Some issues and options for the conservation of native biodiversity in rural New Zealand

By David A. Norton and Craig J. Miller

David Norton *is Associate Professor of Conservation Biology with the Conservation Research Group, School of Forestry, University of Canterbury, Private Bag 4800, Christchurch, New Zealand. Email: d.norton@fore.canterbury.ac.nz*
Craig Miller *is a Conservancy Advisory Scientist with the Department of Conservation, Private Bag 701, Hokitika, New Zealand. This paper is based on a collaborative research programme examining ways to integrate nature conservation, as a key component of sustainable land management, within New Zealand's production landscapes.*

Summary For the 70% of New Zealand under private ownership, native biodiversity conservation has to occur within a landscape that must also provide a productive return to land owners. Recent New Zealand legislation, especially the Resource Management Act 1991, promotes sustainable management on private land by allowing for the economic and cultural well-being of local communities while providing for the protection of natural resources including native biodiversity. We suggest that, to effectively conserve native biodiversity in rural landscapes, we need to consider four key issues: (i) what might be realistic goals for native biodiversity conservation; (ii) how might we better arrange different land uses to meet both native biodiversity and production goals; (iii) what is the optimum arrangement of native biodiversity; and (iv) how native biodiversity conservation can improve productive returns to land managers. Options to enhance native biodiversity conservation include a variety of incentives (e.g. management agreements, financial incentives and regulatory systems) and onsite management options (e.g. remnant management, restoration plantings, weed and pest control, use of native species for commercial and amenity purposes, use of exotic species to facilitate native biodiversity). The importance of taking a landscape-based rather than a paddock-based approach to management is emphasized.

Key words *economic incentives, exotic species, nature conservation, restoration.*

Introduction

While much of the focus of nature conservation in New Zealand and elsewhere is on formally protected natural areas (e.g. national parks and reserves), some of the biggest problems and challenges for nature conservation lie in those areas most intensively used by humans (Molloy 1971; Molloy 1989). In these areas, native biodiversity has been and continues to be severely impacted directly and indirectly by human activities (Ministry for the Environment 1997). Remaining native ecosystems have been extensively modified and highly fragmented, extinctions are ongoing and, in extreme cases, the former native component has been totally extinguished (Ministry for the Environment 1997).

It is essential that we protect and manage the large natural areas as these provide some of the best opportunities for the long-term conservation of a wide range of native species (Mark 1985; Noss & Cooperrider 1994). But while these areas have outstanding values, they are often unrepresentative of the full range of indigenous ecosystems that would have occurred in a region and are especially biased towards upland (e.g. mountainous) ecosystems because the latter had little direct economic value (Mark 1985; Norton 1999). Historically, ecological values have rarely taken precedence over economic values in protected natural area selection and design and, even when they have, the areas protected have often been small. Although there is an awareness of the need to have truly representative protected natural area systems (Kelly & Park 1986), this is unlikely to occur in New Zealand because of the scale of native vegetation clearance and/or the desire of landholders to derive an economic return from their land. As they are not fully representative, we cannot rely on protected natural areas alone to conserve all aspects of New Zealand's biodiversity.

There is a growing awareness of the importance of areas outside protected natural area systems for nature conservation; for example, in North America (Hunter 1990; Knight 1999) and Australia (Hobbs & Saunders 1993; Saunders *et al.* 1993; Morton *et al.* 1995; Davie & Hynes 1997; Hale & Lamb 1997; Lindenmayer & Franklin 1997; Craig *et al.* 2000). Approaches towards achieving nature conservation goals are likely to differ between private and public lands. Recher (1997) commented that 'for too long Western nations have pursued the myth of nature conservation through reserves', with particular emphasis on countries and landscapes with a long history of human occupation and use. In New Zealand, reservation is often perceived as the most appropriate nature conservation tool; even on private lands. While reservation has been, and will continue to be, an important tool for achieving nature conservation goals, it cannot be the only tool. Therefore, we need to look for other approaches to nature conservation on private lands.

New Zealand's domestic legislation provides the legal context for achieving nature conservation goals within the context of sustainable land management on private lands. The Resource Management Act 1991 and the Forests Act 1949, as amended in 1993, both identify production and protection of biodiversity as important in natural resource management. The Resource Management Act seeks to 'promote the sustainable management of natural and physical resources' (Section 5(1)) where sustainable management is defined as:

> *'managing the use, development, and protection of natural and physical resources in a way, or at a rate, which enables people and communities to*

provide for their social, economic, and cultural well being and for their health and safety while:

(a) Sustaining the potential of natural and physical resources (excluding minerals) to meet the reasonably foreseeable needs of future generations; and

(b) Safeguarding the life-supporting capacity of air, water, soil, and ecosystems; and

(c) Avoiding, remedying, or mitigating any adverse effects of activities on the environment.' (Section 5(2)).

The 1993 amended Forests Act aims to 'promote the sustainable forest management of native forest land' (Section 67B) where sustainable forest management is defined as:

'. . . the management of an area of forest land in a way that maintains the ability of the forest growing on that land to continue to provide a full range of products and amenities in perpetuity while retaining the forest's natural value' (Section 2).

Both pieces of legislation position conservation and production as compatible land uses rather than as mutually exclusive land-use options. In contrast, earlier parliamentary acts such as the Reserves Act 1977, National Parks Act 1980 and Conservation Act 1987, while allowing for some economic return from the lands to which they apply (e.g. from tourism), effectively alienated these two types of land use. The recently released draft New Zealand Biodiversity Strategy (Anon 1998) outlines a strategic framework for action to conserve and sustainably use and manage New Zealand's biodiversity across all land tenures. This strategy places a strong emphasis on sustaining native biodiversity in areas outside the protected natural area system; for example, in rural production landscapes and urban environments.

This article reviews some of the issues and options available for the conservation of native biodiversity in New Zealand's lowland rural landscapes. Initially we review the status of native biodiversity in these environments and then look in more detail at four key questions that are likely to underpin native biodiversity conservation in these areas. Finally, we outline some of the options available for biodiversity conservation.

Native biodiversity in New Zealand's rural landscapes

Approximately 30% of the New Zealand land area is currently held in the public conservation estate, one of the highest protected land areas of any OECD country (Ministry for the Environment 1997). However, this is strongly biased towards upland mountainous areas with 49% of land above 500 m, and only 18% of land below 500 m, being part of the public conservation estate. These figures largely mirror the extent of habitat modification that has occurred in New Zealand since human settlement. Most of the 82% of the non-conservation land below 500 m is dominated by production ecosystems, especially pastoral and plantation forestry ones.

Prior to human settlement, New Zealand was largely forested below the climatic tree line (Molloy *et al*. 1963; McGlone 1988). Vegetation and species loss appear to have been limited during the early phase of Polynesian settlement, but there is evidence that approximately 700 years ago fires were widespread throughout both islands resulting in substantial forest loss and expansion of grasslands and shrublands (McGlone 1983; McGlone 1989; Ogden *et al*. 1998). Nevertheless, much of New Zealand was still dominated by forest when the first Europeans arrived in the late seventeenth century. The impact of European settlement was rapid and the changes dramatic. Forest was cleared to make way for agriculture and to provide timber for the new settlements, while grassland and shrubland were burnt and oversown for sheep and cattle grazing. These changes were most pronounced at lower altitudes where species-rich ecosystems, the alluvial floodplain forests, fertile wetlands and grasslands all suffered extensive loss (Ministry for the Environment 1997). In many areas small isolated forest remnants are now the only representatives of once extensive forest ecosystems (e.g. Park & Walls 1978; Burns *et al*. 2000; Norton 2000).

Despite the great changes that have occurred over much of lowland New Zealand, there are still very high conservation values in these areas — and for some species these areas are their only habitats. It has been estimated, for example, that 20% of threatened vascular plants are confined to private land while a further 60% occur on both public and private land but with many having their largest populations on private land (P. de Lange, pers. comm., 1999).

The changing patterns of native biodiversity within New Zealand's rural landscapes have been extensively documented. The following three examples are representative of what has happened nationally.

South Island's west coast

This region retains the greatest extent of indigenous forest cover and wetlands in developed New Zealand due to the rugged terrain and climate. Seventy-eight per cent of the land area (1.8 million ha) is in the public conservation estate, and many bird species that are regionally extinct or in reduced abundance in the rest of New Zealand are common here. The region has a human population of approximately 35 000 and agriculture, mining and indigenous and exotic forestry are the main productive land uses. Tourism is also a major contributor to the economy. Following European colonization in the 1860s alluvial floodplain and coastal sand forests were extensively cleared and developed. As a consequence, these forests are now represented mainly by small remnants and individual trees in the agricultural areas, and are under-represented in the protected natural area system (Awimbo *et al*. 1996). A study of riparian forest indicates that approximately 90% of forest remnants are smaller than 1 ha, with patch densities between 1.6 and 12 per km^2 (C. J. Miller, unpubl. data, 1999).

Middle Waikato Basin, North Island

This is a rich agricultural area occupying an area of 83 000 ha (Burns *et al*. 2000). The lowlands are largely fertile alluvial floodplains that were once covered with a range of coniferous forest types, including Kahikatea (*Dacrycarpus dacrydioides*) forest, and extensive sedge-dominated wetlands (Burns *et al*. 2000; de Lange *et al*. 1999). These forests were extensively cleared and developed for farming during early European settlement. A survey in 1978 identified 144 individual patches of indigenous forest, of which 121 (84%) were Kahikatea dominated, the rest being patches of gully vegetation. In 1997, 116 of the Kahikatea-dominated remnants were still present, covering an area of approximately 126 ha and with a patch density of 0.15 patches per km^2, with 70% less than 1 ha in size (Burns *et al*. 2000). The canopy and subcanopy species in these stands are largely similar and even-aged, but the density and composition of understorey species vary in response to soil moisture and the intensity or history of cattle grazing. Grazed stands have an open understorey with many exotic plant species while fenced stands have a dense understorey and larger number of native plant species. The native beetle fauna also exhibited greater species richness in stands that were fenced. The bird fauna was largely exotic, with New Zealand Pigeon/Kereru (*Hemiphaga novaeseelandiae*) and Tui (*Prosthemadera novaeseelandiae*) being occasional visitors but regionally uncommon (Burns *et al*. 2000).

South Island's Canterbury Plains

This area was covered by a mosaic of species-rich forest, shrubland and grassland approximately 1000 years BP (Molloy 1969). Forest was dominant on sites with reliable soil moisture, with shrubland and grassland dominant on soils experiencing higher moisture deficits. Pollen and macrofossil evidence shows that fire associated with Polynesian settlement resulted in replacement of much of the forest by shrubland and grassland, and while the new ecosystems were dominated by native species, many fire-intolerant species were lost. European settlement of the plains commenced in the 1840s, and within 50 years, a combination of fire and cultivation saw the majority of the plains converted to an agricultural landscape dominated by exotic plants and animals (Molloy 1969). Today, the Canterbury Plains are characterized by fields of cereal crops and ryegrass (*Lolium* spp.); clover (*Trifolium* spp.) pasture; windbreaks and plantations of coniferous and *Eucalyptus* species (Fig. 1). The vertebrate fauna now more closely resembles that of Europe than New Zealand; and the native flora is now largely confined to a few remnants on the driest soils, although occasional individual native plants persist along fencelines and water races. Unlike other parts of the world where agricultural conversion has been similarly extensive (e.g. the wheat growing areas of North America and Australia), native plants have not persisted along roadsides or in riverbeds across the Canterbury Plains. Even cemeteries provide only limited habitat for these species (Norton & Lord 1992). The native fauna has been similarly affected with only those birds that occur naturally in open communities still common [e.g. Australasian harrier (*Falco novaeseelandiae)* and Paradise Shelduck (*Tadorna variegata*)]. There are not many places in the world where only a handful of native vascular plant or vertebrate animal species can be counted along a 100-km drive!

Figure 1. Aerial view of part of the Canterbury Plains showing the modern landscape dominated by pastures, woodlots and shelterbelts.

General patterns

The Canterbury Plains are perhaps an extreme example of the extent of change that has occurred with human settlement. Similar examples can, however, be found in many other areas of New Zealand and although the persistence of native remnants is greater in some places (especially where rainfall is higher), the almost complete replacement of the native biota is widespread, especially in lowland areas. Despite a low population density, a much higher proportion of the New Zealand land area has been domesticated and native habitats disrupted than in many other countries because of the economic reliance on primary production. By 1993, for example, 52% of the New Zealand land area had been converted to farmland compared with a global average of 37% (Ministry for the Environment 1997). The striking feature of this is that most of this change has occurred at lower altitudes, especially below 500 m.

While native species and communities are far less abundant in modern rural landscapes than before settlement, some remnants are still relatively intact and may be connected to more extensive upland natural ecosystems (e.g. along stream courses), although most comprise a mixture of native and exotic elements and/or are isolated within an otherwise exotic matrix (Molloy 1971). Grazing has reduced the ability of many remnants to support native species in the long term (e.g. Burns *et al*. 2000), and fragmentation has dramatically reduced the number of remnants able to maintain interior forest conditions and species (Young & Mitchell 1994; Norton 2000). In a number of landscapes, only a few, effectively non-reproductive, individuals may remain ['the living dead' of Janzen (1988)].

Many exotic species, including both 'weedy' and 'useful' ones, have established as native biodiversity has contracted (Wardle 1991; Atkinson & Cameron 1993). These new species are now a dominant part of the modern biota of New Zealand's agricultural landscapes and present a range of new situations and challenges for native biodiversity (e.g. as new predators and competitors, and as seed dispersers). Estimates of the numbers of successfully naturalized introduced species include 45% of wild vascular plants and 32% of wild terrestrial and freshwater vertebrates (Ministry for the Environment 1997).

As human activities have intensified there have been dramatic changes in disturbance regimes (e.g. fire) and ecosystem processes (e.g. nutrient and energy transfer) (Hobbs 1987, 1993). Historical disturbances responsible for structuring native ecosystems are often restricted or even prevented (e.g. river flooding through the use of stopbanks) while a variety of new disturbances have been introduced [e.g. new grazing regimes (Burns *et al*. 2000)]. Dramatic changes in ecosystem processes also occur as productive land uses impose new conditions on the land (e.g. fertilizer application and alteration of water tables).

While much of the current pattern of native biodiversity in the production landscape is the result of human actions decades or even centuries ago (e.g. forest clearance), changes are ongoing and native biodiversity will continue to change in the future (Rose *et al*. 1995). These changes reflect the continuing dominance of humans and human-controlled processes in these landscapes. While some of the changes may be beneficial (e.g. increasing woody plant cover) many of the changes are resulting in progressive degradation of indigenous elements.

Not only will future initiatives need to work with these new ecological conditions, but they will also need to work within a cultural context that often sees only limited political and community support for substantial changes in the focus of these landscapes away from traditional productive uses. Recent Australian experience with Landcare, Bushcare and other similar programmes suggests that there is growing community and political will for sustainable landscape management. Despite considerable public profile in Australia, however, participation in such programmes is still low with some 70% of Australian farmers not belonging to Landcare programmes (Curtis 1997). Landcare-type programmes are even less well developed in New Zealand where only 180 Landcare groups existed by May 1999 (New Zealand Landcare Trust, pers. comm., 1999).

Issues for the conservation of native biodiversity

The changes that have occurred in New Zealand are the reality of modern rural landscapes and will have a strong influence on what we can expect to achieve in these areas in terms of native biodiversity conservation. In many ways, these changes act as filters that selectively influence future options for native species. The changing biota, alterations to disturbance regimes and ecosystem processes, and the ongoing management of these areas mean that only a subset of the species that might have occurred previously can occur now (Fig. 2).

The following four questions provide a framework for further considering the issues associated with the integration of biodiversity conservation and production within rural landscapes in New Zealand:

What are realistic goals for nature conservation in production landscapes?

Traditional goals for nature conservation and specifically for ecological restoration have focused on returning a site to some historical condition (Atkinson 1990) or maintaining a current state, particularly through removing all human use. These goals have often included concepts such as representativeness and rarity; the goal being to restore ecosystems that are representative of what might have occurred at the site had it not been disturbed by humans. It is clear from the level of extinctions and invasions that have occurred in rural New Zealand since European settlement that aiming to restore representative or rare communities may well be unrealistic. Furthermore, and perhaps more importantly, such goals are not possible because these areas contribute significantly

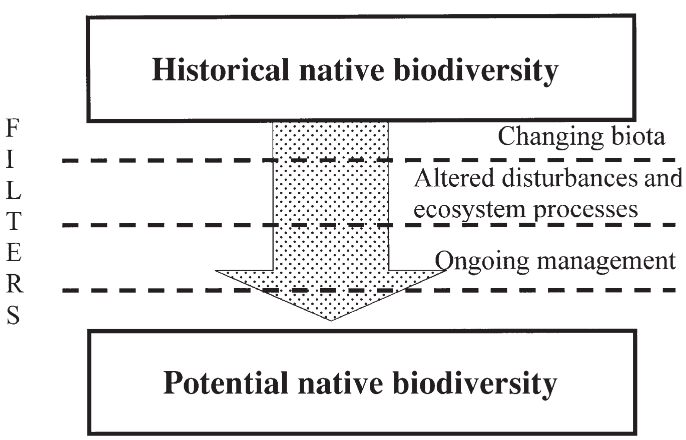

Figure 2. Factors filtering the potential future native biodiversity of agricultural areas.

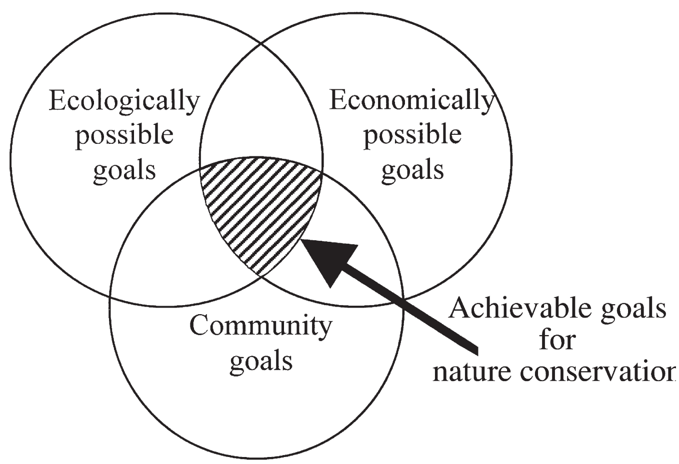

Figure 3. Potential and achievable goals for nature conservation in agricultural areas.

to the economic well-being of local communities and the country as a whole.

We need, therefore, to seek goals for nature conservation in agricultural landscapes that are compatible with the context within which these landscapes now occur, and simultaneously identify a desired future condition for the landscape. These goals need to recognize the massive transformations in biotic composition through the invasion of new suites of species and the alteration of disturbances and ecosystem processes; the need for people to derive a resource or income from the land; and the aspirations local communities have for their lands. In essence, these conservation goals will be defined where the range of ecological, economic and social possibilities for an area overlap (Fig. 3). We suggest that future initiatives that aim to restore native biodiversity in these ecosystems will need to focus on novel ecosystems comprising mixtures of native and exotic species rather than on reconstructing some previous native ecosystem type. In particular, future conservation initiatives will need to focus on the viability of native species, communities and ecosystem processes, rather than on community composition per se.

More appropriate goals might, therefore, focus on improving the viability of what is presently there and, where possible, adding new elements into the area. As such, they could comprise a number of components including some or all of the following:

1. The presence of particular species (e.g. a charismatic species and/or a species which plays a key functional role, e.g. in seed dispersal, such as Kereru). This goal is likely to include a strong social element; the local community might perceive some species to be particularly important (i.e. iconic) and their presence is likely to be a key aim for the area.

2. A satisfactory level of species or ecosystem viability (i.e. will the particular species or ecosystem persist in the future?). Assessment of this might involve the reproductive success of a species or the maintenance of a particular ecosystem process such as nutrient cycling.

3. Increasing overall native biodiversity levels within the landscape across a wide range of taxonomic and functional groups (e.g. as measured by the number of native species present), although recognizing that exotic species can fulfil many functional roles (e.g. in nutrient cycling and seed dispersal).

4. Improving the values of existing remnants through buffering, increasing habitat area and improving connectivity.

Can we better arrange different land uses within a landscape to meet both native biodiversity and production goals?

Clearly not all parts of a landscape have the same values for agricultural production or nature conservation; some parts are likely to be more critical for either activity than the other. In some cases, the key parts of the landscape may have dual values (e.g. fertile alluvial floodplains) but in other cases they may not (e.g. steep hillsides or deep gullies). It might often be possible to meet both nature conservation and production goals in the same part of the landscape, depending on where these are located relative to other land uses.

A key challenge for improving biodiversity values in productive landscapes is to better understand the area requirements and spatial dependencies of different land uses and to try to optimize landscape use to benefit both production and conservation activities (Forman & Collinge 1996). For example, are there parts of the landscape that could be utilized for biodiversity conservation without impacting on overall economic returns? Or are there opportunities to enhance economic production (e.g. through non-traditional activities such as ecotourism) or meet other sustainable management goals through protecting native biodiversity? We are not advocating the replacement of traditional production by protective uses, but rather are looking for ways to integrate the two, including the development of alternative productive uses. This might involve reducing the total area of land under traditional production uses, such as grazing, but it could also involve looking at new ways to generate economic returns while still sustaining native biodiversity.

In redesigning agricultural landscapes we need to consider the way we arrange different land-use activities as much as changing land uses themselves. For example, it has been suggested that it is the way in which forest clear-fells are spatially arranged, rather than the length of the rotation or the plantation species used, that is most important for biodiversity conservation in plantation forestry (Norton 1998). In this case, it is likely to be better to use a rotational harvesting system between native forest remnants than harvest all the forest at once, as the presence of mature plantation forest improves connectivity between the native forest remnants (Fig. 4). Similar examples may occur in agricultural systems where, for example, the location of windbreaks could help provide linkages between native forest remnants, or the location and composition of tree plantings for erosion control could benefit native biodiversity as well as production.

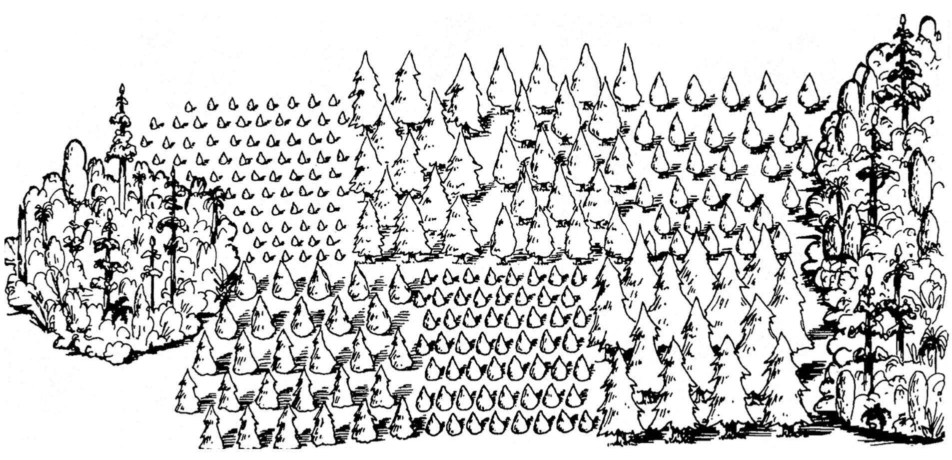

Figure 4. Plantation forest connecting two native forest areas managed on a rotational basis such that there is always continuous mature forest present (reproduced from Norton 1998).

What is the optimum way to arrange native biodiversity to ensure that it is self-sustaining?

Developing from the last question is the need to better understand the optimum way to arrange native biodiversity in productive landscapes in order to ensure that this biodiversity is itself sustaining. What spatial arrangement of different types of revegetation is required to sustain particular bird species? How can we best use shelter plantings to provide habitat or improve connectivity for species in native forest remnants? What land uses can provide key seasonal food resources for particular native species? What land uses best buffer existing native forest remnants? The arrangement of different elements within landscapes, and especially the interactions between remnants and corridors and the surrounding matrix, is a major focus of research in landscape ecology (Forman & Godron 1986; Forman 1995). A good understanding of these issues is essential for implementing integrated native biodiversity and production management in agricultural landscapes.

Can native biodiversity conservation improve productive returns to land managers?

Farmers usually see native biodiversity conservation as resulting in a net loss of productive land and net reduction in economic returns because it involves taking land out of production and placing it under protection. However, this need not be the case. Several studies have shown clear benefits for crop farmers from restoring strips of native vegetation in their fields to act as sources of predators of pest species, thus reducing pesticide usage (e.g. Pimentel *et al*. 1992; Wratten & van Emden 1995). The benefits from windbreaks for both crop and stock productivity have also been well documented (e.g. Horvath *et al*. 1997; Bird 1998; N. Reid pers. comm., 1998) and when windbreaks use native species they also benefit native biodiversity. In many areas of Australia, increased planting of deep-rooted perennials has been identified as a major need to address problems of dryland salinity (Reid 1996). Other benefits of biodiversity conservation in rural areas might include increased soil stability (and hence less erosion), provision of alternative timbers, shelter, alternative produce (e.g. honey and essential oils), and opportunities for environmental education and nature tourism. It is important that these benefits are factored into cost/benefit analyses for assessing the economic consequences of increasing biodiversity conservation in productive landscapes.

Options for the conservation of native biodiversity

Options for conserving native biodiversity in rural landscapes occur at both a policy level (how we provide appropriate incentives for biodiversity conservation) and at a more practical management level (the actual on-site management activities, informed by ecology, that can be used to achieve biodiversity conservation).

Incentives for biodiversity conservation (policy options)

Gunningham and Young (1997) have recently suggested that the best approach for providing incentives for biodiversity conservation on private land involves a mix of mechanisms targeted to the local situation including motivational, voluntary, property-based, price-based and regulatory instruments. In Australia, a mixture of management agreements, financial incentives and regulatory mechanisms have been used (Binning 1997; Binning & Young 1997) and similar approaches are likely to be applicable in New Zealand.

Management agreements These are contracts between a landowner and a third party that outlines the way the land will be managed. Entry into such agreements is usually voluntary, but the agreement can be binding in perpetuity if it is included on the property title. The New Zealand Queen Elizabeth II National Trust provides management agreements through their open space covenants which allow willing landowners to protect, in perpetuity, parts of their properties that have particular values. Such agreements usually describe the type of management that can take place in the covenanted area (e.g. set a stocking limit) and ensure that any future purchaser of the property abides by the terms of the covenant. As well as providing for the protection of particular places, such agreements may also result in the formation of a management plan to guide management by the land owner/occupier.

Financial incentives These can be used to encourage landowners to adapt their management to better meet biodiversity goals and include direct assistance with management activities, such as fencing, planting and pest control; various forms of rates relief and tax deductions; and the provision of free advice and assistance with management planning. The use of financial incentives requires a clear commitment from local and central government to the importance of biodiversity conservation in productive areas (through legislation and district plans) as they are required to provide the funding. Some degree of financial incentive is currently provided in Australia. However, in New Zealand there has been less support for such incentives. One area in which the New Zealand government has been active is in providing funds to purchase, or otherwise protect, significant areas of native vegetation from private landowners through the Nature (formerly Forest) Heritage Fund and Nga Whenua Rahui Trust. Private voluntary organizations, such as the New Zealand Native Forests Restoration Trust and the Taranaki Tree Trust, also purchase properties for conservation purposes.

Regulatory systems The New Zealand Resource Management Act requires that local authorities provide for the protection of significant native vegetation and habitat for native wildlife (Section 6(c) of the Act). Local authorities have, however, experienced some difficulties in interpreting this requirement and have suffered from a lack of guidance from the Central Government on this matter. Furthermore, lack of information or formal criteria on which to assess significance, or to determine the most appropriate ways to provide for its protection, has also been a problem in many areas, although this is now being rectified (e.g. Norton & Roper-Lindsay 1999). Some local authorities have listed areas considered significant in their proposed district plans and included regulatory rules controlling development in these areas (e.g. vegetation clearance or plantation forestry). Others have implemented more general controls in their districts; for example, on native vegetation clearance.

However, such measures have been politically controversial as different interest groups have interpreted the meaning of 'significance' and 'protection' in different ways. The regulatory approach can be an important tool for achieving biodiversity conservation, but there is a clear need for better dialogue between the parties involved and a broader perspective of how protection can be achieved than has often been the case to date.

While the Central Government has a key role to play in both funding and facilitating the conservation of native biodiversity on private land, it is not the total responsibility of Central Government to meet all of the associated costs. Under the Resource Management Act, land managers or developers are required to meet the cost of remedying or mitigating adverse impacts on native biodiversity. This reflects a changing emphasis in the way land management is perceived by New Zealand society today, a change that is asking rural land owners to increasingly forego potential productive returns in order to protect native biodiversity. The Resource Management Act requires and provides for the avoidance, remedy, or mitigation of adverse environmental effects, be they past, present, or future. However, options for addressing past effects (e.g. habitat loss) are likely to be complex and potentially controversial, and require a focus on the desired future landscape condition.

Given the increasing demands for more emphasis on native biodiversity in land management, there does appear to be a case for society in general to pay a proportion of the costs either through the Central Government (i.e. taxes) or through local governments (i.e. rates). Furthermore, a landowner or manager able to derive a good economic return from their land is more likely to be positive towards and prepared to pay for protecting and managing native biodiversity than one who is in a financially marginal situation. The issues of cost sharing in relation to implementing native biodiversity conservation in rural areas urgently require more attention in New Zealand.

On-site management (management options)

As well as direct financial incentives there are also a number of options for on-site management that will enhance native biodiversity conservation in rural areas. These include both the traditional approaches to nature conservation (e.g. remnant management, establishment of additional plantings, and weed and pest control) as well as more novel approaches (e.g. use of native species for commercial purposes and of exotic species to provide habitat for native species).

Remnant management The most important component of native biodiversity conservation on private land is to ensure that remnants of native vegetation are properly managed. While fencing is often seen as an important part of this, it is only the first step in the ongoing management of remnants (Norton 1988). Remnants may require a range of management actions including manipulation of ecosystem processes (e.g. reinstating hydrological processes), control of exotic species and re-establishment of locally extinct species (Porteous 1993).

Restoration plantings Establishment of plantings of native species to enhance existing remnants (e.g. through buffers or corridors) or through the creation of additional habitat (Porteous 1993; Smale & Meurk 1997; Reay & Norton 1999) are likely to be important in achieving biodiversity goals. In these situations, nature conservation goals are often the overriding reason for the plantings, and direct productive uses are of secondary importance. Positive production benefits, however, can flow from such plantings (e.g. as part of a land retirement area to reduce soil erosion, as an alternative form of economic return such as honey, or for sustainable timber production).

Weed and pest control These will continue to be key issues in the management of native biodiversity (Porteous 1993) because of the pervasive impacts that exotic species have on the New Zealand biota (Atkinson & Cameron 1993). However, a better understanding of the roles of exotic species in intensively managed ecosystems might result in different management actions to those taken in the past. For example, European Gorse (*Ulex europaeus*) is being used as a nurse species to encourage regeneration of native forest in some restoration projects (e.g. Wilson 1994) and exotic birds will disperse the seeds of some native plants (Williams & Karl 1996). Recent research has suggested that the Australian Brushtail Possum (*Trichosurus vulpecula*), one of the major threats to native biodiversity in many New Zealand ecosystems, might also act as dispersers of native plant seeds in some situations (Lopez 1998). While exotic species continue to be the predominant threat to native biodiversity in New Zealand, these examples highlight the need to better understand the ecology of the 'new' ecosystems that abound throughout the two-thirds of New Zealand that is in private ownership.

Use of native species for commercial and amenity purposes Such use has the potential to provide for biodiversity conservation in rural landscapes. Examples include the use of native species in plantations or shelter belts, where they can provide a direct economic return while still providing habitat for native species, or the use of native species for providing sustainable products (e.g. oil from Manuka; *Leptospermum scoparium*). The sustainable managements of tussock grasslands or native forests are also good examples of systems where economic returns can be obtained while still maintaining biodiversity values. The restoration of strips of native vegetation through crop fields in Europe has been very successful in reducing the impact of crop pests as the native invertebrate predators resident in the restored strips predate the pests (Wratten & van Emden 1995). In these situations, native species are being planted primarily with production goals in mind, but through appropriate choice of planted species or location of plantings, there can also be substantial nature conservation gains. The use of native species such as New Zealand Flax/Harakeke (*Phormium tenax*) for water treatment (e.g. associated with effluent from dairy farming) can also enhance native biodiversity while providing an important productive return. The possibility of farming native fauna for sale, harvest, or contribution to species recovery programmes has drawn polarized and philosophically opposed views (J. Craig, pers. comm., 1999), and is currently prohibited by the Wildlife Act 1953. However it may be an option in the future.

Use of exotic species to facilitate native biodiversity Tree plantings are common on farms for a variety of reasons including soil erosion control, shelter and aesthetic values.

While there is a clear advantage in using native species, the choice of an appropriate exotic species can also assist in conserving native biodiversity. For example, the planting of trees with good nectar or fruit for birds may well enhance the abundance of native birds; certainly Tagasaste (Tree Lucerne; *Chamaecytisus palmensis*), *Acacia* and *Eucalyptus* plantings on the Canterbury Plains attract Korimako (*Anthornis melanura*), a bellbird, often considerable distances from the nearest native forest remnants. In some situations, controlled grazing by exotic animals, such as sheep, can also be an important conservation tool. An absence of grazing in some New Zealand low-altitude tussock grassland ecosystems can lead to replacement of native plant species by exotic plant species, while particular grazing regimes can maintain certain native species (Meurk *et al.* 1989; Lilley 1990).

Innovative spatial design

It has been suggested that the key to enhancing native biodiversity in New Zealand plantation forests is to take a landscape perspective of the forest, viewing it as a spatial array of different elements that can be arranged in different ways depending on management goals (Norton 1998). In plantations the key elements are individual stands or compartments of trees of different age and/or species, remnants of native vegetation including riparian strips, and amenity plantings. Some of these are fixed in the landscape (e.g. native remnants and riparian strips) but others can be arranged in different ways. Spatial modelling tools have been used in North America to optimize timber harvesting while meeting biodiversity conservation goals (Bettinger *et al.* 1997; Snyder & ReVelle 1997). Similar modelling could be used in New Zealand to optimize the arrangement of different aged compartments and plantation species to maximize timber production and biodiversity conservation (Norton 1998).

There is no reason why similar approaches could not be used in agricultural systems (Forman & Collinge 1996, 1997). The key feature of such spatial modelling is that it considers native biodiversity conservation at the landscape scale rather than at the scale of a forest stand or a paddock and thus removes the direct conflict between protection and production at any given site. In developing appropriate spatial landscape models it is essential that information on both biodiversity and productive returns are obtained as a basis for determining optimal configurations. It should be possible through such modelling to answer a number of 'what if' questions about particular configurations of different land uses and to quantitatively determine spatial arrangements that optimize production and native biodiversity conservation. Such modelling is considered a key research need if we are to successfully integrate native biodiversity and production in agricultural areas in New Zealand.

Conclusions

While there have been many exciting nature conservation initiatives on private land in New Zealand there still appears to be an underlying feeling among many of the interested parties that the only way to achieve nature conservation goals is to take land out of production and legally protect it in some manner. This has led to considerable and often confrontational debate about the identification of significant natural areas in district plans and the implementation of conservation more generally in rural areas. We believe that this debate is the result of misunderstandings about the philosophical basis of native biodiversity conservation on private land, a lack of understanding of the intent of the Resource Management Act, and a lack of exposure to good working examples of how biodiversity conservation and production can be integrated in New Zealand. In this article we have explored a number of the issues that underpin native biodiversity conservation in New Zealand's agricultural landscapes and outlined some of the options that are available for enhancing such conservation. It is our belief that, through integrated land management, it should be possible to sustain both a productive return from the land and the conservation of native biodiversity. However, to be successful, it is essential that we take a landscape-based, rather than a paddock-based, approach to land management. Furthermore, Landcare groups, territorial local authorities and similar groups must work closely together in the future if we are to achieve positive native biodiversity outcomes.

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