RESTORING INDIGENOUS BIODIVERSITY IN THE EASTERN SOUTH ISLAND RAINSHADOW ZONE

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INTRODUCTION

Our contribution to this symposium focuses on the indigenous biodiversity of eastern South Island rainshadow zone. This region presents enormous challenges for conservation. The ecosystems that occur here have been strongly modified, and appreciation of their biological values and realistic goals for their conservation have been slow to emerge. Arguments for further land development for agriculture continue to compete with those for ecosystem protection. In this paper, we discuss conservation restoration goals for indigenous vegetation in modified lowland and montane environments in eastern South Island, based on an understanding of the potential natural vegetation.

WHAT ARE WE AIMING FOR AND HOW ARE WE DOING?

Goal Three of the New Zealand Biodiversity Strategy (MfE & DOC 2000) provides a clear goal for the conservation of eastern South Island's native plants for the 22nd century. The stated aim is to:

Halt the decline in New Zealand's indigenous biodiversity

> *Maintain and restore a full range of remaining natural habitats and ecosystems to a healthy functioning state, enhance critically scarce habitats, and sustain the more modified ecosystems in production and urban environments; and do whatever else is necessary to maintain and restore viable populations of all indigenous species and subspecies across their natural range and maintain their genetic diversity.*

Across New Zealand, the majority of threatened ecosystems and species occur in the lowland and montane environments that have been most modified since humans arrived. In the past, these environments have been largely perceived as unworthy of protection because of the predominance of culturally induced vegetation, and their biodiversity is poorly represented in the national protected areas network. Although about 30% of New Zealand lies within public conservation lands today, most of the land managed for conservation is in

higher, cooler, wetter environments that are less suitable for agricultural and pastoral use (Fig. 1). However, Rogers and Walker (2002) showed that by far the largest number (125; i.e. 47%) of the 264 New Zealand plants listed by de Lange et al. (1999) as threatened with extinction are in indigenous to lowland habitats (Fig. 2a). Few of the threatened species on this list occurred in the alpine zone, which is well represented in the national network of public conservation lands. A similar analysis of the latest national list (Hitchmough et al. 2002) has not been undertaken in full; however, the 40 plants that are listed as acutely and chronically threatened within the Central Otago District land authority boundaries are concentrated in both the lowland and the montane zones (Fig. 2b).

A greater degree of environmental representation (i.e. protection of more modified lowland and montane areas) will be required to maintain viable populations of the full range of New Zealand species within their natural habitats and ecosystems. This requirement to improve environmental coverage is recognised in the New Zealand Biodiversity Strategy's Priority action (b) under Objective 1.1 (Protecting indigenous habitats and ecosystems):

> *Add to public conservation lands those habitats and ecosystems important for indigenous biodiversity that are not represented within the existing protected area network or that are at significant risk of irreversible loss or decline, or in situations where public ownership is needed for effective management.*

PRESETTLEMENT ECOSYSTEMS OF EASTERN SOUTH ISLAND

The history of biodiversity loss in the eastern South Island rainshadow zone follows a similar pattern to that in other parts of New Zealand. Burning by early Māori cleared most of the forest cover of Central Otago. Hunting resulted in the extinction of nearly all of the larger birds, and predation by introduced mammals reduced populations of many smaller birds, as well as reptiles and large invertebrates. The open habitats created by the widespread clearance of forests were initially occupied by indigenous grass and shrub species that formed part of the natural succession and recovery back to forest. Relatively frequent fires maintained these seral communities until the time of European settlement.

Since European settlement, forest recovery has been largely prevented by grazing by feral animals (e.g. rabbits, deer), extensive pastoralism (e.g. sheep, cattle) and regular burning. Because grazing mammals were absent, and birds, reptiles and large invertebrates dominated New Zealand land systems through most of the Tertiary, indigenous vegetation is relatively ill-equipped to cope with

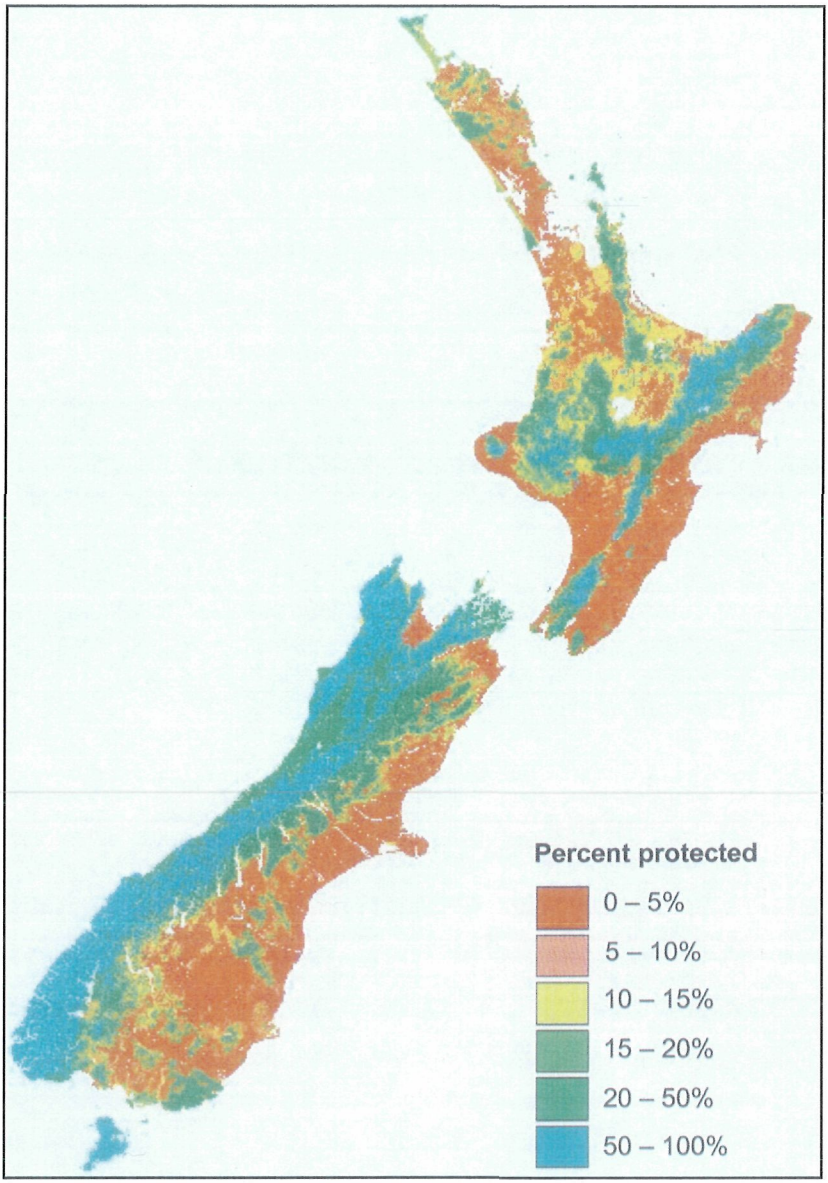

Fig.1. Percentage land area of Level IV land environments (Leathwick et al. 2003) in New Zealand's public conservation lands.

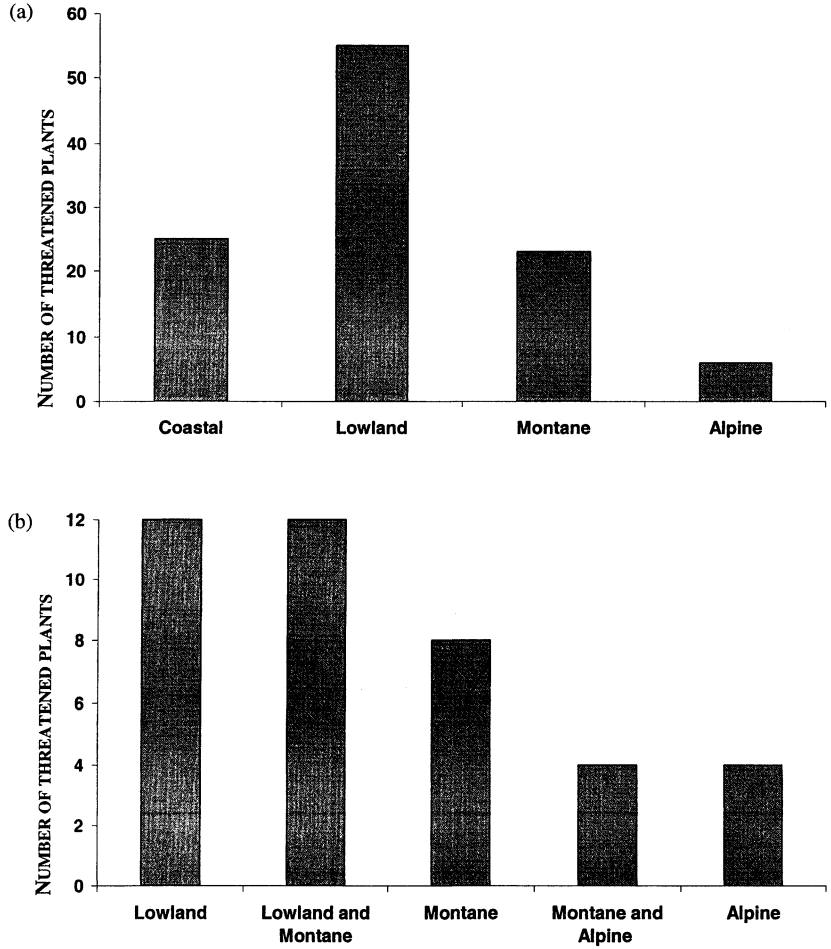

Fig. 2 Numbers of threatened plants by elevation zone: (a) using the national list and categories of de Lange et al. (1999) (after Rogers and Walker 2002) and (b) the 40 plants in Central Otago District, using the list and categories of (Hitchmough et al. 2002).

mammalian grazing, and in general, New Zealand plants have fewer of the standard defence mechanisms (e.g. spines, chemo-toxic leaves) that are common in other parts of the world. In a recent experiment, Bond et al. (2003) demonstrated that the wiry, flexible stems of New Zealand-evolved, divaricating plants are easy targets for a mammals, but less so for birds such as emus. Burning is similarly destructive of native vegetation, and the woody plants in particular have very few features (e.g. serotinous capsules, thick bark, resprouting from the base) to enable them to survive or to benefit from fire.

The rainshadow environments of the eastern South Island were particularly affected by fire following human settlement, and biodiversity loss has been extreme relative to the rest of New Zealand. For example, in Central Otago, Walker et al. (2003) estimated that prehuman forests covered about 57% of the landscape, and other forms of woody vegetation (shrublands) covered a further 22%. The most recent national Land Cover data available (i.e. LCDB1) indicate that 0.3% of the original forest cover remains in Central Otago, which is very low compared with the national average of 25% (approx. 8% of the original forest cover remains across all of Otago, Canterbury and Marlborough).

Restoring modified eastern South Island ecosystems to healthy functioning states will require an understanding of the natural vegetation and fauna that occupied them prior to human settlement. It has been known since the 1960s that tussock grasslands had replaced forest throughout much of the lowland and montane zones of the eastern South Island in the late Holocene (Molloy et al. 1963), and our understanding of presettlement vegetation is improving as more sites of subfossil charcoals, logs and pollen are investigated and published (e.g. McGlone 2001; Wardle 2001). However, present knowledge of the composition and structure of the original woody vegetation is still relatively limited.

More detailed spatial predictions of presettlement vegetation have been possible since the recent development of environmental surfaces for New Zealand (Leathwick and Stephens 1998; Leathwick et al. 2003), and advances in GIS modelling techniques (e.g. Lehmann et al 2002). These tools underpinned our recent study of Central Otago (Walker et al. 2003; Walker et al. unpublished), in which we used a large database of the locations of living relicts, and LENZ environmental surfaces, to model the potential distributions of former canopy-dominant trees and shrubs across the region. These potential distributions were classified to define 12 zones of similar potential natural woody vegetation. Modelled estimates of zone composition were refined by comparing a compilation of the charcoal, log and pollen data that has been collected by others over the years (including the studies published in Molloy et al. 1963; McGlone 2001; Wardle 2001). Our results suggested that tall forests of various compositions covered the slopes of the main ranges in the region, and that tall

tussock-shrublands grew above treeline. However, living relicts and subfossil records are rare on the valley floors, and the greatest uncertainties regarding presettlement composition remain in these zones. Therefore, we mapped the driest, coldest, frostiest 10% of the valley floors in order to demonstrate that a range of tall native shrub and tree species still grow in these areas even today, after 750 years of burning and 150 years of mammalian grazing. Because these are among the most hostile environments for plants in New Zealand, we were led to conclude that tall dry forest or tall shrublands must have dominated almost all of the eastern South Island lowlands at the time humans arrived here. It follows that indigenous grasses and herbs grew mainly as understorey species within forest or tall shrubland, perhaps dominating in local areas of extreme stress or very frequent disturbance, such as recent floodplains, very salty soils, limestone outcrops, ephemeral wetlands, shallow soils over rock, or on cliffs or bluffs. Moreover, the primarily herbaceous vegetation (grasslands, herbfields and cushionfields) that comprise the major indigenous cover on valley floors today may not be the result of an extreme environment, but largely a consequence of indigenous woody plants' poor adaptation to fire, grazing and browsing.

WHAT DO WE HAVE LEFT AND WHAT IS HAPPENING TO IT?

The indigenous grasslands that dominate in the eastern South Island lowland and montane zones today are generally recognised as the de facto natural vegetation cover. However, we question whether it is desirable ecologically and/or achievable to maintain these present-day plant communities in their present states. Our understanding of recent ecological history and the impacts of human disturbance over the last 750 years informs us that parts of the original indigenous ecosystems are now missing and degraded, and that the browse- and fire-tolerant grasses and shrubs that remain in the eastern South Island landscape tend to be the few resistant remnants of a formerly more diverse flora.

There is evidence that the condition of the remaining indigneous vegetation of the eastern South Island rainshadow zone is continuing to change under current management regimes, i.e. periodic fires, and grazing and browsing by a wide range of feral and domestic mammals (including deer, goats, sheep, rabbits, hares and possums). Studies at the landscape scale illustrate the types of changes that are occurring. For example, Duncan et al. (2001) showed that although tussock cover and stature has increased overall in recent decades, *Hieracium* (hawkweed) cover has also increased, and that native species richness has decreased markedly, particularly in small native herbs. In a study of grasslands in eastern South Island valleys and intermontane basins, Walker and Lee (2000; 2002) concluded that native tussock dominance had decreased over the few decades with continued pastoral use, and that invasion by exotic grasses and herbs had increased, especially where these grasslands were grazed by cattle.

Walker et al. (2003) drew attention to the fact that the last remnants of palatable and fire-sensitive presettlement woody dominants are undergoing continued depletion, and are not regenerating. We conclude that eastern South Island ecosystems are continuing to change: in general, they are becoming more structurally simple and more prone to grazing-tolerant exotic invaders like *Hieracium*, while the last remnants of presettlement woody flora (and its dependent vertebrate and invertebrate fauna) are declining. These trends will continue to undermine ecosystem resilience, and the prospects for long-term survival of many indigenous plants and animals.

TURNING THE TIDE: RESTORING WOODY ECOSYSTEMS

Halting the decline in indigenous biodiversity of the eastern South Island rainshadow zone will entail gradually rebuilding the native woody vegetation matrix and its associated fauna. The re-establishment of a representative spectrum of native woody communities in these deforested environments will present considerable challenges.

One issue is that perceptions of conservation priorities in eastern South Island have been dominated by the philosophy of the protected natural areas programme (PNAP), with goals based on the Reserves Act of 1977. The PNAP aimed to identify, and recommend for formal protection, the very best examples of ecosystem or habitat types, that were assumed, in aggregate, to represent the original vegetation of New Zealand. Although this approach represented a considerable advance on previous priorities, in practice, indigenous grasslands were generally perceived to be the 'original' and natural vegetation cover of eastern South Island, while modified and degraded areas were seldom recommended as worthy of protection, even if these were the last that remained of a particular ecosystem. This resulted in large areas of high-elevation land being identified as priority areas for protection, while only small areas of the lowlands were recognised as being significant. With its focus on identifying the best sites, the PNAP also failed to recognise that biological features function as linked components of larger systems, and that sites will depend upon the existence and persistence of other patches for persistence (Norton and Roper-Lindsay 1999).

Today, there is emerging recognition that

(i) present-day eastern South Island communities are seral, rather than original, and will continue to change, whether they are protected or remain under current management,

(ii) it may not be desirable to maintain sites in present condition (assuming this was possible, which we doubt), but instead, in order to maintain and restore biodiversity within an environment, it will be sensible to allow succession to later seral states to occur, and

(iii) protecting only 'elite' individual sites will not be sufficient to ensure the persistence of indigenous biodiversity, but that the wider matrix, including fragmented and modified indigenous communities, will need to be sustained also.

A second problem is that the acquisition and management of lowland and montane areas for conservation may demand considerable resources, since these places are typically of high value for agriculture and other land uses, and are often heavily invaded by weeds and pests. The vulnerability of New Zealand plants to fire and mammalian grazing has meant that there has been little recovery of forest and shrubland since the fires that accompanied initial human settlement, and it will be essential to control these pressures in order to maintain and restore eastern South Island ecosystems. However, the removal of fire and grazing pressures alone may not be sufficient to ensure recovery of degraded ecosystems, especially where seed sources are missing and exotic species are prominent. Methods and technologies may need to be developed to facilitate woody succession: for example, it may be necessary to establish nurse communities and reintroduce seed sources and dispersers. This would require a better understanding of successional trajectories, processes and timescales, and of the ecology of individual species within the woody flora. Overall, we believe that a flexible, innovative, experimental approach will be needed, with management proceeding hand in hand with research.

REALISTIC OBJECTIVES FOR RESTORATION

Many elements of the original indigenous biodiversity are now missing in the eastern South Island rainshadow zone (including the extinct birds and reptiles) and both persistent and transient alien species are now present that will influence successional trajectories in the future. We can be sure that attempts to restore indigenous biodiversity in these ecosystems will not achieve anything approaching a full replication of original structure and composition. Nevertheless, we believe that it is possible to set realistic objectives for protecting and restoring indigenous biodiversity in the eastern South Island rainshadow zone, and that many practical things can be done towards achieving these. We suggest four objectives against which progress might be measured.

Objective 1: Indigenous dominance

The first objective is to return ecosystems to the tallest, most structurally complex indigenous vegetation states that they will support. To achieve this, it may be necessary to accept the presence of many exotic species, including woody weeds, and, where possible, to use them as nurse communities in long-term successions. This would mean that weed management would focus on

taller, more competitive, and longer-lived weed species, such as pines, that native trees and shrubs are unlikely to eventually overtop. For example, following a reduction in the browsing pressures exerted by feral goats and rabbits, several indigenous shrubs, including the native broom *Carmichaelia compacta*, have regenerated in shin-high canopies of exotic thyme subshrubs in the Cromwell Gorge. Controlling thyme will not be useful, since it appears to be facilitating shrub recruitment through suppressing grass cover; we observed no recruitment of native woody species where thyme is absent and exotic grasses dominate. Both the climate and the fossil record inform us that the potential stature of the vegetation is far taller than at present, and that thyme may be gradually overtopped in the process of succession towards climax forest in the centuries ahead.

Objective 2: Regeneration

As noted earlier in this paper, many woody plants are currently not regenerating in eastern South Island environments, since freedom from mammalian grazing and browsing (as well as from fire) is a prerequisite for the recruitment of indigenous species. To enable the regeneration of indigenous woody species, it may be sufficient simply to exclude mammalian herbivores, especially where seed sources exist, and nurse communities (either native or exotic) are capable of suppressing exotic grass cover and assisting the establishment of taller, late successional native plants. For example, in Central Otago, Hall's tōtara (*Podocarpus hallii*) is regenerating vigorously beneath a canopy of kānuka (*Kunzea ericoides*) following the removal of grazing, while on Flat Top Hill several different native shrubs are regenerating with good herbivore control. Elsewhere, however, more intervention may be necessary. For example, in short tussock grassland plots at Luggate in Central Otago (Walker et al. 2003) there was little increase in woody species more than a decade after fencing. However, nitrogen-fixing woody species (native broom (*Carmichaelia petriei*) and matagouri (*Discaria toumatou*)) showed rapid growth where fertiliser was added in the absence of grazing. Ensuring self-regeneration in some other woody plants may be even more challenging, for example, where recruitment has depended on periodic catastrophic disturbance in the past. Natural recruitment of the threatened tree *Olearia hectorii* (Hector's tree daisy) may have been triggered by periodic floods in river valleys, since in recent times it has been known to recruit only in grazing exclosures following the application of a grass-specific herbicide to create a naked seed bed and reduce exotic grass competition.

Objective 3: Full potential occupancy

Fencing, controlling feral herbivores, and applying fertiliser and/or herbicides will not facilitate succession where the woody plants that were once in the landscape are no longer present. The third objective (full potential occupancy) will entail gradually reintroducing those biotic elements that have been lost in the past, but that the environment will support.

'Outcome pictures' such as the zones of presettlement woody vegetation derived for Central Otago (Walker et al. 2003) will be needed to guide species reintroductions, and it should be acknowledged that ideas and restoration management plans may change as information regarding potential natural vegetation improves.

Full potential occupancy will of course also entail the reintroduction of vertebrate and invertebrate fauna; researchers are only just starting to understand the faunal biological diversity that these far more structurally complex woody ecosystems once supported (Worthy and Holdaway 2002). There may even be a case to experiment with the reintroduction of some large browsing birds as moa surrogates, to restore key ecosystem functions such as seed dispersal, selective browsing (e.g. this might impose a competitive balance between broadleaved and divaricate shrubs), or the creation of local disturbances.

Objective 4: Environmental representation

The last goal is to ensure that sufficient areas of all environments are protected and managed primarily for long-term succession to woody vegetation. This will be necessary to provide for the long-term survival of the full range of indigenous plants and animals. The area of lowland and montane land that is presently included in the network of protected natural areas within the eastern South Island is insufficient to prevent further loss of biodiversity.

The Land Environments of New Zealand LENZ (Leathwick et al. 2003) is a recent national classification of environmental factors that provides a more objective, detailed and scaleable framework to assess environmental representation and set representation goals than do ecological regions and districts. Land environments within LENZ may be used to indicate sites that are likely to have similar ecosystem character: these would not necessarily be the same in all respects, but potentially contain broadly similar groups of species and comparable biological interactions and processes. An advantage of using an abiotic framework such as LENZ as a basis for assessing environmental representation (as opposed to an environmental and biotic classification such as ecological districts, or a purely biotic classification such as mapped land cover)

is its ability to predict the potential character of sites where natural ecosystems have been profoundly modified (e.g. by land clearance or fire) or replaced by introduced plants and animals (e.g. pests and weeds).

The tenure review of the Crown's high-country pastoral leasehold lands provides a unique opportunity to achieve improved protection and representation of the modified lowland and montane environments that hold most of eastern South Island's threatened plants. This would allow for the restoration and reconnection of fragmented, degraded or scarce habitats, and so contribute to maintaining a more complete range of New Zealand's remaining natural ecosystems. However, there is little evidence that this opportunity to secure lowland habitats for protection and restoration is being realised. Figure 3 shows the areas of land environments in Central Otago District that have been protected through tenure review. To date, tenure review has largely reinforced the altitudinal imbalance in the eastern South Island's network of reserves, and has so far added very little lowland and montane land to public conservation lands. Opportunities for biodiversity protection and future restoration are likely to have been lost through the freeholding (and consequently the more intensive development) of the lowland and montane portions of those pastoral leases.

CONCLUSIONS

To conclude, we make five points that summarise the requirements for conserving native plants for the 22nd century in the eastern South Island rainshadow zone.

1. Improve protection at low elevations

Firstly, it will be necessary to set more low-elevation land aside for conservation to halt the decline of indigenous biodiversity here. Modified lowland and montane habitats that are presently seen to have little inherent natural value should not be ignored, but appreciated and protected for their potential for the restoration of former ecosystems and habitats for threatened species. Tenure review presents an exceptional opportunity to improve the protection of modified lowland and montane environments, but this potential has not yet been realised. We also recognise that pastoral leasehold land accounts for only a part of the lowland and montane land in the eastern South Island, and that efforts to protect and restore indigenous vegetation on private land will be crucial to meeting biodiversity goals.

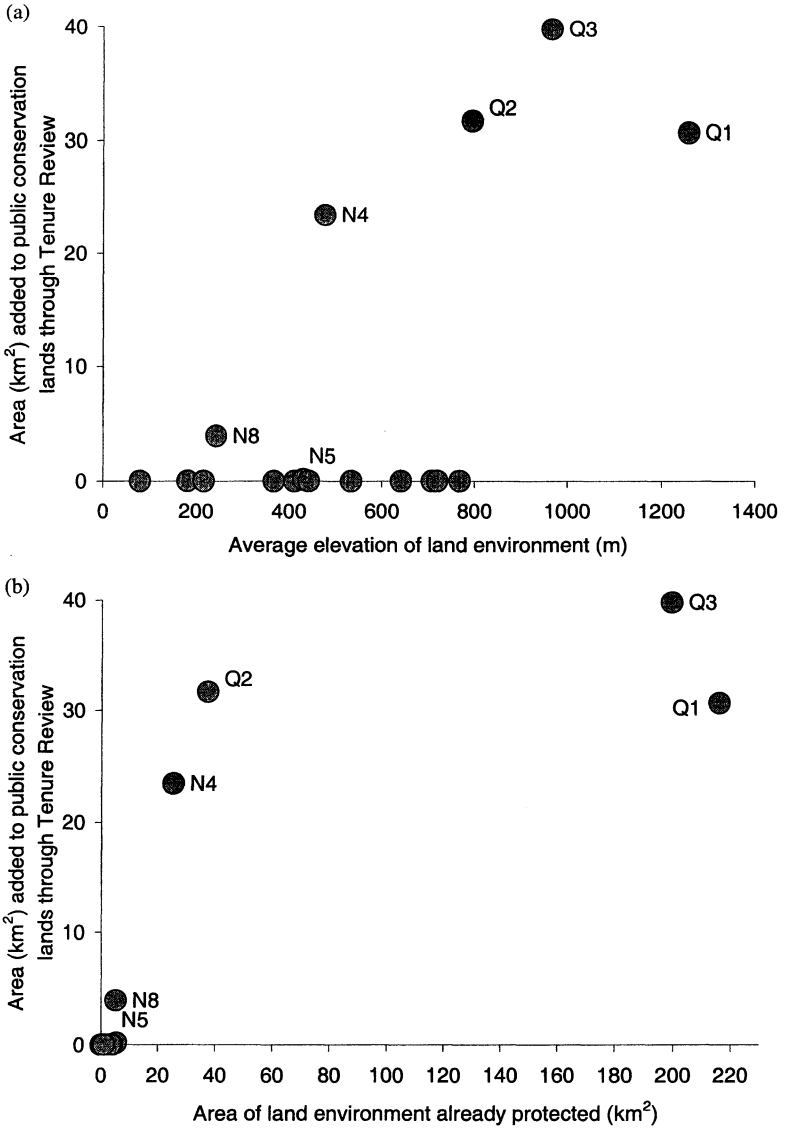

Fig. 3 Land area of Level II land environments in Central Otago District that have been protected through tenure review (a) relative to their average elevation, and (b) relative to the land area that had already been protected by means other than tenure review. Those land environments in which protection has been achieved are labelled.

2. Manage for succession and the return of the woody matrix

Secondly, we believe that the goal of conservation management in eastern South Island ecosystems should be succession to woody vegetation over very long time frames, rather the maintenance of present states (the latter has been the main theme to date in New Zealand conservation). In embracing long-term successional change, it should be accepted that outcomes are uncertain, and that some weeds may need to be tolerated. However, we suggest that tall woody vegetation will be more resilient, and more resistant to invasion in the long term than the present early successional states that predominate today.

3. Do not be limited by the need to accurately recreate predefined states

Although knowledge of the presettlement ecosystems of the eastern South Island should continue to be improved and used to guide restoration, we suggest that restoration efforts should not be limited by the need to accurately recreate any particular predefined states. Restoration efforts will inevitably result in new communities containing a suite of non-native species. Our pragmatic view is that the priority should be recovery and reintroduction of native biodiversity through succession to indigenous-dominated woody vegetation, rather than the creation of pristine or weed-free communities.

4. Take steps to prime the pump

We also believe that habitat restoration may not always proceed unassisted through natural succession processes, and that it may often be necessary to intervene and find methods to "kick start" secondary succession, e.g. to reintroduce seed sources and animals where these have been lost in the past.

5. Foster understanding and access

Finally, it is our experience that public awareness of the place and importance of shrubs in eastern South Island landscapes is low, and even antagonistic. Furthermore, the fragmented and degraded ecosystems most in need of restoration possess little of the aesthetic appeal traditionally associated with nature conservation in New Zealand, and there have been few advocates for their protection in the past. Because of their proximity to urban areas, protection will demand good community relationships, but it will also provide a significant opportunity for public participation. We suggest that a wider understanding and appreciation of the potential natural vegetation of the eastern South Island rainshadow zone, and greater public access to and involvement in dryland ecosystem restoration projects, will be essential for maintaining native plants in this century, and in the centuries after that.

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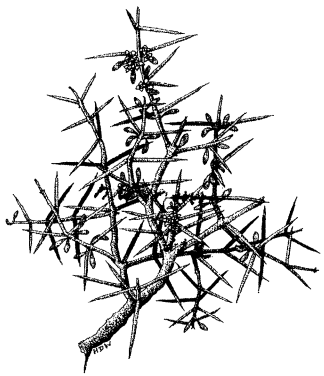

Matagouri, tūmatakuru or wild irishman (*Discaria toumatou*). Along with tawny tussock and riverbed shingle, this fiercely spiny, grey shrub epitomises the wide open spaces of the eastern South Island rain shadow zone. (del. Hugh Wilson).