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PRESIDENTIAL ADDRESS: OPPORTUNITIES FOR ECOLOGICAL RESTORATION

Summary: Ecological restoration is defined as active intervention and management to restore biotic communities that were formerly present at a particular place and time. Examples are given from both New Zealand and overseas of a variety of different restoration projects. The possibility is raised of replacing some animal species extinct in New Zealand with related living forms from other countries.

The arguments for devoting resources to ecological restoration include creation of educational assets, aesthetic benefits, and scientific opportunities. They also include the maintenance of native plants and animals for environmental repair and enhancement work, and genetic conservation at the species and infraspecific levels. Thus ecological restoration is a means of restoring biological diversity to depleted landscapes and, as a consequence, can increase the variety of ways in which people appreciate nature. Ecological restoration of lost biotic communities should be seen as complementary to the protection of those remaining: both activities are needed in a comprehensive approach to nature conservation.

Keywords: biological diversity, biotic communities, education, extinct birds, genetic conservation, islands, management, nature conservation, revegetation.

The meaning of ecological restoration

We are being forced to think more and more frequently about what is going wrong with our environment, whether it be species in imminent danger of extinction, collapse of a coastal fishery, proposals to mine in a Forest Park, the hole in the ozone layer, or the rise in sea-level consequent upon warming of the earth's atmosphere. Recently we learned that the Marsden Point oil refinery has been releasing 68 metric tonnes of sulphur a day into the comparatively unpolluted atmosphere of Whangarei, thus confirming if confirmation was needed, that we in New Zealand are following closely on the heels of most other developed countries in creating our own tragedies of the commons in the manner described by Hardin (1968).

The environmental problems we are facing are of horrendous magnitude. We are in a battle to protect what is left of the biological diversity of the planet in general and of New Zealand in particular. But the heat of the battle may blind us to some good things that are happening, or which can be made to happen, in the field of nature conservation. For example, with the withdrawal of subsidies allowing pine planting or clearing and topdressing of hill country not suited to such use, a major change is occurring. Scrub and forest are regenerating and a more varied hill country landscape is developing in some areas.

This example illustrates what can happen to a landscape when inappropriate land use ceases. In this address, however, I want to talk about *ecological restoration,* a land use in which people are involved more actively than merely ceasing to use the land in some particular way. What I am talking about is active intervention and management to restore or. partially restore biotic communities, both their plants and animals, as fully functioning systems. Thought of in this way a restoration programme has three essential ingredients:

(1) There must be a *restoration goal,* defined in terms of community composition, which is identified as the endpoint of the restoration programme. This conceptual objective is based on historical information and/or interpretation of the kind of biotic community that was present at a particular place and time in the past. The time could be an earlier period this century, some time last century, a period during pre-European settlement, or even a period from pre-Polynesian New Zealand.

(2) There must be *active intervention* to restore plants and/or animals formerly present, rather than simply protection for organisms already present. Only in this way can the ecological, and sometimes evolutionary, processes operating within the earlier biotic community be reactivated. Such intervention may involve a level of management no different in 'degree from that accorded a pine forest or agricultural crop.

(3) There must be *monitoring* of progress and further intervention when necessary, as a normal part of managing a restored area. Thus ecological restoration will usually differ from the revegetation of road cuttings, mining tailings, etc, because, in attempting to replicate a particular kind of biotic community, it will

be more restricted in the species of plants and animals that can be used. The efforts to plant Somes Island, Wellington Harbour, with a variety of native plants from people's gardens and other sources, do not qualify this project as one of ecological restoration. Eradicating an alien animal from an island, while it may be an essential prerequisite for restoring the biotic communities of that island, is not necessarily a sufficient action for such restoration to occur.

Most restoration projects will be labour intensive, at least during some stages of their development, so that care must be taken to select suitable sites. It is possible to restore biotic communities that have been partly damaged, perhaps by re-establishing only a very few species. It is also possible to begin a restoration project in a landscape where a majority of the indigenous plants and animals have been lost. Many of the examples quoted below are in this second category. Each has been chosen to illustrate a different aspect of restoration and they include projects scarcely begun as well as others at an advanced stage.

Some overseas examples of ecological restoration

1. Guanacaste National Park, northwestern Costa Rica

Dry tropical forest is even more threatened than rainforest in the lowland equatorial zone. Most has been felled for timber and cleared for agriculture. However, unlike rainforest species, dry forest species are moderately resistant to habitat disturbance and reinvade previously occupied land much more rapidly. This fact has enabled Professor Daniel Janzen to successfully launch the largest ecological restoration project in the world. It involves the restoration of 700 km^2 of diverse Costa Rican dry forest as a multi-functional Guanacaste National Park integrated into the cultural life of Costa Rican society. The specific restoration goal is to create a dry forest area large enough to maintain all the plant-animal interactions and habitats present when the Spaniards arrived in Costa Rica. Professor Janzen estimates that this involves the conservation of 30,000 insect species, 3000 plant species, 500 bird species, 200 reptile and amphibian species and 160 species of mammal.

Much of the land to be included in the Park is low-grade farm and timber land (Wilcove and May, 1986) that contains damaged dry forest remnants. Its purchase will require large amounts of money and one circulate a 'Christmas shopping list' cataloguing the habitats and organisms, and how much of each, that can be added to the Park for a contribution of $300 (Table 1). Major restorative actions underway include the stopping of hunting and fires, and the planting of young trees, particularly guanacaste *(Enterolobium cyclocarpum)*. The seedlings of this species are planted in cattle dung as a substitute for the fertilizing effect of extinct herbivores that formerly ate guanacaste fruits.

Apart from its size, the outstanding feature of this project is the extent to which local Costa Rican people are being drawn into the educational, scientific and management activities of the Park's creation, thus generating strong national support (Janzen, 1986).

2. Phillip Island, Norfolk Island group, Pacific Ocean

Rabbits were eradicated from Phillip Island (190 ha) in 1986 as a result of an intensive and dedicated effort by staff of the Australian National Parks and Wildlife Service (Hermes *et al.,* 1986). Rabbits had been on the island for over 150 years (as well as pigs and goats during the first half of last century) during which time at least 12 species of native vascular plants appear to have been lost (Fullager, 1978). An endemic shrub not previously recorded from Phillip Island, *Abutilon julianae* (Malvaceae), and extinct on Norfolk Island itself, was discovered by D. Greenwood after removal of the rabbits and is now present on Phillip Island in reasonable numbers. The monotypic endemic *Streblorrhiza speciosa* was known only from Phillip Island but has not been seen since A. Cunningham's visit of 1830. A grass, *Elymus kingianum,* thought to be possibly extinct, was found by D. Greenwood, W.R. Sykes and the writer on the island in December 1987. The endemic shrub *Hibiscus insularis* survives on the island as a single colony surrounded by a low forest of the introduced African olive *(Olea europaea africana)*.

The Australian National Parks and Wildlife Service has initiated revegetation of Phillip Island by establishing the indigenous halophyte *Carpobrotus glaucescens* on some of the island's numerous bare slopes. African olive is widespread and is at present the main limiting factor in achieving restoration of an indigenous cover. Extensive control of small olive (< 1.5 m high) is continuing and this has been combined with a programme of planting seedlings or spreading seed of Norfolk pine *(Araucaria heterophylla),* the indigenous white oak *(Lagunaria pauersonia)* and whitewood *(Celtis peniculata)*. All these species are capable of overtopping the olive.

Table 1: *Catalogue of species and habitats that can be gifted to Guanacaste National Park, Costa Rica for $300 (ex. D.H. Janzen)*

The Christmas shopping menu $300 buys you all of: (forever)	
0.000016 of the join between 330 km^2 dry forest and 210 km^2 rain forest	0.000029 volcano
0.1 adult guanacaste tree	0.001 jaguar
0.01 muscovy duck	0.0071 bird species
200 sphinx moth caterpillars (offer good in July only)	0.04 anteaters
0.1 agouti	0.0029 herp. species
0.05 curassow	25 spiny pocket mice
1,000,000 ants	0.429 insect species
0.03 spider monkeys	0.01 white-lipped peccary
20 toads	400 dung beetles
0.25 tinamou	10,000 mushrooms (early rainy season bargain)
0.4 adult guapinol tree	125,000 acorns
0.5 parrots	0.023 mammal species
5 m riverbank	100 vines
0.005 tapir	5,000 bruchid beetles (rainy season purchase not guaranteed)
1 rattlesnake	100 scorpions
200 ,orchids	0.000028571 peripatus species
3 million unlisted organisms	

Your tax-deductable Christmas purchase order of any amount should be mailed to **Nature Conservancy - Guanacaste Fund, 1785 Massachusetts Ave., NW, Washington, DC 20036.** All purchases will be held for your on-site inspection by the Costa Rican National Park Service. Detailed information available from D.H. Janzen, Department of Biology, University of Pennsylvania, Philadelphia, PA 19104 (215-898-5636).

Eradication of rabbits from Phillip Island has created a unique opportunity to restore a significant part of the original ecosystem that once occurred in the lower and drier parts of the Norfolk Island region below 200 m altitude. The island is now free of all introduced mammals including cats, rats and mice. Re-establishment of many of the woody species originally common on the island should be possible. In addition to Norfolk pine and white oak, flax *(Phormium tenax), Coprosma baueri* (which is already spreading naturally), popwood *(Myoporum obscurum), Hibiscus insularis,* ironwood *(Nestegis apetala),* bastard ironwood *(Planchonella costata), Pittosporum bracteolatum,* hopwood *(Dodonaea viscosa)* and maple *(Elaeodendron curtipendulum)* could all be planted on suitable sites both to help contain the further spread of African olive and as a step towards forest restoration. A few of these species have never been recorded from the island but no comprehensive list of the island's plants was made before modification by introduced mammals was well advanced. In any case the distance between Phillip and Norfolk Islands is so small (c. 6 km) that it can be assumed that most native plant species of Norfolk also grew on Phillip Island if suitable habitats were present. Whether suitable habitats are still available can be put to the test by planting species such 'as those suggested.

In view of the extensively depleted condition of Phillip Island, the restoration goal should focus on restoring the original ecological and evolutionary processes in the Norfolk Island region so far as they are understood. It is not possible to replicate the. composition of the biotic community formerly present before human influence began because we have no quantitative picture of what that was. Some of the original species have been lost, and habitats have changed as a consequence of vegetation depletion and soil erosion. Nevertheless, the opportunity remains for creating and maintaining a biotic community that is distinctively Norfolk Island in character, and which would resemble the community originally present on the island to a far greater extent than the present depleted system.

As native forest re-establishes, other more shade-demanding species can be introduced but intervention

and management may also be necessary for places where vegetation other than forest is more appropriate for the local site conditions. It can be expected that many of the island's formerly large seabird populations (King, 1786-1790) will slowly recover of their own accord. A few species such as the Providence petrel *(Pterodroma solandri),* thought to have been extinct in Norfolk since 1800 but recently re-discovered on Phillip Island, may require special measures to boost their numbers to a safe level. Considering landbirds, some native forest birds can be translocated from Norfolk Island when suitable habitats become available.

A partial replacement of certain extinct birds is possible by translocating the living con specific or congeneric relatives judged to be genetically closest to the extinct species. This precedent has already been set by the introduction of male moreporks *(Ninox novaeseelandiae)* from New Zealand to Norfolk Island in an effort to prevent total extinction of the Norfolk Island boobook owl *(N. undulata).* Thus at some time in the future both the pigeon *(Remiphaga novaeseelandiae novaeseelandiae)* and the kaka parrot *(Nestor meridionalis)* could be introduced from New Zealand to Phillip Island to replace the extinct Norfolk Island pigeon *(H.n. spadicea)* and Norfolk Island kaka *(N. productus)* both of which were formerly on the island (King, 1786-1790). Replacement of the extinct triller *(Lalage leucopyga),* Norfolk Island starling *(Aplonis fusca)* and probably extinct grey-headed blackbird *(Turdus poliocephalus poliocephalus)* will require study of the habitat requirements of the genetically nearest living relatives in Australia and other parts of the south-west Pacific to establish whether such replacements are feasible.

Continuing precautions are needed to prevent rats from establishing on Phillip Island if the survival there of many species of small animal (and possibly some plants), including the gecko *Phyllodactylus guentheri* and the skink *Leiolopisma lichenigerum* is to be ensured (cf. Cogger *et al.,* 1983). Equally, the restoration potential of the island, particularly for some of the bird species mentioned, is dependent on the island remaining rat-free.

It would be naive to suggest that ecological restoration of Phillip Island on the scale envisaged here will not meet difficult problems, particularly those associated with self-introduced alien plants and birds. However, rabbits were removed from the island while some people were saying it was impossible and others thought it not worthwhile. If the challenge is accepted, the problems of restoring Phillip Island may prove no greater than eradicating the rabbits.

3. Round Island, Mauritius, Indian Ocean

Round Island (151 ha), lying 22 km NNE of Mauritius, became the site of another spectacular eradication campaign in 1986 when Don Merton and two assistants from the NZ Wildlife Service with financial support from the Jersey Wildlife Preservation Trust succeeded in eradicating rabbits on the island. This followed the removal of goats between 1976 and 1982 which, like the rabbits, had been present since the first half of last century.

The immediate effect of these two eradications has been to halt the further deterioration of the island's palm savanna, a lowland community now lost on Mauritius itself, and safeguard the habitat of several endangered plant and animal species. These include three endemic palms, one of which had been reduced to 8 adults and another to a single tree by 1986. The island also supports 8 species of reptile including two geckos, a skink and a snake, all extinct elsewhere in Mauritius (North and Bullock, 1986).

There are no other islands present in the Mauritius group that are both free of introduced mammals and as large as Round Island. Thus, as with Phillip Island in the Norfolk group, there is now a unique opportunity to restore part of the lowland ecosystem of Mauritius including both the palm savanna mentioned, and a small area of hardwood forest if individual species of this forest can be re-established. As with other restoration programmes, regular monitoring of the island's plants and animals and occasional intervention will be necessary to achieve this goal.

4. Nonsuch Island, Bermuda, Atlantic Ocean

Bermuda is the world's most densely populated oceanic island; very little indigenous habitat of any kind is left. However, at the mouth of Castle Harbour there are 9 small islands which have been declared a National park although having a total area of only 10 ha. The largest of these is Nonsuch Island (6 ha) and this island has become a classic example of ecological restoration as a result of an inspired effort by David Wingate. This followed the unexpected re-discovery in 1959 of the cahow *(Pterodroma cahow),* an endemic gadfly petrel long thought to have been extinct (Murphy and Mowbray, 1951).

The restoration programme began in 1962, by which time the island was little more than a desert. Wingate's objective was to re-create a microcosm of the ecosystem formerly present on Bermuda itself. To

achieve this end he took the following steps (Wingate 1985):

(i) Reviewed all previous literature on the natural history of Bermuda.

(ii) Made a rust-hand study of the tiny remnants of indigenous community still remaining on the main island.

(iii) Eradicated 5 spp of aggressive alien plants.

(iv) Eradicated goats, dogs, cats and 2 species of rat *(Rattus rattus, R. norvegicus)*.

(v) Spot-planted missing elements of the flora using sources from the main island.

(vi) Mass-planted nursery-propagated native trees and shrubs, including the Bermuda cedar *(Juniperus bermudiana),* to replace the lost cover of the major communities.

(vii) Created saltmarsh/mangrove and freshwater swamp habitats.

(viii) Re-introduced the endangered white-eyed vireo *(Vireo griseus bermudianus)* the yellow-crowned night heron *(Nycticorax violacea),* known only from fossil bones, the green turtle *(Chelonia mydas)* which takes 25 years to reach reproductive maturity, and a top shell *(Cittarium pica)*. The latter species provided shells for an endangered species of giant terrestrial hermit-crab *(Coenobita diogenes)*.

(ix) Launched a recovery programme for the cahow, involving management of the species on four islands including Nonsuch. This involved designing and installing baffles to exclude the common white-tailed tropic bird *(Phaethon lepturus)* from cahow nesting sites, and building artificial burrows for cahows on flat sites unsuitable for tropic birds (Wingate, 1978). The result has been a doubling of the population, from 18 to 35 pairs, in 21 years.

(x) Monitoring and culling of alien species has been continued throughout the programme.

Thus, as a result of one man's conviction and perseverance, the world has been given an exemplary model of what, in an island situation, can be achieved in reversing degradation of our natural environment.

Examples of ecological restoration in New Zealand: Islands

1. Cuvier Island, Hauraki Gulf

Cuvier Island is probably the earliest example of ecological restoration in New Zealand if, as suggested earlier, establishment of species formerly present is accepted as a necessary part of ecological.restoration. This 181 ha island carried goats from the 1880s until their eradication in 1961. Eradication of pigs from Aorangi Island, Poor Knights group in 1936 and eradication of goats from Great Island, Three Kings group in 1946, both pre-date the removal of goats from Cuvier Island but in neither case was there further restorative intervention. Such action is not necessary on Aorangi where no plant or animal species appears to be endangered. However on Great Island there is, in my opinion, a strong argument for careful intervention to increase the numbers in the wild of several of the Three Kings endemic plants.

Cuvier Island, in common with the majority of the northern offshore islands, was heavily modified by fires and cultivation during Maori occupation, at which time kiore *(Rattus exulans)* established. Further modification followed when the lighthouse was established in 1889, the probable time of arrival of goats. Cattle, sheep and cats spread, the island's saddlebacks *(Philesturnus carunculatus rufusater)* and red-crowned parakeets *(Cyanoramphus n. novaezelandiae)* became extinct, and by 1957 when the island became a reserve, its vegetation and animal life were very depleted (Merton, 1972).

At the initiative of B.D. Bell, the goats were eradicated between 1959 and 1961, domestic stock in the lighthouse reserve were fenced out of the main reserve in 1963, the last wild cat was removed in 1964 and on 25 January 1968, 29 North Island saddlebacks *(Philesturnus carunculatus rufusater)* were translocated and released from Hen Island (Merton, 1975). The Cuvier Island saddlebacks are now one of the major remaining populations of this subspecies. There have been subsequent releases on the island of red-crowned parakeets, I formerly present on the island, and stitch birds, not known with certainty to have been present. Monitoring of the the island's birds and vegetation has continued since 1960.

Although the restoration goal for Cuvier Island has never been precisely defined, the state of the vegetation and the presence of kiore dictate that the island is now returning to a condition approximating that of the middle of last century before goats and cats were introduced. A difficulty inherent in restoration work is that the further back in time that we identify a biotic community as a restoration goal, the less we know about what we are aiming for. Stitchbirds were released on Cuvier Island as part of a national effort to establish additional populations of

[1] It has been suggested by Triggs and Daugherty (1987) that some of these birds, which were derived from captive stock, may have been of hybrid origin.

this endangered species. We have no knowledge that they were ever on Cuvier in pre-Polynesian time although apparently they can live in coastal forest. Stitch bird numbers on the island are now low and there is doubt as to whether the island in its present condition can support a permanent population.

2. Tiritiri Island, Hauraki Gulf

In contrast to Cuvier Island, large-scale planting to restore a forest cover to Tiritiri Island (222 ha) has been a central aim of the project. Mitchell (1985) records that the island was long occupied by the Maori (during which time kiore established) but this appears to have ended by the 18305. European farming began last century and by 1975 the forest cover, all of it secondary, was reduced to about 9% of the island's area (Esler, 1978). In seeking to restore a forest 'with a similar species composition to the existing remnants' (Mitchell, 1985), the restoration goal can be identified as that of restoring the island to a state closer to that of the 1835-55 period, although with a greater proportion of forest than is likely to have been present then.

A key feature of this project is the massive input of voluntary labour used for planting young trees raised in a well equipped nursery on the island. Both saddlebacks and parakeets have been released, and there are plans to establish several other rare or endangered species there in the future. The potential for further such releases is directly dependent on whether the island can be maintained free of *Rattus rattus* and *R. norvegicus,* an important objective given that the island is open to the public.

3. Mana Island, Wellington

The original forest of Mana Island (217 ha) was completely lost during Maori occupation and the subsequent period of European farming but neither kiore nor other rat species established on the island. Mice, however, are present. The aim of restoration here is to replicate coastline and lowland communities that are or have been present in the Sounds-Wellington Ecological Region this century. However, as discussed below, this regional aim has to be executed in a manner compatible with the national importance of the island for some endangered species (Timmins *et a1.,* 1987).

Two aspects of the project deserve emphasis. First, the island is very exposed and some of its soils are prone to severe droughts. Unless plant species suitable for the various kinds of site present are used, there is Mangere Island below). The solution to this difficulty is to conduct properly laid out trials with controls to ascertain which species are suitable before embarking on the major planting programme (Timmins *et a1.,* 1988).

Second, the rat-free state of Mana Island makes the island of national importance. There are only 4 other offshore islands within 50 km of the coast that are known to be rat-free and which exceed 100 ha (Atkinson, *in press).* With the increasing role that islands will have to play in conserving New Zealand's coastal and lowland fauna it is apparent that Mana will be needed as a refuge for some nationally endangered animals. As pointed out by Timmins *et a1.* (1987), this generates potential conflicts between the aim of restoring the island and the necessity to protect what remains of the New Zealand fauna. The conclusion that must be drawn is that no restoration project in a particular place or region can be looked at in isolation from a national view of all the measures that are needed to conserve New Zealand's biotic communites.

4. Mangere Island, Chatham group

Mangere Island (113 ha) exemplifies a restoration project that has faltered. During the period when the island was farmed, its forest cover became reduced to a tiny remnant at the foot of the cliffs at the eastern end of the island. The island became a reserve in 1967 and sheep were removed in 1968. In the early 1970s it was expected that the island might be the only place where the black robin, endemic to the Chatham Islands, could be saved from extinction. A major forest restoration project was launched in 1974 using flax and *Olearia traversii* and continued till 1979. As one who helped formulate the planting plan for Mangere (Atkinson *et a1.,* 1973) I have to report temporary failure of the project. The flax shelter has established reasonably well and some *O. traversii* immediately behind this flax is growing slowly, though repeatedly topped and pruned by salt storms. But the main area of' planting within the flax shelter-belts is still in grass. There are probably 3 reasons for failure thus far.

(i) We under-estimated the extreme effects of wind and wind-carried salt in the Chatham Islands and, as a result, planted on sites that were too exposed, failing to make full use of more sheltered sites.

(ii) Notwithstanding the tolerance *O. traversii* to wind-carried salt, it may not have been the best plant to use in establishing an initial cover .The Chatham ngaio *(Myoporum laetum)* may be more suitable to

use in future because it has a greater capacity to resprout after salt damage.
(iii) There was insufficient monitoring of the plantings and insufficient follow-up work to ensure survival of plants. Thus many were loosened in the ground during high winds and then succumbed to drought with resulting heavy overall mortality. This lack of attention can probably be attributed to the fact that the major site for black robin *(Petroica traversi)* recovery was shifted in 1983 to South East Island and the NZ Wildlife Service did not have sufficient staff to manage both projects effectively.
The need to reforest at least part of Mangere Island is as pressing as ever. In the event of a major catastrophe on South East Island, Mangere would at present be the only practical lifeline for several endangered species in the Chatham group.
Even if in the future, Pitt Island plays a more significant conservation role than at present, to have birds such as the Chatham Island snipe *(Coenocorypha aucklandica pusilla),* black robin, and Chatham Island warbler *(Gerygone albofrontata)* on 3 islands will always be safer than their restriction to one or two islands.

Examples of ecological restoration in New Zealand:Mainland

When one considers the state of the indigenous vegetation in many mountain lands, there is so much needing to be done in terms of effective control of introduced browsing mammals, and in some areas effective fire control as well, that it scarcely seems appropriate to talk about restoration. Opportunities are nevertheless there, as demonstrated in the first example below.

In the plains and foothills of the lowlands there are extensive areas of the country that have been almost completely denuded of any kind of indigenous vegetation, with a consequent loss of their distinctively New Zealand character. The Waikato district, parts of western Taranaki, Manawatu, and Hawkes Bay -northern Wairarapa regions spring to mind in the North Island; Marlborough, Canterbury, eastern Otago and Southland similarly have little of their indigenous biota remaining to indicate affinities with New Zealand. Areas of low rainfall such as Canterbury and eastern Otago may provide the biggest challenges for restoration activities.

1. Porter's Pass, Canterbury

This pilot project, to revegetate the roadside slopes above State Highway 73 on the eastern side of Porter's Pass, was inititated in 1974 by G.L. Holgate, then of the Department of Lands and Survey. The project included sowings and plantings of both exotic and native species and the aim was to retain the present open grassland character of Porter's Pass. Although, in terms of this address, the project has so far been one of revegetation rather than restoration, it would be possible to shift the emphasis towards the latter objective. The use of snow tussock *(Chionochloa sp. 'C. flavescens'* of South Island authors) on the site demonstrates that subdivision of mature plants and transplantation of the fragments for planting out on scree slopes is feasible (Holgate, 1976) and it suggests that more comprehensive restorations of tussock communities are possible.

2. Matawai Park, Rangiora, Canterbury

Re-establishing native forest in a landscape as devoid of indigenous organisms as the Canterbury Plains may at first seem hopeless but such areas are the places where the aesthetic and educational impact of restored biotic communites are greatest. At Matawai Park a project to restore a stand of beech-podocarp forest of the kind which covered the southern part of the Rangiora district last century was begun in 1971 by the Rangiora Borough Council. The area covers about 5 ha and after moulding of the landform with bulldozer and excavator, including the creation of a pond, planting began in 1972 using kanuka *(Kunzea ericoides)* and *Pittosporum* spp. as nurse plants. This was followed in 1974 with plantings of taller trees, including kahikatea *(Dacrycarpus dacrydioides),* totara *(Podocarpus totara),* matai *(Prumnopitys taxifolia),* mountain beech *(Nothofagus solandri* var. *cliffortioides),* red beech *(N.fusca)* and silver beech *(N. menziesii).* In 1987 the hardwood nurse canopy had reached a height of 4 to 5 m and the podocarps 2-3 m (Franklin and Thompson, 1983; D.A. Franklin, pers comm.).

3. Cockayne Reserve, Christchurch

Coastal sand dunes, estuaries and wetlands have been greatly changed, if not actually destroyed, by human activity in many parts of the country. Near Christchurch, a 4 ha area on the banks of the Avon River, that was nearly destroyed in the early 1970s by river and road works, has become the site for restoring a swamp. The three most conspicuous species, *Carex secta,* raupo *(Typha orientalis)* and flax *(Phorium tenax)* had been largely replaced by tall fescue *(Festuca arundinacea).* As a result of local concern, the Christchurch City Council initiated a

restoration programme, the first stage of which involved sinking a bore and gaining control of the water table level. In the following two years raupo has regrown to its full height and is now spreading, flax is reinvading, and *C. secta* is resprouting from a few survivors. This regrowth is outcompeting the tall fescue, *Iris pseudoacorus* and other adventive species. Willows have been removed. At a later stage it is planned to replant certain species including *Blechnum minus* and *Carmichaelia kirkii* which were previously present (Dr T.R. Partridge, pers. comm).

4. Hinewai Reserve, Bonks Peninsula

An ambitious ecological restoration project has been launched on the mainland above Otanerito Bay, Akaroa, Banks Peninsula, where a 106 ha block of land has been purchased by the Maurice White Conservation Trust. The land, comprising steep hills extending from 240 to 600 m altitude, has been farmed but patches of tall red beech forest, kanuka forest and secondary hardwoods have survived. The restoration goal is to restore the 'original' vegetation cover (Wilson, 1987) as it might have been during the Polynesian period; the loss of moas and certain other native vertebrates makes restoration of a pre-Polynesian condition unattainable.

Apart from removal of goats within the block, a key element of the programme is the use of gorse and broom, as well as kanuka *(Kunzea ericoides),* as a replaceable nurse cover for taller growing native trees. Although this succession has been demonstrated repeatedly in many parts of the country, some people are still unwilling to accept that one of the most effective methods of gorse and broom control is to overtop these plants with taller trees.

This project deserves strong support from both the local community and regional interests. The area is close to several existing reserves, it will secure protection for Banks Peninsula's very restricted stands of beech forest, provide habitat for several plant species near the limits of their geographic range, boost the native bird populations of the Peninsula, and provide people with a permanent source of educational, recreational and aesthetic interest, in what is otherwise a highly modified landscape.

5. *Keebles Bush, Monowotu*

Keebles Bush (12 ha), a remnant of the forest present when Europeans arrived in the district, is the finest of such remnants remaining in the Manawatu lowlands (Esler, 1962). It is protected by the C.T. Keeble Memorial Forest Trust Board. In 1980 a streamside area of 1.7 ha became available near this bush. On the initiative of R.M. Greenwood, it was decided to use this area to restore forest of a composition similar to that which would have been present prior to European modification last century.

The range of sites within the area includes seepages, swamps, well-drained fertile alluvium, a terrace margin which is dry in summer but wet in winter and steep slopes of both north-westerly and south aspect with both dry and wet slopes. Further to the basic forest restoration, R.M.G. points out that the area can be used thus:

(i) plant species uncommon in Keebles Bush can be planted to ensure that they are not lost from the local area.

(ii) plant species not present in Keebles Bush but present elsewhere in lowland Manawatu can be planted if suitable sites are present. This is particularly important for some species that may be endangered in the Manawatu district, such as *Nestegis montana*.

Neither of these two actions could be pursued easily within Keebles Bush itself because it is managed under a policy of keeping it as natural as possible with minimum human interference.

R.M.G. began planting the area in 1980 at which time the vegetation was largely grasses and some gorse. Tree lucerne *(Chomaecytisus palmensis)* together with koromiko *(Hebe stricta),* kohuhu *(Pittosporum tenuifolium),* lemonwood *(P. eugenioides),* ngaio *(Myoporum laetum),* lacebark *(Hoheria populnea),* lowland ribbon wood *(Plagianthus regius)* and karamu *(Coprosma robusta)* comprised the major initial cover which has now reached a height of 3 to 5 m. On the wetter sites manuka was the predominant species used. By the end of 1987, R.M.G. had planted over 900 tree lucerne and 3000 native plants, including 85 different species. Only local forms of species growing naturally in the Manawatu are used in order to guard against possible genetic contamination.

Replacing Extinct Animals

The range of options available for restoring the plant component of biotic communities, even as far back as those of pre-Polynesian time, is considerable. Few plant species have been completely lost since European colonization and plant extinctions during the Polynesian period may also have been relatively few. On the other hand the fauna, and particularly the amphibian, reptile and bird fauna, has suffered severely. Reconstitution of the moas using genetic engineering techniques is still in the realm of science fiction, and reconstitution of the giant Haast's Eagle

Table 2: *Examples of birds living in other countries that are related to New Zealand extinct birds*

Extinct species/subspecies of New Zealand bird	Related species/subspecies and country of occurrence	Reference
New Zealand pelican *(Pelecanus novaezealandiae)*	Australian pelican *(P. conspicillatus);* Australia	R.B. Sibson, pers. comm.
Flightless goose *(Cnemiornis calcitrans)*	Cape Barren goose *(Cereopsis novaehollandiae);* Australia	Oliver (1955)
New Zealand swan *(Cygnus sumnerensis)*	black swan *(C. atratus);* Australia	
New Zealand merganser *(Mergus australis)*	Chinese merganser *(M. squamatus);* SE Asia	*Kear and Scarlett* (1970)
New Zealand goshawk *("Circus eylesi")*	grey goshawk *(Accipiter novaehollandiae);* Australia	R.N. Holdaway, pers. comm.
Chatham sea-eagle *(Haliaeetus australis)*	Steller's sea eagle *(H. pelagicus);* northern hemisphere	Olson (1984)
Giant coot *(Fulica chathamensis)*	Australian coot *(F. atra);* Australia	
Hodgen's waterhen *(Gallinula hodgenorum)*	dusky moorhen *(G. tenebrosa);* Australia, New Guinea	
Giant owlet-night jar *(Megaegotheles novaezealandiae)*	Australian owlet-night jar *(Aegotheles cristatus);* Australia	
New Zealand raven *(Corvus moriorum)*	forest raven *(C. tasmanicus);* Australia	
New Zealand quail *(Coturnix novaezealandiae)*	stubble quail *(C. novaezealandiae);* Australia	Kinsky 1970

(Harpagornis moorei) would have serious implications for the sheep industry! In general, extinctions of animal species have removed options for restoring biotic communities of the pre-European or pre-Polynesian era. The only exceptions may be on some islands that are unlikely to have been permanently occupied by moas.

There may be a few options remaining for replacement of lost subspecies to islands by related subspecies that have survived elsewhere. For example, bellbirds *(Anthornis melanura)* could be restored to the Chatham Islands, either on South East Island where forest has re-developed or perhaps more certainly, if cats are removed, on Pitt Island. It would be possible to replace the extinct fernbird of the Chatham group by introducing another fernbird subspecies to Mangere, South East or Pitt Island. If the Snares Island snipe *(Coenocorypha aucklandica huegeli)* was established on one of the rat-free islands around Stewart Island, this could replace the extinct Stewart Island snipe *(C.a. iredalei)* and increase security for the Snares subspecies.

Although many full species have been lost from the New Zealand fauna, not all their genetic material has been lost. Species related to our extinct species, some of them closely so, still occur in other countries and examples are given in Table 2. In addition to these examples there is behavioural, external morphological and osteological evidence to suggest that the extinct piopio *(Turnagra capensis)* is related to the bird-of-paradise/bowerbird family (Fleming,. 1982; Sibson, 1982; Olson *et al*., 1983). The similarity of plumage patterns between the tooth-billed bowerbird *(Scenopoeetes dentirostris)* and the piopio is remarkable. Olson (1977) has also suggested a relationship of the extinct *Aptornis otidiformis* with the kagu *(Rhynochetos jubatus)* of New Caledonia.

Without suggesting that all the living species listed are necesarily the most Closely related to the extinct species with which each has been paired, it is apparent that significant amounts of the chromosomal material of New Zealand's extinct birds must still be present in species living elsewhere. It can then be asked whether introducing any of these species to an appropriate habitat in New Zealand would partially replicate a founding population of the past and its subsequent adaptation to environmental conditions peculiar to New Zealand. If so, then options for partial restoration of vanished biotic communities are somewhat greater than realized.

The introduction to New Zealand of the Cape Barren goose and black swan and the self-introduction of the Australian coot demonstrate that suitable habitats are present at least for some of the species mentioned. Such introductions, however, have never been coupled in any way with a planned restoration of a particular kind of habitat. Can carefully planned species translocations reinstate the evolutionary processes formerly acting on related but extinct species? Assuming that the bush wren is extinct, should we introduce rock wrens *(Xenicus gilviventris)* from the subalpine zone to a partly forested island free of introduced predators in an attempt to re-start the evolution of a low-altitude population of *Xenicus?* When the bowerbirds become better known taxonomically, should we attempt to introduce one of the less specialized forms of bowerbird to an island here on an experimental basis to replace the piopio?

The options for replacing extinct species with related forms are restricted by the amount of habitat and behavioural specialization that has occurred since the two forms diverged. Opportunities for such introductions are greatest on islands, particularly large islands, because these may be the only places where factors that caused the original extinctions are absent. Further, it is unlikely that increased body size, and behaviour leading to flightlessness could be selected for again on the New Zealand mainland in the presence of an array of introduced predators.

Whatever the merits of these various suggestions, it would be irresponsible to suggest than any should be attempted without detailed knowledge of the species to be introduced. This information would be required both to assess the impact of the proposed introduction on fauna already present and to examine the effect that the introduction might have in reducing future options for translocating endangered species. Our first priority is clearly to retain the indigenous species we still have.

Some will ask whether the effort required to replace extinct species with related forms is worthwhile, just as some ask the same question in relation to currently endangered species. I will not elaborate on the gains in scientific understanding that would result from such attempts because I believe the greater significance of such action would be the positive effect it would have on people's understanding and enjoyment of nature. Although impossible to quantify, it is apparent that many people gain a diffuse kind of satisfaction from being in natural or semi-natural environments. But they gain a more acute kind of satisfaction from particular observational experiences such as seeing a spectacular view, finding an uncommon plant, or seeing/hearing a rare bird. For this reason there is great value in rare organisms as spot sources of enjoyment; the problem is to prevent rare species from becoming endangered. The establishment of organisms related to those now extinct would increase the availability of such spot sources of enjoyment and facilitate the partial restoration of biotic communities rather-than just 'plant communities'.

Reasons for ecological restoration

I can think of at least five reasons why we should put effort into ecological restoration:

(1) Educational assets. A restoration project, if properly cared for, is a regional and national asset for the intellectual enrichment of people of all ages. The act of restoring an indigenous biotic community would be a continuing source of interest and producer of information about New Zealand plants and animals and their environment. It is the more so if carried out in surroundings where agricultural systems and their introduced plants and animals are commonplace, and to some boring.

Used as an outdoor classroom the restored community would enable people to become more aware of what we have lost and the value of what we still have. Restored biotic communities could complement the educational role of a network of other areas protected for educational purposes in the manner outlined some time ago (Atkinson, 1961). There is so much emphasis in our society on the use of land for economic profit, be it through food, fibre or fuel production, that we pay little attention to the use of land for production of interesting and sometimes useful biological information.

(2) Aesthetic benefits. The restoration of an appropriate biotic community to a landscape that has been stripped of everything indicative of indigenous New Zealand, can bring aesthetic pleasure to many people, whether visitors or local inhabitants. The aesthetic impact of any particular project will tend to increase with the size of the restored area and will be influenced by the way in which it is blended into other parts of the landscape. A whole catchment, may be easier to manage for restoration than parts of several catchments. If the restored community is associated with bodies of water such as streams, rivers, lakes or sea, the aesthetic benefit can be still further heightened.

(3) Scientific opportunities. At present we have insufficient knowledge to restore some kinds of biotic community and even the apparently easier options for

restoration will bring to light many unanswered questions about our plants and animals. A restoration project could be treated as a large-scale experiment within which differing methods of establishing plants and animals are compared, and hypotheses about plant succession and the dynamics of animal populations are tested.

(4) Sources of native plants and animals. Once established, an indigenous biotic community could be carefully managed to produce seeds, seedlings, and cuttings, as well as some animals, for use in repairing neighbouring indigenous habitats or for other purposes such as urban beautification or revegetation of damaged landscapes. Such action may not be permissable in other kinds of protected area.

(5) Genetic conservation at the specific and infraspecific levels. Genetic variability within native plants and animals has been drastically reduced in the lowlands and will become more so unless strategically placed habitats are either protected or created for the permanent survival of native organisms. In this respect, restored biotic communities can complement the role of protected natural areas, as is happening at Keebles Bush, Manawatu.

In summary, ecological restoration is a means by which biological diversity can be restored to the landscape. The result is to increase the variety of experience and diversity of ways through which people can appreciate nature.

Ecological restoration on any scale cannot be achieved by a few enthusiastic ecologists working by themselves. Nor should it if widespread public support for such programmes is to be generated. Ecologists will need to work as members of restoration teams which may include historians, landscape architects, soil scientists, philanthropists, teachers, nature tourist promoters, recreational experts and individuals who value native plants and animals for their own sake. To be viable in the long term, a restoration project should involve the local human community in planning and implementation to an extent that such projects are seen by society as 'useful'. Because of this, most restoration sites should be reasonably accessible.

Some will say that we should not divert resources into restoration projects while so much remains to be done in protecting from destruction or deterioration those natural areas that still remain. Protecting natural areas and restoring lost or damaged biotic communities are twin conservation thrusts that need not compete with each other. Restoration can capture the imagination and motivation of some people who might not give their time, money or knowledge so readily to protecting what we have left. This is not a criticism but a statement of the obvious fact that not all people are alike. And, as demonstrated by Janzen, it may prove easier in involve the local community in imaginative and dynamic schemes of restoration than it is to capture their interest in passive protection. Both initiatives need to be pursued because both must be part of our "comprehensive concern for the healthy operation of the whole range of native plant communities, native animal habitats and landscapes" (Rudge, 1986). A more comprehensive approach to nature conservation is essential if wider public support is to be won.

The problems that will arise during ecological restoration projects are challenging, scientifically worthwhile, and relevant to the interests and needs of people. If some of you feel that I have at times strayed too far into the realm of an idealistic fairyland, then I understand your feeling. All I can say in response is that sometimes it is necessary to test and explore the seemingly improbable in order to extend what is practical and possible.

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