ECOLOGICAL RESTORATION FOR VERTEBRATES: ecosystems will not work without them!

M.N. Clout & J.L. Craig

School of Environmental and Marine Sciences, The University of Auckland, Tamaki Campus, PB 92019, Auckland, New Zealand.

Abstract

Following the human settlement of New Zealand and the introduction of alien mammals, native vertebrates (particularly birds) suffered disproportionate rates of extinction and endangerment. Lowland forest ecosystems were especially diminished by clearance and degraded by invasive species. The towns and cities of the lowlands are where most New Zealanders live, and for many of these people the presence of native birds improves their quality of life.

In this paper we therefore focus primarily on prospects for the restoration of lowland ecosystems, including those in urban areas, to benefit native birds. We consider the "ecoservices" provided by natural ecosystems and the wildlife which they contain, explore what degree of restoration is feasible for vertebrates, and discuss some of the complexities of managing the threats to restoration posed by invasive species. Finally, we discuss the seasonal food resources of key native bird species, such as kereru (*Hemiphaga novaeseelandiae*) and tui (*Prosthemadera novaeseelandiae*), and the pivotal role which these birds can play in restoring and sustaining vital ecological processes in forest ecosystems.

Preamble: a sense of loss

New Zealand was among the last habitable landmasses to be settled by humans; perhaps as recently as only 800 years ago (McFadgen 1993). Before this colonisation by Polynesian voyagers it had been isolated from other landmasses for over 65 million years. This had resulted in the evolution of high levels of endemism in both the flora and fauna. The vertebrate fauna of its terrestrial ecosystems was particularly unusual: it was dominated by birds and reptiles and contained no indigenous land mammals apart from some small bats.

An ecological holocaust followed the arrival of people and the alien mammals which they brought with them. Polynesian settlers burned and cleared large areas of forest and they introduced dogs (*Canis familiaris*) and kiore (*Rattus exulans*). At least 35 bird species were lost in this initial settlement phase, including several large flightless species such as moa (*Dinornithidae*), which were probably hunted to extinction by people and dogs (Anderson 1989). The introduced kiore seem to have eliminated several species of small birds, flightless insects, and reptiles (Atkinson & Moller 1990). Although many endemic vertebrates were lost in this first onslaught, the forests still had sufficiently abundant and diverse birdlife for the first European explorers to remark on how they literally rang with song.
Ò*This morn I was awaked by the singing of birds ashore .... the numbers of them were certainly very great .... their voices were certainly the most melodious wild musick I have ever heard, almost imitating small bells with the most tuneable silver sound imaginable*Ó (Joseph Banks, 1770).

European settlement of New Zealand started about 200 years ago, and the initial trickle of alien species rapidly became a flood. In the past two centuries Europeans have introduced over 80 species of alien vertebrates, including 34 mammals. Among these are three further species of rodents, three mustelids, six marsupials, and seven deer species. Predatory European mammals (e.g. ship rats (*R. rattus*), stoats (*Mustela erminea*), and cats (*Felis catus*)) caused the extinction of a further nine bird species and isolated several other species of endemic birds, reptiles and frogs to a few mammal-free islands.

Prior to the arrival of humans about 78% of the land area of the main islands of New Zealand, from coast to treeline, was covered with forest (King 1990). Podocarp/hardwood forest covered most of the lowlands, and southern beech (*Nothofagus*) forest much of the hill country. Fires set by Polynesian settlers destroyed large areas of the original forest, especially in drier areas, so that by 1840, when European colonisation started, the forest cover had been reduced to about 53% of the land area. Large scale clearance for farms over the past 160 years has since further reduced this native forest to about 23% of the land area. Approximately 52% of the land area is now farmland; most of it under pastures of introduced grasses and clover. A further 6% is covered by crops, exotic forestry plantations, or cities (King 1990). The remainder is mostly tussock grasslands, shrublands and snowfields. Most of the native forest which remains is on hill country and a disproportionate amount of it is in the wetter and cooler parts of the South Island, in the west and southwest of the country. Lowland forests have mostly been cleared and the remnants which remain are prone to further degradation due to browsing by introduced mammals and weed invasion.

The rapid change from a primarily forested landscape to one of lowlands dominated by pasture, with fragments of native vegetation, has greatly diminished the habitats of native flora and fauna, especially those which are naturally restricted to lowlands. Nevertheless, for most threatened animals, and many plants it is not habitat clearance which now poses the main threat to their continued survival, but the more insidious one of invasive species. Competition and predation by introduced mammals, in particular, threaten the extinction of many endemic species. Brushtail possums, deer and goats are significant agents of floristic change, through their selective browsing and inhibition of regeneration of many native plants (Cowan 1990, Challies 1990). Possums are also significant nest predators of threatened birds (Brown *et al.* 1993), so this particular introduced mammal has multiple impacts on native ecosystems. Rats, cats and stoats are important agents of faunal change through their predation on behaviourally vulnerable and slow-breeding native animals such as large-bodied invertebrates and ground-feeding or hollow-nesting birds. Larger flightless birds have proved especially susceptible to mammal predation, with surviving species such as takahe (*Porphyrio mantelli*) and kakapo (*Strigops habrobtilus*) now close to extinction as a result (Clout and Craig 1995). Even New Zealands national bird, the brown kiwi (*Apteryx autralis*), is declining at a rapid rate (Heather and Robertson 1996).

New Zealand's Department of Conservation classes 403 New Zealand taxa (species, subspecies and forms) as threatened (Molloy & Davis 1994), including 159 plants, 98 invertebrates, and 146 vertebrates. the IUCN Red List (IUCN 1996). Analysis of the recent IUCN Red List (IUCN 1996) reveals that no country has a higher proportion of its avifauna classed as threatened. Forty-five of 287 surviving bird species are listed as threatened. Forty-one of these threatened species are endemic (out of 150 surviving) and many of these now occur only on mammal-free islands.

The history of recent ecological change in New Zealand justifies special attention to the restoration of vertebrate populations in lowland terrestrial ecosystems. Vertebrates (especially birds) have suffered disproportionate rates of extinction and endangerment and lowland ecosystems have been the most diminished and degraded. Furthermore, the towns and cities of the lowlands are where most New Zealanders live, and many of these people (who call themselves "Kiwis") empathise with native birds and enjoy their presence.

The maintenance or restoration of populations of native birds and other wildlife in cities, towns and the surrounding lowlands therefore has the potential to improve the quality of life of many New Zealanders. In this paper we therefore focus primarily on the prospects for ecological restoration of lowland ecosystems, including those in urban areas, considering both the benefit to native vertebrates and the necessity of including vertebrates in restoration planning. We consider the "ecosystem services" (Daly 1997) provided by natural ecosystems (including the vertebrates they contain), we explore what degree of restoration is feasible, and we discuss the pivotal role which key bird species can play in restoring and sustaining vital ecological processes in forest ecosystems.

Why restore?

Life, be it plant, human, or other animals, relies on functioning ecosystems and the services which they provide. Oxygen, clean water, waste disposal and carbon storage are all provided by ecosystems. Global warming and changes in weather patterns along with air and water pollution are all expected consequences of people living out of balance with natural systems. Restoring wetlands, forests and other natural ecosystems (in association with reduced demand) is the least expensive way to restore balance and quality of life for people, as New York City authorities have recently found (Chichillnisky & Heal 1998).

Restoration of ecosystem services can be achieved in part by ecological communities and plantations dominated by introduced species, although typically these are inferior to the services provided by diverse communities of organisms that have evolved in the area. Moreover, only in New Zealand can we conserve our own special biota, and hence there is a moral duty for New Zealand restoration programmes to involve native communities. The government recognises this responsibility through national laws such as the Conservation Act and the Resource Management Act, as well as through ratification of international agreements such as the Biodiversity Convention.

The loss of ecosystem services through the loss of lowland forests and wetlands has the greatest effect on urban New Zealanders. Not only do they have the greatest need for the greenhouse gas regulation and pollution mitigation that forests offer, they have also suffered the greatest loss of access to the native birds and other vertebrates that so fascinated the first European visitors. Up to half of the New Zealand population do not have access to, or have never seen, supposedly common species such as bellbirds (*Anthornis melanura*), let alone their national bird the kiwi (*Apteryx* spp.).

Without native birdlife, "restored" forest habitats could merely be silent shells, missing the calls of bellbird, tui and morepork (*Ninox novaeseelandiae*), and inhabited only by blackbirds (*Turdus merula*), sparrows (*Passer domesticus*) and starlings *Sturnus vulgaris*); ubiquitous aliens which can also be found in many other places around the world.

Can restoration reverse the losses of the past?

The loss of ecosystem services, including the loss of so many species, results from the replacement of native ecosystems with pasture, plantations and cities, and the introduction of alien species. Ultimately, both of these causes of loss relate to economic disincentives for the long term sustainable use of native systems, relative to introduced communities. In assessing the feasibility of restoration we have to determine if we can reverse these negative influences.

Functioning ecosystems provide services for people and industry, but are disregarded from all economic considerations. People and companies who own land with ecosystem values receive no recognition over those who harden all surfaces and eliminate ecosystem services. Rates levied by local government relate to capital value and never include natural value. Moreover, no resource consent applications or conditions of approval, to our knowledge, include any consideration of ecosystem services let alone restoration of them. National policies that exclude the economic use of native animals ensure that Òworthless nativesÓ are replaced by valuable exotics. Such perverse incentives (Myers & Kent 1998) favour continued unbridled development and relegate restoration to the realm of recreation and welfare by concerned individuals and groups.

Extensive research and practical experience on the control of pest species has provided managers with the ability to minimise or even eliminate many invasive pests. In particular, there is an increasing armoury of techniques for use against invasive mammals, including the development of sophisticated traps and baiting techniques and the availability of a range of modern poisons. Introduced mammals (especially rodents, mustelids, cats and possums) are arguably the greatest biological impediments to restoration of native vertebrates in New Zealand. Habitats can be re-planted and regenerated, but the pervasive presence of predatory mammals can preclude the recovery of vulnerable native wildlife. Although temporary reduction or local eradication is possible for some species of alien mammals (especially possums, rats and cats), recent experience has illustrated the need to realise that each of these species exists in an ecological community in which it interacts not only with the native wildlife on which it preys, but also with other species, including other mammals.

Rats, in particular, have ecological connections with several other mammals (Fig y) and can therefore be viewed as "keystone aliens". They are important prey of stoats and cats, and are themselves predators or competitors of mice. Murphy and Bradfield (1995) showed at Mapara Forest that when rats were reduced by poisoning, stoats unexpectedly switched their diet to include more birds. Studies have now shown that mouse populations in forests often irrupt after rats are reduced (e.g. Clout *et al.* 1995, Innes

1995, 1998, Brown 1996). Poisoned rats (including still-living ones which have taken anticoagulant poisons) may be eaten by carnivores such as cats and stoats, causing secondary poisoning (Alterio 1996, Gillies 1998), but the consequences may again be unexpected, including irruptions of normally rare carnivores such as weasels (*Mustela nivalis*), as stoats and cats temporarily decline and mouse numbers increase. Cats are known to be predators of stoats (Gillies 1998) and stoats probably prey on (or exclude) weasels. A modified small mammal community may therefore result from the control of any one species within it, with unknown implications for the recovery of native animals. The lesson is that control of alien mammals, although likely to be beneficial overall, is a far more complex matter than previously thought. An ecosystem view of management is necessary, as is research to properly unravel some of the ecological relationships alluded to above.

Within urban or suburban areas a different mix of alien mammals is likely than in rural areas. Mustelids are likely to be absent or rare in cities, possibly because of the high density of domestic cats, combined with low numbers of wild rabbits. Possums, although present, are likely to be at relatively low densities, because of dog predation, road kills, and control by people. Rodents are likely to be present, but possibly at lower densities because of high levels of cat predation. Native birds and other vertebrates in cities therefore have to contend with a different mix of predatory mammals. Whilst there are very high densities of domestic cats and dogs, this may be offset to some extent by lower densities of tree-climbing mammals such as stoats, possums and ship rats. This may have implications for restoration of native wildlife in cities, perhaps making restoration of some species (kereru, tui, bellbird?) easier, but restoration of ground-feeding species (e.g. robins *Petroica australis*, weka *Gallirallus australis*) very difficult because of the risk from domestic predators. Experimental releases plus research are needed on this issue.

What restoration is feasible?

Progress with the eradication of alien mammals from islands (Veitch and Bell 1990, Veitch 1994), and successful translocations of threatened bird species, have increased confidence in the potential for ecological restoration on islands (Clout and Saunders 1995). The restoration of native vertebrate populations on the mainland is a far more difficult task, because of the continued presence of alien mammals. Nevertheless, the mainland restoration of native bird populations has been advocated in the past (Clout 1989) and is now being tested by the NZ Department of Conservation in a "mainland islands" programme (Mansfield 1996, Saunders this volume). Similar intensive pest control programmes are undertaken through co-management by Timberlands West Coast in areas of sustainable logging on the west coast of the South Island.

Problems in the establishment of the mainland island programme included a general ignoring of island biogeographic principles in site selection, a lack of clear goals for the restoration programmes, lack of planning for public access, and a lack of foresight of the ecological and social consequences of the intensive, perpetual use of toxins for mammal control at the chosen sites. Despite these shortcomings there is good potential for research-based "adaptive management" to yield useful insights from the existing programme.

With present techniques and resources, large-scale ecological restoration such as the DOC mainland islands programme will probably remain rare. However there is considerable scope for smaller scale ecosystem restoration involving native vertebrates, run by local government authorities and community groups. It is such programmes which are our focus here.

Populations of all native vertebrates clearly cannot be restored everywhere. Translocation is a powerful tool for ecological restoration, but it is not always appropriate. Firstly there is the constraint that not all species had natural distributions covering the whole of New Zealand. Introductions of species outside their known range are generally to be avoided because of the risks to local species and ecological processes. Secondly there is the constraint of continuing threats which caused the species to disappear in the first place. Some species (e.g. kakapo, takahe, saddleback *Philesturnus carunculatus*) are so vulnerable to mammal predation that they flourish only in its complete absence; a situation which is only feasible on the mainland within mammal-free exclosures.

However there are some other situations (e.g. the loss of bellbirds, *Anthornis melanura*, from Auckland and Northland last century) where the original causes of decline are unknown or may now have abated, and translocation experiments to test our ability to restore important ecosystem processes are urgently needed (see Craig 1997).

Finally there is the oft-ignored constraint of the long term viability of a population established by translocation. Small, isolated areas capable of supporting only a few individuals of a native vertebrate are unlikely to retain self-sustaining populations in the long term, unless they are part of a network of reserves between which individuals can migrate, forming an effective metapopulation. It is important to remember that while size of areas often limits vertebrates, many plant and invertebrate species are not so critically limited by the size of remnant areas typical of urban environments (Kuschel 1990, McDonald 1997). The persistence of remnant lizard populations in small habitat patches similarly suggests that critical thresholds of patch size may also be smaller for native reptiles than for birds, presumably because reptiles can exist at higher densities. Translocation of native vertebrates to small isolated areas where a viable population is unlikely cannot be justified unless there are other acknowledged motives (e.g. education, research) which transcend the goal of restoring a self-sustaining population.

The above constraints will often limit vertebrate restoration goals. In small ecosystem remnants, such as many of those in urban areas, it may only be possible to restore populations of species which are less vulnerable to predation, and which can either exist at relatively high densities (e.g. reptiles, small passerines) or are highly mobile and can be supported by a series of small patches (e.g. kereru (Clout *et al.* 1991) and tui (Stewart & Craig 1985, Bergquist & Craig 1988)).

Linkage of isolated patches by "corridors" along which individuals can move may be necessary for species which will not cross large open areas (e.g. fantails, *Rhipidura* *fuliginosa*). In urban areas, suitably planted gardens or parks may enable such species to move between fragments of natural habitat.

Viewing remnant patches in the context of the wider matrix of urban or production landscapes allows further options. Restoring native shrub communities on urban sections, commercial properties and on road verges can create a habitat matrix providing seasonal food and movement corridors for native birds, even though they may rely predominantly on larger remnants of native vegetation for nesting. This approach is currently being trialled in Waitakere City (Wilson 1999). Small insectivorous birds such as fantail and grey warbler (*Gerygone igata*) and even larger, highly mobile species such as tui and kereru are common in small remnant ecosystems and surrounding gardens.

Feasibility of restoration also benefits from considerations of "who is the restoration for?" and "who will pay?". A high proportion of New Zealanders have a strong interest in conservation (Department of Conservation 1992, Craig *et al.* 1995), but in a climate of "user pays", more restoration will be achieved if more people, councils and businesses can see that they benefit personally or collectively. Viewing restoration in terms of ecosystem services, reinforced by the philosophy that people are part of the New Zealand environment, is fundamental to change.

Costs are a major limit to the size of restoration programmes, their speed and even their acceptance by many authorities. The ability to identify costs for predator removal, revegetation etc. is rarely matched by financial estimates of benefits. As Costanza *et al.* (1997) suggest, this failure frequently results in the ongoing loss of natural systems rather than restoration. No economic valuations of native vertebrates are available for New Zealand, but the koala (*Phaloarctus ursinus*) has an estimated annual value of $1.1 billion to Australia. Studies by Mortimer *et al.* (1996) suggest that ecosystems such as Little Barrier Island, which have a high diversity of native vertebrates have an annual value of between $5 million - $9 million ($2 - 3000/ha). By building in the value of all ecosystem services, restored urban areas are likely to exceed this value greatly. Research to quantify values and marginal costs is needed urgently.

Encouraging greater restoration

Do people want restoration and do they want to be involved? Anecdotal evidence suggests that they do. Replanting programmes in large urban areas typically produce as many people and spades as there are plants. Nationwide surveys (e.g. Craig *et al.* 1995) show public support for ecosystem over species work and a wish for greater public involvement.

A recent survey of Aucklanders living near public parks (Abbott 1998) found that 95% of respondents wanted to see greater plantings of native plants, with 50% wanting Òlots moreÓ. Eighty nine percent of respondents believe that it is important to see native birds in urban parks. The frustration that urban Aucklanders have for their colonised surroundings is reflected in their overwhelming desire to see more native birds and fewer introduced vertebrates (Fig x). Indeed, 85% would plant native plants in their gardens if it would increase their ability to see more native birds. Tui and kereru lead their "wish list". Capitalising on these desires through targetted information would allow urban environments to become a matrix which is more amenable to native vertebrates.

Empowering people with greater information on ecosystem services and their value would build on existing public demands for greater restoration. The more charismatic native vertebrates and plants will lead the move. Ways by which councils can be encouraged, educated or forced to value natural capital as much as they value built and (to a lesser extent) social capital are needed before restoration will achieve its rightful place. It is important to realise that Òrates reliefÓ for covenanted land is solely a recognition of tagging ownership rights and is not an acceptance of natural values as it sustains perverse subsidies for the destruction of natural systems!

Vertebrates are integral to New Zealand restoration

Ecological restoration is by definition and action an ecosystem approach. Restoring processes is as important as restoring component species and hence approaches based only on concepts of ÒumbrellaÓ, ÒkeystoneÓ or ÒflagshipÓ species are inadequate (e.g. see Craig 1997). The use of organisms which are close to the heart of many members of the public as icons to market a restoration programme can be useful for carrying the support of the public, but the restoration of these species alone should not be confused with success in the restoration of a natural ecosystem.

It is important that restoration planners use a balanced and representative group of species as guides to success. For example, restoring freshwater communities is best achieved through the elimination of water pollutants and invasive weeds and the restoration of riparian vegetation. The use of the riparian trees and shrubs by birds such as tui or kereru does not necessarily show that there are adequate terrestrial invertebrates to support native fish populations in a waterway. Moreover, the presence of native birds and fish does not necesarily show that diverse invertebrate communities exist. Monitoring needs to be ecosystem-based.

Because birds were the dominant vertebrates in native New Zealand ecosystems, they have co-evolved with many tree and shrub species and are the sole pollinators or seed dispersers for several of them. Hence they are fundamental to ecosystem processes such as pollination and seed dispersal. Some avian pollinators or seed dispersers have a large number of ecological linkages with other species through these roles and their presence is important for restoring and sustaining ecosystem function.

An obvious example of such a "keystone" species is the kereru, which is known to disperse the seeds of over 70 species of native plants and is probably the sole disperser of a whole suite of large-fruited ones (Clout & Hay 1989). Without the services of this mobile bird, natural regeneration of these large-fruited plants will be severely impaired. Honeyeaters such as tui and bellbird are similarly important species; research has shown that they are not only seed dispersers, but also important pollinators of a variety of native plants (Craig et al. 1981, Castro 1995, Anderson 1997). The total absence of bellbirds from Auckland and Northland for over 130 years may therefore have altered the very processes that determined the original forest structure.

Introduced birds (e.g. blackbird) or self-introduced birds (e.g. silvereye *Zosterops lateralis*) may also provide services of seed dispersal or pollination, but this is often of poorer quality than that provided by native birds with which plants have co-evolved (Williams and Karl 1996, Anderson 1997). For example blackbirds , although important frugivores (Clout and Hay 1989), are much more sedentary than kereru and tui, and therefore offer shorter-distance seed dispersal within a habitat patch and none between very isolated patches. Silvereyes visit the flowers of a large number of native species, but they rob the nectar from large tube-shaped flowers of species such as puriri (*Vitex lucens*) by piercing the base of the flower, unlike co-adapted native species such as tui (Anderson 1997).

Not all seed dispersal into restoration areas is a good thing. Frugivorous birds do not discriminate between native and introduced plants. Kereru, for example, are not only the sole dispersers of several large-fruited native plants: they are also important dispersers of the invasive monkey apple (*Acmena*). To avoid kereru dispersing this plant into native forest remnants the only solution is to remove the plant from surrounding areas, up to several kilometres away, since kereru are so mobile (Clout *et al*. 1991).

In general it seems that adventive (introduced and self-introduced) birds are more significant dispersers of introduced plants than are endemic birds. In a study of birds in native forest remnants near Nelson, Williams & Karl (1996). found that adventive blackbirds, songthrushes and silvereyes ate more introduced fruits than did endemic tui and bellbirds. Dispersal of weed seeds by birds was most prevalent into the native forest remnant closest to a town.

Some introduced frugivores (e.g. mynas *Acridotheres tristis*, starlings) are typical of open habitats and forest edges. It may be that in this situation they feed particularly on invasive fruiting plants such as woolly nightshade (*Solanum mauritianum*), inkweed (*Phytolacca octandra*) etc. and disperse their seeds into native forest remnants. Starlings congregate in large roosts at night and at these sites weed seeds are common. The habit of starlings roosting on inshore islands provides a constant negative input of weed seeds into restoration programmes at such places . In Auckland the negative effects can flow both ways: starlings visiting inshore islands such as Motuihe and Motutapu are bringing weeds such as *Rhamnus* back to mainland parks and urban gardens (J.L. Craig pers. obs.).

Williams and Karl (1996) pointed out that one important part of the interaction between adventive birds and weed species is the development of extensive new habitats of introduced scrub and shrublands (*Crataegus, Berberis, Ribes* etc.) which offer particularly suitable fruit for the adventive birds responsible for formation of these habitats. In contrast, where there are few native shrubs or birds (e.g. in large areas of gorse *Ulex europaeus*) adventive birds can play a critical role in dispersal of seeds of colonising native plants such as *Coprosma, Melicytus* and *Pseudopanax* into such areas. They conclude that the outcome of the seed rain from introduced birds and silvereyes depends on their seed loads and the nature of the receiving vegetation.

Planning restoration to ensure birds are present

In a very real sense it can be argued that native forest needs native birds, both as pollinators and as seed dispersers. Yet ensuring birds are present requires a targetted mix of pest control and the provision of year round food supplies. The depletion of lowland forests and extensive logging of podocarps over the past 200 years, along with the presence of possums and ship rats that feed on flowers and fruits, means that many remnants lack food for pollinators and seed dispersers at certain times of the year.

Mobile birds such as kereru and tui can exist in a network of patches, provided that they have access to food resources in this network throughout the year, and access to suitable breeding sites. To retain and restore populations of such species in a network of patches will depend on a complete seasonal succession of food resources, not just the availability of attractive foods in a single season. Often the planting of restoration areas to "attract birds" consists of the establishment of fast-growing, spectacular and well-known bird food plants such as kowhai (*Sophora* spp.) or flax (*Phormium tenax*), without thought to a seasonal succession, or the provision of food resources for successful breeding. Slower-growing species such as podocarps are often neglected, despite the fact that these may provide vital autumn and winter food for frugivorous birds. There is growing evidence that the successful breeding of species such as kereru depends on the availability of abundant fruit of these and other large native trees (Clout 1990, Clout *et al.* 1995). The negative impacts of possums on fruit availability (A. Dijkgraaf pers. comm.) may mean that in marginal fruiting years there is insufficient ripe fruit produced to allow successful breeding of kereru in areas where possums are abundant.

Abbott (1998) surveyed food availability in six urban parks including two forest remnants and two areas that have been extensively replanted. In only one of these was there food in all seasons. The two replanted areas had minimal diversity and lacked food for fruit and nectar-feeding birds for periods as long as six months. The most extreme example we know of is in Shakespeare Regional Park on the Whangaparaoa Peninsula where restoration is mimicking past fire-induced succession, involving the widespread planting of species such as kanuka (*Kunzea ericoides*). The fact that the succession concerned resulted from fires lit to manage farm pasture, appears to have escaped the notice of restoration planners. The area is being slowly recolonised by bellbirds from the nearby Tiritiri Matangi Island restoration programme, but this (and the local recovery of other fruit or nectar-feeding birds) could have been enhanced by planting of a greater diversity of native species providing a range of food resources for birds.

Establishing forest restoration programmes around existing vegetation can ensure the presence of insectivorous bird species which can provide a level of invertebrate control on newly established plants. Fantails, grey warblers, bellbirds and tomtits (*Petroica macrocephala*) are most likely targets in early restoration phases. The importance of this form of invertebrate control is exemplified on Tiritiri Matangi, where there was widespread insect damage to young pohutukawa (*Metrosideros excelsa*) in the early stages of the restoration of this island. Planting pohutakawa as a monoculture, and a long way from established forest and shrub patches, meant that no birds foraged on the young plants in open areas. Similarly, irruptions of beetles (possibly resulting from removal of kiore (*Rattus exulans*)) resulted in severe leaf damage to all karaka (*Corynocarpus laevigatus*) trees on the island. The prior establishment of predators of large invertebrates may have reduced this.

Many restoration programmes deal with the obvious: large plants and large diurnal vertebrates such as birds. However, ecosystems function both day and night and it is valuable to also plan for nocturnal communities. For example, night-feeding bird species such as morepork also need consideration in restoration planning. Most forest areas on the mainland contain rodents which considerably reduce both the density and diversity of large invertebrates, which are the primary food of moreporks (Haw 1998). If rodents are removed, recovery of populations of large invertebrates such as weta (*Deinacrida*), large-bodied moths and beetles is likely; improving the prospects for recovery of morepork populations.

The future: planning, action, experimentation and evaluation

- For functioning New Zealand ecosystems, vertebrates are integral but no more and no less important than plants, fungi, bacteria or invertebrates.
- Basic guidelines are to restorate using local sources, concentrate on restoring basic structure and function first, and remember that natural patterns are rarely identical in all places. So restore some of the variability. Variability is also valuable for marketing and fund raising - called differentiation.
- Reestablishing process is as important as species composition.
- Pest control is imperative and may require ongoing and adaptive management.
- Build toward sustainable solutions: ecologically, economically & socially.
- Plan for people: they are part of the environment
- Empower people to take charge. Responsibility for biodiversity rests with everyone not just government (whether national or local).
- Where possible, try more than one option. Replicate if at all possible and evaluate. Restoration is young, and needs better understanding of possiblities.
- Consider the total matrix - do not think that reserves are more important than the matrix they sit in.
- For marketing restoration, for capturing imagination and pockets of people, vertebrates are extremely valuable.

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