Indigenous biodiversity and land use - what do exotic plantation forests contribute?

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Abstract

Major decisions on large scale land use appear to be being made with little consideration of the relative contributions to indigenous biodiversity made by activities such as exotic plantation forestry and pastoral farming. Both foresters and farmers would undoubtedly argue that both land uses have positive values for indigenous biodiversity. It is not a simple picture for plantation forests, with patchy information, regional differences, and significant information deficiencies. It is nevertheless clear that plantations do provide habitats for a diverse array of indigenous plants and fauna, including rare species such as kiwi, bats, and falcon. The latter has a major stronghold in Central North Island plantations and forest managers have developed systems to accommodate falcon on an ongoing basis. Biodiversity values of plantations are increasingly recognised by forest managers and deserve wider recognition and further investigation to address information deficiencies.

Introduction

This article reviews the effects of land use on indigenous biodiversity, with a focus on the science underpinning our current level of understanding. What this amounts to is consideration of the relative contributions made by exotic forest plantations and farming (pasture and cropping). Current initiatives involving large scale clearance of exotic plantation for the establishment of new dairy farms means that this issue is very topical, although media coverage of this issue to date has focussed largely on economic and water quality issues rather than effects on indigenous biodiversity. This probably reflects a poor level of understanding of the relative habitat values of both exotic plantations and farmland. While there is considerable information on biodiversity in indigenous remnants and a limited amount on plantation forests, information on biodiversity on pastoral farms is very limited, and almost nothing could be found comparing plantation forestry with farming.

Clearance of indigenous forest has generally ceased and few people are making decisions on land uses that include this option. It is of interest, nevertheless, to compare the suite of species found in both indigenous forest and exotic plantations. There are unlikely to be significant differences between protected indigenous remnants in plantation forests or on farms (providing they are fenced to exclude domestic stock), except that those in a plantation forest matrix are better buffered from external influences (Denyer 2000). There are also many variations in farm and forest locations (and hence the ecosystems, habitats, and species present), climate, farm-forestry mixes, and management practices, all of which influence biodiversity.

Thus, to keep the comparison reasonably simple, this article only considers indigenous biodiversity of a typical pasture/crop farm and industrial exotic plantations. It is important to draw a clear distinction between pasture dominated by introduced species and high country runs, many of which have very extensive areas of indigenous tussock grasslands (and indigenous forest). These latter farmed habitats, many of which are subject to the high country tenure review process, can have very high ecological values for both indigenous plants and fauna. The 'pasture' under consideration in this paper is the former type.

Both farms and plantation forests also contain varying types and amounts of exotic biodiversity, which can obviously be highly beneficial to people (otherwise we wouldn't establish these systems for economic and social benefit). Nevertheless, as we well know, many of the multitude of exotic species we have introduced have become invasive (of exotic and indigenous systems), and have resulted in highly detrimental effects. In the interest of maintaining focus we have not considered the relative benefits of exotic biodiversity.

The purpose of this paper is to provide an overview of some key information and issues rather than a comprehensive literature review.

Pasture habitats

Most literature suggests that indigenous biodiversity in pasture or crops is extremely limited (MFE 1997; MFE 2000; MFE 2004; Wratten 2002). This view is also held at an international level (UNEP 1996; quoted in Moller *et al.* 2001). Transformation to pasture of half the New Zealand landscape has been beneficial for a limited suite of indigenous organisms whose needs are met by pasture (Perley *et al.* 2001). Some, such as grass grub beetle and porina moths, were even transformed from minor components of the New Zealand biota to major pests (Perley *et al.* 2001).

Pasture does provide good habitat for some indigenous birds, including, in the North Island, paradise duck (*Tadorna variegata*), pukeko (*Porphyrio porphyrio* ssp. *melanotus*), Australasian harrier (*Circus approximans*), pipit (*Anthus novaeseelandiae*), kingfisher (*Todiramphus sanctus*), pied stilt

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(*Himantopus himantopus* ssp. *leucocephalus*), welcome swallow (*Hirundo tahitica* ssp. *neoxena*), and spur-winged plover (*Vanellus miles*).

There are distinct regional differences in species complements. Pasture habitats in South Canterbury, for example, are utilised by South Island pied oystercatcher (*Haematopus ostralegus*), banded dotterel (*Charadrius bicinctus*), black-fronted tern (*Sterna albostriata*), black-billed gull (*Larus bulleri*), black-backed gull (*Larus dominicanus* ssp. *dominicanus*), pied stilt, and spur-winged plover. Nevertheless, most birds commonly associated with pastoral farms are exotic species such as starling (*Sturnus vulgaris*), Indian myna (*Acridotheres tristis*), blackbird (*Turdus merula*), song thrush (*Turdus philomelos*), skylark (*Alauda arvensis*), and a range of small passerines such as goldfinch (*Carduelis carduelis*), chaffinch (*Fringilla coelebs*), greenfinch (*Carduelis chloris*), and yellowhammer (*Emberiza citrinella*).

Soil biota are a particularly important part of agricultural systems, but there is a significant lack of knowledge of soil biodiversity (Perley *et al.* 2001).

Pasture can provide habitat for rare species, particularly invertebrates, although the often direct relationship between invertebrates and particular "host" plants (McGuiness 2001) means that potential habitat is limited.

One area where some coastal and lowland farms in particular have retained some significant values for indigenous biodiversity is fish habitats in artificial drains. Drains, particularly close to the coast, may have eels (*Anguilla* spp.), banded kôkopu (*Galaxias fasciatus*), and even threatened species such as giant kôkopu (*Galaxias argenteus*). As such, they represent some of the last vestiges of habitats for species which relatively few people are aware of. Having said that, these habitats are often very degraded, have barriers to fish movement (such as culverts), are nutrient-enriched, provide little cover, and may be infested with pest fish species such as mosquito fish (*Gambusia affinis*). Irrigation abstraction for both drystock and dairy farming has also resulted in significant degradation of waterways throughout lowland New Zealand.

Overall, the effect of farming on aquatic biodiversity has been detrimental and in particular the adverse effects of farming practices on fresh water quality and indigenous biodiversity has been well documented and reported in recent times (Environment Waikato 2004; PCE 2004; NIWA 2003). As a result, farming practices are coming under greater scrutiny as the effects of farm-generated pollutants (e.g. nitrates, phosphates) are better understood. In response, large farming corporates, such as Fonterra, have developed and adopted codes of practice for waterway protection on farms that supply them milk. It must be acknowledged, also, that increasing numbers of farmers are proactively protecting and enhancing the state of indigenous biodiversity[4] along riparian margins, streams, wetlands and ponds and in indigenous remnants. However there is little evidence of any direct management for indigenous biodiversity in pasture or crops (MFE 1997, 2000, 2004; Wratten 2002). In general the potential for indigenous biodiversity management in pasture or crops, under conventional farming regimes, is very limited.

[4] *Many forest managers have also initiated inventories of indigenous remnants and streams and are addressing management requirements for the sustainable management of these sites.*

Exotic Plantations

Plantation monocultures are often criticised as being biological deserts. However, most plantation foresters who have spent time in forests would argue otherwise, as would farmers who actively work their land. What is the actual situation in plantations? A review of survey, monitoring, and management of indigenous biodiversity in Kaingaroa forest (Shaw *et al.* 2000) indicated that there is much more to plantation forest biodiversity than many people would believe. Information on indigenous biodiversity in exotic plantations can be summarised by groups based on life forms:

Birds

Several studies have demonstrated that indigenous birds can be numerous in plantation forests (e.g. Jackson 1971) and in some cases individual species may be present in numbers comparable to those present in nearby indigenous forest remnants (Gibb 1961; Clout & Gaze 1984). The number and diversity of bird species present in plantation forests reflect the diversity of avifauna in the indigenous forest of the region (Table 1). In each of three study regions the diversity of bird species in plantation forests was only slightly less than that of nearby indigenous remnants.

A consistent trend is for the number of common and uncommon species present in plantation forest to approximately equal the number of common species in indigenous forest in each of these three regions. Thus in volcanic plateau plantations, the majority of North Island forest bird taxa which occur in adjacent indigenous forest have been presented with the opportunity to colonise the new forest types.

Conversely, in Northland, forest bird diversity is low, because several species have completely died out, e.g. NZ falcon, yellow-crowned kakariki, NI robin, and whitehead. Although there has been no opportunity for these birds to colonise Northland plantations, there is an opportunity for reintroductions to occur from further south, particularly in light of advances in predator control technology. The presence of plantations in Northland has, however, allowed the dispersal of at least one regionally rare species (NI tomtit) throughout large tracts of Northland from which this species had previously disappeared. Kiwi and many other species also benefit from the corridors provided by plantation forest and shrubland.

The bird species present in plantation forests occupy a wide variety of ecological niches and include predators, insectivores, frugivores and omnivores (Table 2). Predators comprise NZ falcon, morepork and kingfisher, each of which can be locally common in plantation forestry,

Table 1: Bird species associated with plantation forests and indigenous forests in three North Island regions – Northland, Coromandel, and Volcanic Plateau.
C = common and/or widespread in this habitat; U = uncommon or occasional visitor. Note includes primarily forest birds and excludes predominantly open country birds, e.g. kahu and New Zealand pipit. Data from Pierce et al. 2002, R. Pierce pers. obs.

Species	Northland plantations	Northland indigenous	Coromandel plantations	Coromandel indigenous	Volcanic plateau plantations	Volcanic plateau indigenous
North Island kiwi	C	C	U	C	-	-
NZ falcon	-	-	U	U	C	C
NI weka	-	U	-	-	-	-
NZ pigeon	U	C	U	C	C	C
NI kaka	-	U	U	C	U	C
Yellow-crowned kakariki	-	-	-	U	U	C
Red-crowned kakariki	-	U	-	-	-	-
Shining cuckoo	C	C	C	C	C	C
Long-tailed cuckoo	-	U	U?	U	C	C
Morepork	C	C	C	C	C	C
NZ kingfisher	C	C	C	C	C	C
Rifleman	-	U	-	U	U	C
NI fernbird	U	C	U	C	U	C
Whitehead	-	-	-	-	C	C
Grey warbler	C	C	C	C	C	C
NI fantail	C	C	C	C	C	C
NI tomtit	C	C	C	C	C	C
NI robin	-	-	-	-	C	C
Silvereye	C	C	C	C	C	C
Bellbird	-	U	C	C	C	C
Tui	C	C	C	C	C	C
NI kokako	-	U	-	-	U	U
Total	9-11	11-18	9-15	13-17	14-19	18-19

although falcon numbers can be depleted by mammalian predators. Omnivorous species include kiwi, weka and silvereye, the former two of which can also be depleted by mammalian predator species.

"Frugivores" comprise fruit-eaters and/or nectar feeders, i.e. kereru (NZ pigeon), three parrot species, two honeyeaters, and NI kokako. None of these species appear to reach as high densities in plantation forestry as they do in nearby indigenous forests because of the scarcity of food, although at least three species (NI kaka, tui, and bellbird) also eat significant numbers of insects and could also be regarded as omnivores. Tui and bellbird are present in most plantation forests and are listed as the two "common" frugivores in plantation forests in Table 2.

Insectivorous species are the group most prevalent in plantation forests and include two cuckoos, whitehead, grey warbler, NI fantail, NI tomtit, NI robin, NI rifleman, and NI fernbird. All but the last two of these species can reach high densities in plantations. In addition, two of the three "predator" species (morepork and kingfisher), both "omnivorous" species (kiwi and silvereye), three of the seven frugivorous species (kaka, tui, and bellbird) also include a high proportion of invertebrates in their diet, taking the total number of insect-eaters to *c.*17 of the 21 indigenous bird species present in northern plantations.

Studies of other regions would reveal other species utilising plantations, e.g. weka and brown creeper. Some additional indigenous bird species commonly occur in clearfell areas of plantation forestry, e.g. kahu (Australasian harrier), spur-winged plover, New Zealand pipit, and welcome swallow. Most of these species are predominantly insectivorous, although kahu is predatory.

Some of the forest bird species present in plantation forests are threatened and would require active management for their populations to be maintained or to recover. Key issues are the impacts of predators on species such as kiwi, NZ falcon, kaka, and yellow-crowned kakariki. Other species, such as robin, whitehead, and long-tailed cuckoo, appear to flourish in plantation forests, possibly because of less intense predation levels compared with those in indigenous forests.

Table 2: Dietary categories of bird species present in northern plantation forests (Northland, Coromandel, Volcanic Plateau)

	Predator	Insectivore	Omnivore	Frugivore
Plantations - no. of species present	3	9	2	7
Plantations - no. of species common	3	7	1	2
Indigenous - no. of species present	3	9	3	7
Indigenous - no. of species common	3	9	2	7

Bats

Long-tailed bats are known to forage in a range of habitats in plantation forests, including harvested or unstocked land, young radiata pine (*Pinus radiata*) forest, mature radiata pine forest, and other exotic species, although they favour older pine forest (Moore 2001). Bats also favour roads as travel and forage routes. A study in Central North Island plantation forests found long-tailed bats to be widespread in and roosting in old crop plantation trees that have sufficient roosting nooks (Moore 2002).

Plants

It is well known that indigenous plant species can form dense and diverse understoreys within exotic plantations (Shaw *et al.* 2000; Pierce *et al.* 2002; Pawson *et al.* 2002; Brockerhoff *et al.* 2003). A recent study for Fletcher Challenge Forests (Pierce *et al.* 2002) recorded 12-26 indigenous species (and 1-10 exotics[5]) in stands of radiata pine, and 17-26 indigenous species (and only 1-2 exotics[5]) in Douglas fir stands. There were no significant differences in species richness and diversity indices in the stands of different age, plantation species composition, and at different locations in Whakarewarewa and Kaingaroa.

Species diversity/stand age relationships have been investigated previously in radiata pine by Allen *et al.* (1995) and Ogden *et al.* (1997). These studies investigated stands ranging from 1-67 years old. Allen *et al.* (1995) found that species richness in 29 year old radiata pine was similar to comparatively diverse indigenous forests, and, although there were strong species affinities with selected indigenous forest, there were also clear floristic differences. Ogden *et al.* (1997) found that richness and species composition were related to stand age and probably also to topographical heterogeneity and aspect. Similar conclusions were reached by Van Wijk (1993) and Souness (1996), and various authors have noted the likely relationship with adjacent indigenous seed sources. Greater diversity of indigenous plants is usually found in mature stands and in the second (or more) rotations which reflects responses to light availability and ground disturbance (Pawson *et al.* 2002; Van Wijk 1993).

A study by Brockerhoff *et al.* (2003) highlights the contribution of plantations to indigenous plant biodiversity. Plant diversity under age 5, 16 and 27 *Pinus radiata* plantations across four bioregions was assessed. A total of 202 indigenous plant species were recorded with a range of 48 to 135 species per site of which between 50% and 86% were indigenous. Relatively open understoreys, as found in stands of *Pinus nigra* and Douglas fir, are good habitat for orchids. It does need to be acknowledged, however, that harvesting and subsequent site preparation for planting results in the loss of practically all understorey plants.

Photo 1: Indigenous understoreys in plantation stands can be diverse and well-developed. Harvesting does have major impacts on vegetation but promotes detritivores.

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Terrestrial Invertebrates

While there is still relatively little information on terrestrial invertebrates, there are indications that indigenous invertebrate diversity in plantation stands can be very high, and even higher than nearby indigenous forest (McLean 1998; Hutcheson & Jones 1999; Hutcheson, J. unpublished), with a large proportion of endemic species

[5] *Other than the crop species.*

(Hutcheson & Jones 1999). Forest and open habitat generalists and detritivores are the most common invertebrates in plantations, while forest specialists are less likely to survive clearfelling operations and are therefore less common (Pawson *et al.* 2002). A study by McLean (1998) of invertebrates and different land uses on the Coromandel Peninsula found that indigenous diversity in pasture was comparatively low compared to that present in forest plantations.

Frogs

There is evidence that native Hochstetter's frogs (*Leiopelma hochstetteri*) are surviving in indigenous remnants in a plantation forest matrix in Northland, Coromandel, and east of Opotiki. Retention of this species will require protection and careful riparian management of the high quality small streams that they require.

Reptiles, Fungi, Mosses, Lichen, and Algae

Information on the distributions (and relative abundances) of reptiles, mosses, lichens, and algae within plantation forests appears to be limited or absent. Due to its large size and bright red colour the fly agaric toadstool (*Amantia muscaria*) is the fungi that is probably most commonly encountered by foresters. However, there are many others found within plantation stands.

Aquatic Habitats and Biota

Several studies on aquatic fauna indicate that well-managed plantation forests can provide high quality aquatic habitat (Shaw *et al.* 2000). The retention of riparian buffers during harvesting is essential to preserving this state (Graynoth 1979). Little information exists on aquatic plants in plantations but they will reflect habitat type and quality. Retention or development of healthy aquatic communities is subject to the implementation of best management practices.

Rare Species

Falcon in Kaingaroa

Perhaps one of the best and most recent success examples of a rare bird thriving in plantation forests is the New Zealand falcon or karearea (*Falco novaeseelandiae*). Recent work by raptor specialists from the Wingspan Trust has found falcon at their highest known densities within Kaingaroa Forest (Wingspan 2002). Other studies and observations around New Zealand also suggest falcon are present in relatively high numbers in other plantation forests. What's even more encouraging for plantation foresters is that this presence is associated with clearcut areas (Spurr & Colman 2002).

When you consider the nature of falcon it is not surprising that they thrive in plantation forests. The habitat created by cutover is almost perfect, with open hunting areas and abundant prey species (such as finches, quail, and other small species, which are often abundant in plantations). Falcon, generally nest in small cavities or scratches on the ground and cutover areas provide suitable sites. Being ground nesters (in plantations) and having almost no night vision falcon chicks are vulnerable to predation. However, pest control undertaken as a part of plantation management helps to control predator numbers.

Many forest companies have now realised that the presence of falcon can indeed be a very positive feature. One example is joint sponsorship by Kaingaroa Timberlands, Carter Holt Harvey Forests, and New Zealand Forest Managers of a PhD student, Richard Seaton, to study "the ecological requirements of the NZ bush falcon (*Falco novaeseelandiae*) in plantation forestry". To date the results have been more than encouraging. Twenty nests were located in Kaingaroa in the 2003/2004 season and 29 nests have already been located to date this breeding season. With a fledging rate of over two per nest this bodes well for the future of falcon in Kaingaroa.

Photo 2: A juvenile NZ Bush Falcon is measured and banded in Kaingaroa cutover.

The drivers for this apparent increase are probably a combination of greater awareness, interest, research, and the presence of greater areas of cutover.

Other rare species

As already noted, falcon are not the only rare species that actively utilise plantation forest habitats. North Island brown kiwi, Hochstetter's frogs, long-tailed bat, long-tailed cuckoo, weka, kereru, *Powelliphanta*, and kauri snails are all known to reside in plantation forests or associated indigenous remnants (Pawson *et al.* 2002; Spurr & Coleman 2002; Shaw *et al.* 2000). Others, such as kaka and kokako, are also known to visit and forage within plantation stands (Beavan 1996; Shaw *et al.* 2000). Giant kôkopu, short-jawed kôkopu, other galaxiids, and short finned eel are often found in plantation streams that have good riparian cover (Shaw *et al.* 2000).

Protection and Management in Plantation Stands

The greatest emphasis on protection of indigenous biodiversity in Regional or District plans prepared under the auspices of the Resource Management Act is generally

related to potential effects outside plantation stands, particularly related to aquatic ecosystems and indigenous remnants. Protection of indigenous remnants in plantations is also being addressed, through the Forest Accord and FSC commitments. Regulatory protection of indigenous biodiversity within exotic plantations has generally not been a concern except in limited cases where resource consent conditions have, in some cases, restricted operations in plantation stands that contain significant populations of rare species, such as kiwi. The Conservation Act provides legal protection for threatened species from threats such as poaching, but has limited relevance to indirect threats such as habitat destruction through plantation harvesting.

The voluntary protection of plantation stands for biodiversity protection is rare. For example in Kaingaroa Forest (140,000 ha) only two stands have been protected specifically for indigenous biodiversity. These are some old crop trees used by long-tailed bats at Waiotapu and a small stand of *Pinus nigra* at Iwitahi - the Iwitahi Orchid Reserve.

In many cases, particularly where various age classes are present, foresters assume that mobile indigenous species will survive and shift between stands as they develop and are harvested or that plants and other less mobile biota will continue to be represented in the different-aged stands. Little emphasis has been placed to date on understanding or actively managing biodiversity in plantation stands. The developing pressures of environmental conformance and certification are, however, now driving foresters to take greater heed of plantation stand biodiversity. This has been manifested in various approaches, including assessments, research, changed management and harvest patterns, relocation of rare species before operations, and active management to protect and enhance indigenous species.

Kaingaroa Timberlands work procedures related to falcon nests provide a good example of how foresters can manage a rare species in a plantation estate. Forest operations do not usually disturb falcon except in the nesting season when mechanical land preparation can disturb nesting birds. To minimise disturbance during this critical phase, and until the nestlings have fledged, Kaingaroa Timberlands have developed a system of recording sightings. This allows work in areas with nests to be postponed until the birds have fledged. New nests are often found by land preparation operators and in these cases strict protocols, including operational buffers, are adhered to, while allowing the operation to continue.

The increasing interest in indigenous biodiversity has led to the development of a guide for the management of rare and endangered species in plantation forests by the NZ Forest Owners Association. With funding from the Government's Biodiversity Advice Fund and technical development provided by Wildland Consultants the guide aims to provide a practical means for plantation foresters to manage rare species that may reside within their plantation estates. The guide will be internet-based and is expected to be on-line by mid-2005.

What information is available and where are the gaps?

In researching this article more than 70 references were found relating directly to indigenous biodiversity in plantation stands. While birds and understorey plants are relatively well studied, comprising 24 and 18 of the references respectively, information on other categories was very limited. For example only four references could be found on invertebrates, two on bats and none for reptiles, frogs, fungi, or micro-organisms. The balance were on general plantation biodiversity (11) and stream biodiversity directly affected by plantation management (11).

While there are undoubtedly more publications and references in non-plantation specific publications, this highlighted a relative dearth of scientific understanding on plantation biodiversity, particularly on aspects that are not obvious to the eye.[6] These species represent some of the more important components of functioning forest ecology and, in the case of invertebrates, are considered critical bio-indicators. This was recognised by Fletcher Challenge Forests and latterly Kaingaroa Timberlands who have supported a PhD student to study the effects of clearfelling on invertebrates. The project investigates the effects of clearfelling from small coupes to larger clearcuts. While the initial results are encouraging the vast quantity of data collected over three summers is yet to be analysed.

Whilst there are clear advantages for foresters to support research into icon species such as the falcon, kiwi, and kokako, there would also be potential gains, from a biodiversity perspective, of additional research into the less glamorous invertebrates and fungi. Some pleasant surprises are the likely result and, if this is the case, this will further enhance the reputation of plantations when compared with pastoral farming and cropping.

There are also still significant information deficiencies in terms of landscape level management of plantations. Key requirements include determining the age of radiata pine and Douglas fir stands at which birds will use them as corridors and for breeding, determining dispersal distances from harvest sites, and determining the levels and impacts of rats and other predators. This information can then be used to refine harvest planning, to maximise opportunities for indigenous biodiversity while not compromising economic return from plantations.

Conclusions

Well managed plantation forestry in NZ provides many environmental services and the contribution to indigenous biodiversity is an important component. Foresters have many reasons to promote the position that the mere act of growing trees (and undertaking pest control) contributes significantly to New Zealand's indigenous biodiversity. There are, though, still some significant information requirements and an active programme to address these issues will enable foresters to refine management techniques to achieve improved sustainable management.

[6] *The authors would greatly appreciate readers providing plantation biodiversity reference material to further their interest in this subject.*

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