would have saved many conservation dollars and would have given the best chance for certain eradication.

VEGETATION MANAGEMENT STRATEGIES

Piecemeal attempts at vegetation management frequently fail to achieve their goals and may even be counterproductive in the long run. Fully thought out and widely discussed strategies are needed for all islands, although many aspects of individual island strategies will be applicable to other islands and even classes of islands.

For the purposes of this discussion, three northern islands have been chosen to illustrate possible scenarios for vegetation management strategies. Aorangi Island in the Poor Knights Group is an example of an island with quite exceptional biological values. Despite a (mainly prehistoric) history of human modification, the island is rodent free, and it has extremely high floral, faunal, archaeological and landform values. Great Island in the Three Kings Group is an example of an island with similarly high floral and faunal values but which underwent considerably more recent and devastating human-induced modification - right up to 44 years ago. Stephenson Island, lying off the entrance to Whangaroa Harbour has been extensively farmed; it is presently clothed in dense swards of Kikuyu grass, and would be viewed by many, at least at first glance, as a near write-off in terms of wildlife values.

By looking at the biotic values of each of these islands we can arrive at a particular vegetation management strategy which best conserves existing values, hopefully enhances them for the future, and may even restore values which have been severely reduced or lost altogether.

Great Island

The Three Kings Islands lie about 60 km from the northern tip of the North Island. Their isolation from the mainland for at least two million years (Hayward 1986a) has seen the evolution of a variety of plants and animals found nowhere else. Their history of modification by both Maori and European is considerable and has had far-reaching effects on the flora and fauna.

Great Island is largely fringed by cliffs, with a summit of more-or-less gently rolling plateau and valley topography. It contains the only permanent stream in the group and has an area of just over 400 ha. Abel Tasman noted Maori inhabitants and cultivations in 1643, and archaeological evidence of occupation is still widespread. The deforestation by Maori settlers who left the islands about 1840 was so complete that even when T.F. Cheeseman visited 50 years later he found Great Island predominantly covered by manuka and kanuka, with nothing approaching the dimensions of an ordinary forest tree. During Cheeseman's second visit in 1899, four goats were released to provide food for castaways.

Scientific exploration and study of the Three Kings began in earnest in the 1930s and 40s. These early trips saw the discovery of many additional endemic plants and animals. Perhaps more importantly, the immense amount of damage being done to the flora and fauna by goats was recognised, and the urgent need for their eradication was communicated directly to the government. (How different governments must have been in those days!) In 1946 professional hunters effected the complete destruction of the goats (393) in a little over a week.

A staggering amount of regeneration and vegetation growth occurred in the intervening years, some of which has been clearly documented by the study of permanent vegetation quadrats (Turbott 1948, Baylis 1951, Holdsworth 1951, Holdsworth and Baylis 1967, Cameron *et al.* 1987). Small areas of goat-induced pasture are now covered in kanuka/*Coprosma rhamnoides* scrub well over 2 m high (Figs. 2, 3). Kanuka scrub, then 1.5 m high, has matured to a 6 m canopy. Completely eaten out undergrowth has reappeared, with widespread dominance of *Coprosma rhamnoides.*

Fig. 2. Quadrat III, Great Island, Three Kings Group, 28 April 1946. Goat induced *Zoysia* turf and clumps of *Isolepis nodosa* cover the quadrat with wind-swept kanuka adjacent.

But the most dramatic change has been the reappearance of the distinctive Three Kings coastal forest dominated by endemic tree species. Puka was entirely absent from Great Island when goats were eradicated in 1946. Now it is widespread, particularly associated with sea-bird burrowing, damper areas and better soils. It occasionally forms a pure canopy excluding almost all undergrowth, but usually occurs with other large-leaved trees such as the Three Kings rangiora and the Three Kings milk tree, often sheltering the endemic sedge *Carex elingamita.*

Fig. 3. Quadrat III, Great Island, Three Kings Group, 14 December 1982. 36 years of regeneration have seen the replacement of turf by kanuka/ *Coprosma rhamnoides* scrub up to 2 m tall.

For plant lovers, the endemic species probably provide the most excitement. They are all safely in cultivation on the mainland, but with two species reduced to single individuals in the wild, they provide a number of problems for vegetation management on the island. Table 1 summarises a range of vegetation management options for the island.

Strategies 1 to 4 are extremely low impact options. Although by virtue of their isolation the Three Kings probably have the lowest illegal visitor pressure amongst the northern offshore islands, education of targetted groups is still needed. Fishermen operating out of Houhora and Mangonui, dive boat operators, and yachties would be more likely to respect the need for strict controls on landings if the extraordinary biological wonders of the Kings were adequately explained to them, along with the potentially catastrophic results of fire, or rodent or weed introductions. It is significant that the vast majority of the 45 or so weed species on the island have been directly introduced by humans. The only New Zealand occurrence of the Australian umbrella grass *Chloris truncata* presumably has its origins in the survivors of early trans-Tasman shipwrecks at the Kings. Garden celery is naturalised on the cliffs where fishermen are known to go ashore to maintain their watering hose. But the bulk of the weed species occur on disturbed ground around the automatic lighthouse installed in the late 1960s at the top of the northern cliffs. A bed of white clover looks significantly out of place on the summit of a rugged and isolated island! Legal as well as illegal visitors need education on the need for sterilisation of clothing, equipment and building materials; fortunately none of the weed introductions thus far on Great Island are particularly aggressive or visually dominant. The warnings are there though. Lilac oxalis was introduced to Motumuka Island (Hen and Chickens group) amongst building materials used to construct an aviary used in bird transfers.

Monitoring of the vegetation on a regular basis is needed to give an early warning of change, particularly of potentially destructive or negative change. Since goats were removed in 1946 there have been about seven visits by botanists - an average of one every six years. However, in reality a report on the conservation status of the endemic flora in 1982 (Wright 1983) noted that although the endemics had been last surveyed in 1963, the most recently published detailed information on distributions and population sites had appeared in 1951. It is quite conceivable that several extremely rare species could have declined and become extinct in the periods of time between those surveys. It is also possible that an aggressive and conspicuous weed such as one of the pampas grasses could have established and spread to an extent where eradication would be nearly impossible. Regular visits are made to service the lighthouse, and a tightly organised monitoring programme could be worked in with those visits.

Strategy 4, the removal of aggressive/problem weeds, has fortunately never had to be implemented, and with reasonable care, should never be necessary.

With two species reduced to single plants, we believe there is some obligation to maintain and even enhance the wild 'population' of them. But we suggest that the path of minimal interference should be tried first (Strategy 5). *Tecomanthe speciosa* is a robust liane well known in cultivation and is New Zealand's only native representative of the tropical and subtropical bignonia family. The Great Island plant is centred on a pigeonwood on a small 'island' in Tasman Stream. Layering has produced rooted plants at six points up to 10 m from the original plant. Flowering has been observed once on the wild plant - in 1946. Since then, however, the kanuka canopy has grown up many metres, and despite long tendril-like stems seen spiralling upwards earlier in 1989, the plant was still many metres from the canopy and the full sunlight required by all members of this family for flowering and seed production (W.R. Sykes pers. comm.). So why not give the wild plant a little assistance and erect a few strings to bridge the gap between its centre of growth and the canopy? If it then flowered and set seed, some minor clearance of the very dense ground cover of *Colensoa physaloides* in the surrounding area might be required to assist seedling germination.

The other species reduced to a single individual is in an even more precarious position. *Pennantia baylisiana* is listed in the *Guinness Book of Records* as the world's rarest tree. First found in 1945, it grows in steep, rocky forest on the northern cliffs. Today it presents a different picture from the exposed, lonely tree pictured in 1945. The species is apparently dioecious - that is, female and male flowers occur on separate plants. The Great Island tree is female, though fortunately small amounts of viable pollen are produced. Manipulation of the flowers on mainland grown clonal material has produced sound seed from which a number of seedlings have germinated. The Great Island plant is known to flower well; we suggest that the first step in management of the wild population is to hand pollinate and encourage seed production. In fact, a small amount of ripe, naturally set fruit was observed on the wild tree in March 1989, presumably as a result of several seasons with mild, wet weather. If this low level manipulation of the wild plant does not lead to natural regeneration, we hope that one of the mainland produced seedlings will be male and provide pollen for artificial pollination of the Great Island female.

Table 1. Summary of range of possible vegetation management strategies of Great Island, Three Kings Group. Ranked from 0 (lowest impact) to 11 (highest impact)

Strategy		Effects
0.	Do nothing	Potentially catastrophic; Invalid option
1.	Educate local people	Reduce illegal visitor pressure Increase local watchdog action Increase understanding and appreciation of asset
2.	Require sterilisation clothing/equipment/ building materials and anti-rodent precautions for any visitors	Minimise risk of introduction of foreign organisms
3.	Monitor vegetation and flora	Early warning of change
4.	Remove aggressive/problem weeds	Maintain natural character
5.	Assist natural reproduction of endangered species (*Tecomanthe, Pennantia*)	Cause seed production and hence natural spread
6.	Cut access track(s)	Easier access for humans but little advantage to plants
7.	Propagate and plant out rare plant cuttings	Clonal - lacks genetic diversity
8.	Spread seed of rare endemic and other native plants	Widen distribution of endemic species. Quicken succession of climax forest. Destroy opportunity to study natural regeneration
9.	Create canopy gaps	Opportunity for wider establishment of climax forest species. Windthrow of surrounding trees
10.	(?Re-) introduce New Zealand pigeons	Spread puriri, tawapou, karaka, *Elingamita*; can be destructive of vegetation; deleterious to present fauna
11.	Replanting of mainland propagated material of rare plants	Unacceptable risk of foreign introductions e.g. soil-borne diseases

The cutting of access tracks (Strategy 6) is not justified under the present occasional visitor regime. The geography is such that exploration occurs radially from the campsite.

Strategy 7 suggests the propagation of a small number of cuttings of *Tecomanthe* and *Pennantia* using a natural in situ nursery adjacent to one of the streams. Although this would only produce clonal material, it would increase the population on which the manipulations described above could be carried out. It could be seen as a backup to the attempts to encourage the plants to reproduce sexually, and there would be no need to use the plants if the Strategy 5 manipulations were successful.

The hand-spreading of seed of rare endemic and other native plants (Strategy 8) is another possibility. Before 1989, the populations of the endemic *Myrsine oliveri* were small and scattered, and only two ripe fruit had been observed. This strategy might have been applicable to this species, but observations in March 1989 showed that a dramatic spread of seedlings had occurred over the past five years, with all the adult female plants fruiting heavily.

The creation of canopy gaps in the kanuka (Strategy 9) could allow a speeding up of the spread of climax forest species. In view of the dynamic regeneration occurring it can hardly be justified.

The re-introduction of New Zealand pigeons (Strategy 10) would assist spread of large-seeded species such as puriri (only one tree present), tawapou and karaka (both still rare). However, pigeons can be highly destructive of vegetation and with endangered plants present as single individuals the risks are unacceptable. If populations of pigeons in the far north of the mainland ever recover it is possible that they will find their own way to the Kings.

The highest impact strategy would involve the wholesale replanting of rare and endangered plant species on Great Island. This has already been proposed (Kennedy and Simpson 1982) and discussed (Simpson 1983). A major concern regarding the introduction of plants to Great Island lies in the very real risk of introducing pathogenic organisms, especially soil-borne fungi, to a situation where they are so far absent (P.J. Brook pers. comm.). Puka is highly susceptible in mainland cultivation, and sudden death of large, healthy specimens is a common sight around Auckland. Numerous examples of the devastation caused by, for example, *Phytophthora cinnamomi* root rot have been documented (Newhook and Podger 1972), and the implications for the Three Kings Islands would be extremely serious.

There is no doubt that efforts must be made to ensure the survival of the Three Kings' endemic plant species in situ. However, bearing in mind Great Island's value for the study of plant dispersal and succession, any steps involving manipulation of the wild habitat should be at the lowest level possible, and then only after substantial agreement amongst scientists from a number of disciplines. In view of the dramatic recovery of species and the overall vegetation since the removal of goats just over 40 years ago we believe that the low impact Strategies 1 - 5 summarised in Table 1 should constitute the Vegetation Management Plan for Great Island.

Aorangi Island

One of the two main islands in the Poor Knights Group, Aorangi lies just over 20 km offshore, and has an area of just over 110 ha. It shows abundant evidence of prehistoric occupation and modification, and pigs were present until 1936. However, there are no rodents, and plants and animals flourish in a manner which can no longer be seen on the mainland. Unlike the vast majority of the northern offshore islands, the Poor Knights are one of only two island groups which remained separated from the mainland at the peak of the last interglacial. The period of their separation may even be as long as one million years (Hayward 1986a), and this is supported by the evidence of endemism amongst the plants and invertebrates.

Access to the island - a publicly owned nature reserve - is strictly controlled and relatively infrequent. Of the varied flora, only one endemic fem has an uncertain future. Thus a fairly simple vegetation management strategy is called for, and a summary of a range of options is presented as Table 2.

Table 2. Summary of possible vegetation management strategies for Aorangi Island, Poor Knights Group. Ranking from 0 (lowest impact) to 7 (highest impact)

Strategy	Effects
1. Do nothing	Potentially catastrophic; Invalid option
2. Educate local people	Reduce illegal visits; increase local policing; increase local knowledge and understanding of assets
3. Policing presence	Reduce illegal visits
4. Insist on sterilisation of clothing/equipment/ building materials, anti-rodent precautions for visitors	Reduce likelihood of accidental introduction of weeds, fungal pathogens, exotic animals
5. Remove noxious/problem weeds	Maintain native assemblages
6. Cut axial access track	Reduces vegetation and habitat damage
7. Manage *Asplenium pauperequitum* a. Inventory - how much? Why dieback? b. Ensure survival in cultivation c. Spread populations on island	Ultimately save from extinction

All the elements of the strategy are low impact. As noted, to do nothing is an invalid option in view of the island manager's responsibilities to a nature reserve. In the case of Aorangi Island, education of nearby people has already been shown to be successful. Talks and slide-shows introducing the inhabitants and charter boat operators of Tutukaka (the major port servicing the Poor Knights) to the wonders of the islands' biota and the enormous risks posed by fire, the introduction of rodents or problem weeds, and unnecessary physical disturbance were very well received. Having been made aware of the reasons for so strictly protecting a unique asset, the charterboat operators offered to act as 'watchdogs'. We are pleased (but embarrassed) to have to admit that an unscheduled landing on one of the Knights just a few months after the Tutukaka talks resulted in several reports of our unauthorised landing to the authorities. (The landing was subsequently accepted as justified by the Park Board.) In the absence of any significant official policing of illegal landings, the fostering of local pride and protection of the asset is essential. However, the popularity of the surrounding waters with boaties and divers is such that an at least occasional official presence is highly desirable.

Regular monitoring of the vegetation and flora is required (perhaps annually, but at different seasons) to provide an early warning of detrimental change within communities or species. Prime objectives would be to prevent establishment of aggressive weeds and to assess the conservation status of endemic, rare or endangered plants. Monitoring requires someone on the island, and this raises the question of precautions to minimise the possibility of introducing foreign organisms. We believe that much more rigorous sterilisation of clothing, equipment and building materials should be mandatory for the most strictly reserved classes of islands. Almost all the adventive plant species present on Aorangi are found only in the immediate environs of the main landing point and campsite. We were surprised in 1988 to find the non-native ant *Amblypone australis* nesting by the main stream, well away from the campsite where it was presumably introduced amongst camping equipment or stores.

We see the removal of noxious/problem weed species as a vital facet of vegetation management on Aorangi. A large and conspicuous population of the introduced purple pampas grass was noted near the main landing area in 1984 (Fig. 4); despite repeated notifications of the infestation and strong recommendations for eradication it is still there, and the population has probably doubled. Eradication will have to be very sensitively handled, not only for the protection of the whole sensitive ecosystem, but also to protect the similar looking native coastal toetoe which grows throughout the same habitat.

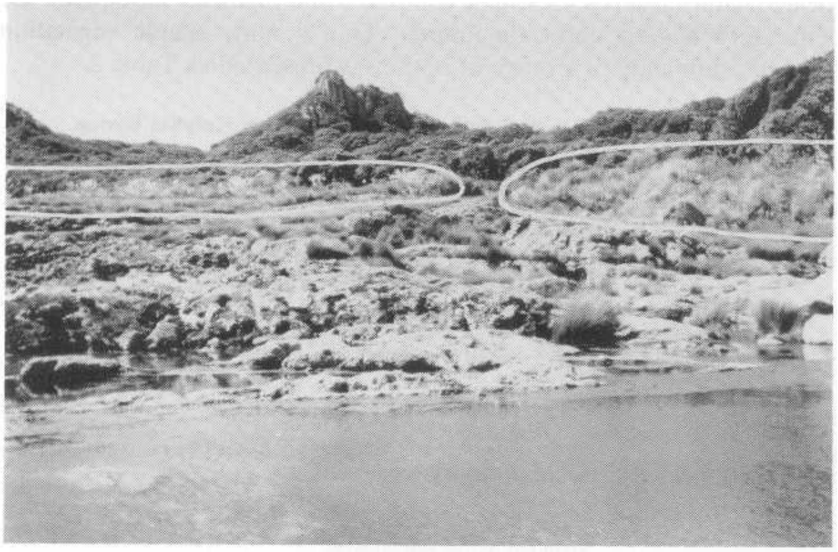

Fig. 4. The Landing, Aorangi Island, Poor Knights Group, 2 February 1985. *Cortaderia* spp. dominate the zone between open rock in the foreground and forest at rear. Circled at left is the native coastal toetoe; circled at right is a bad infestation of the exotic purple pampas grass.

The geography of Aorangi is such that access from the main landing area and campsite to the bulk of the island is channelled through a narrow valley entrance. Because of the dense vegetation on the valley sides, people always use the stream bed as a route for the first 100 m or so. This is the only stream on the island - a centre of diversity for many biotic groups - and a very fragile physical environment. The cutting of a discrete line to allow human access through the vegetation away from the stream is long overdue and would be of far lower impact than the continued use of the stream bed.

The only species management problem concerns the endemic fern *Asplenium pauperequitum*, first discovered in 1982. It grows in rock crevices on inland bluffs (Fig. 5) and in crevices between the roots of pohutukawa. The populations have always been small, and the most commonly viewed plants have undergone severe dieback over the past five years (Fig. 6). The reasons for this are unclear; if we wish to ensure the survival of this species we must move now to get it into cultivation and discover why the wild populations are apparently declining. We still lack a basic population count for the species.

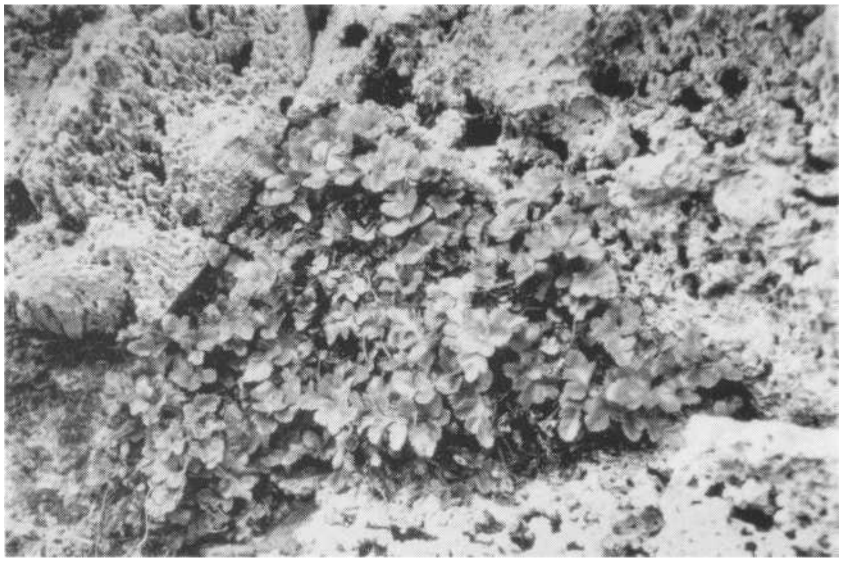

Fig. 5. The rare endemic fern *Asplenium pauperequitum* in rock crevices on Tatua Peak, Aorangi Island, Poor Knights Group, 2 February 1985.

Fig. 6. Severe dieback of *Asplenium pauperequitum*. Causes unknown.

None of the presently prevailing conditions on Aorangi suggest the need for any higher impact options such as those which might apply to Great Island. Thus we believe that the low-impact strategies summarised in Table 2 should constitute the vegetation management plan for Aorangi Island.

Stephenson Island

Stephenson Island lies 4 km off the entrance to Whangaroa Harbour. The Maori-owned island of 112 ha has a long history of firing and farming and is mainly covered in tall grassland with remnant pohutukawa and other coastal species on the low cliffs. Ki ore, but no other rats, are present. Cattle were finally removed in the 1970s, although intermittent grazing has occurred since then. The observations on which the following discussion is based were made in August 1982.

The presence of such a dense and extensive cover of grass hinders regeneration of shrub and forest species, but there are a number of encouraging signs that a more varied native cover will eventually clothe the island and that the return to forest might be quicker than at first expected. The major gullies support forest pockets including puriri, tree fuchsia, karaka, mahoe and whau, which are gradually colonising surrounding grassland. Bracken has established on some of the hillsides and provides a nurse cover for young manuka. Slump scars are quickly colonised by pohutukawa, manuka and flax. The coastal cliffs retain small pockets of forest which include such ubiquitous island plants as karo and *Melicytus novae-zelandiae*. A diverse community of seabird species including grey-faced petrels (*Pterodroma macroptera*) and the rare Pycroft's petrel (*P. pycrofti*) survived farming operations, and the burrows of these birds are now spreading inland from the cliffs in the absence of trampling cattle. They are efficient top-dressing agents, and their burrows break up the grass sward allowing the forest plant species to spread away from the cliffs with them.

Just a few metres to the north of Stephenson is a small island named Cone. It was probably never farmed but was fired semi-annually by mutton-birders. It has not been burned for perhaps 20 years now, and regeneration is spectacular when compared with Stephenson in the background (Fig. 7).

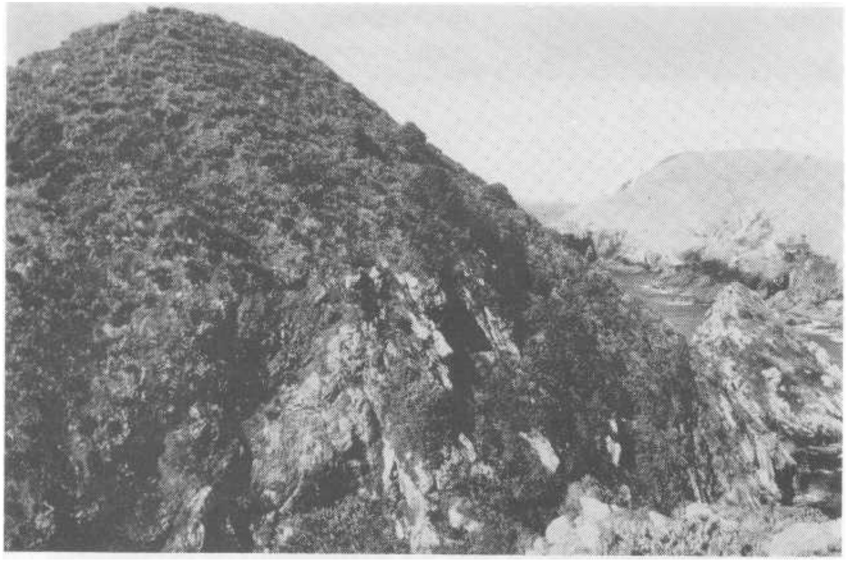

Fig. 7. Cone Island on 26 August 1982 showing ca. 10 years regeneration since burning. Grazed Stephenson Island in right backgound.

A final healthy pointer for the future is the survival of a tiny remnant of 'real' offshore island forest on one of the small islets just off the coast of Stephenson Island. Fruiting trees of large-leaved milk tree, tawapou and wharangi which are now absent on the main island can still be found here, and will provide a seed source for the eventual recolonisation of Stephenson Island.

Because the history, biota, and dominant vegetation cover of Stephenson Island are so markedly different from Great and Aorangi Islands, several new strategies are introduced. Because the island is relatively unstudied, a full survey to provide a detailed inventory of the resource is an early requirement. For the native plants this would include numbers, location, and breeding status of species likely to be useful in revegetation or restoration (either natural or induced).

Strategies 2 and 3 are somewhat linked. Before any major effort is put into flora and fauna management some kind of assurance of the future stability of the island's conservation status is required, e.g. purchase by the Crown, covenanting, or some form of reservation. The latter two imply a degree of commitment from landowners and the local community. Unconfirmed reports of tree and shrub planting followed by the liberation of goats since our observations were made serve to reinforce this point.

Table 3. Summary of range of possible vegetation strategies for Stephenson Island. Ranking of 0 (lowest impact) to 7 (highest impact).

Strategy		Effects
0.	Do nothing	Invalid option
1.	Full survey of resource	Obtain baseline data on which management can be based
2.	Educate owners and local people	Increase understanding and appreciation of island ecosystem
3.	Purchase/covenanting/reservation	Ensure long-term stability
4.	Destock	Natural regeneration
5.	Reserve adjacent mainland forest	Pigeon/seed source
6.	Eradicate aggressive problem weeds	Enhance native regeneration
7.	Propagate and plant	Speed up regeneration

Stephenson Island is close enough to shore to provide a good example of the advantages of reservation of forest on the adjacent mainland to provide a 'support system' for the island. Such a mainland resource could supply both the seed source and the pigeons to transport that seed to Stephenson Island. Fortunately, large areas around the adjacent Whangaroa Harbour Heads are already part of the DoC estate and with suitable management could provide this support system.

An island with open, low vegetation such as Stephenson provides a good opportunity to eradicate potential problem weeds (Strategy 6) before revegetation with a more natural cover proceeds. Gorse, mist flower and Mexican devil are all present in small amounts and could be sprayed before they became a threat to advancing native regeneration. This is the only northern island we know of where the aggressive tropical weed *Lantana camara* has a strong foothold. It chokes several gully bottoms and prevents the spread of coastal forest species in these habitats.

Propagation and planting of native plants (Strategy 7) should only proceed if a clear case (both biological and economic) can be demonstrated for the need to recreate a taller more diverse vegetation cover more quickly than natural regeneration would allow. (Given ideal conditions we estimate that planting would speed up natural regeneration by some 20-30 years.) If planting were necessary, the salient points discussed in the first part of this paper must be accommodated. It is essential that a record be kept of the source and numbers of the plants introduced.

CONCLUSIONS

Fundamental strategy of minimal interference

We strongly advocate a baseline strategy of minimal interference with the flora and fauna of the northern offshore islands. The guiding principle in any departure from this strategy should be that low impact management options be exhausted before higher impact options can be implemented.

Need for scientific authority

There is a clear need for a scientific authority to control the present largely arbitrary and whimsical management of island flora and fauna. After discussing examples of restoration on New Zealand islands Atkinson (1988) concluded that "no restoration project ... can be looked at in isolation from a national view of all the measures that are needed to conserve New Zealand's biotic communities."

The authority would need representation of expertise in all facets of the biota and should be somewhat independent of island management. It should be charged with the application of the strategy (which will presumably involve some kind of classification of the islands), with evaluating proposals to alter current flora and fauna values following environmental impact assessment, and with ensuring maintenance of adequate records of all changes undertaken. It may even be a suitable vehicle for gaining the urgently needed prioritisation of the scarce governmental conservation effort in New Zealand (as far as this relates to islands).

Ranked strategies

Management plans are required for all islands in the Crown estate in order that the public may have input into their control. As far as vegetation management is concerned, we believe that ranked strategies such as those examples presented here for Great, Aorangi and Stephenson Islands should be a part of these management plans, and that they are essential precursors to any proposal for alteration of existing natural values.

ACKNOWLEDGMENTS

Dr Ian Atkinson kindly critically reviewed a draft of this paper and made numerous suggestions for improvements. Graeme Taylor provided additional examples of islands for Appendix 2. The Auckland University Field Club and the Offshore Islands Research Group organised expeditions during which the vegetation of over 200 northern islands has been studied.

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Appendix 1. Scientific equivalents of all plant common names mentioned in text.

Australian ngaio	*Myoporum insulare*
beech	*Nothofagus* spp.
black beech	*N. solandri* var. *solandri*
bracken	*Pteridium esculentum*
brush wattle	*Paraserianthes lopantha*
cabbage tree	*Cordyline australis*
Chatham Islands forget-me-not	*Myosotidium hortensia*
coastal maire	*Nestegis apetala*
coastal toetoe	*Cortaderia splendens*
Cook's scurvy grass	*Lepidium oleraceum*
flax	*Phormium tenax*
garden celery	*Apium graveolens*
gorse	*Ulex europaeus*
hard beech	*Nothofagus truncata*
Japanese honeysuckle	*Lonicera japonica*
kanuka	*Kunzea ericoides*
karaka	*Corynocarpus laevigatus*
karo	*Pittosporum crassifolium*
koromiko	*Hebe* spp.
kowhai	*Sophora microphylla*
kohekohe	*Dysoxylum spectabile*
large-leaved milk tree	*Streblus banksii*
lilac oxalis	*Oxalis incarnata*
mahoe	*Melicytus ramiflorus*
manuka	*Leptospermum scoparium*
Mexican devil	*Ageratina adenophora*
mile-a-minute	*Dipogon lignosus*
mistflower	*Ageratina riparia*
northern tree rata	*Metrosideros robusta*
NZ ngaio	*Myoporum laetum*
pampas grasses	*Cortaderia jubata* & *C. selloana*
parapara	*Pisonia brunoniana*
pigeonwood	*Hedycarya arborea*
pohutukawa	*Metrosideros excelsa*
Poor Knights lily	*Xeronema callistemon*
poroporo	*Solanum aviculare*
puka	*Meryta sinclairii*
puriri	*Vitex lucens*
purple pampas grass	*Cortaderia jubata*
silvery sand grass	*Spinifex sericeus*
tawapou	*Planchonella costata*
Three Kings milk tree	*Streblus smithii*
Three Kings rangiora	*Brachyglottis arborescens*
tree fuchsia	*Fuchsia excorticata*
tree lucerne	*Chamaecytisus palmensis*
tree privet	*Ligustrum lucidum*
wattle spp.	*Racosperma* spp.
wharangi	*Melicope ternata*
whau	*Entelea arborescens*
white clover	*Trifolium repens*

Appendix 2. Problem and potential weeds of northern New Zealand islands in 1989 (excluding the Kermadec Islands). * known northern island weed; # potential northern island weed; ** aid forest regeneration but persist in open areas.

Weed name	Examples of islands where weed is known
Agave americana * century plant	Rimariki, Kawau, Beehive
Ageratina adenophora * Mexican devil	Aorangi, Stephenson, Little Barrier
Ageratina ripara * mist flower	Haraweka, Whatupuke, Little Barrier
Anredera cordifolia * Madeira vine	Kawau
Araujia sericifera * moth plant	Great Barrier, Tiritiri Matangi
Asparagus asparagoides * smilax	Kawau, Tarakihi (west Waiheke)
A. scandens * climbing asparagus	Little Barrier
Chrysanthemoides mondifera * bone seed	Inner Hauraki Gulf
Cortaderia jubata * purple pampas grass	Aorangi, Hauraki Gulf, some Mercury Is.
C. selloana * pampas grass	Hauraki Gulf
Dipogon lignosus * mile-a-minute	Moturemu, Maria, Rangitoto
Ehrharta erecta # veld grass	
Elaeagnus x *reflexa* * elaeagnus	Goat
Eriobotrya japonica * loquat	Kawau, Rangitoto
Euonymus japoncus * Japanese spindle tree	Inner Hauraki Gulf
Furcraea foetida *	Kawau
Hakea gibbosa * downy hakea	Great Barrier
H. salicifolia # willow-leaved hakea	
H. sericea * prickly hakea	Great Barrier, Rangitoto, Red Mercury
Hedychium gardnerianum * wild ginger	Great Barrier, Kawau
Lantana camara * lantana	Stephenson
Ligustnun lucidum * tree privet	Kawau, Tiritiri Matangi, Motukaraka
L. sinense * privet	Inner Hauraki Gulf
Lonicera japonica * Japanese honeysuckle	Tiritiri Matangi
Lupinus arboreus * tree lupin	Whale
Lycium ferocissimum * boxthorn	Inner Hauraki Gulf, Mercury Is.
Paraserianthes lophantha ** brush wattle	Rimariki, Muriwhenua, Tiritiri Matangi
Passiflora mixta # northern banana passionfruit	
Pennisetum clandestinum * Kikuyu grass	Sugarloaf (Moturoa Is.), western Bay of Islands
Pinus pinaster * maritime pine	Bay of Islands, Kawau, Rangitoto
Polygala myrrifolia * sweet pea shrub	Cavallis, inner Bay of Islands, Kawau
Racosperma longifolium ** Sydney golden wattle	Kawau, Pollen
R. mearnsii ** black wattle	Kawau
R. paradoxum * kangaroo acacia	Whale
Rhamnus alaternus * evergreen buckthorn	Inner Hauraki Gulf
Rubus fruticosus agg. * blackberry	Widespread minor occurrences
Solanum mauritianum * woolly nightshade	Bay of Islands
Stenotaphrum secundatum * buffalo grass	Rimariki, Burgess, Chickens, Pollen
Ulex europaeus ** gorse	Bay of Islands, Hauraki Gulf

Pages 240-254 in Towns, D.R, Daugherty, C. H., and Atkinson, I.AE. (Eds), 1990. *Ecological restoration of New Zealand islands*.
Conservation Sciences Publication No. 2 Department of Conservation, Wellington.

PROTOCOLS FOR TRANSLOCATION OF ORGANISMS TO ISLANDS

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ABSTRACT

Translocation as a technique for protection of rare species has been conducted in New Zealand since the 1890s but has never operated within publicly specified guidelines defining the most suitable species or locations. An approach to translocation through a three-step process is proposed here. An island classification system is applied where priorities for management of each island or island group are defined. A framework is established to include data collection, identity of species, definition of goals, consistency of approach, provision for quarantine, and co-ordination of effort. Protocols are defined relating specifically to islands with the highest inherent biological and conservation value. The rationale for each step is discussed using examples from New Zealand and overseas.

INTRODUCTION

The importance of the New Zealand island resource requires special emphasis when consideration is given to using islands as locations for management of endangered species. There are many ways in which New Zealand island ecosystems are either unique or distinctive, but the following ones have particular relevance to this account:

First the duration of isolation of islands from the mainland varies. Some outlying islands, such as the Kermadecs, have never been in contact with landmasses which are now part of mainland New Zealand. Others, such as the subantarctic islands, have not been in contact with the rest of New Zealand for many millions of years, whereas many offshore islands were part of the mainland until relatively recently (Hayward 1986, Stevens 1985). With varying periods of isolation different groups of islands have developed their own complements of plants and animals. Some islands have high levels of endemism, whereas others do not, and some are extremely diverse, whereas others have relatively small numbers of species.

Second, whatever the species complement, the communities of some islands have survived intact without the influence of mammalian predators which first appeared with the arrival of humans 1000 yr BP (Davidson 1984).

Because of isolation, area, age, and history of formation, New Zealand islands are globally regarded as particularly rich and distinctive (Diamond 1990, Diamond this volume, Carlquist this volume). This distinctiveness increases the need to plan before translocations to islands are conducted, and also increases the potential for creating expensive new conservation problems while trying to solve old ones (Diamond 1990). In their position statement on the translocation of living organisms (1987a), the IUCN Species Survival Commission makes a clear statement on the importance of islands such as these:

> Islands, in the broad sense, including isolated biological systems such as lakes or isolated mountains, are especially vulnerable to introductions because their often simple ecosystems offer refugia for species that are not aggressive competitors. As a result of their isolation they are of special value because of high endemism...evolved under the particular conditions of these islands over a long period of time. These endemic species are often rare and highly specialised in their ecological requirements and may be remnants of extensive communities from bygone ages... (p. 2).

The unique qualities of resident island communities require first consideration when transfers to, or between, islands are being contemplated.

The first documented translocation of New Zealand species onto islands was conducted by Richard Henry in the late 1890s as an attempt at removing rare forest birds from the effects of introduced mustelid predators (Hill and Hill 1987). These attempts, which involved the translocation of Fiordland kakapo (*Strigops habroptilus*) and kiwis (*Apteryx* spp.), failed on Resolution and its neighbouring islands, which were invaded by mustelids, probably stoats (*Mustela erminea*), from the mainland in about 1900.

Island transfers, especially of birds, have been resorted to frequently since 1900 (Bell 1989, Atkinson this volume), but there has never been an established protocol around which the choice of a new island location is based. Too often there has also been little consideration given to the impacts of the species to be released on the indigenous biota of its new location. As a result, some native species, such as wekas (*Gallirallus* spp.), are now being eradicated from the islands to which they had been introduced (Kennedy *et al*. abstract this volume). Some guidelines and models which can be applied to animal translocations have recently become available. The IUCN position statement on the translocation of living organisms (1987a) and the IUCN policy statement on captive breeding (1987b) provide a useful framework for policy, and empirical data on the field applicability of translocation methods are provided by Griffith et al. (1989).

In contrast to the situation with animal transfers, New Zealand botanists have been working with well defined protocols since 1974 after warnings by Godley (1972) about the dangers of mixing genetically distinctive stock, and about establishing plants in reserves outside their natural range (Timmins and Wassilieff 1984). To our knowledge only one translocation of animals has applied criteria similar to those used by botanists to island faunas (Towns *et al* in press).

Three developments have forced the need for an analysis of the way translocations of fauna are being handled in New Zealand. First, success with eradicating Pacific rats (kiore) (*Rattus exulans*), Norway rats (*R norvegicus*), cats (*Felis catus*) and possums (*Trichosurus vulpecula*) from quite large islands have provided prospects for island restoration which were not contemplated a decade ago (Towns 1988).

Second, responsibility for resource management has been decentralised. In combination with the absence of guidelines for island management this development has increased the risk of uncoordinated and hasty action.

Third, new techniques have enabled cryptic species to be defined, differences between populations to be measured, and more precise assessments of source populations, species diversity and levels of endemism to be obtained. On the other hand, many of the newly discovered species are very rare, thereby increasing the list of species which could benefit from island management. Without guidelines unrestricted translocations to islands could lead to many becoming little more than open zoos (Towns 1988), diminishing the inherent values of some locations (Diamond 1990).

In their position statement (1987a), IUCN proposes that governments should formulate policies on translocation of wild species, artificial propagation of threatened species, and the prevention and control of invasive alien species. This paper is an attempt at defining some of the issues and conflicts raised by this request and rationalising the various approaches to island translocations with criteria and priorities for island management. The management-based classification of islands used by Atkinson (this volume) has been used as a framework onto which the transfer protocols can be added.

DEFINITIONS

This account follows the following IUCN (1987a) definitions: "The movement of living organisms from one area with free release in another" (p. 1) is a translocation. Two classes of translocation are referred to here:

Introduction is "the intentional or accidental dispersal by human agency of a living organism outside its historically known native range."

Reintroduction is "intentional movement of an organism into part of its native range from which it has disappeared or become extirpated in historic times..."

Within the context of these definitions, species, whether native or not, which are introduced to a location from which there is no historic or strong circumstantial evidence of previous presence, should be considered as alien (or exotic) to that particular location.

ISLAND MANAGEMENT

Any translocations should be conducted within the framework of defined management goals. For individual islands a relatively few (21) such goals exist in the form of completed management plans (Department of Conservation records). A partial solution to this lack of management plans is to classify islands into the following five management groups (Atkinson this volume, Towns *et al.* this volume):

1. **Minimum impact islands.** The primary aim of management on these islands is to conserve the relatively unmodified status of endemic communities, to protect threatened species and communities, or both. Thus it is necessary to minimise both active human interference and the influence of introduced plants and animals which would be removed where feasible. Plants and animals naturally absent from these locations would not usually be introduced from other areas. Islands showing local endemism, such as the Poor Knights and the outlying islands (more than 50 km from the mainland), also would generally be excluded from translocations from other locations.

Minimum impact islands could form the primary source of plants and animals used in restoration campaigns. They have high intrinsic conservation and scientific value (Daugherty *et al.* this volume) because all of them house rare species or communities. Preliminary estimates indicate that fewer than 15 % of all offshore islands over 5 ha would fit into this category (see Atkinson 1989b). Most of the minimum impact islands are small. For example half of the 65 north-eastern offshore islands surveyed for lizards are less than 10 ha (Towns and Robb 1986). Many are fragile islands sensitive to human use, fire and climatic catastrophes. The minimum impact islands are also beyond the swimming range of introduced predators on the mainland.

Many of these islands are mistakenly regarded as being in a near pristine state, but in fact most have been altered by past human interference. They are, however, our closest approximations to "natural islands" because all of them lack introduced mammalian predators and browsers. Examples in order of increasing past modification are Adams Island (Auckland Islands), Middle Island (Mercury Group), the Aldermen (except Middle Chain), Three Kings and Poor Knights Islands. The "natural" character of the latter two groups is the result of rapid regeneration following the removal of browsing mammals.

2. **Restoration islands**. The primary aim of management here is to restore whole biotic communities as fully functioning systems. The term restoration is defined by Atkinson (1988 this volume) and Simberloff (this volume a). Islands classified for restoration would, in the literal sense, be used for reconstruction of communities which probably were there in the past rather than as refuges for threatened species not native to the island. Restoration islands are the ones which have been modified by human activities and often house introduced predators and browsers. They are locations to which vulnerable species and communities can be transferred from adjacent less modified islands.

Two kinds of restoration islands can be recognised. The fast and largest category includes islands where, by eradication of predators or introduced browsing species, the original biota could be restored. These are the locations that would form the focus of conservation efforts for rare species and communities restricted to small, highly vulnerable islands and islets. Examples, with the source location in parentheses, include Cavalli Islands (Motuharakeke), Mokohinau Islands (Stack "H"), Korapuki and Double Islands (Middle) (Towns *et al.* this volume). Cuvier Island could also be placed in this category, as partial restoration has already been undertaken (Atkinson 1988), although further concerted effort will be required there to save the resident tuatara (*Sphenodon punctatus*), which may be functionally extinct (McCallum and Harker 1981).

In the second category are the few islands which, although heavily modified by human activities, have retained many elements of their original fauna and flora. Restoration would have to include extensive habitat rehabilitation. Examples are Stephens and Maud Islands, both of which naturally house rare and endemic species. Mana Island might also fit into this category, although the extent of destruction of habitats and biota is greater there than elsewhere.

3. Refuge islands. The primary aim of management for this island type is to ensure the survival of species and biotic communities already on the island, as well as the survival of certain vulnerable or endangered species compatible with the island's biota. Action would range from removal of introduced plants and animals to restoration of habitats necessary for the survival of threatened species. In a few instances an island could be used as a source for founder populations of threatened species translocated to other islands, but only as long as this does not adversely influence the maintenance of indigenous rare species at the source location. Examples: Red Mercury Island, Little Barrier Island.

4. Open sanctuary islands. The primary aim is to provide an island where the public can have free but controlled access to appreciate and enjoy native plants and animals in a predominantly indigenous environment. This aim is therefore one of education and interpretation and would be met by maintaining an interesting array of native plants and animals in a semi-natural environment. Example: Tiritiri Matangi Island.

5. Multiple-use islands. These are the islands on which intensive management activities could focus. Management would vary according to the impact of the activity required and the degree of modification to which the island has been subjected, possibilities varying from open range management of large birds such as takahe (*Porphyrio mantelli*) on island farm parks to reconstruction of artificial "seminatural" island habitats using species well outside their natural range. For example, a management island for Antipodes Island biota would have to be outside the group, which only consists of two islands.

Such management should be conducted at a specified location where other values would not be compromised by these activities. Multiple use islands may be farmed, used for exotic plantations, or for various kinds of recreation. On islands such as these it would often be possible to develop either limited restoration programmes for indigenous biotic communities or imaginative management programmes for native species (including those endangered) in suitable habitats using either native or introduced plants. Islands used as farm parks, as well as some privately owned islands, would fall into this category. There are few locations where the potential for this kind of management is being explored in a planned way. It happens by accident on Kawau but probably could be done much more effectively elsewhere.

PUBLIC ACCESS TO CONTROLLED ISLANDS

Public access could be defined in any of the categories, remembering that access should be highly restricted on most minimum impact islands. Some restoration and refuge islands could be open to controlled visits. Stanley Island is proposed as such an example by Towns *et al.* (this volume).

Many multiple use islands could be open to unrestricted public access. Some of these islands occur within the swimming range of predators from the mainland, either directly or through intermediate "stepping-stone" locations. Some highly modified islands, in addition to Tiritiri Matangi, could be designated for recreation, revegetated and turned into open sanctuaries with an array of native species visible to the public (e.g., Craig this volume).

At present some islands, such as Titi Islands in Foveaux Strait, provide for harvesting of burrowing seabirds as muttonbirds. A special category might be allocated to such locations. Other locations could come into this category in the future, but here again, the management goals must be clearly defined so that conflicts do not arise between preservation, restoration, and the effects of human disturbance.

DERIVING THE CLASSIFICATION

The above classification can only be regarded as a preliminary one, because at present there is no mechanism by which such a classification can be objectively implemented. The easiest category to define is that for minimum impact islands. Other listings require an information base, public input to the planning process, and, for some islands, agreements between trust boards and landowners and the Department of Conservation over compatible uses.

Once the classification is agreed upon, there are additional requirements which should be met before translocations are conducted. One requirement should be fulfilled at the planning phase and the second before the plan is implemented. The requirements are relevant also to transfers on the mainland. The first requirement is referred to here as "prerequisites" and the second as "translocation protocols." A wide range of examples is available to illustrate points made, some of the most useful being for New Zealand reptiles. The studies on skinks (Daugherty *et al* in press, Patterson and Daugherty 1990, Towns in press a, Towns *et al* in press, Vos 1988) and the tuatara (Daugherty 1989) have particular relevance.

PREREQUISITES

Databases

Many species of fauna have been translocated to islands around New Zealand (Bell 1989, Atkinson this volume), and other transfers have been proposed (e.g., Timmins *et al.* 1987). If the information on translocations has been documented at all, it is extremely scattered, and not always useful or retrievable. For some species, such as little spotted kiwi and kakapo, there are some suggestions that the only viable populations have originated from translocations to islands around the turn of the century, but the documentation is too poor for unequivocal assessment (Bell 1989, R. Powlesland, R. Colbourne, pers. comm.). The need for useable data on the success *and failure* of translocations receives comment in the IUCN paper (1987a), is restated by Simberloff (this volume a) and apparently restricted the quality of information used by Griffith *et al.* (1989) in their review.

Computerised databases are needed to record as much as possible of the historical information on species which have been translocated in the past, and to include the following basic information on species to be moved in the future:

- (a) The species to be moved.
- (b) Where the population originated.
- (c) Where the population was moved.
- (d) When and how many individuals were moved.
- (e) Some "vital statistics" about individuals moved, such as band numbers, body weight and other body measurements.
- (f) Sex ratios (if known), and demographic structure of the population (whether juveniles or adults).
- (g) Genetic information (if any).
- (h) Whether the translocation was considered successful.

The Department of Conservation is the logical custodian of this information, because it is the only organisation which provides permits to handle protected species (see also IUCN 1987a).

Identity

There needs to be a means of ensuring that the target species is the one being translocated. This requires accurate identification of the source species for the transfer. Botanists have side-stepped this difficulty by restricting the distance to which transplanted or propagated material is taken to a 5 km radius from the parent stock (Timmins and Wassilieff 1984). For fauna, which can have highly disjunctive distributions, more sophisticated techniques may be required.

Clearly defined goals

Species translocations are usually justified on the basis of one of the following:

Restoring species which have disappeared from their former range, and/or restoring communities of plants and animals as fully functioning systems (in the sense used by Atkinson 1988). Ideally, this would be part of a defined and planned campaign. Atkinson (1988) gives four examples of restoration on New Zealand islands: Mangere Island in the Chatham group; Cuvier Island and Tiritiri Matangi Island in the Hauraki Gulf; and Mana Island near Wellington. The first two examples would probably best be regarded as partial restoration efforts, although they have not been explicitly designed as such (I.A.E. Atkinson, pers. comm.) The latter two, Tiritiri Matangi and Mana Islands, have been designed as restoration islands for plants, but the faunas being proposed for them are not necessarily part of their original (prehuman, or forested) ecosystems. This can raise confusion between refuge and restoration objectives. Unlike Tiritiri Matangi, Mana Island has its own complement of rare species for which habitat restoration should be undertaken. Timmins *et al.* (1987) noted the potential for conflict between the needs of endemic species and the needs of native species which might be introduced to Mana. Assessments of these conflicts have yet to be undertaken. Mana Island could become a restoration island, but it remains unclear from current management actions whether a restoration or a refuge status is the primary goal. There are no island restoration programmes currently under way along the lines proposed by Atkinson (1988). The Mercury Island proposal (Towns *et al.* this volume) could be one of the first with restoration as an explicit objective.

Conserving species threatened by extinction. This is the most frequent reason for transfers of species to or between islands. There have been notable successes using this technique with saddlebacks (*Philesturnus carunculatus*) and Chatham Island robins (*Petroica traversi*). Only one of the 29 taxa involved in such translocations (Atkinson this volume) has operated with an approved management plan (kakapo; Powlesland 1989), but even that one was after the entire breeding stock was transferred to new locations. Public input for translocations has in the past been obtained through the Fauna Protection Advisory Council, which, in the absence of Departmental policies on translocations, treated each case on an *ad hoc* basis. In some instances this lack of direction has led to conflict of objectives, with the possibility that transferred species would compromise rare endemic species of the host island. Some examples of this will be provided later.

Saving mainland populations of species not threatened by extinction. This has most frequently been when logging has threatened forest bird communities. There are a number of difficulties posed by salvage operations followed by transfers to islands. First, the birds have often been moved far from their natal areas. Central North Island forests have provided North Island robins (*Petroica australis longipes*) which have been shifted to the Bay of Islands, and bellbirds (*Anthornis melanura*), which were moved to Waiheke Island. Second, the transfers have sometimes been made at short notice, so the genetic identity of the stock has never been determined. Third, the transfers do not necessarily relate to any planned conservation objectives of the host island and could ultimately result in causing damage to rare species or communities. Fourth, the salvages are highly selective and when analysed may be little more than public relations exercises. There are few examples of similar concern shown for reptiles, invertebrates or native frogs, many of which are in more danger than robins or bellbirds. Finally, salvages give developers the wrong message. If the high public-profile species can simply be moved aside, why bother with habitat protection on private land?

"It seemed like a good idea at the time." It is difficult to determine what proportion of transfers fall into the latter category. Some certainly do, and possibly one example would be the release of *Placostylus* (flax snails) onto the Noises Islands by Powell in 1934 (Bell 1989). Even today the source (Poor Knights?), and identity of the landsnails is unclear. There must also have been many clandestine releases. One which could have exterminated one of New Zealand's rarest lizards was the release of weka (*Gallirallus australis*) (probably from Arid Island) on to Great Barrier Island in the late 1970s or early 1980s. Fortunately the birds failed to establish.

Consistency

It is difficult to reconcile the careful approach taken to restoration of plant communities on islands using well-tried and accepted protocols with the scattergun approach taken to fauna at the same locations. One reason given for this is that regional priorities are being applied to plants and national priorities to animals (e.g., Timmins *et al.* 1987). Such an approach is understandable, but at present there is no nationally defined priority list for endangered fauna other than the conservation status reports of Williams and Given (1981) and Bell (1986). Priority bird species and the potential for conflict between them were discussed by Timmins *et al.* (1987) for Mana Island. Their list, which includes a range of birds derived from as far south as the Snares and Antipodes Islands, was a collation of various proposals and was aimed at promoting discussion (I.A.E. Atkinson pers. comm.). Unfortunately the intent of the list has been overlooked, it is being applied without question, and the potential for conflict has not been addressed.

Consistency becomes an issue when one realises that of Snares and Antipodes Island fauna only birds are listed as potential candidates for translocation to Mana Island. There has been no suggestion that invertebrates from these locations should be transferred along with the birds, even though whatever threats the birds are under are threats to invertebrates as well. This point was not lost to Diamond (1990), who cautioned on the danger of concentrating efforts on island populations of charismatic species while ignoring or even damaging populations of ugly or cryptic invertebrates of equal conservation value.

Co-ordination of effort

Analysis of the transfers of fauna to islands suggests that many decisions about the translocations have been at best *ad hoc* and at worst extremely hasty. A change is occurring now that several draft species-specific and location-specific management plans are in circulation. There will still need to be co-ordination between these management plans, and some still need to make clear statements about whether they are leading towards restoration goals or fauna and flora management ones. What most species management plans should lead up to is a defined final objective and a stated date and cost by which it will be achieved. It is not good enough to transfer a species with large area requirements onto a small island which can support only a relatively small population on the grounds that any offspring that the species produces will inevitably put it into a better situation than currently it suffers. This hit or miss option, which may have been inexpensive at the time, may force future managers to mix stocks on offshore islands to overcome the deleterious effects of inbreeding - a logistically difficult and expensive process likely to receive low priority when funds are tight.

Quarantine

There are no quarantine provisions in existence for the transfer of animals or plants, and it is not clear whether any precautions about introductions of diseases or pathogens are being undertaken. The risks are particularly high for populations raised in captivity. Two examples will be used to illustrate this.

The desert tortoise (*Xerobates agassizii*) of North America has been declining in the wild in California due to habitat destruction and predation, so a campaign of reintroductions from captive-breeding programmes has been undertaken by several United States state agencies. Unfortunately these were conducted without quarantine provision and have resulted in the introduction from captivity of an upper respiratory disease hitherto unknown in wild populations. This disease has reduced numbers of tortoises in some of the largest populations by up to 60% (Kristin Berry, US Bureau of Land Management pers. comm.). This well intentioned "conservation" programme, with a high level of public involvement, may have done more damage to wild populations of tortoises than have the previous causes of decline.

An example closer to New Zealand is the incidence of fowl cholera in rockhopper penguins on Campbell Island (deLisle *et al.* 1988), possibly contracted when domestic poultry were on the island in the 1920s.

Some very serious thought needs to be given to the risks of releasing captive stock into the wild. Properly planned, captive breeding could be an essential support for conservation programmes. The breeding programmes need to be designed with the quarantine provisions provided rather than added in haste as an afterthought.

PROTOCOLS

When determining the information requirements for transfer of the rare Whitaker's skink (*Cyclodina whitakeri*), Towns *et al.* (in press) elected to use highly restrictive criteria in determining both source populations for translocation and host sites for receiving the relocated lizards. The criteria used were similar to those of Timmins and Wassilieff (1984) and seemed necessary because of the number of island reptile species whose taxonomic identity was unclear. The caution was well founded, because cryptic species of *Cyclodina* skinks have since been discovered in the Mokohinau and Poor Knights Islands (Vos 1988), and significant population divergences have been found in the tuatara of Cook Strait (Daugherty 1989).

Well-considered protocols are essential to restoration programmes: They provide for consistency of approach for plants and animals, and they give the highest chance of success of the restoration.

We propose that the following protocols, summarised from Towns *et al.* (in press), should be applied to the islands/island groups listed as either minimum impact islands or restoration islands (see Atkinson this volume).

No species should be introduced to any islands naturally free of mammalian predators.

There have been some suggestions that islands free of introduced predators have particular value as sites to which species vulnerable to predation can be transferred (e.g., Brockie *et al.* 1988). This suggestion overlooks the inherent biological importance and likely vulnerability of such locations, many of which have undergone long periods of isolation, either with unique combinations of species, or with species endemic to the location (IUCN 1987a). Species should not be added to this complement unless they can be demonstrated as having been removed due to human interference, i.e. as reintroductions, rather than introductions.

Some of the "natural" islands or island groups, such as the Three Kings, show the effects of past human influence but are now in advanced states of regeneration. Any manipulations of islands such as these should aim to reduce the long-term impact of human influence. Under these criteria propagation of species such as the liane *Tecomanthe speciosa* on the Three Kings would be justifiable (e.g., Simpson 1986), and would satisfy the IUCN criterion of restocking (IUCN 1987a).

Species which can survive only in locations free of exotic predators should, if possible, be translocated to habitats specifically managed for their needs by eradication of introduced predators.

The exclusion of the more "natural" islands from further introductions means that other locations will be required for species that are vulnerable to predation. For most, there are techniques which, by eradication of introduced predators, will provide habitats managed specifically for their needs. Removal of rodents and cats from islands has become far more ambitious and effective over the last few years. Mice (*Mus musculus*) are now being eradicated from Mana Island (217 ha), Norway rats have been eradicated from Breaksea (170 ha) and Whale Islands (150 ha), possums and weka from Codfish Island (1360 ha) and cats from Little Barrier Island (2800 ha) (Veitch this volume). We have the potential to eradicate mammalian predators from islands for species with all but the very largest area requirements.

Native birds have the largest area requirements. There are no land birds on the mainland of New Zealand that are unable to withstand minor predator pressure. The 33 known bird species which could not withstand human interference or predation by Pacific rats are now extinct (Towns in press b). The requirements of the species which remain can be met in a number of ways.

Geographic distances between source populations and proposed new sites should be kept to a minimum, especially when past geographic range can only be inferred.

Both Towns *et al.* (in press) and Timmins and Wassilieff (1984) stress the need to move species only within their past natural range. There is a practical reason for this, because translocation into the core of the historic range of birds and mammals have been more successful (76% of attempts), than those to the periphery or outside (48% of attempts) (Griffith *et al.* 1989). For plants, short distance movements overcome problems of artificially established populations being spread beyond their natural range. Botanists commonly use the ecological district and region concept for guidance over distribution, e.g. revegetation of Mana Island (Timmins *et al.* 1987), but the ecological district scheme does not account for the distribution patterns shown by many animals.

For groups which have disjunctive distributions such as reptiles and invertebrates, past geographic range can only be inferred. In the former case, distributional patterns can become an important guide to likely host islands. For example, although up to four species of the skink genus *Cyclodina* can co-exist on islands free of rats north of the Aldermen, no more than one species of the genus occurs on islands free of rats in the Bay of Plenty. This pattern should be borne in mind when planning restoration of Bay of Plenty islands. Indeed, low reptile diversity is a feature of Bay of Plenty islands, in contrast to the high diversities which are a characteristic of the islands further north (Daugherty *et al.* this volume). The reason for this difference is not known, but there would be little chance of determining its significance if an arbitrary decision is made to transfer additional northern species into Bay of Plenty locations free of exotic predators.

In most cases where restoration is being planned, nearby island groups or islands within the same group should serve as models for the fauna and flora to be restored. Restoration of the Ohinau Islands would best use the neighbouring Mercury Islands as a model; Middle Chain Island would use other islands in the Aldermen group, and Korapuki, in the Mercury Islands, should be modelled on Middle Island in the same group (Towns *et al.* this volume).

Where related species do not occur sympatrically, leapfrogging populations into induced sympatry should be avoided.

If movements of species are restricted to short distances between islands within the same group or between groups already in close proximity, the problems caused by artificially inducing sympatry should not arise. The results of placing two closely related species which do not naturally co-occur into the same location cannot be predicted. One outcome could be that the introductionwould fail because the resident species would out-compete the introduced one. Or, the introduced species could out-compete the resident one. If the resident species is itself rare, its demise would create more problems than the introduction would solve. The two species might hybridise, thereby raising a new suite of conservation problems. Low-level natural hybridism is found in closely related sympatric species of *Cyanoramphus* parakeets (S. Triggs pers. comm.), but it can rise to high levels following habitat destruction (e.g., Taylor 1975). Potential problems exist for some skinks where cryptic species (such as the undescribed species of *Cyclodina* in the Mokohinau Islands (Vos 1988)) occur within the broad geographic range of the closely related marbled skink. In geographic terms the two are broadly sympatric, but in fact they do not occur on the same island. The Mokohinau skink may be New Zealand's rarest lizard, and the marbled skink is also uncommon. Well-meaning efforts to lower the vulnerability of both species by introductions to the same location could prove to be disastrous because of the risks of the two interbreeding or otherwise interacting.

Individuals released into new locations should be derived from known wild populations or purpose-bred captive stocks.

The fewest problems are incurred if transfers of animals use wild stocks which have never been in contact with captive-reared animals. Not only does this lessen risks of the transfer of disease, but translocations of wild-caught animals are much more successful (75% of attempts) than for those raised in captivity (38%) (Griffith *et al.* 1989). Restricting transfer to wild stock sidesteps most of the provisions which may be required for quarantine. For practical reasons, however, captive breeding may be an integral part of the conservation plan for rare species (IUCN 1987b). In the latter event, care must be taken to ensure that animals reared for release are specifically bred from animals of origin. Hybrids in captivity have been documented for New Zealand parakeets, for which there may be no pure-bred stocks held by breeders (S. Triggs pers. comm.). Some of the potential red-crown x yellow-crown hybrids (*Cyanoramphus novaezelandiae* x *C. auriceps*) raised in captivity have been released into the wild, most notably onto Cuvier, Whale and Tiritiri Matangi Islands (Triggs and Daugherty 1988, S. Triggs pers comm.). The potential impact of these hybrids, should they mix with pure stocks at other locations, remains unclear but could conceivably result in loss of the characteristics which separate the two species where they co-occur (such as on Little Barrier Island).

Genetic analyses, or other "resource inventory," should be carried out to determine the possible relationships of the source populations to other populations.

For some species transfers it may be necessary to establish the genetic relationships of each population to ensure that their management is based on the correct taxonomic criteria. Where widely scattered populations occur - as with Whitaker's skink, which has three populations scattered over 500 km - there is always a chance that two of them are genetically highly distinctive but morphologically similar. As these genetic analyses must rely on small sample sizes, the difficulties inherent in this can be overcome by identification of large numbers of gene loci (e.g., Daugherty et al. 1981, Daugherty *et al* in press). Identification of genetically distinctive populations could alter the emphasis of the long term conservation strategy for the species.

Two examples of distinctiveness in the New Zealand amphibian and reptile fauna have recently been publicised. Chromosomal studies on Hochstetter's frog (*Leiopelma hochstetteri*) (Green 1988, Green *et al*. 1987) have shown that the species is unique amongst vertebrates in the large number of supernumerary (extra) chromosomes it may have, the number varying with location. Studies of genetic variation (Daugherty *et al.* 1981) and of supernumerary chromosome complement (Green *et al*. 1989) indicate that each regional frog population is distinctive and requires conservation in its own right.

Genetic surveys of most tuatara populations in 1988-1989 revealed the presence of three geographic groups of populations of which one, on North Brother Island, is sufficiently distinctive to warrant species status (Daugherty 1989). The genetic data are consistent with species identifications made in the late nineteenth century, but which have only been confirmed recently. These data have revealed for tuatara that there are three stocks and therefore three conservation problems, not one, and that the tiny Brothers Island population urgently requires its own conservation strategy (Daugherty 1989).

The results of genetic analysis can be used to help determine which source population, or combination of populations should be used in releases. When the release of Whitaker's skink was being planned, little detectable genetic divergence was found between populations (Vos 1988), so the nearest large population (Middle Island) was selected as the ideal source (Towns *et al* in press). Low levels of heterozygosity (natural variability) need not impair the viability of reptile populations (e.g., tuatara; Daugherty unpublished), but it is still prudent to work on the assumption that there is a positive relationship between heterozygosity and fitness (including survival and fecundity) (Vrijenhoek *et al*. 1985). This approach is taken by IUCN (1987a). In practical terms high fecunditity, which is translated into high levels of breeding success, will minimise the time over which bottlenecks may occur in new populations. Griffith *et al.* (1989) found that rare, threatened and endangered species tend to have a low success in translocations. This is possibly because many of them are slow to reach sexual maturity and have a small clutch size, compared with the more successful translocations of early breeders with a large clutch size (Griffith *et al.* 1989).

For Whitaker's skinks, which are slow to mature and have a small clutch size (Southey 1985, Towns in press a), this approach raises two questions. How many animals should be released in order to minimise potential genetic bottlenecks? How many releases might be required?

The number of animals required for a translocation is the first question asked by conservation managers. Theoretical population genetics, combined with an understanding of the ecological and behavioral requirements of the species, provide guidance on the question of suitable population sizes to be used for release, but the genetic criteria are not universally accepted. For the Whitaker's skink programme, the minimum effective population size (N_e) of 50 defined as that sufficient to overcome the detrimental effects of inbreeding and short-term loss of variation (Franklin 1980), was used as a starting point in designing computer simulations of possible release strategies (Towns *et al* in press). However, this minimum was not derived in the context of establishing founder populations, and even when applied to the more relevant question of inbreeding depression, should not be applied uncritically (Simberloff 1988). A similar, but slightly higher figure of 80 was given by Griffith *et al.* (1989), but whether the similarity between these two figures is significant remains unclear.

Most theoretical population models have either never been tested in nature, or have not been tested in the context of conservation to which they are applied in New Zealand. Some instructive conclusions were reached by Griffith *et al.* (1989), who in their review of translocations found that the fewer the number of birds released into the wild, the higher the likelihood of extinction due to chance events, but increasing the number beyond a certain point did not significantly improve the chances of success. Failure due to insufficient numbers released has been reported in New Zealand for North Island saddleback (*Philesturnus carunculatus rufusater*). Six saddlebacks were released onto Lady Alice Island in 1950, but failed to establish until a second release of 21 birds 20 years later (Merton 1975). Overall, only 52% of saddleback releases have been successful (S. Triggs, pers. comm.), and for some locations the cause of failures remain unknown.

Such failures provide little support for the suggestion that maintaining scattered small populations might minimise extinctions of small birds on oceanic islands (Pimm *et al.* 1988). On the contrary, recent reanalysis of data from Pimm *et al.* indicated that high rates of extinction of small-bodied birds at low densities, and low risks for large-bodied birds at high densities, are the more likely outcome (Tracy and George in press). The population and genetic models provide little substitute for a thorough understanding of the ecological requirements of the species to be reintroduced as well as an assessment of the attributes of the environment being provided (Simberloff 1988, Tracy and George in press). Unfortunately, rather than derive N_e independently, which requires information on biological characteristics of species, too many wildlife biologists have accepted the figure of 50 without question (Simberloff 1988).

There are situations in New Zealand where tests of some of the genetic models could be applied. The North Island saddleback, with all transferred populations derived from a relatively small number of individuals (20-50) from one location (Hen Island) would make a useful test species (J. Craig pers. comm.). In some cases, saddlebacks have been transferred from Hen to a second location, allowed to expand, then moved from the second location to a third. Whether the series of bottlenecks thereby incurred has had any effect on heterozygosity or fitness remains unknown. Low levels of heterozygosity could be remedied by additional releases from Hen Island.

DISCUSSION

In compiling this account, there is one question which repeatedly has been asked of us: "Why is it important to preserve these "pristine" islands, when some of them have naturally depauperate faunas and floras?" There are two reasons.

First, the more "natural" islands retain the remaining fragments of mainland communities which elsewhere have been lost. They are not necessarily the same as mainland ecosystems once were (Daugherty *et al.* this volume), but they are the repository for much of our remaining biological diversity. New species are still being discovered on these mammal-free locations. Recent examples are the tuatara from Brothers Island, the *Cyclodina* skinks of Mokohinau and Poor Knights Islands and the giant weta of Middle Island. There are certainly others yet to be found. The impact of introduced species on this unknown resource is unmeasurable and, without adequate protection, species will be lost before they are discovered. (See also Simberloff this volume b.) The more pristine islands house many rare and endangered species and some communities which were once widespread but are now confined to a few hectares of eroding rock. Statutory responsibilities towards the more pristine locations are stated explicitly in the Conservation Act. There are also obligations to the international community, such as island species survival strategies of the IUCN (e.g., 1987a), which cannot be ignored. On a world scale the diverse seabird-based island ecosystems found in New Zealand are possibly unique (Daugherty *et al.* this volume).

Second, the communities have a high level of scientific importance as living laboratories. The way that these island ecosystems function, the relationships between seabird populations and the genesis of soils, and how such diverse reptile communities are sustained, are either barely understood or remain a mystery. These questions have their own relevance to conservation of the habitats, because inshore fishing activities could have severe consequences if they were to remove a significant proportion of the seabird fauna either as bycatch, or through competition for resources (Ballantine this volume). At present we can only guess at the interrelationships between the islands and their surrounding seas, but such questions are bound to arise in situations where there is conflict over use of finite resources.

When protocols for transfer are proposed the main criticism likely to be made is that they reduce flexibility and leave managers with little room to manoeuvre in crisis situations (e.g Craig and Veitch this volume). Because of the potential conflicts that the latter point could cause we have proposed the classification of islands into categories in which various management goals are broadly defined (see also Atkinson this volume). Emergency situations are likely to arise, and species should not be allowed to become extinct because acceptance of the protocols proposed here argues against their introduction to certain locations. In such instances, however, we would argue that the transfers be regarded, and designed, as a temporary measure, and that their impacts on other components of the biota are assessed, possibly through a formal environmental impact report, so that the risks are understood. A checklist of relevant questions is given by Atkinson (this volume).

With very few exceptions (Stead's bush wren, South Island saddleback, kakapo), most recent transfers to islands around the coast of the mainland of New Zealand cannot be regarded as a last desperate act to avoid a species' extinction. It is worth examining the philosophy of island transfers, and likely future needs for safe habitats to see whether conflicts between proposals outlined here and perceived needs are likely to arise.

In such an analysis, the point should be emphasised that invertebrates and most reptiles can form extremely diverse and dense communities on very small rodent-free islands (Daugherty *et al.* this volume), with the 11 species of reptiles on 10 ha Middle Island providing a good example (Towns *et al.* this volume). There are a few exceptions. The Great Barrier skink, striped skink and Hochstetter's frog seem to require the large (28 500 ha) area of Great Barrier Island to provide the mature forest and running water habitats required, and not available on smaller islands. All three species co-exist with introduced predators on Great Barrier Island, all three suffer habitat degradation (Newman and Towns 1985), and all three require that Norway rats, weka and mustelids continue to be excluded from the island. Those three species aside, most New Zealand reptiles do not have large area requirements. In contrast, many endemic birds, especially the rarest ones, often have very large area requirements (Williams 1986, Atkinson 1989). This problem, the one of availability of specific habitats (e.g., those on Great Barrier for frogs), and the large number of threatened species to be considered (about 500; D. Butler pers. comm.), means that basing management on a predetermined minimum number of separated populations has doubtful prospects (cf. Craig and Veitch this volume).

Most species proposed recently for island transfer are birds. Considering these as an example, and adding those that are now considered to be vulnerable (and therefore likely to be candidates for transfer), it quickly becomes apparent that some species cannot be managed on islands because of their habitat requirements. Examples are the black stilt, yellowhead, and blue duck. Others, which are becoming rare on the mainland, are already widespread and common on many islands. In this category can be placed parakeet species and kaka. Two species currently receiving conservation effort are black petrel and yellow-eyed penguin. Black petrel are being transferred from Great Barrier, where productivity and predator pressure are high, to Little Barrier, where productivity and predator pressure are now low - the reverse of the previous situation. Yellow-eyed penguins are suffering the impacts of nesting habitat destruction as much as predator pressure and probably could be adequately managed on the mainland. It seems that kokako and stitchbirds may require large tracts of mature forest, which cannot be provided on many islands, and saddleback cannot now be regarded as a species in immediate danger. Little spotted kiwi, kakapo and takahe form a category on their own. For each of these species any island transfers will take the birds out of their natural environment and into an artificial one. Indeed, kakapo are now functionally extinct in their natural habitat (the three mainland islands of New Zealand), and both remaining populations with any chance of survival result from introductions outside their natural range. Similarly, it is not clear whether the Kapiti Island population of little spotted kiwi is artificially or naturally derived, but all others (Hen, Red Mercury and Long islands) are the result of translocations.

The curious observer must wonder whether a value judgement has been made that it is best to try to manage rare species in places which look "natural", even if the species either were not there, or were unable to sustain themselves in such locations in the past. If conservation of the species is the primary goal, perhaps management should be considered anywhere that will manifestly improve the size of the stock. For many species the best opportunity to take such an approach would be on highly modified islands (such as some farm parks), which are large, have few introduced predators and can be artificially manipulated to the species' requirements.

Managers should be concerned that some locations proposed for takahe and into which little spotted kiwi have been released already, either probably cannot support large populations in the long term, or may require intensive management which could jeopardise other inherent values of the islands. For example, the release of little spotted kiwi onto Hen and Red Mercury Islands appears not to have recognised the precarious state of the tuatara populations on these two islands, and now leaves the Department of Conservation with the need to decide between the conservation of indigenous tuatara and the introduced kiwi. A similar situation could arise on Mana Island where there are potential conflicts between the goals of conserving the indigenous giant weta and McGregor's skink, and the release of takahe (see also Atkinson this volume).

These situations should not arise if an island management classification system is derived, and species for which open-range management is required are only transferred to locations designated for that purpose.

At the edge of the continental shelf and beyond it are a number of islands which have faunas which are vulnerable to disturbance, or suffering from habitat destruction. Examples occur in the subantarctic islands, Chathams, Snares, Three Kings and Kermadecs. In many, if not most cases, habitat restoration within the existing geographic range would lessen vulnerability of the whole resource. If the threats are imminent, specific management locations should be defined and all of the vulnerable elements of the fauna and flora considered for management. In most cases where threats have been identified, there is ample time for remedies to be undertaken in a planned fashion with priorities, management locations and fallback positions defined and debated well in advance.

ACKNOWLEDGEMENTS

We are grateful to Mary Cresswell, Dave Hunt, Don Newman, Susan Timmins and Drs Ian Atkinson, Mick Clout, Richard Sadleir and Sue Triggs for comments on draft manuscripts.

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TRANSFER OF ORGANISMS TO ISLANDS

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ABSTRACT

Translocation of threatened fauna and flora to offshore islands is an important aspect of New Zealand conservation. Such transfers involve a series of interconnected questions, but no simple recipe will suffice, as many programmes must be species- or island-specific. This paper addresses aspects of such problems as which islands, how much habitat alteration before transfer, methods, population size, number of populations and release sites, proximity to source populations, impacts on existing biota and public involvement, finances and accountability. We strongly recommend the formulation of clear goals, the abandonment of the 50/500 rule, the establishment of multiple populations on both small and large islands, a geographic spread of populations and greater involvement and access for the public in future translocations.

INTRODUCTION

The importation of a large number of herbivorous and predatory mammals to much of New Zealand means that islands still free from such introductions are especially important in the conservation of native fauna and flora. Islands allow easy long-term maintenance, as the surrounding sea offers a barrier to most unwanted introductions. This barrier of sea also allows control of human visiting, although the past emphasis on exclusion of the public seems excessive (see Craig this volume).

Translocations of flora and fauna onto islands have increased greatly in recent years (Atkinson this volume). The majority of species moved have been threatened birds. The choice of island often appears ad hoc, although an uncritical adoption of the 50/500 rule (Frankel and Soule 1981) has meant that island size has been given a disproportionate significance. Short-term planning has also meant that islands with a suitable existing habitat are considered first, often with minimal thought to the existing animal and plant communities. Extensively modified islands rarely suffer this impact constraint and hence offer enormous potential for the establishment of additional populations of rare and endangered fauna and flora.

Transfer of rare and endangered flora and fauna to offshore islands involves many related questions. These must be considered and goals and priorities set before further transfers occur. No single recipe of translocation methodologies should be followed without careful re-evaluation of every point, as problems and advantages will vary for different islands, populations, species and communities. When setting goals both national and regional interests should be considered, and there should be wide consultation. This paper seeks to address many of the questions we consider important for the planning of transfers and draws primarily from our experiences with bird releases.

CHOICE

Which species for which islands?
Which islands do we exclude from transfers?

Some general principles appear in common use, even though they do not seem to have been formalised before this conference (see also Towns *et al.* this volume). For example, islands that have high levels of endemism should not be considered as sites for translocation (Lang 1982, Atkinson this volume). This principle should be maintained.

We should use only islands within historical ranges. There is empirical support for this internationally (Griffith *et al.* 1989), and this principle is violated by only one transfer in New Zealand - the Antipodes Island parakeet, *Cyanoramphus unicolor,* onto Stephens Island. (This includes kakapo, but see Towns *et al.* this volume.) Position within the historical range of the species rather than the demonstrated or inferred presence on the particular island should be the preferred criterion. We uphold this idea for early transfers, but in order to reduce the influence of catastrophes, this rule should be applied flexibly. Conservation is becoming an increasingly international concern, and New Zealand may be asked to help conserve species that have no safe refuges within or even near their historical range. Indeed some of our own species, such as Snares Island birds, are so localised that they must be moved outside their known geographic range if any new populations are to be established.

Island size is frequently considered, and larger islands have priority (unpublished minutes of the Hauraki Gulf Maritime Park Board). Small islands and even groups of many small islands are usually excluded. We would argue that all islands are important and, as discussed below, feel that in many instances size alone is a poor criterion.

In addition to these considerations, we suggest that increasing attention should be directed to highly modified islands that seem to have little biological value. Development of such islands will not only provide refuges for threatened species without threat to local values but also an avenue for public involvement in conservation.

HABITAT REPAIR OR DEVELOPMENT

What level of island repair or development is appropriate?

The degree of development or rehabilitation needed for introductionor reintroduction of native fauna and flora will vary from island to island (see Atkinson this volume, Craig this volume) and species to species. Near-pristine islands that have not required or have had minimal predator removal, weed control or habitat development will be the least modified and should be excluded from translocation programmes.

How long after development do we wait before transfer?

This is a difficult question, whose answer is likely to be highly island- and species-specific. The apparent habitat preferences of organisms in their wild refuges is often a poor guide to performance in a new habitat. For example, the hesitancy to put saddleback (*Philesturnus carunculatus*) onto Tiritiri Matangi because of a lack of mature forest, and the hesitancy to put takahe (*Notornis mantelli*) onto islands lacking tussock (Mills *et al.* 1984) have both been shown to be ill-founded. If anything, both these birds have fared better in their new habitats than they did in their original refuges. While caution is a virtue in caring for endangered and threatened organisms, well-considered trials and innovations can advance the welfare of many of our threatened populations far faster than conservative approaches can.

METHODS OF TRANSFER AND RELEASE

Trials

Capture, captivity, transfer and release methods are often species-specific and should be tested. The recent trial for whitehead (*Mohoua albicilla*) (Allen 1989) is a model of how most aspects of a future transfer, including re-release at approximate capture sites, were tested to ensure maximum success for the actual release.

Influence of social systems

Past releases have had little regard for social relationships. Results from field studies suggest that birds and other animals that know each other either as pairs or neighbours are more likely to establish and breed successfully (Sherman 1981, Stamps 1987, Beletsky and Orians 1989). The translocation of saddleback and whitehead to Tiritiri Matangi are notable. The adult saddleback were chosen as existing pairs, and neighbours or near-neighbours with the same song pattern were released together. Survival rates at the end of year one were higher for this release than most others (T. Lovegrove pers. comm.). In the release of the communally nesting whitehead, known members of the same flocks were released together.

Influences of habitat structure

Aspects of the habitat requirements of some species have not yet been adequately recognised. For example, can a newly released bird find an adequate roost for the first night or find water within the first 24 hours?

Habitat is rarely uniform, and the release site may influence success of colonisation. This is as true for plants as for animals with limited powers of dispersal. We recommend the use of multiple releases in large habitats; where habitat is patchy or variable, a balanced format of releases with subsequent monitoring will allow evaluation of the influence of release site.

INFLUENCE OF CHANCE (INCLUDING GENETICS)

Small or large islands?

Early ideas of animal populations based on the theoretical suggestions of Frankel and Soule (1981) led to an unquestioning acceptance of the 50/500 rule (Simberloff 1988). The overwhelming justification for these numbers was the likely loss of genetic variability because of inbreeding within small populations. Limited dispersal, high levels of philopatry and year-round occupancy of the same range appear to characterise many New Zealand birds (Craig and Jamieson 1988). Effective population sizes and viable population sizes of New Zealand birds may thus be much less than the 50 suggested for other animals (Shields 1981). We would argue strongly for abandonment of the 50/500 rule unless demographic and behavioural information is available to show otherwise.

Other workers have argued that genetic variability is best maximised in subdivided populations (Wright 1969, Quinn and Hastings 1987), indicating that a number of small populations will be better than a single large one. Given the additional problem of demographic and climatic catastrophes, many populations are always better than one. For all these reasons there should be no priority given to our larger islands unless known life-history or behaviour characteristics demand. Territory, home-range size, or food intake in an existing habitat should not be used in these arguments, as spacing behaviour is a flexible response (Craig and Douglas 1978); the same species may have highly variable densities in different habitats (the brown kiwi, *Apteryx australis*; Potter 1989) or feeding habitats (takahe in Fiordland versus those on Maud, Mana and Kapiti islands). An overall mix of small, medium and large size populations should be the aim.

Number of source populations?

In theory, the highest amount of genetic variability can be reached by mixing individuals from a number of populations. However, it is better to use a single source population for each island unless isozyme or associated analyses suggest that populations are highly similar. (See Triggs 1988 for an opposite view.) Using a single source population has the added advantage that all individuals released can have known neighbours and mates with them. If multiple satellite populations are preferable to single ones (Lacy 1987), different islands' populations can come from different sources; this would keep maximum variability across all populations of the species.

It is common practice in New Zealand to use seed collected on an island to grow plants for that island (Drey *et al.* 1982, Lang 1982, Timmins *et al.* 1987), and there seems little reason to depart from this pattern. Furthermore, when plants are reintroduced to islands, these should come from a nearby island or the adjacent mainland, as was done on Tiritiri Matangi (Drey *et al.* 1982).

Use of single or multiple release sites?

The chance of failure of releases is the multiple of the probability for each individual release. As a consequence, multiple releases are usually more successful than single ones (see Griffith *et al.* 1989). The problem is deciding what is the ideal minimum number of individuals that should be released at each site and in total.

The number of individual animals released in New Zealand transfers has been variable. Some large translocations (40+) have failed, whereas very small numbers (as few as five; Lovegrove and Veitch unpublished data) have established viable populations. The longer-lived a species, the fewer members are needed for any single release. Combined results for many species of birds translocated in a number of countries (often to modified mainland habitats; Griffith *et al.* 1989) suggest that eighty birds is the ideal minimum. The species involved in this study were predominantly wider ranging (raptors and game birds) and were released into a considerably more complex environment than would typically be involved in New Zealand. Lower numbers may be more realistic here.

Griffith's results suggested that dividing birds for release in different areas was advantageous down to a total release of forty birds. Studies of extinction rates of birds on islands around Great Britain (Pimm *et al.* 1989) suggested that seven or eight pairs was the most successful minimum population size and that this could be taken as the absolute minimum number for a single release. Even though some of the latter conclusions have been challenged (see Tracy and George in press), the studies suggest a minimum total release of thirty-four to forty birds with division between islands or areas (or years) to a minimum of fourteen to twenty. Where birds are long lived this absolute minimum can be attained over a number of years (half the average life span). If larger numbers can be obtained, more individuals should be released.

Proximity of source and satellite populations

Strong arguments can be advanced that translocation distances should be minimised (Towns *et al.* this volume). In order to get the highest genetic diversity and the lowest likelihood of chance demographic extinctions, a number of island populations should be established, and we would recommend that most of these be close to their source. This not only reduces stress associated with translocation but also accommodates any possible local adaptations. However, it is imperative that at least one population be geographically distant. Tropical cyclones, volcanic events and other catastrophes are typically localised but devastating in their impact. Captive populations can provide a hedge against such a problem, but we believe that a geographically separate population should always be the first option. It would be irresponsible management that did not accommodate such chance events.

IMPACT ON EXISTING FAUNA AND FLORA

Likely effects

The likely impact of translocated organisms on existing fauna and flora is often hard to estimate. Likely predatory action such as that of takahe on Mana Island giant weta (*Deinacrida rugosa*) (Atkinson this volume) or Maud Island frogs (*Leiopelma hamiltoni*) is an obvious danger, as is the potential for interbreeding among closely related species. Less easily assessed are such effects as the likely competitive depression of population size. Comparison of diet, nest site, growth patterns and the like can give a idea of potential interaction, but much will remain guesswork. Our almost total ignorance of invertebrate fauna on many islands will reduce our ability to predict the likely impact on existing organisms.

Some of these deficiencies can be overcome by further research, but how long should translocations await research programmes? Perfect knowledge will never be attained, so clear goals are needed to set the duration and financial limits of research before any programmes start. Baseline data on species composition and numbers from selected and little modified habitats as well as from translocation islands is urgently needed for comparison and control.

Impact of disease, pathogens and weeds

All translocations carry a potential for the introduction of these unwanted organisms. Wild flora and fauna are less likely to carry a disease or pathogen and, in the case of birds and mammal releases, wild organisms tend to establish more successfully in a new habitat than stock reared in captivity (Griffith *et al.* 1989). Where there is a history of a disease not known in the wild, potentially contaminated captive stock can still be used to establish one or more satellite populations, but these must not be mixed later with stock from a wild source unless it has been shown clear of disease. The establishment of takahe on Mana and Kapiti from captive stock which once carried a haemolytic disease (D. Crouchley pers. comm.) is a case in point. This disease occurs in other wild birds and typically only shows in times of stress. Current plans are that these populations will always be kept separate from the Maud Island and Fiordland populations, but this needs careful re-evaluation. Where the opposing view prevails (I. Atkinson pers. comm) and captive stock must always remain isolated, the use of captive rearing for any organism must also be questioned.

Translocated animals are a potential source of weed seeds or seed that may alter local genetic variability. This can be overcome by quarantine. Most birds are held in aviaries or transfer cages long enough to reduce this danger - which will always be small, compared with the potential contamination from the boots and clothing of the humans involved!

PUBLIC INVOLVEMENT, FINANCES AND ACCOUNTABILITY

Conservation, including translocations, is ultimately for people (Department of Conservation 1989) and can only succeed with the support of the public. Involvement of the public should start at the planning stage, and the ultimate levels of both protection and public access must be declared from the beginning.

Media reports of past translocations have emphasised success and ignored failures. This leads to unrealistic expectations among the public. Well-planned programmes can afford to be fully accountable and should maintain a high media profile for both successes and failures. Less than half the translocations of threatened species in Australia, Canada, Hawaii, New Zealand and the continental United States between 1973 and 1986 were successful (Griffith *et al.* 1989). Results for New Zealand are well above this combined average, and we can afford to be more vocal about all outcomes. Inviting the public to witness the release of whitehead onto Tiritiri Matangi in 1989 was a bold step. The supportive enthusiasm generated would not have been dampened by the chance deaths of some of the birds. In a professional approach to conservation nothing should be hidden.

Translocation, like all aspects of conservation, costs money. True costings, including labour, must be included when priorities are set. For example, the priority of hand-rearing takahe for reintroducing into Fiordland is a much less desirable and more costly alternative than using the first generation of birds to establish populations on Maud and Tiritiri Matangi islands and then translocating the chicks into Fiordland. The increased accessibility and public profile gained by the second alternative would probably be more beneficial for takahe conservation than the financial savings, considerable as they might be.

CONCLUSIONS

New Zealand's conservation managers face a complex of difficult and often conflicting questions when considering translocations. No simple set of guidelines (Towns *et al.* this volume) should be used unquestioningly. The ultimate goal of "protecting New Zealand's distinctive fauna and flora for the benefit of present and future generations" (Department of Conservation 1989) must be kept to the fore.

We argued earlier that long-term protection would be best achieved by establishing several (probably five) populations. As islands provide the most protected habitat, most of these populations should be on islands. We do not have enough islands to maintain the freedom to use only those that previously supported the organism in question. Nor can we ignore the possibility of chance catastrophes and hence must not keep all translocated populations near their source. Development of highly modified islands offers the flexibility needed to meet these needs.

Finally, we cannot maintain the policy of excluding public access to the majority of the populations we establish. Three things are needed to improve public perception of this important conservation work: greater public access to islands, increased protection of island ecosystems, and more information for the New Zealand public.

New Zealand has a proud record in translocations, but we must ensure flexibility in future planning if we are not only to continue as leaders in the field but also to have the support of the public and the scientific community.

ACKNOWLEDGEMENTS

We wish to thank many of our colleagues, who through discussion helped us develop these views. J. Craig's research is funded by Auckland University Research Committee and the New Zealand Lotteries Board.

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PAKEHA PERSPECTIVES ON THE RELATIONSHIPS BETWEEN HUMANS AND THE NATURAL ENVIRONMENT

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ABSTRACT

The paper reviews Pakeha perspectives on the relationship between humans and the natural environment, using typology techniques to discuss the range and variation of views derived from a European cultural tradition including philosophical, scientific and Christian religious influences.

The main themes covered are (1) identification and discussion of the diversity of Pakeha perspectives and values; (2) examination of these with cultural practices to explain how the values have emerged and been justified; (3) examination of European colonial settlement of New Zealand and the resultant, inevitable clash between two world-views; and (4) discussion of a planning strategy for the ecological management of islands which focuses on understanding the range of values in the community.

INTRODUCTION

Conservation is shaped by the values of our society. So that we can achieve the Department of Conservation's three main goals, we need to understand these values. Firstly, the goal of protecting the intrinsic and cultural values of natural and historic resources depends upon how our society defines the worth of an object, such as a wetland, or an activity, such as weed control. Secondly, the Department's interest in ensuring the sensitive use of natural and historic resources is affected by people's needs and aspirations concerning both their livelihood and leisure. Thirdly, in achieving the goal of promoting public understanding of conservation, the Department must be aware of the range of attitudes towards the natural environment.

The social implications of the Department of Conservation's goals are especially important in developing a conservation strategy for islands. Some islands, for example in the Hauraki Gulf, are frequently viewed as potential sites for recreation, but many others offer the only opportunity for the management of rare and endangered species, and the preservation of historical and archaeological sites.

To emphasise the importance of values in the development of conservation strategies for islands, this paper explores Pakeha perspectives on the relationship between people and the natural environment. A perspective is a 'view of the world'. It includes beliefs (the ideas an individual holds about a particular situation) and values which express what the individual considers is good or bad, appropriate or inappropriate. It also includes assumptions about how the world works and how the various parts relate to one another. Consequently, a perspective provides guidelines to action.

Human actions on the environment are affected by the perspectives people have. An understanding of these perspectives can tell the ecological manager a great deal about people's responses to the natural environment and what choices they may make about land use or land management. This understanding will help managers to:

(1) identify what people consider to be important about the natural environment;

(2) identify which management strategies will have a better chance of succeeding because they are compatible with values held in the community;

(3) focus more effectively on promotional and educational activities that will raise people's awareness about conservation matters.

The Maori, as the indigenous 'people of the land' have well defined understandings of their relationship to the environment which have informed their management of the impact of human activities on the natural world. These understandings need to be taken into account by natural resource managers. It is equally important to examine the perspectives of Pakeha, i.e. New Zealand born people of European descent. Pakeha perspectives derive from two important historical sources; the values and cultural practices of British society, and the responses of colonial settlers to the challenge of making a home in what they saw as a wilderness.

The majority of settlers coming to New Zealand shared a common British culture. Along with their material possessions, they brought their beliefs and values which derived from a cultural tradition formed over many centuries. These included philosophical, Christian, scientific and aesthetic influences. Their beliefs and values were further defined during the course of massive social upheavals in Europe between the seventeenth and nineteenth centuries. The development of capitalism, urbanisation and industrial society changed the whole of life and work.

The perspectives of British settlers have come to dominate the way we view the natural environment today, and they have been used to justify action taken on that environment. The four major perspectives discussed in this paper are exploitation/domination, scientific, aesthetic and ecological. The way that these perspectives are used and understood is much more detailed and complex than presented below. The brief outline of each perspective aims to provide a starting point for discussion and comparison with other cultural views on the relationship between humans and nature.

THE FOUR PERSPECTIVES OUTLINED

Exploitation/Domination

This perspective is characterised by a sense of superiority over and a desire to control nature. Natural resources are regarded as existing for the material benefit of humans, to be used for practical or profitable purposes.

The origins of this perspective are found in both Judaeo-Christian tradition and western philosophy. Passmore (1974) explains that domination over nature is the most influential understanding of the relationship of humans and nature that emerges from the Old Testament. This belief hinges on the notion that nature is non-sacred, and thus inferior to 'man' who is made in the image of God.

The themes of domination and exploitation of nature are also apparent in the philosophy of Aristotle, who asserted that animals were created for the use of humans. Although not all philosophers have agreed with this idea, human dominance over nature has a long history in philosophical thought. This has resulted in many philosophers considering human relationships with nature to be free from moral censure.

The domination view of nature differs substantially from that of many traditional tribal cultures, such as the Maori where nature is regarded as sacred and gods are found in nature. Humans exist within nature, and are dependent on it. They are not set apart or superior to it (Sinclair 1975, Marsden 1975).

In Western European thought, culture is separated from nature. This does not, by itself justify domination over nature, but makes it much simpler to devalue nature and disregard the intimate connections between human society and the natural environment.

Many westerners now consider that a rediscovery of spirituality and a 're-sacralisation' of nature will help solve environmental problems. While a change in ethics is certainly required, it should also be acknowledged that there are many examples of societies where nature is valued as sacred, who have nevertheless destroyed natural habitats. All societies face the basic problem of survival and have used natural resources for social ends. However, human ability to exploit the natural environment has been the most profound in societies with complex technologies.

The western european scientific perspective

Western Europe's scientific perspective rose to prominence in the seventeenth century. Other cultures have their own forms of scientific knowledge, but the western tradition is distinguished by its close association with industrialised society. Science has been called the 'mode of cognition' of an industrial society; that is, people commonly draw on ideas from science which are popularised and often misinterpreted, to justify their actions. It has also profoundly changed the way people in European cultures think about the natural world and act towards it.

The scientific ideas which have most influenced society can be summarised as follows:

(1) Facts are obtained from observation, not from traditional or religious sources of authority. Scientific and technological developments have profoundly altered the way that Europeans view the world. Matters previously mystified by religious or traditional folk beliefs have become known and commonplace.

(2) The concept of 'divine purpose' is irrelevant to science. Before Darwin, the adaptation of living things to the environment was explained as fulfilling God's purpose.

(3) Human understanding of their position in the universe is changed. Firstly, people come to believe, through science, that the Earth is not the centre of the universe, nor are humans. Secondly, the basis on which people believe they gain power is altered. Power is acquired, no longer through religion, but through gaining knowledge of the natural laws of the physical world. (For further discussion, see Russell 1976.)

The traditional western scientific perspective on nature shares some characteristics with the domination/exploitation view. It sees nature as non-sacred and separates human society from nature. Nature has been regarded as an object of study, as a means to the desired end of acquiring knowledge. Science has also been used as a means of controlling an unpredictable and dangerous natural world. This has been viewed very positively in European cultures because it has increased the chances of survival.

But in the late twentieth century, traditional scientific methods and values are being increasingly questioned. Science is now regarded by many scientists and non-scientists as a means through which we are making the world uncontrollable, i.e., science has enabled even greater exploitation of the natural environment and consequently the balance of the ecological system has been upset.

Despite these well-founded critiques of one particularly influential scientific paradigm, it should also be acknowledged that science has also provided crucial insights for the development of ecological and conservation principles.

The aesthetic perspective

The aesthetic perspective focuses on nature's beauty and artistic appeal. This perspective has characteristics in common with the two previous perspectives. Firstly, it assumes a distance between nature and human society.

> ...landscape, as the aesthetic attitude to the land requires... a somewhat detached kind of observation... It requires a standing still simply to look at it. (Pound 1987: 57).

As well as making the natural environment an object apart from the human observer, the aesthetic view is translated into practices which seek to control nature. One example is the seventeenth century formal garden where the raw materials of nature were 'civilised' and 'perfected' by the imposition of human order. Bushes were clipped, water channelled and landform changed to bring out nature's hidden beauty.

In New Zealand, pioneer settlement prevented an acknowledgement of beauty in nature, as the demands of survival caused settlers to battle with the wilderness. But by the 1890s, where frontier settlement was largely accomplished, an aesthetic concern for forest preservation became apparent (Roche 1983: 237).

The ecological perspective

This perspective differs from the others because it regards humans as part of a complex environmental system. It neither sets humans above, nor apart from, the natural environment and includes the following main principles:

(1) All aspects of the environment are interrelated.

(2) Human beings are part of the environment. They both depend on it and influence it.

(3) Change in one part of the environment brings about change in another part.

(4) The population of any organism is limited by the availability of resources. Many resources are non-renewable and, therefore, sustainability must be achieved.

(5) Resources must be carefully managed and future use planned. (Simpson 1983: 4).

The origins of the present-day ecological viewpoint are found in the latter half of the nineteenth century when an awareness of conservation emerged. But it has gained most impetus since the 1970s with the rise of the environmental movement in Western European societies and New Zealand. This has popularised and politicised debates concerning the degradation of the natural environment.

THE EXPRESSION OF THESE PERSPECTIVES IN NEW ZEALAND

The predominant perspective in all phases of British colonial settlement has been exploitation/domination. Before 1840 Europeans were quick to exploit the raw materials such as timber, marine mammals and flax, offered by the natural environment of these islands. After 1840 the enduring economic basis of survival for settlers shifted from natural resource exploitation (although it was still significant, for example, with gold mining and kauri felling) to agriculture.

Two important ideas justified land settlement practices. They were a utilitarian view of land and the concept of individual ownership of land. The utilitarian view treats land as a commodity, only useful if it is productive. Non-productive land is defined as waste land. Settlers considered that much of Maori land, because it was neither occupied nor cultivated was waste land. Many thought that the Crown should claim ownership of waste lands and grant Maori people ownership rights only to cultivate and occupy land. This reflected settlers' desire to acquire large areas of land for development which had clear ownership title.

In the 1850s colonist pressure on the government to obtain Maori land overrode the protections guaranteed by the Treaty of Waitangi. The inevitable result was the land wars of the 1860s which secured large areas of Maori land under European ownership.

Throughout the latter half of the nineteenth century, the government encouraged land settlement by the colonists, particularly those without property. While Pakeha as a whole benefitted from the taking of Maori land, there were landless among the settlers. The pastoral elite had monopolised land available to settlers and through this became a potent economic and political force. Successive governments attempted to improve the opportunity for landless settlers to gain agricultural property by reducing the price of rural land and promoting the idea of small freehold farms. Ballance summed up the view, stating "...small farming should be the rule and not the exception" (quoted by Arnold 1987: 36).

Individual land ownership was part of the nineteenth century image of New Zealand as 'Arcadia'. This is a vision of an ideal society where human problems and ills are solved by nature's provision of everything to satisfy human wants. New Zealand was believed to be a land of 'milk and honey' where land was very fertile, there was mineral wealth, and the climate was health-giving. The natural environment was seen as abundantly endowed for human use:

> ...the Arcadian vision possessed a strong moral and economic appeal, which found expression in such terms as "honest toil", "family life", "taming the wilderness". "sturdy independence", "fruit of the soil" (Arnold 1987: 35).

The Arcadian vision of New Zealand not only supported exploitative practices but also embodied an aesthetic appreciation of the natural environment, especially as it was transformed into productivity. Herbert Guthrie-Smith, founder of the Tutira sheep station in Hawke's Bay, wrote of

> ...the glories, the delights, the ecstasies of improvements, for there is no fascination in life like that of the amelioration of the surface of the earth ... to note a countryside change under your hand from a wilderness ... How pastoral! How Arcadian!" (quoted in Lockley 1970: 105).

Guthrie-Smith's actions in radically changing the natural environment through the introduction of pastoral farming were compatible with the exploitation/domination perspective. But as a keen botanist and ornithologist, he also expressed scientific and ecological views on the natural environment. Guthrie-Smith wrote an account of Tutira which was "...a critique of the ravages of Europeans, their despoliation of the land in contrast to the natural balance which had been maintained by the Maori" (Gibbons 1984: 319).

To understand why the settlers viewed the natural environment in such an exploitative way we must look for the foundations of these values in the society that the settlers had come from. The majority of migrants to New Zealand were fugitives from the industrial revolution. They had been alienated from the land in the countryside and drawn into the city factories which increasingly demanded labour. The factory system, involving the mechanisation of work, completely redefined the relationship of humans to nature and to one another. Many rural labourers were quite detached from the land, living only in the country for planting and harvesting, and then returning to swell the city populations (Gillis 1983: 179).

For working-class people and agricultural labourers especially, migration to New Zealand meant an opportunity to regain the self-reliance and dignity of control over one's life and work that was more typical of an agrarian pre-industrial society. This is why obtaining land was so important for all classes of settler (James and Saville-Smith 1989: 22-23).

As well as coming from a rapidly industrialising society, settlers came from a country where the natural environment had been subjected to centuries of human impacts. Rural Britain in the nineteenth century was very different from rural New Zealand. The majority of England's population in the nineteenth century did not even live in rural areas. Britain was one of the first major areas of the world to urbanise, and urban growth was on such a grand scale that the existing city systems were overburdened. Air and water pollution were major problems in cities such as London.

Both the city and country origins of the British settlers were radically different from anything they would encounter in New Zealand. These experiences had shaped their understanding of the natural world. They were totally eurocentric[1] in their view of the New Zealand natural environment (Adams 1977: 5). The land was seen as wild and barbarous, and so were its indigenous inhabitants. Consequently, in seeking to control the environment, the settlers attempted to re-establish the known and comfortable environment they had experienced at 'home'.

The most obvious way of doing that was to introduce plants and animals. Lady Barker, a member of the South Island pastoral elite, gives us an insight into station life as an attempt to recreate England in the wilderness. She describes a station homestead in Canterbury in 1865: "The verandah is covered with honeysuckles and other creepers, and the gable end of the house ... is one mass of yellow Banksia roses ...a stream runs through the grounds, fringed with weeping willows..." (Barker 1973: 26).

She also records the attempt to replace of native fauna with introduced fauna: "... I am assured that they [weka] are most mischievous, and that it would be useless to turn out the pheasants and partridges ... until the numbers of wekas are considerably reduced." (Barker 1973: 28). The introductionof game animals was not only part of making the natural environment familiar. It also reflected the cultural practice of using

[1] Believing in the superiority of the European beliefs and practices pertaining to land, and applying that body of belief to their activities in the New Zealand environment.

nature for recreation. The British countryside was a playground, as well as a workplace, where fishing, shooting and riding to hounds were popular pastimes, at least for the aristocracy. In New Zealand, the introduction of game animals was particularly appealing to less privileged settlers, who regarded their ability to pursue recreational hunting and fishing as indicative of the development of a new, classless society in New Zealand.

The introduction of plants and animals for livelihood, recreation and decoration, the clearing of forest for production and settlement, and the exploitation of natural resources all resulted in major costs to the environment. The nature and extent of these costs were not altogether understood in the nineteenth century and were only slowly addressed by those in power.

Yet from the middle of the nineteenth century, conservationist ideas were gaining currency in the United States and were being taken up by some in New Zealand. A new understanding of the relationship between humans and the natural environment was emerging. It drew primarily from scientific and ecological perspectives. Instead of accepting human exploitation of natural resources as an individual right, some, such as politician Sir John Cracroft Wilson, argued in 1874 for state controls: "...in the matter of forests, the Anglo-Saxon is the last man in the world that ought to be let alone!" (quoted in Wynn 1977: 131).

Debate over state preservation of forests in the 1870s highlighted the conflict between the exploitation/domination view on the one hand, and the ecological perspective on the other. At this time, the word 'conservation' gained currency in New Zealand and was almost entirely associated with ensuring the sustainability of forests (Galbreath 1989: 121).

The forest question revealed struggles between different interest groups with opposing values. For example, central and provincial government disagreed over which authority should have control over forest lands. Business interests were concerned that government intervention into forestry management would stifle private enterprise. Others wanted to provide for immediate timber needs as against conserving for future generations. There was even a group that opposed the protection of forests on the grounds that overseas conservationist theories were irrelevant.

State protection of forests gained some support from aesthetic appeals for preservation of wilderness areas. While the arcadian image emphasised the appeal of the transformed landscape, in the 1890s the wilderness itself came to be seen as beautiful. In particular, the visual diversity of the natural environment and its scenic value were noted.

However, there was a tension between development of scenic reserves and demands for farmland. It is no accident that areas set aside for reserves were those regarded as useless for settlement or economic gain. This activity reflected the perception of certain land as waste, and in some cases Maori land was taken.

But economic considerations also worked in favour of the preservation of some areas. An additional incentive for the preservation of scenery was growing tourist interest in natural areas. "Tourist guidebooks extolled natural glories; in 1898 such local scenes as Mount Cook and Lake Taupo replaced the face of Queen Victoria on postage stamps" (Gibbons 1984: 308).

The scientific perspective was also important in promoting conservation because it highlighted the damage to flora and fauna, and to the land itself from forest clearance. But in some respects the scientific perspective also supported the continued exploitation of the environment.

An influential view, widely accepted among both scientists and non-scientists, was derived from a crude version of Darwin's theory of the survival of the fittest. It was assumed that all indigenous species would be inevitably displaced by introduced species, which were regarded as superior. This view was also used to justify the poor chances of Maori survival: "The parallel was often drawn between the dying native race and the disappearing native birds and trees to prove the inevitability of it all" (Galbreath 1989: 81).

The practical and political implications of this view were that many people believed nothing could, or should be done to preserve the indigenous inhabitants of the country. Their demise was scientifically 'proven'. Only a few, like the politician T.H. Potts, argued that the idea of inevitable extinction was "...simply an excuse for indifference and inaction" (Galbreath 1989: 122). Potts was one of the first to promote the idea of island reserves for birds, but did so in London because there was little support for the idea in New Zealand.

It was Walter Buller, a well-known collector of birds, who was finally instrumental in establishing island reserves in the 1890s. One of these islands was Little Barrier; it was forcibly purchased in 1894 from the Maori owners, who were then evicted (Roche 1983: 234).

While Buller worked hard for the preservation of birds, his own actions showed contradictions between crude Darwinist scientific ideas and the ecological perspective. Publicly he was committed to the concept of island reserves as a means of saving endangered species from extinction. But privately he held to the view that indigenous species would be inevitably displaced. He also continued to collect bird specimens, although it was illegal.

COMPARISON WITH THE MAORI PERSPECTIVE

Some elements of these perspectives, particularly the ecological one, parallel Maori views of the environment, but there are important contrasts.

Specifically, Pakeha views on the natural environment differ from Maori views in four key areas:

Ownership: The Pakeha concept of individual, private ownership contrasts with the Maori concept of collective ownership. For the Maori, ownership is not an individual right. Traditionally, individuals have rights to resources, occupation and cultivation in common with other members of the kin group and in accordance with the decisions of the rangatira.

Use: For the Pakeha, usefulness is primarily defined as what can be gained from the land profitably and productively. Land which appears to have no obvious use or profitability is defined as waste. In contrast, economic utility was not the only, nor the primary factor in determining the traditional Maori response to land.

A further distinction between Pakeha and Maori views of land concerns the mandate to use land. Christian religion gave humans the mandate to use the land and its flora and fauna. Traditional Maori beliefs were that the gods controlled the relationships between the human world and the worlds of other environmental inhabitants.

Spirituality: The Pakeha perspectives of exploration/domination and of science regard the natural environment as non-sacred. The Maori view the environment as sacred. Laws of tapu mediate the relationship between Maori people and the natural environment.

Identity: Pakeha identify with the land through their ownership of it, activity on it and aesthetic perceptions of it. Maori have a strongly developed symbolism which links them to the land where they were born. This is specifically expressed through burying the placenta and umbilical cord on ancestral land. Dann (1988: 336) observes that many English proverbs about land refer to it as a source of trouble and income. In comparison, Maori proverbs frequently refer to the connections between the natural environment, human survival and spiritual identity. (For further discussion of the Maori perspective, see Puia (this volume).)

THE IMPLICATIONS OF THE FOUR PERSPECTIVES FOR THE ECOLOGICAL MANAGEMENT OF ISLANDS

Problems of ecological management are as much about people's relationship to the natural environment as about the interrelations between land, water, plants and animals.

In order to effectively manage human activity in the natural environment, it is necessary to know people's perspectives on their relationship to nature. This paper has examined four culturally significant Pakeha perspectives. The exploitation/domination perspective has, until recently, prevailed. It reflects fundamental values in modern European societies concerning a devotion to economic growth, private property rights, limited government intervention and a faith in science and technology. But there is some evidence that this perspective is waning in the United States and in Western Europe, where new "green" political parties have arisen and established parties are developing environmental policies.

In New Zealand too, concern about the environment has become increasingly prominent through formal party politics and an active environmental movement. There has been widespread public interest in the Resource Management Law Reform Bill, which received 3500 submissions. Many submissions on the environment were also received by the Royal Commission on Social Policy in 1987. In these submissions the ecological perspective was strongly expressed by individuals and organisations. They were "... aware of the dangers of ignoring the spiritual and scientific principles which confirm the interconnectedness of all things" (Dann 1988: 332)

Concern about the natural environment is expressed by all categories of the population; it is not exclusively associated with the young, urban or well educated - although these groups may be more active in publicly expressing their views.

We are at a time where none of the four perspectives is dominant, although each may become dominant in specific contexts. Dann suggests that as yet there is no consistent Pakeha perception of the New Zealand natural environment, shared by all. Instead, there are deep divisions between those embracing a profit ethos and those "... trying to find valid Pakeha ways of expressing their deeply felt 'sense of place', and also trying to find management mechanisms which validate this sense of connection" (Dann 1988: 338).

The lack of a commonly defined and accepted perspective on the relationship of humans to nature is both a challenge and an opportunity for managers. It means that they need to identify those who may support conservation, work on changing the views of those who do not, and convince those who are indifferent that they must become environmentally aware.

There are two major ways in which people develop an awareness of conservation. The first is through direct personal experience of changes to their local environment. The second is through an awareness of environmental issues that goes beyond one's immediate situation, to an understanding of national and even global problems.

Managers can use both types of awareness, but each has different implications for getting the conservation message to the public and involving them in ecological management

Awareness arising from personal experience

Many people are motivated to express their views publicly if they believe the issue affects their immediate circumstances and well being. For example, individuals may be prompted to comment on changes to recreational opportunities in a nearby reserve area.

Response to local environmental issues is especially likely if community members feel adversely affected. A management proposal may receive more negative responses than support if it is perceived to restrict activities. In Gray's (1988) New Zealand study she found that many of those interviewed said they would be stirred to protest about an environmental matter if they felt employment opportunities would be threatened. Some said they would not make the effort to publicly express support for a proposal, although others said they would give support if it was made easy, or if they were specifically asked to do so.

Many people, not necessarily involved in the environmental movement, are nevertheless concerned about perceived threats to health and safety. Their response to changes in the natural environment is influenced by "...the way that [environmental] degradation is perceived to affect the human and the nonhuman environment" (Gunter and Finlay 1988: 504).

This has implications for the way that managers explain the need for conservation measures to the general public. They need to address the specific, tangible concerns that many people have about the threats to their wellbeing from environmental degradation. Managers need to focus on people's interests by emphasising how environmental damage adversely affects their everyday lives and by explaining how they will benefit from the protection of habitats and species.

For example, exploitation of resources, such as fishing or grazing, beyond a sustainable level affects productivity. On the other hand, preservation of the natural environment can lead to the development of a tourism industry in economically depressed areas. The conservation estate is a crucial part of our national economy, as over 50% of international tourists who come here visit national or forest parks. Such interest is not confined to the package-tour visitor who may take in Mt Cook as part of the set itinerary. Increasingly, international visitors are showing a preference for unstructured tourism, including more active outdoor holidays which take them beyond the usual tourist circuit (Booth this volume, O'Connor and Simmons this volume).

By directly linking people's immediate concerns to the advantages of conservation, managers not only change the way people think about their relationship to the natural environment, but also help to foster individuals' commitment to conservation.

Awareness of wider environmental issues

The gradual development of a wider understanding of environmental issues reflects the influence of the ecological perspective and its emphasis on the interconnectedness of all parts of the environmental system. For example, people are becoming more aware that the seemingly distant and abstract threat of ozone depletion has real consequences in their everyday lives.

This awareness represents a shift away from acting on the basis of short-term, individual interests, to a realisation of collective and long-term interests. This is the realisation that the actions of one group of people in one place affect the lives of others, even on the other side of the globe. The costs and benefits of destroying or protecting the natural environment are borne by all (Dann 1988: 345).

We need to find ways of focusing the general awareness of environmental issues on to islands, because very few people have direct experience of those islands where restoration or other kinds of protection programmes are undertaken.

With regard to human activities on islands, we can identify three broad categories:

(i) Islands with a resident population
(ii) Islands which are accessible and frequently visited, e.g. for recreation
(iii) Islands of high ecological sensitivity where human access is restricted.

The Chatham Islands stand out as an example of the first category. Local communities are very closely involved in determining the success of ecological work. The recent *Review of the Chatham Islands Economy* made the connections between human activities and successful ecological management very clear. The Chatham Islands are of considerable ecological importance nationally and internationally. They are also home to around 780 people, most of whom rely on primary industry, particularly fishing and agriculture, for their livelihood. This situation throws up potential conflicts between the use and protection of natural resources which must be addressed by managers:

> ... human activities are part of the ecological equation and have traditionally been the root cause of ecological problems. If attitudes, experience and practices of local people are not an integral part of the future conservation work, then ultimately their behaviour will be dictated by an environment which may have suffered irreparable change. (Taylor Baines and Associates and Lincoln International 1989: 106.)

Several management issues are raised by the Chatham Islands example. The benefits to be gained from using and producing from the resources of the land and sea may conflict with the high ecological value of some areas of the islands. Commercial and recreational advantages to be gained from tourism must also be examined in making decisions about conservation management of the islands.

Examples of the second category of islands are found among the islands of the Hauraki Gulf Maritime Park, a very popular recreational area. Tiritiri Matangi Island offers a very special experience to members of the public who, as volunteers, have planted thousands of trees and helped in the establishment of rare and endangered birds and plants (see also Galbraith this volume).

In the third category are many of the islands focused on in this conference. They provide significant and in some cases the sole refuges for endangered species, such as the Black Robin and the Little Spotted Kiwi which are central to New Zealand's image as a place of unique wildlife.

Surveys of international visitors to New Zealand (New Zealand Tourism and Publicity Department 1986) indicate that many are attracted here by our unique wildlife and are interested in seeing it. But most leave the country without having done so, although they will undoubtedly have seen performing sheep. What opportunity is there for both international visitors, and New Zealanders to experience some of this fascinating wildlife?

At present, access to islands such as Tiritiri Matangi are exceptions. The requirements of protection, preservation and restoration determine that members of the public are usually excluded from direct involvement.

Spatial separation of the public from ecological work poses a problem for managers, because that work cannot be seen to directly benefit individuals or communities. This raises two matters for consideration. Firstly, how to ensure that the public is adequately informed and educated on conservation issues. A general awareness of conservation cannot be developed unless people have information. It also requires an effort on the part of individuals to collect and analyse information (Rohrschneider 1988: 352).

Secondly, the role of the public in conservation management needs to be addressed. Those with wide concerns about the environment tend to have high expectations of government action and press for greater public involvement in decision making. For example, the Royal Commission on Social Policy received many submissions on the environment which advocated that:

> More information be given to the public on environmental issues;
> Planning procedures be made more democratic;
> Specific groups, such as Maori, be provided with more opportunity for involvement in environmental policy-making and management;
> There be greater public input into government agencies with responsibilities for the environment (Dann 1988: 350-1).

People do not just want to respond to the agenda of a government agency, they also want to initiate and promote their own aspirations for the natural environment. Developing ways in which members of the public can be involved in conservation projects will provide those who are concerned about the natural environment with a direct experience of conservation.

CONCLUSION

To conclude, the challenge and opportunity for successful management of island habitats starts and ends with human values. At the outset, conservation is defined on the basis of human evaluation and appreciation of the natural environment. But threats to that environment also come from human values and actions, whether it is through the exploitation of natural resources, transformation of the land for development purposes or the use of nature to gain scientific knowledge.

Human values and actions are inseparable from environmental problems, so they must be included in the solutions. This can be done in three ways. First, ecological managers need to focus on the human actions that pose problems for the natural environment Second, the many groups with interests in islands must be involved in defining the solutions to those problems. Finally, the public may be involved in achieving the solutions.

These steps will help to enhance the links between people and the natural environment in ecologically and culturally beneficial ways.

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PROTECTION AND CULTURAL USE: MAORI CONCEPTS OF THE RELATIONSHIP BETWEEN MAORI PEOPLE AND NATURE

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ABSTRACT

The paper examines the Maori view of nature and its relationship to Maori culture, the effects of European impact, including Christian religious beliefs and the requirements of modern technology, on the Maori perspective.

Essential points covered include the relationship between perspectives (values) and cultural practices (activities) the emergence of values, the clash of cultural practices, and the diversity of Maori values and their link to nature.

INTRODUCTION

The diversity and constant change of ethnic cultures around us has in many ways inspired people to form on their own - cultural maps to interpret every crook, cranny and contour of tikanga Maori and add this knowledge to the growing literature. This is so, not only for Maori, but for Rarotongan, Samoan, Fijian, European and others.

Traditional Maori beliefs, as historians have led us to believe, emerged in the three centuries after 1350 AD. Most characteristics of this era are still maintained today. Cultural unity was strongly supported by the Maori language. Oral in nature, simple in construction, it encompasses a tradition of thought, attitude and mythology. Most of all, it preserves a distinctive Maori identity.

Maori mythology and tradition are both echoed in the God-like images of life itself closely intertwined in our whakapapa (our genealogy). According to the Maori, Papa and Rangi were the creators of the world and the origins of the human race and its institutions.

A high cultural value was placed on the delivery and transmission of detailed facts and beliefs in order to ensure continuity, accuracy and consistency. The learning process was long and repetitious; it was surrounded by concepts like mana, tapu, and mauri - the life force. These concepts ensured respect; they promised retribution on anyone who took it upon themself to ignore the overall meaning which would guarantee total compliance.

All life has to submit to the law of the survival of the fittest; this entails a struggle for existence. Many cultures did not always have words to express their feelings of reverence, benevolence and worshipful adoration; gods were necessary to meet this need for expression. For the Maori people, their karakia were invocations to the gods - to preserve them from the unknown, to placate them, to propitiate them. When the Maori invented a cosmogony, it of necessity was cast in the mould of that striving nature of which they, as a people, were the highest developed members. The gods were to preserve them from the unknown. It is at this point we looked past the familiar - the whakaporepore, whakamarimari, petipeti, na mea and ngarara or ngangara - to explain the great unexplored beyond. [1] Where, for example, did someone go when they were sucked into a great whirlpool and disappeared? To appease the needs of a taniwha. And when streams disappeared every season, why other than to satisfy the thirst of a reptile?

These 'explanations' in fact also served the function of imprinting on the Maori listeners the idea of their relationship with nature. The tangata whenua, the people of the land, placed a high value on protecting nature, as this allowed them to survive in harmony with nature. This sense of value provided a theory behind the actual practice of preserving, protecting, and conserving things Maori. The general intention behind the way these things were done was to maintain harmony with nature.

Even at its most basic, the very fact that a society exists justifies recognising the value of an uru pa amidst a commercial forest, preserving a stretch of water running from the highlands to the sea, or valuing a piece of paper 150 years old that dares to challenge the inequitable monopoly held by the Pakeha. One of the Department of Conservation's goals is "to protect the intrinsic and cultural values of the country's natural and historic resources." If we accept this, we must accept the need for a strategy that promotes cultural awareness, understanding and acceptance.

The colonisation of New Zealand was conducted and controlled by British settlers and missionaries who shared a common British/European culture. One aspect of this culture that had a major influence on the Maori as a people was Christianity.

Christianity, in its most basic sense, established a sense of values that had a similar approach to creation and nature. But in a society dominated by the settler mentality and its concepts of management, science, conservation ethos, and ethnocentric values, there was a radical division from what Christianity had promised. And promise it did.

For the Maori people, Christianity became a life force that allowed their basic survival needs to be heard and to expand in the Pakeha world. But while exploring these needs, there developed a conflict between an established way of life and a new way of life - between tino rangatiratanga and kawanatanga.

As a people, the Maori have understood, and still do understand, their relationship with nature and with the environment. This relationship defined for them the concepts of management that would justify not only their understanding but also how they chose to deal with it. This idea of guardianship was included under the concept of kaitiaki, and it is this concept that will be examined in the rest of this paper.

CULTURE AND VALUES

For the Maori, awareness of the life force entailed creativity, refinement and education. Their close spiritual relationship with the land and supernatural ancestry justified the desire to be in harmony with nature. Sinclair (1975) explains that this relationship stemmed from the tradition that people were created from the loving union of the earth mother, Papa-tu-a-nuku, and the sky father, Ranginui-e-to-nei. Eventually the terrestrial world was populated by myriads of vassal spirits and inanimate creatures. For the Maori, these spirits control the relationships among the human, animal, vegetable, insect, reptile, fish, bird, mineral and spiritual worlds. Te Rangi-putea-to-rangi was the origin - in the earth, in the ocean, and in the heavens (Best 1925).

It was because of these ancestral and spiritual relationships that the Maori fished, hunted, and cultivated only to the extent necessary for well-being (Sinclair 1975). It would have been inconceivable to develop senseless exploitation of the environment. The land - the forest, the rivers, the animals, everything - was regarded as a whole, as a sacred trust and asset of the people. To reinforce the value and the significance of this trust, laws of tapu were invoked, but only to protect a resource from human exploitation or

[1] "...[the Maori's] 'karakia' (incantations) were invocations to his gods to preserve him from the Unknown; of placation, of propitiation. To express these he had many words, as 'whakaporepore', 'whakamarimari', 'petipeti', etc." (Baucke 1928: 37). The phrase 'na mea' can be translated as 'a collective phraseology of things'; a 'ngarara' or 'ngangara' is an indescribable demon or animal.

pollution. Tapu was applied for a long enough time to preserve or recover the sanctity of the resource that was affected (Metge 1967). Although tapu may imply a lock-up mentality to some people today, this was never its intention. It was, and still is, a prohibition made for the sake of protection.

In essence, the system of tapu took the place of religious system with the Maori. Best (1925) writes:

> ...tapu, and even that of makutu tended in a way to discipline people. Also, they taught the fierce and independent Maori that there was something besides physical human strength to obey, fear, or propitiate.
>
> The term tapu is generally rendered as meaning "sacred', but "prohibited' would convey its meaning better to the European, for it may be said to consist of prohibitions.

For the Maori, tapu also entailed a social structure within the human categories of iwi, hapu and whanau. Depending on one's ranking, there were different levels of tapu status. For example, the first-born of a noble family (ariki) would have a very high tapu status as compared with a commoner. The way tapu was structured and applied served its basic function of letting the spirits involved make good the wrong that had been done them. When heavenly beauty met a physical presence of spirits, such manifestations as aura signals indicated that the spirits had responded. And this response was interpreted as meaning that the supernatural spirits had been placated by the reverence of the Maori people.

Like anyone else, the Maori were capable of exploiting their environment. (The extinction of the moa, for example, has been attributed in part to the Maori people.) Today other species are under threat, and we could argue that the whole idea of exploitation involves the interrelationship between what nature is providing and what humans are taking.

Tapu had a significant effect on tribal management and cooperation in preserving this relationship, particularly in addressing the ever-growing problem of food shortages that resulted from unpredictable disasters. Migratory patterns of fish, birds, and eels - for example - could change. As with other disasters, this was attributed to the offended gods or spirits. As W.M. Baucke (1928) wrote:

> "Teach a system of life behaviour which would neutralize these fearful imprecations?" "Because," he answered, "the gods knew best. They made the Maori, his desires, his requirements, his fears, in fact, as he was: and beyond that we know nothing: and it is an impertinence to inquire."

Whether singing karakia or using magical rites, every effort is made to protect the mauri of whatever resource was affected. In some cases where a tapu had been imposed, chiefs would set up a rahui as a symbol to indicate the significance of the tapu. If it were violated, punishment was usually in the form of sickness or death. The transition of tapu is by contact; once its purpose has been served it could be removed or nullified by whakanoa, which could only be performed by a tohunga, or priest. The tohunga became the focal point for maintaining a holistic relationship between nature in its spirit and its physical manifestation; in this respect the tohunga was able to meet the needs of his gods and the demands of his inner spirit.

EUROPEAN IMPACT

The first recorded encounter between Maori and European took place in 1642, when Abel Tasman's two ships anchored in Golden Bay (formerly Murderers' Bay) in Nelson. Maori canoes rammed a cockboat, killing four Dutchmen (Metge 1967). A series of European arrivals thereafter included Captain Cook (1769), whalers (in the 1790s), and the Reverend Samuel Marsden, who arrived in the Bay of Islands in 1814. The first arrivals had little effect on the life style of the Maori people, nor did the Wesleyans and the traders, who arrived about this time. Marsden founded stations of the Church Missionary Society at Rangihoua (1815), Kerikeri (1819) and Pahia (1823), and the Society provided the first catalyst for change among the Maori people.

Christianity changed the way the Maori lived and thought; by the early 1900s they were totally immersed in it. At the beginning, there was little interest in it, but this was changed by a number of serious setbacks in the 1830s. Intertribal wars and introduced diseases took a heavy toll of the Maori people. Weakened and disheartened, they increasingly turned to the missionaries for assistance in making peace. Out of sheer need, the northern chiefs accepted Christianity, and this in turn led to the opening of new stations in the north and inland in the Waikato, the Bay of Plenty and Rotorua.

During this time, the number of Europeans living permanently in New Zealand rose to 2000. The arrival of more ships, mainly in the north, brought prosperity to local tribes, who traded their resources and provisions to local traders for export. With this increase in people, different classes of Europeans - sailors, whalers, thieves and murderers - became prevalent, and these created serious problems of law and order in the main settlement of Kororareka. European settlers combined with missionaries and northern chiefs to force formal (documented) annexation in hopes that this authority would provide effective control. Land speculation became a catch-cry from 1838, as large blocks of land were either bought from or traded by the Maori.

Two years of speculative land grabbing, continued lawlessness, tribal conflict and conflict with settlers caused a lawful and legal means for an authority to be surveyed, contemplated, and finally completed on 6 February 1840, when Captain William Hobson arrived at the Bay of Islands (Waitangi Treaty House) to treat with the Maori and to participate in the cession of New Zealand to the British crown.

This is only a small example of the eurocentric privilege which has, since 1840, formed a continuum. Historical records and scientific studies indicate that before 1840, social and humane structures existed (Best 1925), and communities were scattered all over New Zealand. But already the wheel of change was moving. Important changes to the Maori people had affected their culture and their life. Traditions were giving away to ideals far beyond their comprehension. Treasures (taonga) were given away and neither replaced nor returned.

As many tribes embraced Christianity, the power of the tohunga was undermined. Practices of polygamy, slavery, cannibalism and warfare were abandoned. Diseases and sickness overwhelmed the small communities that had contact with Europeans. More often than not, they had no adequate immunity against influenza, measles, social diseases, and the like. And these are only a few of the changes that have been documented up through the present day. The domination of this part of the world by eurocentric privilege had begun, and from the 1840s onwards, historical records show the ascendency and domination that took place.

The Treaty of Waitangi was signed; its legality and status is still argued today. Maori attempts to invoke the Treaty often had negative results, although some change in official attitude has been discernible in recent times. The chronology of events shows that the issue was as much alive in earlier years as it is now (Royal Commission on Social Policy 1987). Section 4 of the Conservation Act 1987 states:

> This Act shall so be interpreted and administered as to give effect to the principles of the Treaty of Waitangi.

The New Zealand Maori Council identified ten implicit principles, but only five were identified by the Crown:

(a) That a settled form of civil Government was desirable and that the British Crown should exercise the power of Government;

(b) That the power of the British Crown to govern included the power to legislate for all matters relating to "peace and good order";

(c) That Maori chieftainship over their lands, forests, fisheries, and other treasures was not extinguished and would be protected and guaranteed;

(d) That the protection of the Crown should be extended to the Maori both by way of making them British subjects and by prohibition of sale of land to persons other than the Crown; and

(e) That the Crown should have the pre-emptive right to acquire land from the Maori at agreed prices, should they wish to dispose of it.

These principles emphasise the Treaty's application to land and the natural environment (Royal Commission on Social Policy 1987). The Tainui Trust Board made this submission:

> The Treaty is at its firmest and most secure as a base when we are speaking of land, physical resources, and the physical and metaphysical matters that govern the uses, occupancy, ownership and rangatiratanga of these. To stretch the Treaty to do everything may well indeed make it again a nullity and bring upon it disrespect.

The Treaty of Waitangi is a document that is seen to permeate different areas, diametrically oppose others, stifle progress, antagonise the economy and - probably last, but not least - threaten people. Irrespective of what the outcomes are, history has ensured it shall never die. European impact has influenced the Maori people in a period of documented change, a period which gave benefits and privileges to which they are still adapting today.

ON BEING MAORI

There are many aspects of human experience - a thing, a feeling, a thought, or even a person - that can inspire a people or an individual to express their feelings. For the Maori people, all feeling is rooted in the land. Land features in almost every issue, whether identifying one's turangawaewae, wairua, or whakapapa,[2] or arguing definitiveness of title and ownership in a court of law.

The Maori way of expressing this feeling is so different from the gusto and excitement typical of the Pakeha that the Maori people are often seen as lacking in commitment. The two ways of expressing feeling differ because we are separated by our roots. For example, environmental and ecological issues don't affect us as individuals as much as they affect us as members of our whanau, iwi, or hapu. An imbalance of nature affects us as a group and affects not only the group but also the fish, the birds, the insects and the forest, for example. The Pakeha, in direct contrast, are more likely to take on issues that affect them as individuals; these issues may be, by coincidence, the same issues that affect the Maori as a group.

The concept of closeness expressed by whanaungatanga, whanau, hapu and iwi includes nature, the environment, and all living things; it includes the forest, birds, fish and the like as part of all three. The Maori people do not see these separate the way the Pakeha do. The concept of "going into the future backwards" is sometimes misinterpreted as being backward; it simply means that if you want to understand the present, you must first understand the past. Today's circumstances are formed by yesterday's events. Temm (1988) explains further and says, "To predict what will happen tomorrow, you always need to understand what is happening today."

Change has come so fast that the Maori people have been isolated and forced into a less than acceptable quest to assimilate, to conform, or to do whatever is trendy at the moment for maintaining the one-people myth. It would be easy to say yes and ease the country of a nightmare that refuses to gallop away. But, for a hundred and one reasons, challenge beckons the Maori - particularly in adversity.

Having had the same opportunities as their Pakeha counterparts, the Maori have excelled in some fields and failed in others. But their concept of 'success' or 'failure' is changed by the fact that they are Maori - and this change is often to their disadvantage. The Maori generally view most matters with a laid-back attitude that more often than not engenders a mixed reception, ranging from cooperation to outright disapproval. Remember that a view of worldly things to the Maori embraces their origin, their identity, their culture, their tradition, and their language. Hohepa explains:

> Today his Maoritanga (tikanga Maori) embraces a way of life, a way of thinking, and feeling; of attitudes to language, traditions and institutions; of shared values and attitudes to people, places and things to time, the land and sea, the environment, life and death.

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[2] 'Turangawaewae': a place to stand; 'wairua': spirit.

CONCLUSION

Nature in its presence is still a challenge for the Maori people: Its very inclusion as part of their whanaungatanga, its not being separate, gives a name to those virtues, as though nature were a living family member.

Maori values do - and will - influence decisions made about the environment. Because of this influence, they should be part of the decision-making process in both problem solving and in solutions. These are human values that see the environment and nature in a different way.

The principles needed for managing the environment are the same virtues the Maori extract from their tapu laws, mana, and mauri and from the intimate closeness of iwi, hapu and whanaungatanga. These satisfy the ethos and spirituality that the Maori seeks to balance with nature.

It is by the acceptance of these simple concepts of wise implementation, combined with the Pakeha perspective, that managers will be able to link nature, the environment, and people in a way that will not only benefit one, but all, and all our future generations.

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RECREATION - A POSITIVE FORCE FOR ISLAND RESTORATION

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ABSTRACT

Strong demand for recreation on islands is already evident, and recent growth in nature tourism is being manifested in more people seeking an experience "at one with nature." Island managers can harness this demand by transforming the recreation experience into an advocacy tool. A concerned public will act as a management watchdog; its members' involvement will give direct management benefits. However, visitors to islands also pose problems. These include waste disposal, introduction of pests, trampling and disturbance of wildlife. The challenge to management is to provide appropriate facilities, controls and visitor education to manage the resource for both ecological and recreational purposes.

CHARACTERISTICS OF ISLAND RECREATION

Visitors perceive that New Zealand's offshore islands provide a unique recreation experience (Hook 1978). Islands attract visitors for their isolation, high biological and scenic values, and the sense of adventure that an island visit holds (see for example Hook 1978, Rea 1981). Gibbs (1986: 57) has attempted to encapsulate the mystique of island recreation as "that special quality of 'being on an island.'" More specifically, islands attract visitors both for their isolation and the sense of adventure that an island visit holds. Recreationists also visit islands for their high biological and scenic values (see for example Hook 1978, Rea 1981).

Island recreation is a natural extension of New Zealanders' coastal orientation for their recreation. It is not surprising that the number of visitors recreating on some islands is increasing. O'Connor and Simmons (this volume) report that the growth in private boat ownership is a contributing factor to visitor growth, while the emergence and increasing popularity of nature tourism highlights the trend for recreationists to seek "wrap-around new experience(s), enjoying themselves and enriching their knowledge at the same time" (Bellamy 1989: 30).

Islands, particularly those under some form of restoration or protection, offer the nature-seeking recreationist an inspiring environment. As has been found elsewhere, it is likely that designation of an island under protection or restoration status will increase the number of visitors wishing to go there. The dramatic growth in visitors to Tiritiri Matangi, in the Hauraki Gulf, is a good example of this phenomenon. Visitor numbers doubled between 1987/1988 and 1988/89 (March years) and look set to continue this growth rate to reach 8000 visitors by March 1990 (Barbara Walter, pers. comm.). The majority of visitors participate in tree planting during their island visit, satisfying the desire for "wrap-around experiences", to use Bellamy's phrase.

The nature of island visitors is shaped by the necessity of boat access, or plane access in some cases. Visitors must either have a private boat available for their own use, or pay commercial boat hire charges. Individuals with private boats are likely to be the most frequent island visitors owing to boat availability and their boating interest.

In a recent Wellington survey, boat-owning households were found to include an over-representation of males, those aged 30-49 years and people with a university education (Tourism Resource Consultants and Lincoln College 1988). Commercial boat operations are frequently used, however, for organised groups. Both Kapiti and Tiritiri Matangi Islands, for example, have a high proportion of visitors from groups such as tramping clubs, schools and conservation groups. Members of some of the visiting organisations are arguably also from a high socioeconomic group (i.e., professional, tertiary educated, high income earners). Islands visitors, therefore, do not reflect the diversity of individuals found in society. Indeed, the characteristics exhibited by boat-owning households offer parallels to active backcountry mainland recreationists (the tramping, climbing, skiing fraternities).

As an aggregate group, people visiting islands may be described as the well-educated, the articulate, the doers in society. These attributes can be useful to managers who wish to exploit the benefits of recreation for island management.

RECREATION VALUES

Recreation is one of the most powerful advocacy tools available to island managers. It is a pleasurable means for the public to increase their awareness of and commitment to conservation (Department of Conservation 1989a). This idea is not new (see Devlin and O'Connor 1989) and builds on current conservation marketing, including media events such as the release of kakapo on Codfish Island by the Minister of Conservation. The advocacy role of recreation can be developed in two ways: conservation education, and public support.

Conservation education

Some islands offer an ideal educative environment, particularly those close to urban areas which are a large potential catchment area. On Kapiti Island off the Wellington coast, for example, all visitors are met on arrival by one of the resident conservation officers, who educates them about the island sanctuary and ways to respect the environment and the island's integrity.

Conservation education is likely to be reflected in more appropriate visitor behaviour on islands, also improved environmental behaviour on later visits and visits elsewhere. Crouch and Hackman (1986) suggest that visitors' attitudes become more conservation conscious when visiting an island which the visitor knows is protected. They use the example of a marine reserve where spearfishing is permitted but not condoned by most visitors (divers) because of the island's reserve status. Many divers choose to leave their speargun in the boat.

Island managers can build on the existing environmental ethic of visitors to enhance their conservation consciousness and thus gain public support for conservation.

Public support

One facet of island management seldom acknowledged is the management of public support. Sympathetic and interested adherents of island restoration can offer tremendous benefits to managers. A misdirected, uncontrolled public will not. Managers should take advantage of the type of person visiting islands and put their active and articulate clientele to good use. For example, island recreationists may act as conservation watchdogs, vetting proposals received from developers and speaking out against inappropriate plans.

Island managers need to state the conservation agenda, so the public can understand how they can contribute within the specified management parameters. Failure to outline the management framework carries the risk that the public may pursue a separate, perhaps conflicting, agenda. Supporters of Tiritiri Matangi are a good example of a group working successfully within the bounds of the management plan. In addition to on-site tree planting and similar work, the group is a conservation watchdog and has been actively involved in the political issue of the Americas Cup (Galbraith this volume).

Another approach is to put recreationists' money to good use. For example, if a casino were to be established on an island in the Hauraki Gulf, enough revenue would be earned to finance numerous restoration projects.

Knowledge of conservation issues gained from a recreation visit can also directly benefit island conservation. For example, possums and wallabies have caused widespread vegetation damage on both Rangitoto and Motutapu Islands in the Hauraki Gulf. The Hauraki Gulf Maritime Park Board recognised this problem as early as 1981, but to date the only animal control has been a private possum hunter working on the islands. However, visitors to the islands who had seen evidence of vegetation damage exerted pressure through letters to the editor of newspapers, forcing the issue into the public arena. As a direct result, the Royal Forest and Bird Protection Society and the Auckland Botanical Society asked for detailed costs of an eradication programme, and Villa Maria Wines agreed to donate $1 per case of wine sold to the public, for eradication. It is expected that approximately $10-15,000 will be raised in this way towards possum and wallaby eradication on both Rangitoto and Motutapu Islands.

Commercial recreation entrepreneurs may also become conservation advocates. Part of the Poor Knights Marine Reserve is covered by a fishing ban, while fishing is permitted in most of the reserve. Earlier this year, the largest commercial charter boat owner wrote to the Minister of Conservation suggesting that the entire reserve be placed under a fishing restriction. The operator went even further, advocating that more marine reserves and parks be established around New Zealand.

Desire for a "wrap-around" recreation experience has been effectively used in current revegetation programmes on Tiritiri Matangi and Mana Islands. Visitors combine recreation with a personal involvement in the restoration of the island. Furthermore, supporters of the revegetation programme on Tiritiri Matangi have organised a fund-raising operation and raised money for a farm bike and nesting boxes for the project (Neil Mitchell pers. comm., Galbraith this volume).

To maximise the benefits of recreation to island management, problems associated with use must be minimised. These problems relate to the impact of visitors on the environment.

IMPACTS

Types of impact by visitors on and around islands include inadequate waste disposal, litter, vegetation trampling, disturbance to wildlife, and the potential threats of fire and pests, particularly rodents. Other impacts are activity specific, such as fish feeding by divers, which can result in a change in fish behaviour (aggregation and biting) and depletion of sea eggs, which are often fed to the fish (Bill Ballantine, Andrew Jeffs pers. comm.). These problems are not specific to recreationists. Other types of visitor also impact the environment, including scientists, commercial fishers, and Department of Conservation staff.

There is a growing literature, however, discussing measures to mitigate these impacts. With appropriate management action - for example, visitor education - these problems associated with use can be controlled and minimised.

RECREATION MANAGEMENT STRATEGIES

The challenge to island managers is to maximise the benefits from recreation and minimise the detrimental impacts. The critical management question is how should this be done? There are a number of factors that island managers can manipulate to maximise the benefits from recreation. These variables form what I call the 'recreation management package'. It includes:

1. WHO is allowed to visit islands?

Potential management strategies range from no restriction to prohibition of all recreationists. An intermediate position is to restrict use to 'society's teachers'. I use this term in the broad sense to include, for example, artists, school teachers and community leaders such as guide and scout leaders. The teachers act as a conduit to pass on conservation values of islands to society. The 'Art in the Subantarctic' project is an example of this approach, inviting well-known artists to visit the subantarctic islands and ultimately provide society with artistic responses to their experience.

2. WHERE are visitors allowed to go?

The exclusion of recreationists from entire islands is only feasible for a limited number of ecologically sensitive islands. This could be done in conjunction with the promotion of recreation 'designer islands', i.e., islands especially catering for recreation. Alternatively, parts of islands could be closed off to recreationists, to protect ecologically-sensitive areas. The islands of Rangitoto and Motutapu in the Hauraki Gulf, could effectively be managed as one island (as they are connected by road). Use restrictions could be placed upon the more ecologically important Rangitoto, focusing visitors on Motutapu.

3. WHEN can people visit?

An example of temporal restriction comes from the subantarctic islands draft visitor guidelines (Department of Conservation 1989b) which prohibit visits to wildlife breeding grounds during the breeding season. Visitor prohibition during periods of high fire risk on islands is another example.

4. WHAT activities can be undertaken in and around islands?

Restriction of activities can reduce impact. As already suggested, some visitors may limit their own activities to minimise environmental damage. The spearfishing example given earlier is supported by other evidence that most visitors to the Cape Rodney-Okakari Point (Leigh) Marine Reserve support a fishing ban within the marine reserve (Department of Lands and Survey n.d., Crouch and Hackman 1986). Any restrictions on current activities should be introduced in conjunction with visitor education about the reasons for such management action.

Restrictions upon the number and/or type of visitor to islands is often implemented via a visitor permit quota system. This method is arbitrary and ad hoc. While it may be a useful first step to address the problem of recreation impacts, it should not be used as a long-term solution. A quota, or carrying capacity, approach is based on the principle that impact is directly related to the number of visitors. It is clearly inadequate, as two irresponsible visitors can cause more damage than 20 environmentally-conscious visitors.

As the recreation management package implies, an island does not have a single carrying capacity. Rather, each island has a range of capacities, dependent upon management objectives (Manning 1985). A more appropriate management focus is the amount of change to the recreation environment, both the resource and the recreation experience. Limits of Acceptable Change is a planning technique which recognises that carrying capacity is a means to an end (management of impacts) rather than an end in itself (Manning 1985).

A MANAGEMENT PROPOSITION

Islands offer an ideal environment for the implementation of the Limits of Acceptable Change (LAC) technique, both the terrestrial and marine environments.

The LAC planning system is a nine-step process that identifies the desired resource and social conditions and then prescribes management actions to preserve, restore or enhance those conditions (McCool *et al.* 1987). The technique uses impact indicators to alert managers when predetermined acceptable environmental and social standards have been passed. One input into the process, therefore, is visitor impact monitoring.

LAC emphasises public involvement; input from affected individuals and groups is fundamental. Public involvement throughout the planning process has minimised conflict between users and managers, and also between different user groups where the technique has been applied in the USA (George Stankey, pers. comm.).

An island is both an entity in itself and part of a larger system, such as the islands of the Hauraki Gulf. Island managers have the opportunity to apply the LAC technique to an island system, identifying opportunities for recreation and ecological restoration and managing these to maximise recreational and ecological benefits.

A useful tool to achieve this aim is visitor education. On-site and off-site education provide the best means to minimise impact and increase conservation support. Changing visitor attitudes through education is a more effective management approach than law enforcement. An example of an educational approach is the development of a Minimum Impact Code for visitors to islands. Existing visitor codes could be adapted and expanded to cover all aspects of an island visit, for example, the correct landing procedure with and without jetties, waste disposal, and behaviour to fish when diving. The resulting code could then be incorporated into boating guides, visitor brochures and so on, to reach all island visitors.

CONCLUSION

Islands offer a unique recreation experience. Moreover, recreation has potential benefits for managers seeking to conserve island systems. To achieve this end, an island's recreation strategy should be developed, by manipulating the components of the 'recreation management package' and considering the following issues, among others:

1. Will islands continue to attract the same number and type of visitor? Will visitor numbers increase to all islands or only selected islands?

2. Should islands offering 'wrap-around experiences' be identified and developed? What will happen to the demand for participation in conservation programmes when Tiritiri Matangi (and similar islands) are 'finished'?

3. Will islands become more important ecologically? If so, which islands? What are the implications for recreation?

The considered outcome of these questions will form a management philosophy for island recreation. Managers then have the opportunity to utilise a management planning process such as LAC, to work towards the goal of wise use of New Zealand's islands.

ACKNOWLEDGEMENTS

Thanks to Jo Ritchie and Andrew Jeffs for supplying me with information, also Wendy Evans, Bev James, Neville Jones, David Palmer and Jo Ritchie for helpful comments on this paper.

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PARTNERSHIPS IN ISLAND RESTORATION

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ABSTRACT

Offshore and outlying islands are only one example of the biogeographical isolation which categorises much of New Zealand's remnant original landscape and biota. While such islands have considerable value as refugia for populations of endangered species, this should not shift the focus from the need for ecological restoration on the mainland.

In island restoration, the Department of Conservation acts variously as gatekeeper controlling access, manager, technical expert, coordinator, advocate and guardian. All these activities can benefit from partnerships with the public and interest groups and organisations. Such partnerships should be encouraged, as they enhance the wider appreciation of conservation as well as increase the effectiveness of particular restoration programmes.

INTRODUCTION

The challenge for New Zealanders into the next century is to accept responsibility for the conservation of this country's incomparable flora and fauna and natural landscapes. Presently, the Department of Conservation has special responsibilities under its Act for those areas set aside by the Crown for conservation. The Department manages over a third of the land area of New Zealand and most of its coastline, its offshore and outlying islands. In addition, the Department has responsibility for historic places, wildlife, and marine animals. An especially important function in the Conservation Act is for the Department "to advocate the conservation of natural and historic resources generally" and it is under this function that a significant shift from a government agency to all New Zealanders is most important. If New Zealand is to see its present conserved estate remain in a largely natural condition and to see those species that are so notably New Zealand survive and multiply, then it will be vital to involve all New Zealanders in conservation activity.

Presently, there is a growing appreciation of the need for conservation and a great deal of support from both organised conservation and recreation groups and by the public generally. In this regard New Zealand mirrors those trends which have become very apparent abroad, where industrial and population pressures are robbing many societies of their natural heritage. In New Zealand we still have a chance to maintain something of that which was originally here: something of the primeval landscape and its creatures. The real challenge is to build community support for conservation into community action for conservation. Instead of a Department of Conservation being the agency primarily protecting areas under threat and species in decline, we need local government, businesses, industry, landowners and all individuals to contribute to conservation as a matter of course and as a mark of their contribution to the community.

Islands have a special role in increasing public awareness of conservation. They are, in a sense, symbols of what New Zealand was once like. By their actions towards islands New Zealanders may expiate the transformation of the landscape that has been the lot of mainland New Zealand following its discovery by humans. The restoration of islands is seen as a measure of our concern to restore something of the original ecology of all of New Zealand. But we should not let our interest in islands divest conservation activity from the mainland where the problems of changing landscape character and people in relation to the land are the greatest.

ISLANDS

Islands as biogeographical units usually bring to mind the offshore and outlying parts of New Zealand. But biogeographical islands also occur in the working landscape of the mainland: islands of relatively original plant communities with their indigenous animals in an agricultural ocean, our reserves and national parks and our mountains. Islands are characterised by their diversity, the range of values they maintain and by their vulnerability - vulnerability to people pressure, development, introductions of predators, pests and diseases. Islands are subject to different pressures by different sections of the public. Some wish to see islands, whether at sea or on land, more available for the public to use, but this must be balanced against the need to limit public pressure in order to maintain ecological health. Onshore islands of natural landscape on the mainland are more vulnerable and accessible than those offshore.

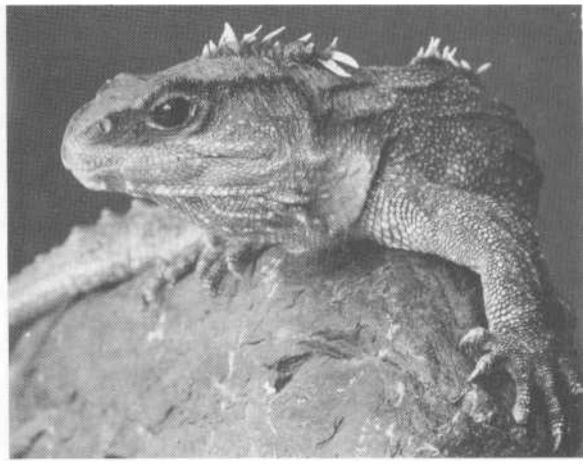
The landscape contributes to our national identity as well as people and their cultural practices. Islands, whether offshore or on the mainland, offer a spiritual dimension for many people. Take away these touchstones of undisturbed landscape and you take away one of the sources of national identity from all of us. If we are to develop a sustainable society in New Zealand, we must be able to maintain our natural islands in the landscape.

In the finish, no matter how we view New Zealand's offshore and outlying islands, it is Aotearoa that is the island at risk and the island for which public involvement in conservation is vital.

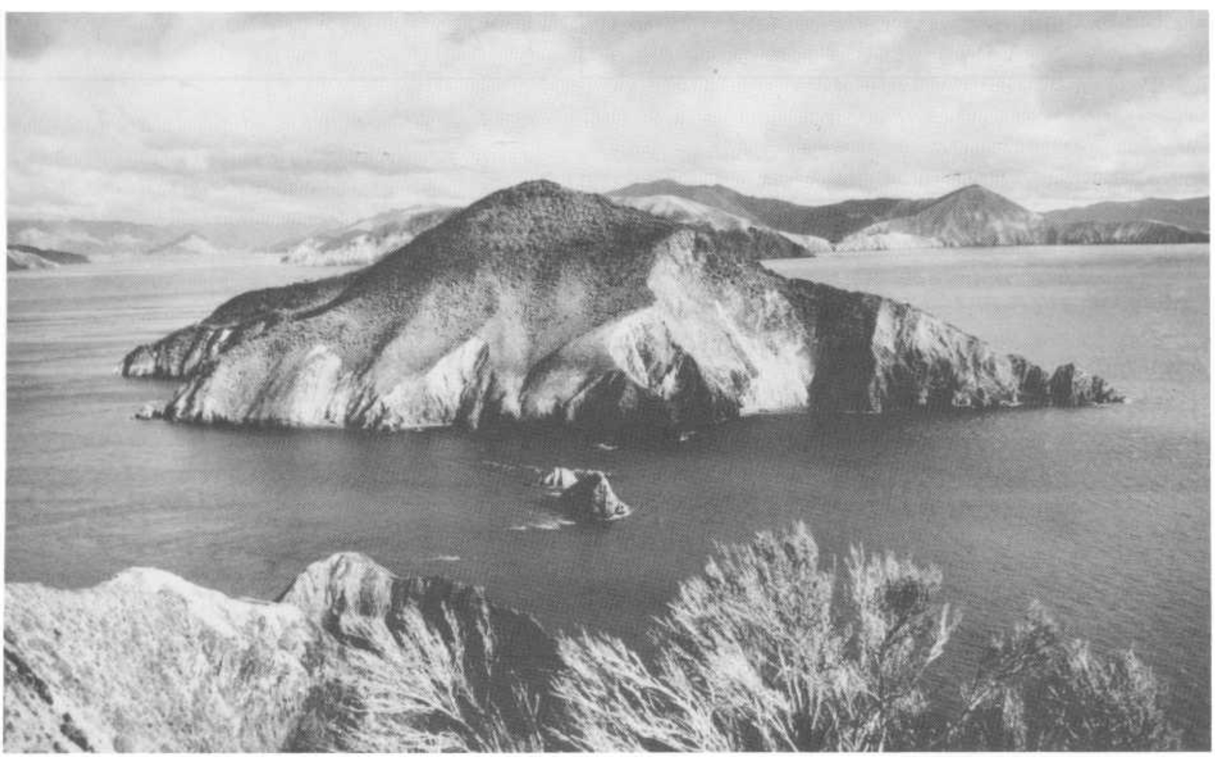
ROLE OF THE DEPARTMENT OF CONSERVATION

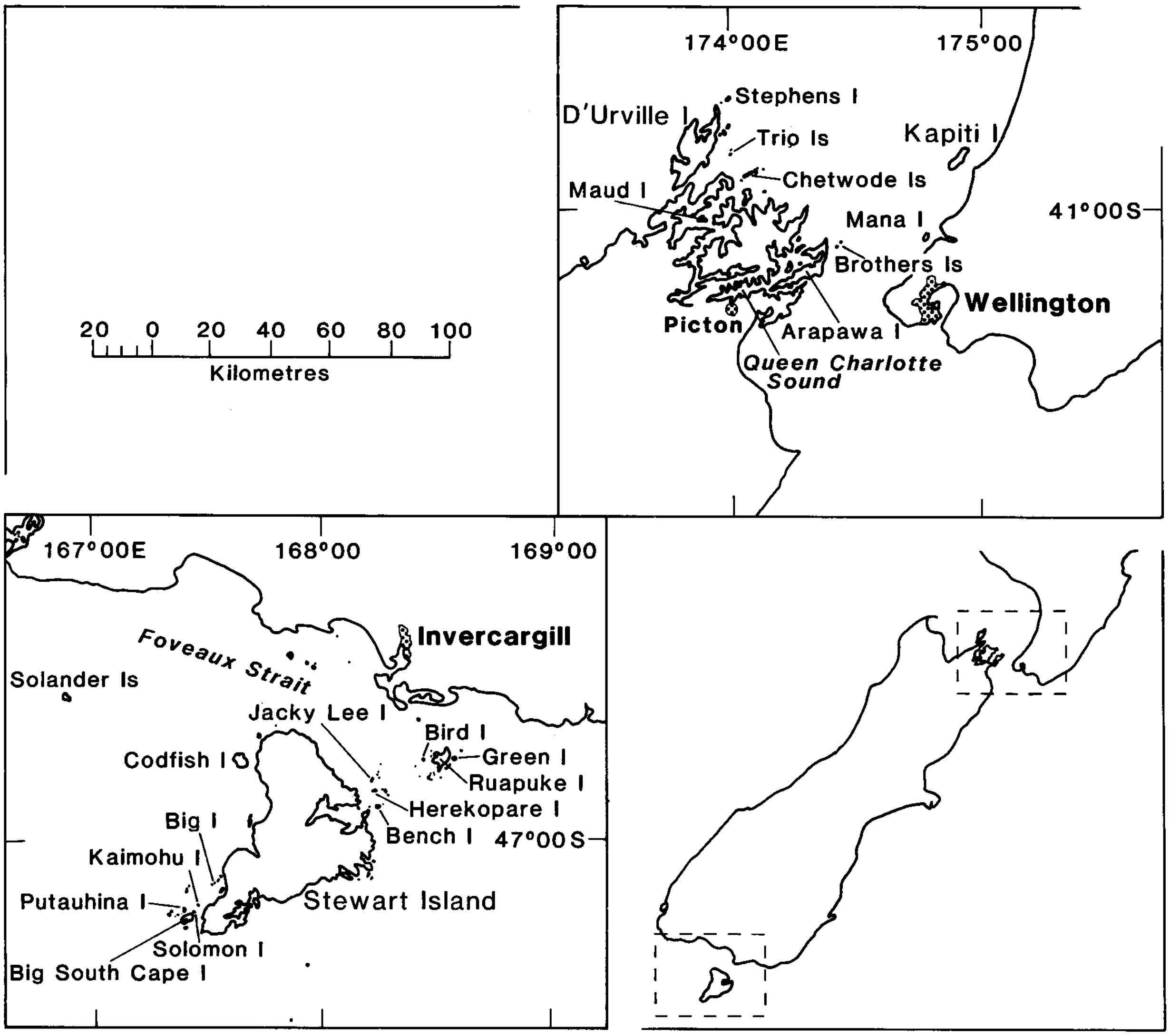
In island restoration, the Department of Conservation is seen to have many roles. For most of the onshore reserves and for many of the offshore and outlying islands, the Department is the Crown agent for management. As well, the Department is seen as the gatekeeper controlling access to the public. The scientific advice within the Department and contracted to it is required to help in maintaining the natural character of offshore islands whose role in conserving endangered species has been well canvassed in this conference. Island management has to be more than just the maintenance or restoration of ecological balance but also has to be seen by the public as contributing in a wider way to New Zealand. It is here that links between islands as symbols of national identity and the conservation of their flora and fauna are so important. The Department of Conservation frequently is seen as the ultimate guardian of islands of original landscape throughout the country. There are many, however, who see the Department of Conservation as a big brother, controlling and regulating access to and conservation of islands.

The public perception of island ownership is important in this. Our property laws give the owner of a piece of land (or an offshore island) powers of control of access, decision making and management. Owners have the right to tell people to keep off; this is mine. In the case of offshore islands used for endangered species management, all these powers are often absolutely necessary. However, the Department of Conservation manages islands for all New Zealanders, and the balance between technical needs and public involvement is important. If New Zealanders think that the Department of Conservation, as guardian of these special places, is unwilling to involve the public, then a real opportunity for advocating conservation throughout the community is lost. The balance between public involvement in management and exclusive ecological restoration by the Department is dynamic. The public need to share in island restoration programmes as they must share in conservation generally.



SECTION 3: SUMMARIES AND RECOMMENDATIONS





Above: Upper right: Islands of the Cook Strait area.
Lower left: Islands around Stewart Island.

Pages 289-290 in Towns, D.R, Daugherty, CH., and Atkinson, I. A.E. (Eds)., 1990. *Ecological restoration of New Zealand islands*. Conservation Sciences Publication No. 2. Department of Conservation, Wellington.

Workshop: ERADICATION

SUMMARY

Two general principles should govern management of exotic plants and animals on islands: the accidental or deliberate introduction of new exotic species should be limited or discouraged, and exotic plants and animals present on islands should be eradicated. Eradication was defined as the permanent removal of the species and it was noted that some measure of risk of recolonisation must be included in claims of successful eradication.

Exceptions to these principles were discussed. The positive values of rare breeds of feral mammals were noted (Rudge 1989), but their continued presence on islands should be conditional upon lack of impacts on the primary indigenous values. Rare exotic biota can be removed to places without indigenous values (e.g., feral goats on Arapawa Island), but evolution of new and perhaps useful genetic stock is halted if the population is removed from the island (e.g., feral goats on Auckland Island). Each case must be judged on its merits.

Other exceptions are where there is either no need to eradicate the exotic biota (e.g., Norfolk pines on Raoul Island) or no possibility of doing so (e.g., blackbirds on Kapiti Island), or where to do so might worsen the situation (Taylor 1968).

The workshop considered which animals or plants should be eradicated from which islands and how and by whom it should be done, and we reached the following conclusions:

There is an urgent need for an accessible, current database on islands. This should include information on the presence or absence (both positive or negative results of survey are important) of exotic biota and their impacts on the indigenous ecosystem. This project is being undertaken by the Department of Conservation but needs to be made more accessible so that everyone can contribute input and benefit from the combined output.

Given that money is limiting, the Department should not now eradicate exotic biota merely because it is possible. Those cases which are most urgent must take priority. How much the Department spends or might spend on eradication campaigns is not known so the workshop could not judge the extent of possible actions. The Department also needs to avoid using money from sustained pest control operations to fund eradication attempts (Parkes in press).

We discussed ways in which cases might be ranked. First, a ranking based entirely on the intrinsic values on islands would be as unsuitable as a ranking based entirely on the "pestiness" of the exotic species. Second, there are three techniques that can be used to rank islands/pests for action: imposition by high authority, consensus among "experts", or an artificial scoring and sorting system (e.g., see Parkes, 1989). We concluded that national coordination with non-Departmental input was desirable, thereby excluding the first technique.

Prevention of colonisation of islands by new exotic biota was discussed. The chances of new colonisations can be minimised by enhancing quarantine actions (e.g., rodent control on fishing boats visiting the Snares Islands), by limiting domestic animals to non-breeding status (e.g., goats on Stewart Island), or by rapid reaction to liberations (e.g., wallabies on Great Barrier Island).

The workshop identified the need for island managers to record and report any attempts to eradicate plants or animals from islands. The techniques used, effort and costs of successes or failures can be used to judge feasibility of future proposals.

Public input at the planning stages of pest and weed management on islands was generally recommended. Involvement at the operational level was more contentious as it is not always possible (e.g., where particular skills are necessary) or desirable (e.g., where it encourages government to subtract funds from budgets).

Finally, the workshop discussed research needs. Despite our successes with some eradication campaigns, there is a clear need to improve control technologies to increase efficiency and extend the successes to other species or larger scales. Research is also needed on measuring the impact of exotic on indigenous biota. These endeavours can be done on islands using the "research by management" concept (Innes 1989) or on the mainland as part of sustained control operations.

Research on the responses of island ecosystems to the removal of exotic species aids in both our understanding of fundamental aspects of ecology and in managers' ability to predict consequences of future actions.

The workshop avoided discussion of who should pay for research.

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Parkes, J.P. 1989. Procedures for ranking and monitoring feral goat (*Capra hircus*) control operations. Report to Department of Conservation. 43 pp.

Parkes, J.P. in press. Feral goats on islands and habitat islands: when is eradication an option. *Journal of the Royal Society of New Zealand.*

Rudge, M.R. 1989. Position statement of the Caprinae Specialist Group: Feral Caprinae. IUCN *Caprinae News* 4:6-9.

Taylor, R.H. 1968. Introduced mammals and islands: priorities for conservation and research. *Proceedings of the New Zealand Ecological Society* 15: 6-7.

RECOMMENDATIONS

1. The Department of Conservation should develop a database on New Zealand islands. This should be PC-based for accessibility and linked with a Geographic Information System for important islands. Written versions should be held on loose-leafed folders so that the information can be easily disseminated and updated. The Department should obtain the USA Nature Conservancy Heritage Database as one possible model.

2. The Department of Conservation needs to identify which pests on which islands are most urgent candidates for eradication. This should be done at a national level.

3. The Department of Conservation should establish a budget for eradication attempts separate from ongoing, sustained control operations.

4. There is a need for ongoing monitoring of islands as part of contingency planning for emergency action. A standard questionnaire could be a condition of access on all islands so that expeditions are forced to record biota other than those in their field of expertise.

5. Managers must record the effort, costs, and effect on the pest of all campaigns. This can be done as part of research by management.

6. Public participation should be encouraged where appropriate.

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Pages 291-292 in Towns, D.R., Daugherty, CH., and Atkinson, I. A.E. (Eds), 1990. *Ecological restoration of New Zealand islands*.
Conservation Sciences Publication No. 2. Department of Conservation, Wellington.

Workshop: TRANSLOCATIONS

SUMMARY

Translocation is a technique for species survival and for island restoration; it is defined as the movement of living organisms from one area with free release in another (IUCN 1987).

New Zealand's island resources are finite (even though some improvement in the numbers of high quality sites is occurring through restoration and eradication work) and as sites of enormous cultural, aesthetic and scientific values, have international, national and regional significance. For some species they may provide the only survival option.

Research prerequisites for translocation programmes fall into two categories: general, for New Zealand's overall programme, and specific ones for particular translocation projects.

There is a need for general research into ordering priorities and setting management options and timetables, and for studying the coordinating role of the central agency. This role requires a considerable data base in which islands and species can be related to threats and opportunities. To facilitate management there should be an island classification or designation system. That being developed for New Zealand islands by Towns and Atkinson was given good support by the workshop. The workshop accepted the following classification system: Minimum impact islands - the most valuable set of habitats, restoration islands, refuge islands, open sanctuary islands, and multiple use islands (see Atkinson this volume, Towns *et al.* this volume). These designations may be applied to whole islands or part of islands. Highly modified islands do offer great scope for restoration and translocation and should not be neglected. All island values should be taken into account in order to make a proper designation.

The workshop debated the role of science values - the value of islands as natural laboratories and as repositories of history and evolutionary processes. It was concluded that it would be wrong to restrict science on islands solely to the demands of the management programmes. Basic sciences should be fostered as providing knowledge and understanding of natural processes. The concept of 'science islands' was not supported by the workshop.

As islands are an important component of the survival of New Zealand's natural heritage management, research should not be confined only to those islands falling within the direct control of the Department of Conservation but should be extended where possible both to private islands and to islands held by other agencies. Corporate ventures with all owners are to be fostered.

Particular research goals need to be tightly defined for each species; they must have precise objectives and a definite time table. No translocation should be tried before this is done. Preliminary investigation should look at feasibility, technique, and impact - both during and after the translocation as well as on the source community. There is a need to understand the genetic make-up of the possible source biota and its relation to that in the new habitat and geographic region. Certainty about the identity of the animals and plants to be shifted is of utmost importance. There is also a need for quarantine, to ensure that diseases are not transferred, and that animals and plants were clean. Seeds carried by birds was a particular case noted.

The workshop strongly endorsed the need for a central coordinating body. In the case of transfer programmes involving threatened species, this role is to be undertaken by the Threatened Species Unit of the Department of Conservation. Part of their work would be to prepare species survival plans. Coordination at the next level, at a mix of islands and species, is also possible within the DoC structure, using species and habitat protection personnel, but the workshop remained sceptical that this would provide an adequate forum for resolving the complex and conflicting demands of species survival and island use. We concluded that a somewhat broader review, with a larger and more diverse group of participants, was necessary. There seems no immediate need for a formal committee, although this may be necessary in time. The central group should provide the main thrust of translocation programming for the conservancies. Species survival is clearly a national problem and cannot be planned and executed piecemeal by the 14 conservancies. The direction of work in this area to ensure the national objectives were being met and pursued in the individual regions could be gained by central control of funding.

The actual work of transfers need not be carried out by experts from the central body; much of the effort would come from the conservancies. This approach requires considerable training of local staff in the techniques of translocation and of monitoring impact. The workshop stressed on a number of occasions the importance of involving the public in this work, but noted that some of the work is so specialised and difficult that it must remain with expert staff. There was overwhelming support for making environmental impact assessments mandatory for all translocation projects. These should to be open to public scrutiny. It was not resolved how auditing would be undertaken.

The need for information about programmes planned, their execution and the results was raised many times at the workshop. At the moment not even the most informed DoC staff have a complete record of the work being undertaken and planned. The poor record of reporting and publication on translocations is a major shortcoming. International reporting is of high significance, provoking comment and interchange of technical and other information and encouraging assistance. There is currently no annually published record of translocation work, even in brief, for schools and universities.

Much more needs to be done in soliciting public support and encouragement to ensure that work is fostered in the long term. Maintaining public support requires good communication both by direct participation in selected programmes and through the media. There does not seem to be any specified unit responsible for developing this interest or involvement.

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RECOMMENDATIONS

1. A central body, to coordinate island management at a national level, should be fostered.

2. There should be an island classification or designation system developed to facilitate management.

3. Management and research on islands should extend, where possible, to those islands owned privately and held by other agencies, rather than being confined to those under direct control of the Department.

4. Research on specific translocation projects must be well organised and tightly monitored.

5. The Threatened Species Unit should coordinate translocations and provide species survival plans.

6. Environmental impact asssessments should be mandatory for all translocation projects. These assessments should be open to public scrutiny.

7. Much more information on translocation programmes should be provided to the public and to the national and international scientific community.

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Workshop: REVEGETATION

SUMMARY

Restoration was defined as active intervention and management to restore biotic communities formerly present (Atkinson 1988). We focused on large-scale programmes in depleted landscapes and discussed the reasons for and against revegetation.

Although much still needs to be done to protect remaining natural areas from destruction or deterioration, the workshop participants agreed that on some occasions revegetation should be undertaken. The following were suggested as valid reasons:

1. Human depletion. We have a responsibility to restore at least some representative landscape samples to their former state.
2. Complement to mainland conservation activity. Islands offer conservation opportunities not always available on the mainland, including the chance to restore particular vegetation communities lost from, and which cannot be re-established on, the mainland, and provision of mammal-free refugia for threatened animals or plants. The latter could include creation of an appropriate habitat or just introduction of particular food species.
3. Genetic conservation. Distinct genetic forms of plants or animals, which require the isolation of an island to remain distinct, may require provision of appropriate habitat by revegetation before they can be either established or protected.
4. Representative soil types or microclimates. In some cases islands have distinctive edaphic or climatic features not present on the mainland. Revegetation of depleted island landscapes improves the representativeness of New Zealand's protected natural areas network.
5. Representative archaeological sites. Some sites need revegetation programmes to ensure their protection.
6. Natural regeneration may be too slow or inhibited by other factors. Revegetation can augment natural seed sources, so that the resultant vegetation resembles more closely the original cover.
7. Provide a source of native plants and animals for restoring neighbouring islands.
8. Landscape protection. Revegetation may be necessary for protection of soil and water values, to manage weeds, or to reduce the risk of fire.
9. Provide an educational and recreational asset for understanding and experiencing what we have lost from the mainland.
10. Advocacy. People's imagination can be captured by revegetation programmes in a way that does not occur so often with more passive protection projects. Wider conservation issues and values can be communicated.
11. Aesthetic benefits. These include the pleasure people derive from landscape diversity, particular landscapes, and the return of a familiar, characteristic landscape.
12. Scientific opportunities. A revegetation project can be a large-scale experiment. Differing methods of establishing plants and animals can be compared, and hypotheses about plant succession and the dynamics of animal populations can be tested.

Some reasons against revegetation are:

1. Impatience. Because revegetation projects are expensive they should not be engaged in unless there is a very good reason; impatience with the pace of natural regeneration, which can sometimes be very fast, is not sufficient reason.
2. Compromise primary objective. If an island is protected primarily for its intrinsic scientific value, revegetation would remove the chance to observe primary regeneration processes.
3. Compromise other values. Revegetation could threaten other values such as animal habitat, archaeological sites, geological or landscape features.
4. Cost/benefit unfavourable. The cost may be strictly financial or a lost opportunity to engage in an alternative project; either way, the cost should not be greater than the resulting gain.
5. Biological risks. Revegetation programmes can increase the risk of introducing: exotic weeds, geographically or genetically inappropriate native plants, soil-borne pathogens, insect pests, and rodents (Wright and Cameron this volume).

6. Logistics. All revegetation projects should have a realistic goal and recognise prerequisites for success.

7. Revegetation is an unnatural process. It is driven by human activity, and some say it always produces a "spurious" result. Often planned revegetation is conducted without knowledge of what the original vegetation was like and it is difficult to achieve the same hybrid ratio as occurs in the wild. Natural regeneration results in plants better suited genetically to their habitat as they have undergone a strong selection process in order to survive. We owe it to future generations to preserve natural processes.

There was much discussion, and no agreement, on point 7. The disparity in views seemed to stem as much from differences in degree of depletion of island landscapes being considered as from real differences in philosophy. There were varied opinions on appropriate revegetation goals for islands. Some felt that the goal must always be to restore the island as near as possible to its original state. Others suggested a more realistic goal was to restore the community to just a similar structure and function to that of the original. Yet others felt that revegetation goals could include restoration to a more recent state or creation of a particular habitat.

Most people agreed that revegetation should largely be restricted to severely modified islands where it is a prerequisite to meeting the primary conservation objectives of the island. Islands should be managed in such a way as to maximise their advantages and special values.

Procedures involved in revegetation would: (1) determine need, (2) conduct research into the project's feasibility, (3) develop a proposal, including goals and planned activities, (4) develop a management plan, (5) consult with the public and possibly seek formal independent assessment, (6) establish and follow a set of principles, and (7) maintain regular monitoring and review of any programme.

Principles behind revegetation programmes could include: (1) adapting a minimum impact procedure, (2) encouraging natural revegetation in preference to planting, (3) removing alien plants and animals (and keeping them out in future), (4) using only appropriate plants (see Timmins and Wassilieff 1984), (5), establishing revegetation trials to determine the best plants and techniques to use, (6) recording and monitoring the entire activity, (7) encouraging public participation at all stages, and (8) publicising the activity.

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Wright, AE., and Cameron, E.K. this volume. Vegetation management on northern offshore islands.

RECOMMENDATIONS

1. Develop national policy guidelines for revegetation, outlining acceptable practices.

2. Explore minimum interference vegetation management options before using more major revegetation techniques.

3. Assess all islands for their revegetation requirements and establish a list of national priorities.

4. Assess all islands for weed eradication or control requirements and list national priorities.

5. Convene further workshops to develop national policy guidelines for revegetation and to share techniques developed in different parts of the country.

6. Establish a national overview body to review island management policy. This could be a sub-committee of the National Conservation Authority. Revegetation programmes command a lot of resources and can have a large impact on islands, so they need special attention at national level.

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Conservation Sciences Publication No. 2. Department of Conservation, Wellington.

Workshop: CULTURAL PERSPECTIVES

SUMMARY

Our group seemed to consist predominantly of managers, from the Department of Conservation, territorial authorities, archaeologists and a sprinkling of others. While we were fortunate to have the guidance and advice of Sid Puia from Rotorua, our access to a variety of Maori views was limited. Position papers outlined a variety of Pakeha approaches, and an exploration of Maori concepts.

Similar topics of discussion came up under the headings of Maori issues and Pakeha issues. The meeting recognised that the separate communities would place quite different emphases on these topics. Common topics were provision for traditional exploitation of islands and sea resources, provision for spiritual, aesthetic and traditional values and sites, and recreation uses.

In addition, under Maori issues the questions of ancestral lands, and of interisland and island-mainland connections and values were discussed. For Pakeha an additional need was that for non-ecological scientific research and knowledge, i.e., historic or cultural sites.

Ian Atkinson's classification of islands for ecological ends was discussed. From the differing points of view of Maori and European cultural perspectives, it was felt that parallel classifications were necessary and that decision making must take these other classifications also into consideration.

Groups of islands rather than single islands were the unit most likely to show a range of cultural values and allow good management decisions. Some islands might be set aside and managed to preserve the intrinsic value of their Maori cultural or historical values. Cultural isn't the same as recreational.

Maori cultural values and concepts need to be extended to include the sea and the sea-bed.

The question of cultural/community input into the drafting of management plans and culturally appropriate forms of consultation. At least for some areas, even most areas, decision making should have consist of co-management structures, tangata whenua input, particularly when ancestral or gifted lands are involved.

The final topic was that plans and structures needed to be able to change, re-arrange priorities to fit in with new needs.

RECOMMENDATIONS

1. Consider islands in wider contexts - geographical and cultural.
2. Consider Maori, historical, recreational and other cultural values as well as ecological ones.
3. To ,provide a balanced approach, we need more than one classification system.
4. Plans need to be flexible to respond to changing values; we must keep options open for future generations.
5. There should be more effective public input into preparation of Department of Conservation management plans.
6. Educational needs should be recognised as a means of reducing conflicts.
7. There should be co-management structures in appropriate circumstances.

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Conservation Sciences Publication No. 2. Department of Conservation, Wellington.

Workshop: RECREATION AND TOURISM

SUMMARY

Nature conservation objectives for natural or modified environments must be clear so that management objectives can be formulated. The acceptability of changes depends upon their appropriateness to the opportunity defined by management objectives. For example, "recreation reserve" means something different than "nature reserve", and this is without any consideration of the resource base. Objectives for resource conservation must be set before those for recreation itself.

Our management practices are based upon inadequate knowledge, both of the resource base and the users. Nature conservation and recreation are also influenced by wider environmental changes. Recreation can be a potent force for nature conservation; experience in conservation activities such as tree planting may lead some people into new recreation activities.

We need more research and flexibility in that research. Little is known of the recreation and tourism potential of many of our islands, and recreation values will need to be clarified to determine how appropriate they are in the management of particular islands. Workshop participants recognised the pre-eminence of the "setting" to achieving satisfying recreation experiences.

Growth in recreation participation may well be outstripping our current ability to plan and manage for it. A gap between national and regional planning strategies is most noticeable for islands of national significance for nature conservation, as much recreation and tourism planning is done on a regional basis. Careful coordination of plans and the various levels of planning is essential.

The "Limits of Acceptable Change" planning process is based on defining a "recreation opportunity spectrum" comparable to other spectra proposed by Ian Atkinson and John Craig. The LAC process is seen as clarifying recreation output in nature-related settings and providing a management framework. The workshop proposed that an island study be initiated to establish the appropriateness of this technique in New Zealand. Tyson (1989) illustrates a similar proposal, already made to the Department of Conservation.

Better data are an essential prerequisite for efficient management. All participants noted the sparseness of knowledge on all aspects of island management. (Studies such as O'Connor and Simmons' paper in this volume can only be based on inferential data.) We are experiencing a boom in water-based recreation, especially in the northern half of the North Island, and we need to know more about this.

Existing legislation does not consider the effects of tidal movement on land exposure and inundation and depth of the sea. The questions of extending protection to the sea floor and of establishing marine reserves were not discussed at length, presumably because these ideas already have wide support among the workshop participants.

Recreation and tourism are of themselves neither good nor bad - they just happen. When harnessed, as in the case of Tiritiri Matangi Island, they can be a powerful force for nature conservation objectives. Left unmanaged, they can be equally destructive.

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Tyson, B. 1989. Limits of Acceptable Change (LAC): An evaluation of the concept for introduction as a Department of Conservation resource planning technique. Proposal presented to the Department of Conservation, Wellington, March 1989.

RECOMMENDATIONS

1. We should all recognise the benefits of recreation and tourism to further conservation goals.

2. The Department of Conservation should determine each New Zealand island's value to recreation and tourism.

3. Planning for recreation and tourism on each island should be compatible with long-term conservation goals.

4. The Department of Conservation should use an island case study to test the "Limits of Acceptable Change" (LAC) planning process in a New Zealand environment.

5. Where islands are already being used for recreation, management should continue to monitor these islands.

6. Promotional and educational strategies must be an integrated part of island planning and management.

7. Island managers should consult with public users, local communities, and commercial operators about island planning and management.

8. Research should be undertaken on conservation, recreation, economic and other relevant information required for management.

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Pages 298-299 in Towns, D.R, Daugherty, CH., and Atkinson, I.A.E. (Eds), 1990. *Ecological restoration of New Zealand islands.* Conservation Sciences Publication No. 2 Department of Conservation, Wellington.

Workshop: ADVOCACY

SUMMARY

The workshop on advocacy was introduced by a position paper from Alan Edmonds in which the role of the Department of Conservation in forming partnerships with the community was examined. This paper stimulated a general discussion on the Department's role in advocacy revolving around the following points:

Public support: The Department of Conservation now has extremely wide responsibilities. Most funding for these responsibilities is obtained from the public in the form of taxes. Continued support for this expenditure therefore relies on understanding and sympathy from the public. Without public support there would be no money, and without money, no Department of Conservation.

Department of Conservation staff as advocates: Not all Department of Conservation staff are in jobs that require constant contact with the public. However, all DoC staff at some time inevitably deal with the public. Each time this contact occurs the staff member involved is in a position to advocate for the Department. This role is so important specialised training for all staff may be needed.

New Zealand is an island nation: Like other island archipelagos New Zealand has demonstrated its vulnerability to the effects of man and his commensal travellers such as rats and cats. These animals, plus habitat destruction on the main islands, vulnerability of remaining resources on the offshore islands, and additional responsibilities for coastal habitats and historic sites means that the Department of Conservation must overcome some enormous difficulties. These difficulties cannot be overcome by the Department alone. Efficient use of the Department's resources, as well as productive use of public help will rely on DoC presenting clearly defined and understandable priorities.

Priorities: In cases where priorities are unclear the Department's own staff will not be able to effectively advocate for them. In dealing with what at times might be a sceptical public, this may eventually lead to vituperative and damaging conflict. As long as priorities are clear, however, any conflict is more likely to be constructive, from which eventually all parties stand to benefit.

User pays: One of the biggest single sources of conflict identified is the question of "user pays". In some quarters it is argued that unrealistic demands on the Department for revenue generation is likely to be the cause of much loss of public sympathy. On the other hand restrictions on the way that DoC is able to obtain funds, such as an inability to charge entrance fees to Crown land, greatly hampered progress with some projects. The ways in which this had created problems with the Tiritiri Matangi Island project is one example, and the value of this project as a case study should be emphasised.

Goods and Services Tax (GST): One identifiable drain on Departmental resources is either providing facilities for international tourists, or minimising the impacts of them on facilities and natural and historic resources. The tourism industry in New Zealand predicts that by the end of the 1990s the country could be receiving 3 million tourists per year. At present the tourism industry contributes around two billion dollars annually to the New Zealand economy (GDP). Since almost all tourists require the use of DoC facilities somewhere, it is reasonable to expect that some of the income from tourism should be returned to the Department to maintain the resources tourists demand. It was proposed that once again arguments should be taken to Treasury for use of a portion of the GST taken from tourism.

Partnerships: The mechanisms for forming and maintaining partnerships was discussed. It is unrealistic to assume that arrangements between the Department of Conservation and other organisation will always proceed without problems. It is most likely that there will be a mix of sweet and sour - some partnerships operating better than others. There is also likely to be sweet and sour patches within a single partnership. Success will hinge on maintaining a mix that is more sweet than sour. There are three elements required:

Education, in which the public awareness of issues is adequately developed; information shared by the Department of Conservation and those with which partnerships are developed; and willingness of both parties to be involved.

To return to the original point: partnerships require public support, the Department of Conservation requires public support and partnerships in order to meet its wide responsibilities. Without public support there will be no partnerships, without partnerships there will be insufficient funds, and without money there will be no Department of Conservation.

RECOMMENDATIONS

1. All Department of Conservation staff should be made aware that they are the front-line advocates for conservation. All opportunities for training staff should be explored and implemented.

2. The Department should consider using market research (and other such techniques) to enhance/direct their partnership with the people of New Zealand.

3. The Department should clearly define what it is not prepared to place in a market framework.

4. The Department and the partners involved in Tiritiri Matangi should explore the economic opportunities inherent in the restoration of that island. Other models should also be explored.

5. The Department should reopen discussions with the appropriate institutions regarding the surrey of the cost spent on tourism, for use in conserving the national estate.

6. The Department should investigate structures which will allow management of the material estate by all interested parties jointly.

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SUMMARY AND FAREWELL COMMENTS

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Right at the outset I must congratulate those of you who came up with the concept for this conference. I am sure that it will have been pleasing for you to see the concept so well developed and so comprehensively executed this week.

A conference on ecological restoration of New Zealand islands was a concept whose time had clearly arrived. It is also clear from the very wide range of papers presented and topics discussed that New Zealand is in a sound position to lay out its depth and breadth of experience on island restoration management. Delegates who have been here right through the week have commented to me that the papers have uniformly been characterised by possessing real substance - that is to say, the content has not been superficial but represents a substantive resource of experience and ideas that demands respect and attention.

It was observed that the material was too good to simply end up on dusty shelves. It is clear though that the papers and proceedings of the meeting will in fact form the starting point for the development of policies and strategies. Indeed the challenge for all of us will be to ensure that we capitalise on this conference by maintaining the impetus into action and to continue the debate on outstanding issues. I am sure, not the least from the point of view of the conference budget, that the proceedings will be a "best seller".

I believe that Jared Diamond really set the pace for the meeting with his opening keynote address discussing New Zealand as both an archipelago and as a mini-continent in biogeographic terms. We are all sensitive to the prominence of New Zealand taxa in world lists of rare, threatened and endangered species, due so much to the impacts of colonisation and exploitation. Jared Diamond reminded us that there are aspects now to be proud of, in the innovation and application of practical and successful techniques to bring birds, in particular, back from the edge of extinction. The dedication and commitment of those involved thoroughly deserves world recognition.

We have also been reminded by our overseas guests of the real value of sharing our experience with others, and that researchers and field workers alike should not consider the task complete until the information gained has been shared with the widest possible audience - a factor often overlooked in coping with the sheer magnitude of the task and the logistic difficulties of project work in frequently very remote localities.

To attempt to do justice to all the papers contributed to this conference would have required an order of magnitude more time than I had available to me. I would like simply to share with you a number of themes which have been evident or prominent during the week of the conference.

Atkinson - Towns islands classification

This concept clearly caught the imagination of participants - so much so that I believe I heard it discussed in all the workshops I made contact with yesterday.

There would seem to be a real value in developing this concept further, especially given the expectation that management planning for most islands or island groups may well be some way off. Allocating all or parts of islands to a certain classification framework could well serve in the interim to guide management and to formulate operational priorities.

I have a sense of *deja vu* about this classification concept, having been very much involved in the 1970s in the development of zonation approaches for state forest and forest park management. I remember the debates which took place over the integration of recreational zonation needs with those related to the protection/production spectrum. I am sure that similar debate will take place to either integrate the cultural/recreational aspects with those that are ecological, or perhaps parallel systems will develop. Or, indeed, the effort may well be better placed in making progress with island management planning.

Public participation

There is a very understandable desire for wide participation in the policy formulation, planning and operational activities in island restoration management. The interest and active involvement of non-governmental organisations, universities and individuals is something very much to be fostered and utilised to the full. While the Department of Conservation carries the statutory responsibility for many aspects of island management - especially for these islands of greatest value to threatened species and as natural ecosystems of great intrinsic worth - the Department of Conservation's guardianship role is something which cannot and should not be played alone. It is a matter of regret that formation of the Department and then restructuring have caused introspection and ambiguity - and these have got in the way of developing the partnerships essential to do this work right.

I am pleased that Alan Saunders had the chance to say a little of the embryonic Threatened Species Unit at one of the Workshops yesterday, and to emphasise that the Unit owes its conception to the perceived need for coordination - not only within the Department of Conservation but also in the wider community, to ensure that the widest array of resources is mobilised in support of this work. Janet Owen's Protected Species Policy Division will similarly ensure that coordination of species work and habitats of particular importance - such as wetlands and islands takes place. And we must ensure that we do not lose sight of the essential coordination needs with the marine environment, and for cultural, recreational and tourism aspects of island work. There have been calls for a committee or quango to carry out overall coordination - presumably to provide public input on policy and planning, as well as budgetary priorities. We are again in a time of change with quangoes. I believe the appropriate body will be the New Zealand Conservation Authority - which will very likely need some array of committees to help carry its workload. An islands committee of the NZCA has merit for consideration.

Beyond ecological considerations

It was suggested that ecologists have seen islands as single units. Perhaps this focus arises from the fact that the sea forms such a clear boundary both to species dispersal and to invasion or reinvasion by rodents. However, some participants have most eloquently challenged this notion. Cultural issues deal with *parts* of islands or island groups, and the marine ecologists remind us that islands are linked through seabed and marine ecosystems. Why indeed should ecosystem considerations be so sharply divided at the high tide mark?

There has also been a demand for action in respect of the creation of marine protected areas - a demand with which I entirely empathise. While the Department of Conservation can point to survey work in about 20 locations around the New Zealand coastline, with our limited but very committed resources, we cannot actually show gazetted reserves as evidence of success. I would like to think the first success will be the cork out of the bottle, and many more will flow, but the current legislation continues to provide real difficulties and there are cultural dimensions which we must get right.

I pay tribute to the Royal Forest and Bird Protection Society here in recognising that the Department of Conservation cannot and need not take the battle alone - their application for reserve status for Pollen Island will be controversial but deserves every encouragement and success. It would indeed be a magnificent objective to set - to ensure that each of our most valuable island ecosystems was matched by a surrounding marine protected area, especially if such marine areas could cover the main interface with island dwelling species dependent upon the sea. Even better if some of those combined island - marine reserves could be given World Heritage Status.

Just a sprinkling more of random issues and concepts that deserve attention

Kevin O'Connor and David Simmons' warning on the almost exponential rise in boating activity, especially in the north, and the implications of risk of accidental rodent release, and/or increased human visitation to and impact on islands. This issue is well worth investigation.

The strong plea to provide conservation experience and education for the public through involvement in practical island restoration work. Tiritiri Matangi, Mana and Whale islands were discussed. Funding and charging issues were traversed.

There has been real value for the Department of Conservation staff to get together and compare notes in this gathering. Such gatherings for those working in similar fields have been regrettably few in recent stringent budget years, but having the additional contact with such a widely drawn group is especially appreciated.

Valuable discussion on concepts of revegetation, with a plea to discard any expectation that islands can be restored to a pristine state - either naturally or artificially, once modified by human settlement or rodent invasion. There was some acceptance, though, that revegetations should follow a minimum impact priority, dealing with the ecosystem as a whole and leaving as much as possible to natural processes.

A reminder that even artificial lake islands may have a value - the example quoted was of islands in Lake Benmore which, despite presumed vulnerability to swimming rodents, can play a part in the conservation of invertebrates under threat within the Mackenzie Country.

An important theme or message from this final morning's discussion. The management planning challenge is still awesome, especially given the accepted need to involve the widest possible group of interested people. The Department of Conservation faces pressures from many groups lobbying for their perception of priorities, but perhaps the single most repeated clamour is for management planning. We cannot ignore that call!

Finally, a disappointment is the absence of tangata whenua involvement in this Conference, beyond the welcome. Yet these islands issues go to the heart of current debate on Treaty of Waitangi rights and obligations. We may well need to take many of these issues to a hui with the Maori people before long.

Farewell

Well, we have come to the end of a long haul. I would like to express our gratitude for the international perspectives offered by our overseas guests at this meeting. Our especial thanks to Jared Diamond, Dan Simberloff and Sherwin Carlquist for your challenging papers. We are grateful for these impressions from people able to view from a far and with a wide perspective, and provide thought-provoking material to those of us at times too close to see the obvious. I wonder if New Zealand tourism operators can capitalise on the concept that visiting Rangitoto is actually visiting Hawaii?

I have already commented on the real quality of the papers delivered here, on such a wide range of topics, by so many of you. You have created a valuable resource, and thus an opportunity which must be carried on into policy and planning. Thank you for those contributions.

Thanks again to people who chaired the various sessions. It was a pleasure to watch the practised hand on the blackboard of the university folk, and mostly we were able to read the results. It was observed to me that those of you from academia had made a notably practical and informed contribution based on real-life experience. Congratulations for that - how universities have changed over the last 25 years!

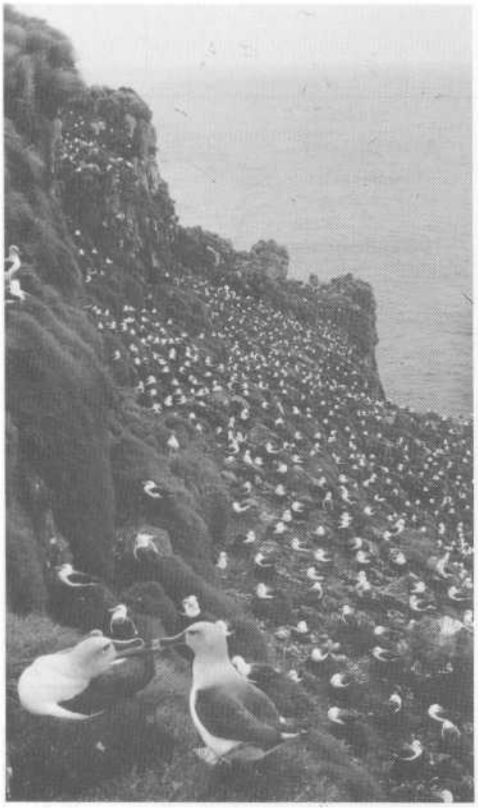
As I said, this successful conference owes much to the organising committee, those who saw the need and carried it through so well. It has gone well this week - you thoroughly deserve our thanks for all your hard work.

Finally, thanks to the participants. Your contributions have been what has ultimately tied the papers together through the workshop themes, and provided resolutions on the distillate of the week's work. The discussion has been notable for its even tone, and although sometimes heated, has lacked rancour.

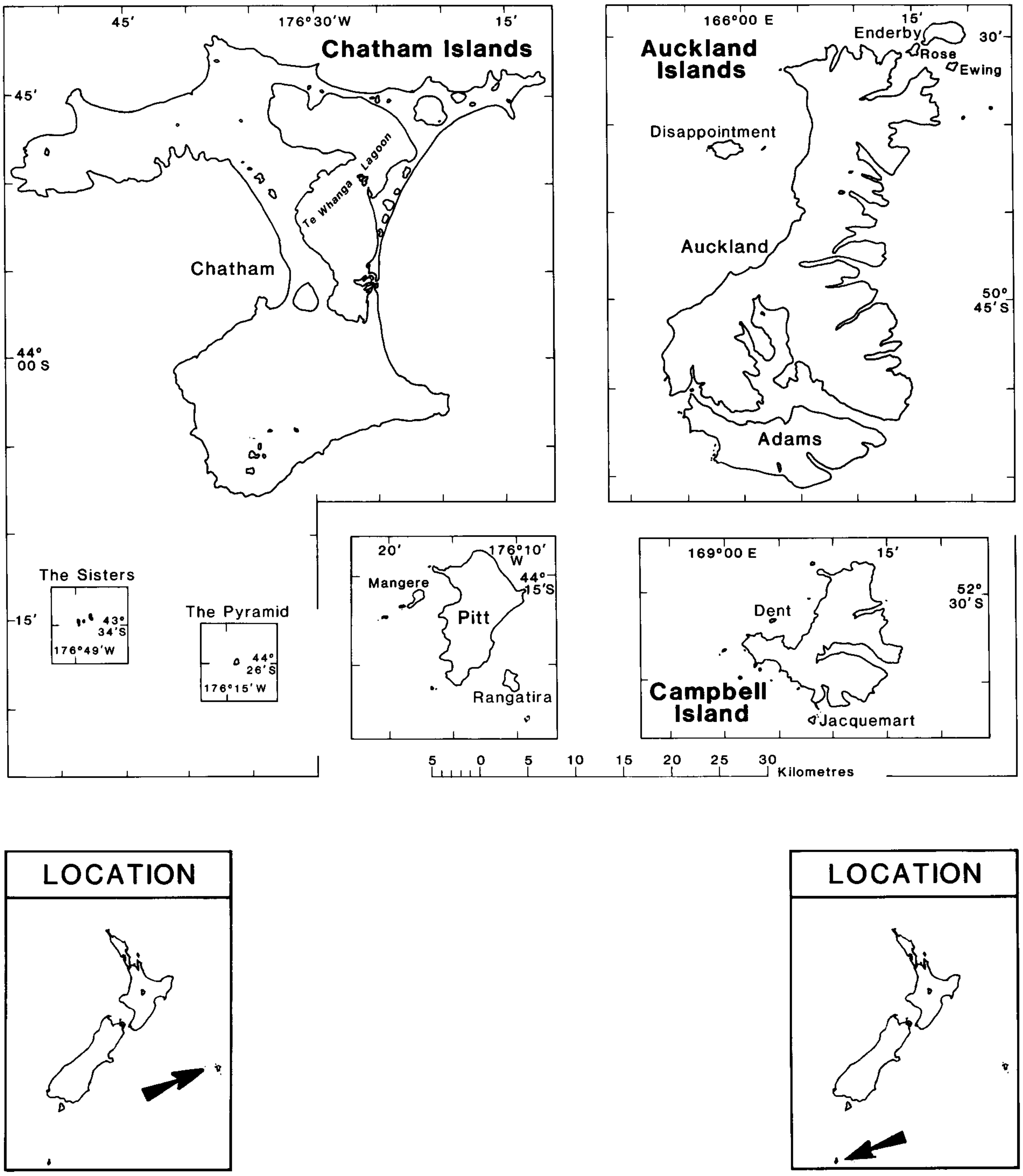
Thank you all for your attendance. Travel well as you leave here. We must ensure that your dispersal is not total but that you remain as a network, able to contribute and be tapped - possibly to come together again in the future.

Thank you and farewell.

Kia ora tatou.




SECTION 4: ABSTRACTS AND PARTICIPANTS



Above: Chatham Islands (left) and subantarctic Auckland and Campbell island groups (right).

ABSTRACTS

ASSESSMENT AND TRANSFER OF THE WHITEHEAD TO TIRITIRI MATANGI ISLAND

D.G. Allen
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Research undertaken to assess the behavioural ecology and transfer suitability of the whitehead (*Mohoua albicilla*) concluded that Tiritiri could support a viable third island population. A captivity experiment on little Barrier Island assessed captive survival. patterns. By totally mimicking capture, handling, and release procedures, the transfer methodology was fine-tuned in preparation for an actual transfer. These findings are discussed with regard to other insectivorous bird species.

Planning of the transfer day (3/9/89) involved co-ordination of the transfer team with media and public presence. As the current management policy for Tiritiri encourages an open sanctuary approach, the voluntary involvement and financial support of interest groups justified their presence. The potential implications of public involvement are discussed in view of similar islands where restoration projects are warranted.

RECOVERY OF COASTAL FORESTS ON STEWART AND BENCH ISLANDS AFTER CANOPY COLLAPSE: THE INFLUENCE OF INTRODUCED BROWSING ANIMALS

R.B. Allen, G.H. Stewart, L.E. Burrows
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Widespread canopy mortality is found in the southern rata-kamahi forests along the coast of Stewart and Bench Islands. Similar mortality elsewhere has been attributed to brush-tailed possums, yet brush-tailed possums are absent on Bench Island. Additionally, white-tailed deer browse the understorey of these forests on Stewart Island, but not Bench Island. These islands provide an unusual opportunity in New Zealand for comparative study of similar forest affected and unaffected by introduced browsing animals. We used permanent forest plots established on Stewart and Bench Islands between 1979 and 1982, and remeasured between 1985 and 1989, to determine mortality and regeneration patterns during canopy collapse, with and without the influence of brush-tailed possums and white-tailed deer. Canopy mortality is not expanding further inland on either island, although southern rata trees continue to die in the open canopied coastal strip on both islands. Seedlings of deer-preferred hardwood species, for example, *Coprosma foetidissima*, and tree fern species are regenerating on Bench Island but require deer exclusion to regenerate on Stewart Island.

VEGETATION AND ARCHAEOLOGICAL SITE MANAGEMENT ON ISLANDS OF THE HAURAKI GULF

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New Zealand was first populated by East Polynesian migrants at least 1000 years ago. Evidence of some of their early occupation sites as well as more recent ones can still be found on islands off the east coast of the North island. By 1840 some of the islands had been denuded of trees by their Maori population. Logging activities in the 19th century removed the vegetation from many other islands. In this paper we look at various means of management of some of the islands and the effect of revegetation programmes on the archaeological sites. We consider the effect of total management by means of farm parks or the planting of exotic forest trees, new revegetation schemes with the planting of native trees compared with the natural revegetation.

REVEGETATION OR NOT?

E.K. Cameron
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A.E. Wright
DEPARTMENT OF BOTANY, AUCKLAND INSTITUTE AND MUSEUM

The paper is complementary to Wright and Cameron's paper in this volume. We will emphasise issues not covered in the position paper, e.g.: restoration - a fallacy; potential harmful effects of revegetation; present revegetation goals often unclear; seral (native or exotic) species for revegetation; disjunct distributions; local races; cryptic species; relative infancy of plant taxonomy in New Zealand; natural regeneration; targeted species monitoring and eradication versus revegetation; need for rationalisation and central recording of all revegetation projects.

ISLAND POPULATIONS OF RARE BIRDS: GENERAL RECOMMENDATIONS

J.L. Craig
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G.S. Dumbell
DUCKS UNLIMITED, LOWER HUTT

Predator-free islands represent a major asset in the management and conservation of New Zealand's rare birds. The current belief that every subpopulation must be of the order of 500 in order to maximise genetic diversity and to reduce risks of catastrophe or demographic extinction means that only large islands are considered in recovery plans. Recent work has suggested that a number of small isolated populations maintain as much combined genetic variability as a single much larger population. New Zealand has many small islands, and if subpopulations were separated geographically this would reduce the risk of catastrophes as well. General recommendations across many species are presented.

PRIORITY AND TECHNIQUES FOR THE RESTORATION OF ISLAND POPULATIONS OF TUATARA

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Tuatara (*Sphenodon punctatus*) currently survive on 29 islands off the New Zealand coast, but about 28% of these populations are endangered by the presence of Polynesian rats (*Rattus exulans*), and a further 52% are at risk because of law population size. In this talk we discuss: (i) why we should try to restore any of these populations; (ii) which population(s) should have priority in restoration attempts; and (iii) how restoration can be achieved. In particular, we discuss applications from our recent survey of geographic variation in reproduction and genetics of tuatara to the restoration of existing populations.

IS ISLAND MANAGEMENT OF SPECIES REALLY SPECIOUS MANAGEMENT ON ISLANDS?

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Current conservation dogma is heavily reliant on the biological species concept. This has led to taxonomic considerations having primacy in conservation decisions as illustrated by the use of terms such as "rare species management". This implies that taxonomic units are realistic conservation units. We will argue that taxonomy is both subjective and variable and has been embraced without question in New Zealand conservation. We must abandon specious management which embalms static taxonomic entities. Instead, we must recognise that we have to manage dynamic, variable populations that are ever changing. As such, species management on islands is an anachronism.

THREE KINGS ISLANDS: A NECESSARY MARINE RESERVE, BUT SO FAR KEPT IN THE "TOO HARD" FILE

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About 45 km northwest of North Cape, the Three Kings Islands are buffeted by rough seas and strong currents, producing upwellings which result in water temperatures about two or three degrees below that on the Northland east coast. Underwater they are different biologically from anywhere else in New Zealand, with a number of endemic organisms, some of which are very common there. Significant absences of some fishes and other organisms are also important. There is a strange mixture of northern and southern types of marine life, and probably the largest gorgonian fans in diving depths in New Zealand. For a recovery of hapuka populations following protection, however, the islands have better potential than anywhere else. The issue of Maori fishing rights is hampering moves to create a marine reserve.

PLASTICS AND ISLANDS

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Plastic litter and debris of all kinds are conspicuous on almost any shoreline one cares to visit today. Unsightly quantities are generally greatest near populated and industrial centres, but such items are being reported with increasing frequency from remote and seldom visited or uninhabited islands. This includes Raoul, Campbell and Auckland Islands. As well as being aesthetically distasteful and an unnecessary pollutant, plastics create a number of environmental problems that have received reasonably wide attention, e.g. death and/or debilitation of wildlife through entanglement; blockages to intestinal tract through ingestion leading to starvation and death, or ulceration of delicate tissues by jagged fragments; reduction in quality of life and reproductive performance. Larger items may also be a hazard to shipping. An encrusting biota, similar to that found on floating *Sargassurn* and other seaweeds, has been recognised on drift plastics. It is suggested that here lies a possible vector for transporting unwanted organisms into island ecosystems.

The sources of plastic pollution are many and varied. Some is truly 'oceanic' and has drifted from afar. Local sources in shipping, fishing and recreational boating activities are also identifiable. However, data acquired during a recent clean-up programme on beaches of inner Hauraki Gulf islands suggest on-land sources are also of considerable significance. There is need to educate the public of the environmental problems that come from the indiscriminate disposal of plastics as well as other persistent synthetic compounds. It is unlikely these problems can ever be solved by regulation, although with technological advances, the problems could be alleviated.

THE USE OF DATABASES AS A CONSERVATION MANAGEMENT TOOL FOR ISLANDS

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The Department of Conservation currently administers the following databases with information likely to be of use to those involved with island restoration: Wetlands Inventory; Land Use Register; Amphibian and Reptile Distribution Scheme; Geo-preservation Inventory; Archaeological Sites Register; Sites of Special Wildlife Importance Register; Kiwi Call Scheme; Islands Bibliographic/Status Register.

Despite the wealth of information, much of it has not been historically used as a management tool. It is the aim of this paper to publicise the use of these databases and present examples of how this information can be used to the benefit of island management.

THE KERMADEC ISLANDS: THE CASE FOR EARLY PROTECTION, BEFORE RESTORATION IS EVEN AN ISSUE

P. Irving
DEPARTMENT OF CONSERVATION, AUCKLAND

There are principal foci for this presentation. The first focus is the Kermadec Island group and its marine environment. Briefly consider the relatively unmodified state of the marine environment, the pressures for change, the push for protection, the priorities for research and the values inherent in the area. These islands are not so much a case study for restoration as a case showing that the environment must never reach such a state as to make restoration impossible.

The second focus is the difference between land- and marine-based protection. We are moving into an era of being able to give marine areas similar levels of protection to land, such as islands. However, the process of creating and managing these marine areas is fundamentally different from any land areas due to the different nature of the property rights involved. The paper considers acquisition versus management and ability of the Crown to change the emphases of activities from ones which are extractive and/or damaging to the environment to those aimed at protection and conservation of resources.

TRANSLOCATIONS OF LITTLE SPOTTED KIWIS (*Apteryx owenii*): A SPECIES DEPENDENT ON OFFSHORE ISLANDS

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The little spotted kiwi (*Apteryx ownii*) is probably extinct on both main islands of New Zealand. Its only known population is that on Kapiti Island (1970 ha). Translocation of the species to other offshore islands is seen as essential to the species' survival. In this paper we will discuss the assessment of islands for translocations and the early results of two transfers. Only seven islands were identified as suitable. None was greater than 500 ha in size. Little spotted kiwis were transferred to three islands, Long, Red Mercury, and Hen Is. All, or nearly all, transferred birds established on Long and Red Mercury Islands. The kiwis have bred on these two islands. The requirements for a minimum viable population of little spotted kiwis in relation to the size of these islands and problems with the suitability of larger islands will be discussed. We suggest that planning for the ecological restoration of islands should allow for the needs of species like the kiwis.

ERADICATION OF STEWART ISLAND WEKAS (*Gallirallus australis scotti*) FROM CODFISH AND KUNDY ISLANDS

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R.J. Nilsson
DEPARTMENT OF CONSERVATION, INVERCARGILL

Stewart Island wekas (*Gallirallus australis scotti*), a regionally threatened species, have been liberated on many of the outlying islands in the Stewart Island group. Until the liberations, many of these islands had been free of terrestrial predators and supported major populations of ground-breeding seabirds. In late 1979, the New Zealand Wildlife Service was prompted by the severe decline in numbers of Cook's petrel *Pterodroma c. cooki* to eradicate wekas from Codfish Island (1360 ha), the largest of more than 70 outliers in the Stewart Island group. Elimination of the wekas continued largely unabated until 1985, when the last of more than 3500 wekas was judged to have been caught. Cook's petrel numbers have recovered rapidly since their removal.

Wekas were eradicated from nearby Kundy Island (18 ha) during visits to conserve South Island saddlebacks (*Philesturnus carun culatus*). Eradication techniques (live-trapping, shooting, kill-trapping, poisoning) were developed successively as the percentage of cautious wekas grew in each diminishing population. Weka releases continue to occur on southern offshore islands. All the liberations have been ecologically inappropriate for the islands on which wekas remain, but a conservation strategy for the species itself seems to demand their maintenance on some of these islands.

SADDLEBACK TRANSFERS, PAST, PRESENT AND FUTURE, AND THE POTENTIAL FOR FURTHER TRANSFERS TO SUITABLE ISLANDS

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In early 1964 the New Zealand Wildlife Service pioneered its technique of successful island bird transfer with the North Island Saddleback, when birds were moved from Hen Island to nearby Whatupuke in the Chicken Group. This was the first time that mistnets and acoustic lures have been used to capture the bird. The experience gained with that transfer proved vital later that same year when South Island saddlebacks were rescued from almost certain extinction when a plague of ship rats swept its last refuge on Big South Cape Island. The rat irruption on Big South Cape illustrated just how vulnerable the saddleback was, confined to only one or two islands. This prompted a series of transfers, which are still continuing, to spread this species around on as many "safe" islands as possible. As a result of these transfers a number of new highly-productive populations have become established.

The North Island subspecies is now well-established on eight islands, where the total population probably numbers about 3000. The South Island subspecies, however, is in a more precarious position with small populations on five islands totalling only about 250 birds.

Records of previous distribution suggest that the saddleback was one of our more widely-distributed forest birds. There are probably very few islands where it did not occur naturally in the past. Thus there are strong grounds for restoring the species to as many of these that are suitable.

There are still a few islands where saddlebacks could be released immediately with little need for future management. On several others (e.g. Whale, Breaksea) recent rat eradication have effectively created new habitat. On Kapiti Island, where Norway rats occur, an attempt is being made to introduce specially-trained box-using birds as a way of providing a defence against rat predation. This is meeting with some success, and may have application on other Norway rat islands. In future a number of other islands could be made suitable with appropriate control of harmful predators and planting of new forest habitat.

BASELINE INFORMATION FOR ECOLOGICAL RESTORATION: THE ROLE OF VEGETATION MONITORING OF DEER IMPACTS ON SECRETARY ISLAND, FIORDLAND NATIONAL PARK

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Results of vegetation on Secretary Island (80 km^2), on the western edge of Fiordland National Park, over the 22-year period of deer occupation are described. Knowledge of the undamaged state and of the types of changes in composition and structure of various forest strata is essential to the assessment of the degree of modification at any future time. Should deer be eradicated, the information would form the basis for assessing the success of unaided restoration and the case for intervention.

REVEGETATION OF MOTUHORA (WHALE ISLAND) WHAKATANE

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Motuhora was purchased by the Crown in 1984. That same year the Wildlife Service began a revegetation programme with the following objectives: to speed up the natural succession by introducing new species, to create buffer zones to alleviate the risk of fire, and to expand the food resource available for wildlife use.

In total 11,888 container-grown trees and shrubs were planted on Motuhora between 1984 and 1989. Of the 45 species, 29 were introduced from within the Whakatane Ecological Zone, the remainder coming from Motuhora.

Before the introduction of these species, the diversity of tree and shrub species was extremely low compared to nearby Kohi Point on the mainland. Some species that did survive on the island were down to single figures and others had no chance of reproduction.

Species selection, site selection, planting problems, transport of stock, source of seed/cutting material and description of the vegetation in 1984 are all covered in the paper.

"ELEPHANT" WETAS (INSECTA: ORTHOPTERA) - UNUSUAL ISLAND INSECTS AND A CONSERVATION CHALLENGE

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The "elephant" wetas are a spectacular giant species (unnamed) from Middle Island in the Mercury Group. Large size (males 9-10 cm to tip of "tusk"), a heavy body (both sexes 25-28 g) and enlarged head of the male with an unusual "tusk" on the mandible, combine to make this species unique among wetas and to New Zealand. Recent ethological and genetic studies using captive wetas at Victoria University emphasise their uniqueness. (A video sequence of weta behaviour was shown.)

These unusual insects exemplify the sometimes bizarre evolutionary consequences of life on New Zealand islands that are naturally free from mammal predators and competitors (gigantism or the "Island Syndrome") and of sexual selection in this context (greatly elaborate structures in one sex which apparently enhance mating success, but at some cost to the possessor). They appear to be a relict population which has survived on one small (10 ha) and ecologically fragile island. Their discovery and future conservation highlights some management concerns regarding invertebrate populations on small islands, with implications for island restoration.

TIRITIRI MATANGI ISLAND REVEGETATION - THE CONTINUING SUCCESS STORY

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R.M. Walter
DEPARTMENT OF CONSERVATION, TIRITIRI MATANGI ISLAND

The current progress with revegetation will be described, and the growth and survival of the various plant species in use will be discussed. The programme has been running for five years, and much of the island area that was proposed to be planted has now received its initial planting. The emphasis of the first phase of planting was to ensure a rapid cover. However, it has also had immediate benefits for the bird populations, providing as it does an additional food source. The second phase of planting is now under way, in which more shade-requiring species are being interplanted. Additionally, these will raise the habitat diversity and provide further food sources for birds.

CONDITIONS, EFFORT, AND COSTS TO ERADICATE FERAL GOATS FROM REAL AND HABITAT ISLANDS IN NEW ZEALAND

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Feral goats (*Capra hircus*) are now found on eight of the c. 700 islands in the New Zealand archipelago (North, South, Great Barrier, Kaikoura, Rakitu, Forsyth, Arapawa, and Auckland Is.). There are about 150 more or less discrete feral herds on the main islands, and new escapees are constantly adding to this total. They have been eradicated from 12 islands, the largest being Raoul (2938 ha).

This paper describes the necessary conditions, effort, and costs to eradicate goats. Three examples are described: a successful, but inefficient campaign on Raoul L; an efficient, but as yet unsuccessful campaign in the northern part of Great Barrier I. (c. 4000 ha); and a suggested attempt to eradicate goats from a habitat island, Mt Egmont National Park (35 000 ha). Costs are both the direct cost of the campaign and the indirect costs caused by the usual abandonment of a sustained control campaign elsewhere to pay for the eradication. The problem of ranking eradication campaigns against the need to limit goat dispersal on the main islands and sustained control efforts in high priority areas where eradication is impossible is discussed.

MANAGEMENT METHODS FOR ENDEMIC INVERTEBRATES IN ISLANDS OF MODIFIED HABITAT

G. Sherley
DEPARTMENT OF CONSERVATION, WELLINGTON

A case for managing endemic species on the mainland is presented for two reasons. First, contrary to the case for native vertebrates, relatively large numbers of invertebrates can still occur in small areas of remnant native vegetation. Second, rare endemic animals cannot forever be translocated to unmodified or "ecologically restored", predator-free islands because (1) too few islands exist for the number of candidate species, (2) it may be important not to modify the original biological integrity of the island with translocations of new species, (3) translocating species outside their original range may place them (and other native species) under unnatural selective pressures and (4) other reasons.

An alternative to island translocations is to manage species on the mainland since many occur in discrete habitats which display some "island" characteristics. These include isolation, small size and an absence of some introduced mammals. The islands of species' habitat include remnant virgin native forest, totally exotic species, and combinations of these. Using Mahoenui giant wetas and *Placostylus* land snails as case examples, this paper presents two extremes of a species conservation problem: that of protecting one taxon at one locality (an "island" of gorse) and a cline represented in a number of islands (modified native vegetation and weeds). Management methods and scientific research are described, and two different styles of decision making which have been used in each case example.

CONSEQUENCES OF ISLAND RESTORATION OF SEABIRD POPULATIONS

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A commonly held view is that seabirds will rapidly recolonise islands once the causal factors that brought about their decline have been removed. In particular, removal of mammalian predators and browsers is considered beneficial to seabird populations. In this paper I examine the consequences of this form of island restoration by studying islands which formerly supported introduced mammals and reviewing the current status of their breeding seabird populations. I found that petrel species, that became locally extinct on islands occupied by predators, failed to recolonise once these predators were removed. However, seabirds that maintain remnant populations on these islands subsequently increased in abundance. Removing browsing mammals has sometimes created new problems for seabirds. Exotic weeds and dense regeneration of native plants have reduced the area available for nesting, and thorny weeds sometimes snare birds. Once plant succession reaches a mature stage, seabird species will presumably occupy parts of islands that they were formerly excluded from. Overall, removing browsers is beneficial to breeding seabirds as it stops the trampling of their nest sites, and the eventual increase in ground cover helps to reduce predation by natural predators.

THE BREAKSEA ISLAND CAMPAIGN: A MAJOR ADVANCE IN RODENT ERADICATION

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Breaksea Island (170 ha; 354 m a.s.l.) is the only large island on the Fiordland coast without red deer or stoats. Its original forest cover remains intact, and human induced modification results solely from a population of Norway rats (*Rattus norvegicus*), which probably dates from the sealing era. Although invertebrate, lizard and bird faunas are seriously depleted, most of these changes are reversible. A series of surveys on various islands in the region, and a successful trial at eradicating Norway rats on nearby Hawea Island (9 ha), culminated in a joint Department of Conservation/Ecology Division campaign to eradicate rats from Breaksea Island. Following track cutting and other preparations, "Talon 50 WB" (Bradifacoum) poison was laid all over the island (in pre-positioned bait stations) in May 1988 and checked and replaced daily for 22 days, and every few months thereafter. No sign of surviving rats has been found during five visits since July 1988, and the island is now considered free of rats. The strategy, techniques and results of the campaign are outlined. Since the earlier (1986) extermination of rats from Hawea Island, observations have been made on the response of that island's fauna, and successful reintroductions of South Island robins and Fiordland skinks carried out. Long-term management is planned to guard against any future colonisation of Breaksea and Hawea Islands by introduced plants and animals, and the restoration of Breaksea Island's wildlife by carefully planned reintroductions can now proceed.

ESTABLISHMENT OF NEW PETREL COLONIES USING TAPED CALLS

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A call attraction method has been used successfully on islands in the North Atlantic to form new colonies of Leach's Storm Petrel (*Oceanodroma leucorhoa*). The method involves digging new burrows and playing recordings of the calls of target species at potential colony sites. This technique has the potential advantages of being cheaper, less labour intensive and requires less handling of birds than alternative methods. It could be used for actively boosting depleted petrel colonies and for re-establishing or creating new colonies. In New Zealand, the only method used to actively boost petrel colonies has been the transfer of Black Petrel (*Procellaria parkinsoni*) fledglings to Little Barrier Island; re-establishing or creating new colonies of petrels has not been attempted. Nearly 40% of the world's burrowing petrel species breed in the New Zealand region, thus we should take a lead role in developing techniques to restore colonies. This may be essential to ensure the survival of endangered petrel species, especially those confined to a single island, e.g. Chatham Island Taiko (*Pterodroma magentae*) and Chatham Island Petrel (*Pterodroma axillaris*). I propose that the call attraction method be fully investigated on a range of petrel species and in this paper suggest several possible projects.

RESPONSE OF ISLAND LIZARD POPULATIONS IN NEW ZEALAND TO REMOVAL OF AN INTRODUCED PREDATOR: PACIFIC RAT (*Rattus exulans*)

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Three species of rat have been introduced to New Zealand. The Pacific rat or kiore (*Rattus exulans*) has been present for much longer than the other two and is still widespread in the north-eastern offshore islands. Kiore have long been assumed to have detrimental effects on island lizard faunas, but the reasons for these impacts remain unclear. In this paper I describe the response of lizard populations to release from predation by kiore. Comparisons are made between islands with and without kiore and one from which kiore have been eradicated. It is concluded that in coastal areas, habitat structure influences vulnerability of lizards to the effects of kiore, so removal of rats can elicit a rapid response from the lizards. In forested areas, however, some lizard species cannot coexist with kiore, resulting in a depauperate fauna. There may be little change in lizard population in these habitats following removal of rats.

IS ECOLOGICAL RESTORATION OF THE MARINE ENVIRONMENT OF NEW ZEALAND'S ISLANDS NECESSARY, AND IS IT ACHIEVABLE?

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One of the Department of Conservation's roles is to protect areas of the marine environment. To undertake this conservation role the Department has an objective of establishing a network of marine protected areas around New Zealand. Many of the locations which will make up the network are islands.

The marine environment of islands, as with many areas on the mainland, are vulnerable to or have suffered from the impacts of human activities. Of particular concern to island environments is the current and potential impacts of overfishing by amateur and commercial fishing.

Kapiti Island, off the Wellington west coast, and Mayor Island in the Bay of Plenty are being proposed by the Department of Conservation as possible marine protected areas. Anecdotal information and fishing competition records indicate that both locations have suffered from overfishing.

Setting both locations aside as marine protected areas is an effective method of restoring marine environments which have been overfished. This has been demonstrated at New Zealand's first marine reserve at Leigh, Northland.

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