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CONSERVATION ISSUES IN NEW ZEALAND

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■ **Abstract** Conservation in New Zealand is failing to halt an ongoing decline in biodiversity. Classical problems of ecosystem loss and fragmentation have largely been countered in some regions by reservation of 30% of total land area. Unsustainable harvesting of native biodiversity has stopped; indeed harvesting of terrestrial species is rare. In contrast, marine reserves do not cover even 1% of the managed area, and harvest of native species, some of it unsustainable, are a major industry. Introduced pests, especially mammals, are the overwhelming conservation problem. Legislation, management, and considerable public opinion is based on preservationist ideals that demand the sanctity of native land biodiversity. Considerable success in threatened species management, island eradications, and mainland control of pests is increasing opportunities for restoration. New legislation is increasingly built on concepts of sustainability and offers the opportunity for integrating conservation, use, and development. Realization of these opportunities requires greater understanding of the relative merits of preservation versus sustainability, the dynamics and costs of pest control, the need for ecosystem processes in addition to individual species, and the involvement of people, especially the rights of indigenous Maori. Understanding marine environments and linking attitudes to land and sea is also a challenge.

INTRODUCTION

World conservation is at a crossroads of decision making (37, 53, 77), and New Zealand provides an extreme example of the issues and possible solutions (4). On the positive side, greater than 30% of New Zealand's total land area has been reserved (4, 79), there is a single government agency responsible for most conservation activities (45), single-species recovery programs are largely successful (26, 78, 79), and there is widespread public support for biodiversity conservation (4, 36, 79). This, however, contrasts sharply with ongoing biodiversity decline (4): For example, 50% of bird species are threatened, introduced pests are degrading all protected areas, the legal framework is based on preservationist ideals (16),

and government funding allows less than 5% of the protected lands to be managed sustainably (45). In addition Maori and local communities have little influence.

New Zealand is heavily dependent on natural renewable resources for much of its income (79), yet the consideration of sustainability is slow and hampered by a management dichotomy based on extremes of market forces versus preservation. Seventy percent of the land and most of the sea is managed unsustainably, while the remaining 30% of the land is locked up in reserves (81). Major gains in conservation have been made since the 1970s, when the rampant mining of natural capital (79) incited calls for protection and preservation (86). Moving New Zealand to sustainable management of all land and sea is the current challenge (4, 35, 47, 79, 81, 87, 95). Without it, New Zealand's biodiversity on the main islands will resemble that of other devastated islands such as Guam (48).

History and Status of New Zealand Biodiversity

The evolutionary history of New Zealand diverged markedly from the rest of the world's about 65–80 million years ago (31, 79), when it separated from the southern continent of Gondwanaland and became a separate island archipelago. While land area has varied with changes in sea level, New Zealand totals 26 million ha in three main islands plus another 700 islands greater than 5 ha. These stretch from the subtropics to the subantarctic (29°S to 52°S). Spanning two tectonic plates results in a diverse landscape dominated by mountains (including volcanoes), rolling hills, and river flats. The marine environment under New Zealand's jurisdiction is an order of magnitude greater than the land mass. Marine environments include long and highly indented coastlines, deep ocean plains and trenches, and underwater seamounts.

Whereas the rest of the world's biota was influenced by the evolution of mammals, in New Zealand birds were the largest animals in all terrestrial ecosystems (8), and there are high levels of endemism in most taxa (14). Ratites were common, and large size and flightlessness or much reduced flight ability were frequent (8). Sea birds comprised 30% of the avifauna. The dominance of birds in turn influenced the form and distribution of some trees and shrubs (7, 94). The reptiles included the tuatara (*Sphenodon* spp.), as well as geckos and skinks but not snakes and crocodiles. Added to these Gondwana relics are a range of invertebrate, reptile, bird, and plant species that have arrived by the westerly wind drift and putative island hopping from the north (55, 64, 108).

Throughout the Holocene (last 10,000 years) most of New Zealand's land surface was evergreen rain forest of differing structure and composition (128): Beech (*Nothofagus*) dominate montane and southern forests, whereas lowlands have conifer/broadleaf forests. South Island mountain beech (*N. solandri*) forests are the least diverse forests. In contrast, kauri forests of northern New Zealand have the highest biodiversity—averaging 18 tree species per hectare including many endemics (74, 98). Many canopy trees are light-demanding: Large-scale

regeneration occurs only after widespread disturbance (99, 101). Disturbances include volcanism and earthquakes, and resultant fires, land-slips, and floods, as well as occasional tropical cyclones in the north and exceptional snowfalls or avalanches in the south. Massive exogenous disturbances with long return times have shaped the forests. Faunal communities of these forests included many large flightless birds (8), most of which are now extinct. Lizard and invertebrate fauna are poorly known with many species undescribed (65, 121).

Effects of People

New Zealand was the last major land mass to be colonized by people (2, 79, 99, 109). Polynesian predecessors of the modern Maori arrived some 700–1000 years ago; Europeans some 200 years ago. Together, people and their companion animals have greatly modified the landscape through ecosystem and species loss. Birds, especially land birds, are the worst affected (75, 76, 79).

Causal agents have been human hunting, ecosystem loss and fragmentation, and predation and competition from introduced pests (4, 45, 79). Rain forests have been reduced from an original 78% of land area to approximately 23% (79). Wetlands have been reduced by over 90% of their pre-European area of 700,000–1,000,000 ha (79, 91). Native grasslands initially increased from 1.5 million ha to some 8 million ha as a result of Maori fires, but degradation by burning, oversowing with European pasture grasses, and poor land management rapidly allowed invasion by introduced rabbits and weeds, making these lands ecological and agricultural deserts (132). Although large tracts of connected forest can still be found on the west coast of the South Island, much of the remainder is fragmented. Introduced pests are universally distributed through most areas. In addition, New Zealand has more introduced vascular plants (2400 species) than there are native species (2300 species, 86% endemic) (79, 102). Arrivals continue naturally, supplemented by the enormous influx brought, intentionally and unintentionally, by people. Six food plants were introduced by Maori, whereas the rest, introduced by Europeans, dominate the production landscape. They continue to enter the country, mostly as horticultural plants, at the rate of ca. 11 species per year (6).

Maori hunting eliminated 26 species (30%) of endemic land birds and 4 (18%) of the endemic sea birds, while ecosystem loss and companion animals eliminated a further 8 land birds. Many other species were reduced to localized populations. Tuatara, some lizards, and some invertebrates were also eliminated from the main islands. Seals and sea lions disappeared from northern areas.

European colonization started with the further reduction of seals and sea lions even in the subantarctic islands. More rapid ecosystem destruction to provide timber and allow pastoral agriculture reduced forest cover and saw the extinction of a further 16 land birds as well as a bat, a fish, and a number of invertebrates and plants (79). An overwhelming majority of the remaining fauna have declined, and many are continuing to do so. Nationally, birds, bats, lizards, frogs, and

invertebrates are characterized by low population density or local extinction, range contraction, and severe population fragmentation (122). Offshore islands provide sole refuge for both species of tuatara and 37% of lizard species (121) and many birds.

Reductions have been greatest in the north, where most people live. For example, historic northern North Island reptile fauna comprising tuatara, 6 species of gecko, and 11 skinks has been reduced by over 50% to 4 species of gecko and 4 or 5 skinks (121).

Introduced Pests

Introduced weeds clearly pose a threat to indigenous communities, especially in small lowland remnants with relatively large edge:core ratios. Among the 230 species of environmental weeds (131), five types can be emphasized: (*a*) climbers (e.g. *Clematis vitalba*) which smother natives; (*b*) shade-tolerant herbs (e.g. ginger *Hedychium* spp.) form extensive clones, suppressing the natural regeneration of the understory species; (*c*) species with long-lived seed banks (e.g. *Lycesteria formosa*), which can colonize natural gaps and subvert the normal gap-regeneration processes; (*d*) woody seral species (e.g. *Hakea* and *Acacia* spp.); and (*e*) bird-dispersed trees (e.g. *Acmena smithii*). Most weeds appear unable to invade intact forest, but others such as *Acmena* do.

Weeds are not the only alien biota affecting landscapes and are rarely the chief concern of conservation managers (25). Polynesian colonists introduced the Pacific rat (*Rattus exulans*) and the dog (*Canis familiaris*). European explorers and colonists introduced more species. Since 1769 over 80 species have become established, including 34 mammals (63). Predatory mammals, including rats, mustelids, and cats, have eliminated or continue to reduce many animal species including those responsible for pollination and seed dispersal. Herbivorous mammals such as brushtail possums (*Trichosurus vulpecula*), deer (*Cervus* spp.), and goats (*Capra hircus*) are nearly ubiquitous, markedly altering the structure and composition of native plant communities (23, 32, 63). Brushtail possums are also significant nest predators of threatened birds (18). In addition to alien plants and mammals, many species of alien insects, birds, and fish have also become established (6, 73). Social wasps (*Vespula vulgaris*) are especially problematic in beech (*Nothofagus*) forests (13, 83, 119).

A government analysis (84) lists 403 New Zealand taxa as threatened, including 159 plants, 98 invertebrates, and 146 vertebrates. Recent reappraisal lists 511 plants (22% of endemic flora) as threatened (43). New Zealand birds include a particularly high proportion of threatened species (25). Forty-one of the 45 threatened birds (10) are endemic, and many now occur only on mammal-free islands (26). Despite greater diversity than vascular plants and terrestrial vertebrates, invertebrate taxa comprise less than 0.1% of all threatened taxonomic groups, a disparity more related to knowledge than reality (65). Large (>10 mm body length), flightless, nocturnal, litter-dwelling invertebrates have been particularly affected.

CONSERVATION ISSUES

Preservation or Sustainable Management

The debate between preservation and sustainable management as alternatives currently polarizes conservation. The Conservation Act (1987) has the overarching goal of "the preservation and protection of natural and historic resources for the purpose of maintaining their intrinsic values, providing for their appreciation and recreational enjoyment by the public, and safeguarding the options of future generations." Largely seen and interpreted as championing the preservation philosophy, this Act sets conservation apart from other human activities, rather than viewing it as an integral part of sustainable management and of managing people as part of functioning ecosystems.

The Resource Management Act (1991), despite its name, is a sustainability law aimed at advancing ecological, social, and economic goals jointly through use, development, and conservation. The requirement to "sustain the life supporting capacity of air, water, soil and ecosystems" sets a clear ecological goal that embodies effective conservation ideals. This requirement allows more effective interpretation of conservation into economic and social understanding than the oxymoron of "maintaining intrinsic values" (34, 38).

Most New Zealanders (85%) live in towns and cities (79) removed from day-to-day contact with functioning native ecosystems. For many, the presence of massive old trees, possibly pre-dating Maori arrival, suggests that areas of "primeval" forest remain. The ancient geological lineage of some genera reinforces this concept of a primeval unchanging forest, deserving of preservation, and as a model for restoration. However, a history of continued vegetation change plus the loss of many animals suggests this is not a long-term reality.

By definition, under preservation ideals, native biodiversity cannot be used and hence has no recognized economic value. Indeed Parliament has ruled that access to public lands is free, effectively making use and abuse also free (34). Such rulings preclude ecotourism (28), as the costs of use or ecosystem maintenance such as pest control cannot be internalized. Government is the sole funder (35, 56), thus ensuring that conservation is influenced more by politics than sustainability. Despite strong public interest (4, 36) and calls by government for greater public participation (4, 45, 79), government publications record ongoing biodiversity decline (4) with this approach. Indeed it is a tribute to individuals that declines have been reversed in some areas and for some species.

Moreover, since it cannot be used, native biodiversity on private land (70%) receives no economic recognition for the ecosystem services that it provides to society. In the absence of realizable value, land owners carry all the costs of pest control, and it is economically rational to replace natives with exotic species that have economic value. Not surprisingly, introduced grasses, sheep, cattle, and pine trees dominate most landscapes. Indeed 50% of New Zealand has been converted to pasture compared with a world average of only 25% (79). Exotic forest

monocultures relatively low in native biodiversity (100) cover 6% of the land and are increasing, whereas less than 3% of the land is in indigenous forestry and none is being planted (79).

Monetary valuation of native biodiversity is abhorrent to most conservationists, yet without realistic valuation, native biodiversity will not be considered in most decision making (30). This will also entrench conservation as the exception across production landscapes, further reinforcing the dichotomy between preservation and sustainable management (81, 93). This issue was recently highlighted in plans for sustainable management of beech forests, where political expediency prevailed. The belief among the largely urban conservation movement is that managers of the productive landscape—foresters, fishers, and farmers—should become more conservation orientated, rather than that any of the conservation estate should be physically used. The abundant possibilities for integrating production and conservation are hindered when these are seen as mutually exclusive land uses (81).

Representativeness

Although 30% of the land area is in reserves, there are ongoing calls for more. Most conservation land is either in the super-humid regions or the uplands and montane areas that are not useful for production (75, 103, 123). In contrast protected areas in the fertile lowlands tend to be small, fragmented, isolated, extensively modified (88%), and generally poorly managed. Yet some 50% of New Zealand is below 300 m elevation. This is clearly illustrated in Northland (80, 82), where ecosystem loss is especially concentrated in the lowlands (Table 1, page 72) and reserves are more common on cooler, less productive slopes (Table 2, page 72).

This pattern conflicts with the requirement of the Reserves Act (1977) and the Conservation Act (1987) that reserves should represent the "original" character of the country. Such views deny the dynamic nature of ecosystems as confirmed from historic ecology (59, 74). Few areas of New Zealand have had a stable forest composition for more than a few tree generations (59). Change, rather than stability, in composition appears to be the rule, at all scales.

This is not to say that there are no relict areas of formerly more widespread vegetation types, nor that preservation of forests that have remained relatively unchanged since before European colonization is not a laudable goal in some areas. However, it is not possible to maintain representative areas unchanged in the long term, nor is it possible to define a primeval restoration goal, except in a very general sense. Moreover, the dynamics of historical ecosystem change also weakens the dichotomy between what is regarded as original (and therefore desirable) versus modified. It provides the basis for a new paradigm in conservation that would accept greater merging of the indigenous and exotic biota and provide a class of conservation land in which management goals would recognize the need to integrate the protected and productive components of the landscape (81). Such a change would also be more accepting of people as part of the landscape and would more closely align with Maori values.

The main response of the Department of Conservation to the ongoing declines in native ecosystems has been to concentrate management in areas where pests can be most easily eliminated or controlled. Thus, as with the production–protection dichotomy, limited resources and a protectionist philosophy may be leading to a division of the public conservation estate into priority areas of intensive management, where the aim is to restore and maintain a largely pre-European biota, and the remainder. In the latter—by far the greatest area—the interaction between the indigenous community and introduced pests is tackled with varying degrees of enthusiasm and effectiveness by inadequately funded conservancies and regional councils.

Intensively managed reserves are necessary to sustain some of the endangered fauna and some forest areas where compositional gradients representative of formerly extensive landscapes can be seen. However, it is clear that ecosystems covering most of the landscape have changed, are changing, and will continue to do so. How these areas are managed requires reasoned debate. They could provide for multiple uses, as envisaged in the Resource Management Act. For example, selective timber yield and recreational hunting in such areas could remove the pressure for these activities in fully protected reserves. They could also be moved to community or even privatized management. Recent reactions to the proposal for sustainable beech forest management that included minimal logging suggest that New Zealand society is not yet prepared to accept these options.

Management of Alien Species

In New Zealand, as elsewhere in the world, the response to invasive species that threaten native biodiversity has been minimal action. New legislation, however, requires action. For most mainland sites, control is the only option, but eradication is possible on islands. Eradication of introduced mammals from islands has been a major advance in New Zealand conservation in recent years (125, 126). Ungulates have been eradicated from islands up to 12,000 ha, cats from areas up to 3000 ha, and brushtail possums and rats from areas up to 2000 ha. These and other successes have resulted from the availability of single-dose anticoagulant poisons, such as brodifacoum, and the development of bait stations and aerial application (115, 126). Rodents have now been eradicated from 60 islands (126; CR Veitch, personal communication). Islands cleared of introduced mammals are now routinely used as important conservation sites for threatened species management (26, 124). Eradication of alien plants from New Zealand islands has been attempted less often, but intensive campaigns are under way, including an attempt to eradicate exotic estuarine grasses (*Spartina* spp.) (92, 102).

Biological control has been tried for a small number of plant and animal species, whereas poisoning is common. The most extensive chemical control of an invasive species in New Zealand is the ongoing campaign against the brushtail possum to protect native ecosystems and to prevent the transmission of bovine tuberculosis to livestock. This typically involves the aerial distribution of baits containing 1080 poison (sodium monofluoroacetate) over large areas of native forest or the use of

anticoagulant toxin in bait stations. Such control also reduces populations of other invasive mammals such as rats, pigs, and deer. Secondary poisoning of feral cats and mustelids feeding on poisoned rodents can also occur (1, 50, 89), although, less beneficial, diet switching to birds by surviving stoats can occur after rats decline (88).

Temporary control of possums and other mammals to enhance the breeding success of native birds is now routine (27, 61, 96). The concept of "mainland islands" has resulted. These are defined areas of natural habitat on the New Zealand mainland, selected for permanent, intensive pest control and ecological restoration (113). Within these areas, invasive species (especially mammals) are reduced to minimum densities to permit recovery of threatened native species and ecosystem processes. Early results are promising (25, 28, 60, 113) although high costs, accumulation of toxins, nontarget game mammal poisoning (46), short-term declines in rare species (107, 112), and public wariness of poisons are concerns.

Reintroductions

New Zealand has a long history of conducting species reintroductions on land as a method of ecological restoration, especially of islands following pest eradications, but comparable experiments in the sea are only just being considered. Since 1960, nearly 260 species transfers involving at least 66 animal species have been documented (51, 124). Numbers of transfers and the diversity of taxa have steadily increased since 1980. Birds dominated initially; thereafter transfers have included frogs, invertebrates, and especially reptiles. More effective predator control has increased the number of sites available for ecosystem restoration. As a result a number of species previously known only as single small populations now have multiple populations and some have a less threatened status (70). Numbers of founders used are typically lower than those used elsewhere (54), but success rates match or exceed overseas levels (5), possibly because New Zealand wildlife is less susceptible to inbreeding depression (33), and managers tend to select destinations in which species are known to do well (5).

Most threatened species in New Zealand are inaccessible to the general public. Current "mainland islands" are distant from major population centers, and most species translocations take place to remote mainland sites or to islands where people are denied access. The exceptions are Tiritiri Matangi Island (36) near the largest city (Auckland), to which eight threatened or rare birds have been translocated, and Matiu/Somes Island, in Wellington, which recently received the highly endangered Brother's Island tuatara (*Sphenodon guntheri*). New initiatives such as the urban wildlife refuge surrounded by a mammal-proof fence, in Wellington, (71) and Wenderholm Regional Park, near Auckland, partly redress the current imbalance between actual and desired access by the public to native wildlife, especially threatened species (36), but much more could be done.

A limit to suitable restoration sites is an emerging problem for species translocations. Predator-free islands are limited, as is knowledge. Reintroductions have

traditionally been conducted as one-off, nonreplicated events (trials) to locations that mirror source habitats. Reintroductions designed as well-planned experimental comparisons will more rapidly advance knowledge (5, 124).

Conservation of Functional Diversity

Although most biodiversity conservation in New Zealand has focused on individual species, there is an increasing awareness of the importance of functional diversity and not just species richness in maintaining the integrity of ecosystems (38, 123). Ensuring pollination and seed dispersal (19) highlights this issue. Some protected forests, especially those in northern regions, lack many of their original pollinators and seed dispersers; hence their future is unknown. Poor understanding hinders management.

Early studies based on floral characteristics (syndromes) suggested that, with few exceptions, the largely generalized native flora was pollinated by a range of unspecialized insects (58, 117). A later review conceded bird and bat visitation but argued this was probably incidental and most likely to result in self-pollination (52). This view remains influential (24). More recent work on island refuges, where predator eradication and species translocations have restored some trophic links, has provided new information (3, 22). Honeyeaters are observed regularly and persistently visiting a variety of apparently "entomophilous" flowers in the cooler months when insect activity is reduced, making these birds the likely pollinators (3, 22, 66). Pollinator limitation attributed to a decline in honeyeaters has been documented for mainland populations of some species (e.g. 44). Native lizards and the endangered short-tailed bat (*Mystacina tuberculata*) are also potential pollinators. Existence of multiple floral visitors belies the fact that only one of these may be an effective pollinator (129). Depletion of the array of endemic pollinators on mainland New Zealand is now cause for concern. Paralleling this loss is the introduction of floral visitors, either intentionally to pollinate the flowers of imported fruit and crop plants (e.g. bees *Apis mellifera* and *Bombus* spp.), or as self-introductions (e.g. silvereye *Zosterops lateralis*). The status of these recent arrivals as pollinators of native flora is uncertain.

New Zealand forests have a high percentage (70%) of woody plants with fleshy fruits suited to vertebrate dispersal (21). While lizards (130), native bats (69), seabirds, and seals (3, 94) disperse some seeds, most fruits are probably dispersed by forest birds (28). Likely impacts of their reduction in variety and abundance in the recent past is recognized (8, 21, 24, 67). Several large-fruited native plants now depend almost entirely on the native pigeon or kereru (*Hemiphaga novaeseelandiae*) for their dispersal, a precarious situation given the current declines of kereru populations (24, 68).

Introduced seed dispersers may compensate to some extent (3, 21), but the extreme fragmentation of lowland forests makes it difficult for widespread seed dispersal to occur. As a result, remnant forests are showing a changing and reducing species diversity (133).

Maori and Conservation

An international consensus is developing, among those concerned with the long-term future of protected areas, that the long-term goal of sustainability is more likely where local communities are involved. Biodiversity benefits, as well the social, cultural, and economic well-being of local people (49). The Convention on Biological Diversity ratified by the New Zealand government affirms such rights for indigenous and local peoples (106). Recent legislation including the Conservation Act, the Resource Management Act, and the Fisheries Act recognize the rights of Maori as recorded in the 1840 Treaty of Waitangi. Article Two guarantees Maori rights over their natural resources including fishing, forests, traditional foods, etc. Yet practical recognition of traditional ecological knowledge (15), environmental responsibilities (111), and resource rights is minimal.

Some agreement has been reached for joint control over the harvesting of traditional resources such as whale bone, pounamu or jade, freshwater fish, and titi or mutton birds (72, 90, 110). Joint management of traditional fishing grounds (taiapure) has also been provided for in legislation (116). But in virtually all cases, ultimate control and decision making still reside with government. True partnerships, involving the application of traditional knowledge in the sustainable management of the resources and biodiversity within protected areas, has been successfully implemented in Australia and Canada. These demonstrate a win-win outcome for both partners and for the environment. Despite these examples, and our own Treaty obligations, co-management of the public conservation estate is still unknown in Aotearoa/New Zealand.

Recognition of intellectual property rights, and the equity issues that arise from them, similarly requires government attention. This has resulted in the 1993 Mataatua declaration and a claim to the Waitangi Tribunal (Wai 262) seeking recognition, restoration, and protection of Maori cultural and intellectual property rights over flora and fauna (127).

Despite these initiatives and some major legislative advances both internationally and nationally, Maori still remain on the periphery of efforts aimed at the conservation and management of biodiversity. Greater effort is needed to identify and remove the individual and institutional barriers that prevent empowerment of Maori and other community groups in achieving sustainable biodiversity outcomes in Aotearoa/New Zealand.

Marine Conservation

Sustainable management and conservation in the sea lags that on land (120). Moreover, the difficulty of marine research (11, 40, 104) means that scientific knowledge of the sea is relatively poor. Marine habitats are poorly described, their extent uncertain, and their resilience to anthropogenic disturbance unknown. Unlike in land management, reserves are insignificant, and harvest of native species is the basis of a major export industry. In line with concepts of maximum harvest rather than sustainable management, stocks of most commercial species have been "mined" to between 25% and 70% of original levels (79).

Fishing impacts both the species being targeted and the surrounding marine environment. Traditional fisheries management is concerned solely with controlling the catch of economically valuable species. New Zealand in 1986 was the first country to implement an extensive system of individual transferable quotas (ITQs) as its primary fisheries management tool. This system requires the government to annually set a total allowable catch (TAC), which includes catch for commercial, recreational, and traditional (Maori) fishers as well as illegal take (poaching). The commercial component of the TAC (the TACC) is then allocated proportionally to each quota holder as a fully transferable property right.

The New Zealand ITQ system is viewed as an economic success because it optimizes fishing effort, despite substantial costs (17). In conservation terms, success is harder to judge. Catch has been stabilized for many harvested species, but poor knowledge of the ecology of most species involved severely limits the ability to estimate sustainable TACCs. In addition, 1999 amendments to the Fisheries Act (1996), driven by the political ideology of deregulation, allow the New Zealand fishing industry a much greater role in the actual stock assessments. Although this internalizes costs, without independent audit public confidence in sustainability is low. Further difficulties arise for many inshore fisheries where the recreational component is relatively large and control difficult. Claims of public rights for everyone to harvest have resulted in classic examples of "the tragedy of the commons," especially with intertidal shellfish. Estimates of recreational take are poor (62) and recovery after depletion slow (85). More worrying is the effect of a species-based management system on the overall structure of marine communities (9, 104), including habitat degradation (118) and seabird and mammal bycatch (114).

New Zealand's 35 cetaceans and 6 pinnipeds are protected within the 200-mile EEZ by the New Zealand Marine Mammal Protection Act (1978). The Department of Conservation administers two marine mammal sanctuaries to protect a population of the endangered Hector's dolphin and the remaining population of Hooker's sea lions (114). Entanglement in fishing nets is a major problem for marine mammals that are the objects of conservation, and the southern trawl fishery for squid has been closed early on several occasions in recent years when the total allowable catch of endemic sea lions was exceeded.

Of 159 foreign marine species known to have entered New Zealand, 130 subsequently became established (39) although their effects are little known (41, 57). Of most recent concern is the brown seaweed (*Undaria pinnatifida*), which has become established in southern ports. The risks of importation of additional marine invaders on the hulls of boats or in ballast water are now controlled by the Ministry of Fisheries under the Biosecurity Act (1993), but effective control of existing marine exotics is nearly impossible.

The Marine Reserves Act (1971), introduced to provide protected areas for scientific study (42), has been used to create 16 reserves ranging in size from 748 km^2 to less than 1 km^2 (40). Under this legislation, all marine life is protected from all forms of disturbance. Past action has been largely ad hoc, and there are calls for a broader network (11, 12) to increase representation. As on land, evaluation of the

TABLE 1 The conversation status of forests at different altitudes in the Northland region, New Zealand, based on a survey of 1500 sites >5 ha

Altitude	Area (ha)	% of land area	% loss of forests	Mean forest area (ha)	% area in protection
<100 m	324,330	59.0%	79.3%	35	15.6%
100 m–200 m	140,751	25.6%	66.7%	68	17.7%
200 m–300 m	54,193	9.9%	66.0%	258	17.6%
>300 m[a]	30,538	5.5%	17.0%	910	53.0%

[a]The highest point in the region is 774 m, but for this study the data above 300 m has been aggregated.

TABLE 2 The distribution by aspect of protected sites in a survey of 900 sites in Rodney District (Auckland/Northland)

	North	North-east	East	South-east	South	South-west	West	North-west	Flat
Proportion of slopes	20	13	6	16	7	10	8	12	8
Proportions of protected sites	19	4	26	11	26	9	1	4	0

Note: At these latitudes sourtherly aspects are cool and easterly most exposed to severe storms.

effectiveness of these reserves in enhancing fish stocks and restoring ecosystem functioning awaits planned experimental comparisons.

CONCLUSIONS

New Zealand's biodiversity has been severely affected by the actions of people. These changes are relatively recent and ongoing. Increased understanding and action plus legislative changes have all assisted, but recognition that the declines are ongoing requires more radical and urgent action. More open debate of the ecological, social, and economic realities of New Zealand's environmental management is required to sustain both biodiversity and the economy in the long term.

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