New Zealand's remaining indigenous cover: recent changes and biodiversity protection needs

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Cover: Remnant of beech forest cut and burned in the 1920s–1930s, Huiarua Station, Tokomaru Bay. *Photo: P. Morrison (1974).*

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ABSTRACT

There has been substantial loss of indigenous habitat in New Zealand's coastal, lowland and montane environments—and what does remain has little legal protection. We define five categories of environments that contain indigenous biodiversity most at risk of loss due to land clearance; risk was determined based on the level of legal protection and past habitat loss. Land clearance and loss of indigenous habitats continues across New Zealand, and highest rates of loss are occurring in the most threatened environments. Moreover, ecosystems in these most threatened areas support a disproportionate percentage of New Zealand's most threatened species and habitats. Thus, this pattern of clearance will exacerbate threats to biodiversity. We recommend that the Land Environments of New Zealand database (LENZ) be used to identify environments that are most threatened by land clearance. The Land Cover Database will need to be updated regularly to monitor progress in halting biodiversity declines.

Keywords: indigenous cover loss, at risk biodiversity

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1. Introduction

This work has four objectives, addressing the current status of New Zealand's indigenous cover and change, and the consequences of the latter:

- To explain the likely consequences for indigenous biodiversity of historical (prehuman to 2001/02) changes in indigenous land cover
- To identify New Zealand's terrestrial environments (as defined in the Land Environments of New Zealand database (LENZ); Leathwick et al. 2003b) that are most vulnerable to biodiversity loss
- To calculate the area of unprotected indigenous cover, identified in the national Land Cover Database (LCDB), in threatened land environments by local authority district
- To estimate the change in indigenous land cover from 1996/97 to 2001/02 in land environments, and the consequent likely change in risk to remaining biodiversity, in each local authority district and Department of Conservation (DOC) conservancy and area

1.1 BIODIVERSITY PATTERN AND PROCESS AT RISK OF LOSS

The persistence of biodiversity requires the protection of both biodiversity pattern (the 'full range' of biodiversity from genes to species, communities, habitats and ecosystems, and landscapes) and the ecological and evolutionary processes that sustain it (Margules & Pressey 2000; Moritz 2002).

Both pattern and processes are under threat in New Zealand. Indigenous biodiversity *pattern* is under threat from 'insufficient and fragmented habitat', while *processes* are under threat from 'introduced invasive species which damage their habitat and important ecosystem processes'.

1.2 RISK OF LOSS OF BIODIVERSITY PATTERN

The first objective of *The New Zealand Biodiversity Strategy* (*NZBS*) (DOC & MfE 2000: 41) regarding biodiversity on land addresses the threat posed to biodiversity pattern by insufficient and fragmented habitat. Specifically, Objective 1.1 for biodiversity on land is to:

- Enhance the existing network of protected areas to secure a full range of remaining indigenous habitats and ecosystems.
- Promote and encourage initiatives to protect, maintain and restore habitats and ecosystems that are important for indigenous biodiversity on land outside of protected areas.

Priority actions associated with this objective require New Zealand agencies to work to protect and maintain habitats and ecosystems important for indigenous

biodiversity that are not represented in the existing protected area network or at significant risk of irreversible loss or decline.

National databases can assist agencies to identify places where biodiversity pattern is at significant risk of loss or decline. In this work, we combine databases describing land environments, land cover and protected areas to determine the extent of past habitat loss and legal protection within land environments. We use past habitat loss and the legal protection status of land environments to indicate places where the risk of irreversible biodiversity loss or decline through land clearance (and the combined effects of fragmentation, pests, weeds and other pressures) is likely to be greatest.

Specifically, this work suggests that indigenous habitats remaining in land environments that have been much reduced in the past (much reduced environments) are likely to support some of New Zealand's rarest biodiversity today. Further loss of these indigenous habitats would be a major setback to the goal of maintaining a full range of biodiversity, and could result in disproportionate loss of species (see below). Effects of habitat fragmentation are also likely to increase the risk of biodiversity loss in much reduced habitats. Indigenous habitats remaining in land environments with little of their land area legally protected for conservation purposes (poorly protected environments) are also likely to contain biodiversity at high risk of loss. This is because indigenous habitats that are not legally protected are more likely to be cleared for future land development than legally protected habitats. Unprotected indigenous habitats are also less likely to be fenced against stock, and/or to receive regular pest and weed control to maintain biodiversity.

Work to protect, maintain and restore unprotected indigenous habitats in much reduced and poorly protected environments would, therefore, make a major difference to the security of a full range of New Zealand's biodiversity.

1.3 LIMITATIONS OF THE WORK

This work directs attention to places that are vulnerable to loss of biodiversity *pattern* only. Specifically, it identifies places where biodiversity is vulnerable because remaining habitats and ecosystems are likely to be at high risk from land clearance and vulnerable to the effects of fragmentation, and where the costs of further clearance to biodiversity could be disproportionately high.

The persistence of biodiversity requires protection not only of pattern but also of essential ecological and evolutionary *processes*. Therefore, agencies with responsibilities for biodiversity must allocate their resources to maintain both. This work does not identify places where biodiversity is vulnerable to pressures that damage ecosystem processes (e.g. predators, weeds, pollution, fire, drainage and/or extractive land uses such as selective logging and extensive grazing). These pressures threaten biodiversity processes in all environments in New Zealand, not just in those environments that are much reduced and poorly protected. Many indigenous species survive today only in relatively intact, extensive and well-protected environments, depend upon ecosystem attributes and processes that have been lost from more fragmented landscapes, and remain vulnerable to ubiquitous pests, weeds and extractive land uses that continue to degrade them.

Accordingly, this work does not suggest that indigenous habitats in much reduced and poorly protected land environments are the only places that require biodiversity protection. Nor do we suggest that maintaining indigenous habitats in relatively intact and well-protected environments is superfluous to the goal of halting biodiversity decline. We simply indicate that more intact and better-protected environments will tend to support biodiversity that is less threatened by direct land clearance and the effects of fragmentation than biodiversity in much reduced and poorly protected land environments.

Unfortunately, national, spatially explicit measures and estimates of process disruption are not yet available to reveal how risks to biodiversity processes are distributed across the landscape. Although the magnitude of impacts of pattern and process loss cannot be objectively compared at this time, we may be sure that their combined effect is considerably greater than loss of pattern (i.e. habitat loss) alone. Therefore, our assessment of threat to remaining indigenous biodiversity in environments on the basis of habitat (pattern) loss and legal protection will considerably underestimate actual threat.

2. Background

2.1 PAST LOSS OF BIODIVERSITY AND THE THREAT OF EXTINCTION

Historically, protection for New Zealand's indigenous biota has largely been opportunistic, expedient and ad hoc (Kelly 1980). As a consequence, the national network of protected areas is strongly skewed towards higher, wetter, mountainous environments, and there is little protection of habitats and ecosystems in productive lowland and montane environments. There has also been differential concentration of human impacts and loss or removal of indigenous biodiversity across New Zealand's environments. In general, environments of the alpine and upper montane zones remain dominated by indigenous cover, while environments of the warmer lower montane and lowland zones contain only traces of indigenous communities, as a consequence of more intensive land-use activities.

Similarly uneven patterns of protection and loss are evident in most nations in the world (see Pressey et al. 1993; Pressey 1994; Stewart et al. 2003). Worldwide, the consequences include increased loss and extinction of indigenous species in those habitats and ecosystems where indigenous habitat loss has been greatest, and where the proportion of land set aside for protection is smallest (e.g. Heijnis et al. 1999; Heydenrych et al. 1999; Gaston et al. 2002).

Direct (or 'active') clearance for human land use (e.g. ploughing, felling, planting in exotic forestry trees) is the principal cause of loss of indigenous cover in New Zealand. Some additional loss also occurs through attrition and the deterioration of fundamental processes (or 'passive' clearance; e.g. dieback of forest edges may be caused by browsing). The consequences of habitat loss for biodiversity are perhaps most plainly illustrated by the distribution of threatened plant species,

which is strongly skewed towards lowland environments (e.g. Rogers & Walker 2002). For example, of New Zealand's 278 Acutely and Chronically Threatened vascular plant species—the two highest categories of extinction threat in the New Zealand threat classification system of Molloy et al. (2002)—20% are coastal, 37% occur in the lowland zone and a further 31% in the montane zone, while the subalpine and alpine zones contain only 7% and 5%, respectively (de Lange et al. 2004). The concentration of threatened species at low elevations is also seen at the regional scale. For example, Lee & Walker (2004) report that 80% of the Acutely and Chronically Threatened vascular plants of the inland Central Otago District occur in the lowland and montane zones.

2.2 THE VULNERABILITY PRINCIPLE

It is recognised in New Zealand (e.g. in *NZBS* (DOC & MfE 2000: 41, Objective 1.1a, above)) and internationally (Margules et al. 1988, 2002; Rouget et al. 2003) that there is an urgent need to establish more representative networks of protected areas if much of today's biodiversity is to survive into the future. However, some species, habitats and ecosystems are less likely to persist under current and future land-use trends and pressures than others[1]. Therefore, over time, realistic opportunities for the protection of biodiversity are reduced, by incremental or rapid loss, to a subset of the full range. This subset will typically contain only those elements of the full range that are safest from clearance, pest invasion and other pressures (Pressey & Taffs 2001a, b; Rouget et al. 2003).

Because realistic opportunities for the protection of biodiversity decrease over time, achieving representativeness becomes less likely. If representativeness is to be achieved, priority for protection must be given to the most vulnerable elements of the full range of biodiversity pattern, i.e. those ecosystems, communities and/or species for which there is the greatest likelihood of imminent loss or degradation (World Resources Institute 1992; Pressey 1994; Pressey & Taffs 2001b).

This vulnerability principle ('priority for protection must be given to the most vulnerable elements of the full range') is emphasised in the *NZBS* (DOC & MfE 2000). For example, the first Priority Action (Objective 1, Biodiversity on Land, Action b) states that priority for addition to public conservation lands should be given to 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'.

These two characteristics—poor legal protection and risk of loss—are two components of vulnerability.

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[1] For example, The *NZBS* (DOC & MfE 2000: 34) highlights a number of examples of imminently threatened 'scarce habitats' that remain largely unprotected and vulnerable to ongoing decline because of the pressure to clear land for intensive use (e.g. agricultural development, urbanisation) and/or the pressures imposed by introduced weeds. In contrast, most alpine and forest environments are comparatively safe from direct clearance, since they are largely legally protected, and are either unsuitable for human use or remote from human-induced pressures

2.3 LAND ENVIRONMENT UNITS

LENZ provides a national spatial framework of units ('land environments') to assess the vulnerability of remaining indigenous habitats and ecosystems. We use the measures 'poor legal protection' and 'susceptibility to biodiversity loss' (SBL), respectively, to represent the two components of vulnerability within land environments.

2.4 INDICATING POOR LEGAL PROTECTION

New Zealand is an island with an unusual evolutionary history of prolonged isolation, and its indigenous biodiversity is distinctive and particularly vulnerable to introduced herbivores, predators and weeds (e.g. Atkinson & Cameron 1993). These ubiquitous pressures reduce the viability and persistence of biodiversity across the landscape (including legally protected areas), and active ongoing intervention is generally needed to secure biodiversity (Perley et al. 2001). The combination of innate vulnerability with extreme habitat loss in lowland environments has resulted in New Zealand having one of the worst records of biodiversity loss of anywhere on earth (DOC & MfE 2000: 4). In Australia and other Commonwealth nations, legal protection of 15% of original ecosystem extent has been adopted as a pragmatic (and arbitrary) target for conservation planning purposes (e.g. Pressey & Taffs 2001a). However, to sustain biodiversity in New Zealand, it is probably necessary to retain and actively manage indigenous biodiversity across greater proportions of the original ecosystem than in most other nations.

Accordingly, we suggest that in New Zealand a safety net of legal protection covering at least 20% of the original area of each land environment is desirable to retain a full range of biodiversity (see Lee & Walker 2004; Walker & Lee 2004; Walker et al. 2004). Support for this suggestion is also drawn from the species–area relationship (see section 2.5.1), which indicates that indigenous biodiversity decreases particularly rapidly once less than about 20% of original habitat remains (but as we note in section 2.5.2, the onset of rapid decline may occur earlier owing to isolation, co-extinction and other associated factors).

2.5 INDICATING RISK OF LOSS (SBL)

Generalisations from ecological research suggest that risk of future biodiversity loss is related to the extent of past loss of natural habitat. Below we give synopses of two relevant generalisations from ecological science: species–area relationships and fragmentation effects[2].

[2] The species–area relationship and fragmentation effects are the basis for various international predictions of extinction risk related to habitat loss (see for example Brooks et al. 1997, 1999; Fahrig 1997, 2002; Thomas et al. 2004).

2.5.1 The species–area relationship

Characteristics of the species–area relationship

The generalised species–area relationship describes the relationship between area of habitat and that habitat's species richness (i.e. the number of species) (Rosenweig 1995) (Fig. 1). The relationship between the extent of an area (A, being the proportion an area relative to a reference area) and the number of species (S, being the proportion of species relative to a reference number of species) that it holds is not linear, but a curve, usually described by the generalised power function ($S = A^z$ where $z < 1$). That is, the number of species contained in any area (be this a quadrat, a paddock, a lake or a mountain range) will be more than half the number of species in an area twice that size.

The species–area relationship is derived from the sampling of areas of different size and is a consequence of the manner in which species are distributed along environmental and geographic gradients. The shape of the species–area curve depends on body size and life history and, therefore, differs for different biotic groups (e.g. vertebrates, plants, micro-organisms). It also varies across different habitats, ecosystems and landscapes. Nevertheless, the general shape of the curve remains the same (Fig. 1).

The species–area relationship predicts that any loss of part of the area occupied by an ecosystem, habitat or community will lead to the loss of some species associated with it. With initial decreases in area (upper right portion of the curves in Fig. 1), the rate of species loss may be relatively low. The plants and animals most likely to be lost from a habitat at this early stage of habitat loss include large-bodied, host-dependent, and/or habitat-specialist species with a narrow range, as well as those dependent on large, contiguous habitats.

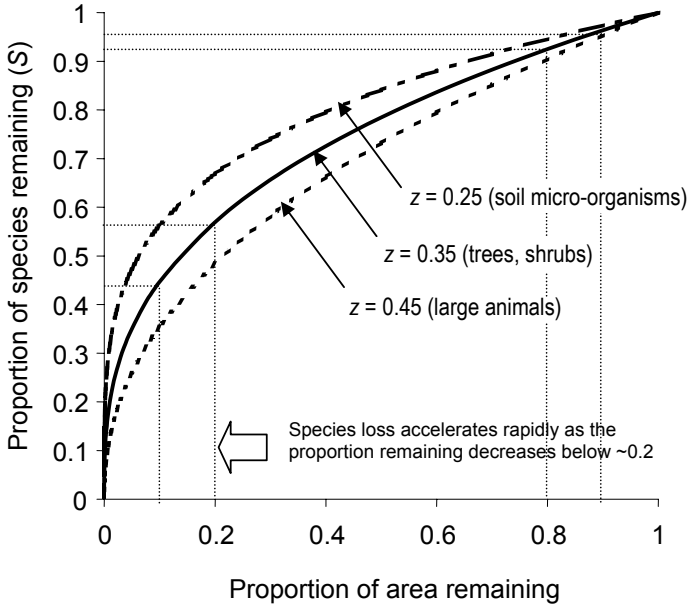

Figure 1. Generalised species–area relationship applied to the proportion of indigenous habitat remaining (A), showing curves for biota of different body size (z = 0.25, 0.35 and 0.45). The vertical and horizontal lines are interpreted in the text.

As habitat area is further reduced, the rate of species loss increases, and biota in smaller size classes also become affected (middle portion of the curves in Fig. 1) together with more wide-ranging, generalist species. As the area of indigenous habitat decreases, each increment of further loss results in a greater magnitude of loss of remaining biodiversity (lower left portion of the curves in Fig. 1). However, because of the nature of the relationship between area and richness, the last indigenous remnants in an environment are predicted to still contain a proportion of the biodiversity associated with that environment.

Indicating SBL using the species–area relationship

A species–area relationship with an exponent (z) of 0.35 (see Fig. 1) may be an appropriate 'average' to apply to biodiversity protection in New Zealand. This exponent represents the end of the range of 0.25–0.35 suggested for islands (Rosenweig 1995) and is most appropriate for prominent components of vegetation, which are readily recognised (including by remote sensing), and is often pragmatically used as a surrogate for other elements of indigenous biodiversity.

The curve of the species–area relationship with an exponent $z = 0.35$ predicts that a 10% change from 90% to 80% remaining habitat (i.e. a change in the proportion remaining from 0.9 to 0.8) will remove 3.9% of the original full complement of species and 4.0% of those remaining in an area, but a 10% reduction from 20% to 10% remaining habitat removes 12.3% of the original full complement of species and 21.5% of the species remaining. (These different rates of loss are indicated by the distances between each pair of horizontal lines in Fig. 1.)

We refer to this increasing rate of loss as habitat loss proceeds as 'susceptibility to biodiversity loss' or 'SBL'. It can be quantified as a function of the proportion or area of habitat remaining, being the derivative of the generalised species–area relationship (i.e. the slope, or instantaneous rate of change at any point; Fig. 2).The mathematical expression to calculate SBL is based on a generalised species–area relationship with an exponent of 0.35:

$$\text{SBL} = 0.35 \times (\text{proportion remaining indigenous cover}^{(0.35 - 1)}).$$

SBL ranges from 0.35 in an intact habitat to infinity when habitat area remaining is negligible (Fig. 2).

In this work, we use SBL to indicate the relative impact of any increment of further habitat loss within an environment, based on the loss that it has undergone in the past.

2.5.2 Fragmentation effects

The species–area relationship and SBL indicate the likely non-linear consequences of loss of habitat area for remaining biodiversity. However, in biological systems, habitat loss and fragmentation also alter the *nature* of habitat, with negative consequences for biodiversity beyond that due to the loss of habitat area alone.

Some fragmentation effects, like area effects, are also non-linear. In other words, as with the species–area relationship, their effects increase more rapidly in severity as habitat loss advances. For example, Andrén (1994) demonstrated that there is a rapid increase in the average distance between habitat patches (isolation) as the proportion of habitat in a landscape decreases below about 0.3 (or 30%) (Fig. 3).

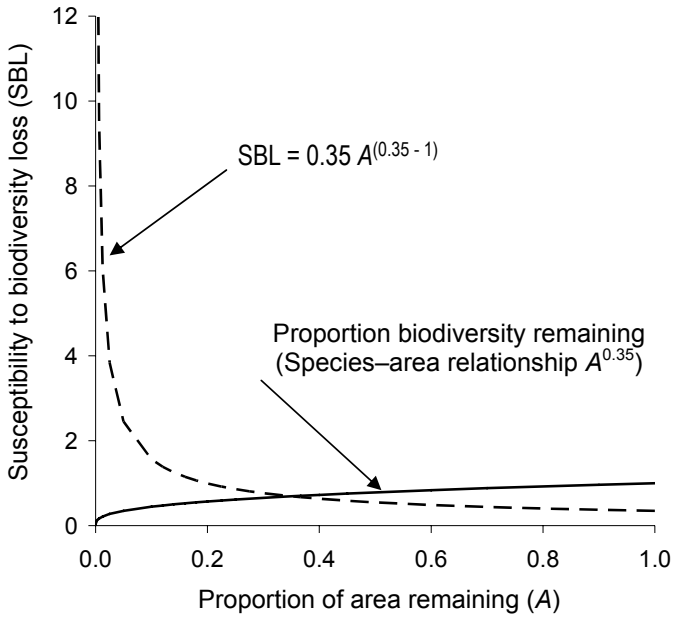

Figure 2. Susceptibility to biodiversity loss (SBL) v. the proportion of species remaining for each land environment (*A*). SBL is the instantaneous rate of change at any point of the species–area curve where $z = 0.35$.

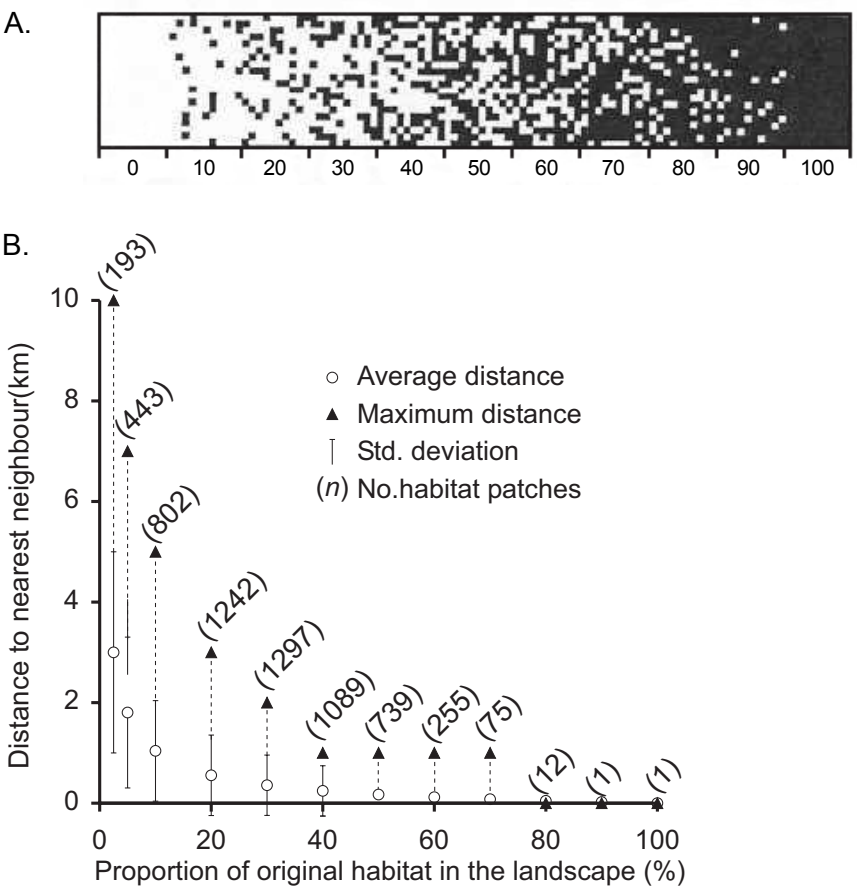

Figure 3. Average and maximum simulated isolation (distance to nearest neighbouring habitat) in relation to the proportion of habitat remaining based on simulations of habitat fragmentation (redrawn from Andrén (1994)). A: One possible configuration of fragmentation of habitat (black pixels). B: Average and maximum isolation of remaining pixels derived from multiple random spatial configurations of fragmentation for different proportions of remaining habitat.

Increased distance between habitat patches can: limit species' access to key resources; restrict the potential of migration for species and populations (for example, as climate change progresses); and prevent the exchange of genetic material between populations. Resulting inbreeding then lowers long-term viability and limits resilience (i.e. ability to survive extremes or adapt to change). For a New Zealand example, see Berry et al. (2005). Andrén (1994, 1996) suggested that increased isolation may lead to sharp population declines once a threshold of loss (generally between 10% and 30% habitat remaining) is exceeded. As with the species–area relationship, this threshold is likely to vary across different landscapes and biotic groups.

The ratio of fragment edge to fragment interior area also increases exponentially as the average habitat patch area decreases with increased habitat loss. Small fragments in modified landscapes may be largely or entirely edge habitat (i.e. they have little or no buffered interior). The adverse physical and biological consequences of high edge-to-interior ratios include increased exposure to desiccation and climate extremes, and increased penetration by weeds and pests (Harrison & Bruna 1999).

Effects of fragmentation may contribute to more rapid biodiversity loss, and higher risk to remaining indigenous biodiversity, than would be predicted by habitat area loss alone. Consequently, the onset of rapid loss of biodiversity is likely to commence earlier, and declines may be more rapid than suggested by the species–area relationship and measures such as SBL that are based on it.

2.5.3 Limitations of the SBL measure

The SBL measure indicates the relative risk to remaining indigenous biodiversity within any land environment, based on the species–area relationship. Our application of the index is straightforward: environments are treated as individual units, and no attempt is made to account for relationships among environments (e.g. the effect of habitat loss within one environment on biodiversity within another, adjacent or similar environment). The index does not quantify actual biodiversity either within or across environments; this is because understanding of potential and actual biodiversity patterns is still too rudimentary to allow us to do so. It is very likely that more sophisticated measures of risk to indigenous biodiversity across landscapes will be developed in the future, based on a deeper and more detailed understanding of actual and potential biodiversity pattern within and across environments.

2.6 THREAT CATEGORIES FOR NEW ZEALAND'S LAND ENVIRONMENTS

We propose a classification of threat to the remaining indigenous biodiversity in New Zealand's land environments based on the two components of vulnerability (likelihood of loss): poor legal protection and risk of loss.

We use the past level of habitat loss (represented by percentage remaining indigenous cover) as the primary threat criterion. Based on the above principles (species–area relationships and fragmentation effects), remaining indigenous biodiversity within environments with less than 30% indigenous cover is

considered 'threatened' by land clearance (Table 1). Indigenous biodiversity is classified as 'At Risk' in environments where 20–30% of indigenous cover remains, and 'Chronically Threatened' in environments where 10–20% indigenous cover remains. When less than 10% of indigenous cover remains, indigenous biodiversity is considered to be 'Acutely Threatened'. We have chosen the terminology for these three threat categories to be consistent with the national system for classifying species according to threat of extinction (Molloy et al. 2002)[3].

Two further threat categories are erected to take poor legal protection into account (Table 1). Environments that have more than 30% indigenous cover remaining and are poorly protected (i.e. they have less than 20% of their area under legal protection) are categorised as 'Critically Underprotected' if less than 10% is protected, and 'Underprotected' if 10–20% is protected.

For convenience, we refer to environments within any of these five categories as 'threatened environments'.

Environments that have been less preferred for intensive land uses in the past, and have a fifth or more of their land area protected against future loss, fall into a sixth category that we name 'Less Reduced and Better Protected' (more than 30% indigenous cover remains, and over 20% of it is protected). This name reflects that biodiversity within these environments is not entirely secure; rather, it remains vulnerable to future loss should land-use patterns change, and to ubiquitous pests and weeds. Vulnerable elements of the full range of biodiversity (e.g. large-bodied, host-dependent and/or habitat-specialist species with a narrow range, and those dependent on large, contiguous habitats) will be lost from environments well before loss of 70% of original habitat has occurred. Therefore, environments that are less reduced and better protected today support indigenous species that can survive only in relatively intact, extensive and well-protected environments. Their persistence will depend on the maintenance of extensive areas of native cover, and of healthy, functioning ecosystem processes that have been lost from the more fragmented landscapes represented in threatened environments.

TABLE 1. THE SIX RECOMMENDED LAND ENVIRONMENT CATEGORIES, AND DEFINING CRITERIA.

NO.	CATEGORY	CRITERIA
1	Acutely Threatened	< 10% indigenous cover remaining
2	Chronically Threatened	10–20% indigenous cover remaining
3	At Risk	20–30% indigenous cover remaining
4	Critically Underprotected	> 30% indigenous cover remaining, < 10% legally protected
5	Underprotected	> 30% indigenous cover remaining, 10–20% legally protected
6	Less Reduced and Better Protected	> 30% indigenous cover remaining, > 20% legally protected

[3] The New Zealand threat classification system was designed specifically for taxa that occur in New Zealand. Three higher-order categories and seven classes of threat are recognised, in order of increasing threat: At Risk (Range Restricted and Sparse classes), Chronically Threatened (Serious Decline and Gradual Decline classes), Acutely Threatened (Nationally Critical, Nationally Endangered and Nationally Vulnerable classes).

3. General methods

3.1 DATA SOURCES

Five sources of spatial data in digital format (GIS shapefiles and grids) were used in the analyses.

3.1.1 Land Cover Database

Three versions of the Land Cover Database are available:

- LCDB 1_2 (derived from satellite imagery acquired in 1996/97, second version, released in 2001, 14 cover classes)
- LCDB 1C (corrected version, derived from satellite imagery acquired in 1996/97, released July 2004, 43 classes)
- LCDB 2 (derived from satellite imagery acquired September 2001–March 2002, released July 2004, 43 classes) (Terralink 2004)

We used LCDB 1C as the principal data source defining the status of indigenous cover in New Zealand in the summer of 1996/97. LCDB 2 was used to represent land cover in 2001/02. Note that in this report LCDB 1C is referred to as 'LCDB 1' and that LCDB 1_2 data are presented only in section 4.6.

The 43 classes of land cover within LCDB 1 and LCDB 2 were assigned to indigenous (22 'natural' LCDB 2 cover classes) and non-indigenous (21 'exotic' LCDB 2 cover classes) categories (Appendix 1). A third category (non-indigenous cover recently disturbed, 'NIRD') was developed for LCDB 2 and represents areas that had been classified as 'Non-indigenous' in 1996/97 that had changed by 2001/02 to one of the following LCDB 2 classes: 10, Coastal Sand and Gravel; 11, River and Lakeshore Gravel and Rock; or 12, Landslide. Because NIRD areas do not represent recovery of indigenous vegetation, and are unlikely to revert to indigenous cover over time, we assigned them to non-indigenous cover.

As stated previously, past level of habitat loss was to be our primary threat criterion, so the percentage of indigenous cover remaining in an environment in 2001/02 (based on indigenous cover classes of LCDB 2) was used to estimate the risk to remaining biodiversity within that environment, i.e. its SBL. Change in the percentage of indigenous cover remaining in an environment between 1996/97 and 2001/02 was used to estimate the change in the risk to indigenous biodiversity within an environment.

3.1.2 LENZ

The LENZ classification (Leathwick et al. 2003b) identifies the diversity of New Zealand's terrestrial environments, based on climate, soil and landform. Because these factors are major drivers of the patterns of living organisms, it is reasonable to assume that each different environment supported a unique assemblage of ecosystems, habitats and species in the past—not different in all respects, but in important features, from that in other environments. LENZ can, therefore, be used as a surrogate for the potential 'full range' of terrestrial ecosystems, habitats and biodiversity once found across New Zealand.

Land environments are classified at four different national scales: Level I (20 land environments, A to T), Level II (100 land environments, A1 to T1), Level III (200 land environments, A1.1 to T1.1) and Level IV (500 land environments, A1.1a to T1.1a). Each level is nested within higher levels.

Because LENZ is not a map of ecosystems or vegetation, but a map of abiotic environments; the boundaries often divide environmental gradients that are generally not visible on the ground. Because environmental gradients are often gradual rather than sharp, and because the land cover seen on the ground today is the product of both history and environment, current vegetation patterns are most unlikely to ever match LENZ boundaries. Even at the finest level of LENZ (Level IV), each land environment is likely to contain a variety of native habitats and ecosystems that grade continuously into habitats and ecosystems of adjacent environments. Loss and protection statistics for a land environment are an average taken across the different native habitats and ecosystems contained within it.

3.1.3 Protected areas

We used the 'protection' dataset compiled for MfE, DOC & LGNZ (2004), comprising land managed by DOC, and covenants administered by the Nature Heritage Fund, Nga Whenua Rahui and Queen Elizabeth II National Trust. Limitations and methods relating to these data are described by Rutledge et al. (2004). Note that council-protected lands are not included in this dataset.

The percentage area of land and/or indigenous cover of a land environment that is protected (i.e. set aside for biodiversity conservation purposes) is a useful index of how well the ecosystems, habitats and biodiversity associated with that environment are protected from further loss (Leathwick et al. 2003a; Lee & Walker 2004).

3.1.4 Districts, regions, DOC conservancies and areas, and pastoral leases

To define political districts and regions, we used national GIS databases delineating 73 local authority districts and cities, and 16 local authority regions. We did not split political districts where they spread across more than one political region (e.g. Franklin District, which spreads across Auckland and Waikato regions, was kept distinct) (Table A2.1). DOC supplied spatial data showing its conservancy and area boundaries in August 2006. To define the spatial extent of the 304 pastoral leases in the South Island high country, we used a spatial database of lease boundaries supplied by DOC in January 2004.

3.1.5 Land-use capability

Eight classes of Land-use capability (LUC) were used from the NZLRI (New Zealand Land Resource Inventory; held by Landcare Research). The NZLRI is a spatial database of 100 000 polygons (land parcels) covering the whole of New Zealand. The characteristics or attributes (e.g. rock, soil, slope, erosion, vegetation, LUC) of each parcel of land is described. LUC is an assessment of the land's capacity for sustained productive use taking into account physical limitations, soil conservation needs and management requirements. 'Class' is the most general unit of LUC, categorising land into eight classes, from Class I (the most versatile and productive class with the highest value for agricultural production) to VIII (the class with most limitations to use and, therefore, the lowest value for agricultural production).

All shapefiles were converted to 25-m grids for analysis. The spatial database and analysis methods were based on, and described by, Rutledge et al. (2004).

3.2 DATA ANALYSIS

3.2.1 Identifying threatened environments

Using LENZ, LCDB 2, and the protection dataset, we calculated (1) the total area of each land environment and (2) the area of each land environment within an indigenous cover class (hereafter referred to as 'indigenous cover remaining'), and (3) the area of each land environment that was legally protected. Then, for each of the five environment threat categories, we calculated the number of land environments, the total area of the environments, and the total area of indigenous cover.We then assigned each land environment to one of six categories, based on the criteria in Table 1. This analysis was performed twice, with categories determined at Levels IV and II of LENZ, respectively.

To provide an overview of the distribution of threat categories across New Zealand's land environments, we (1) calculated the number of Level IV land environments in each threat category within each Level I land environment, and (2) mapped the national distributions of threatened environments.

3.2.2 Indigenous cover not protected

We calculated the area of each land environment that was under indigenous cover and not within legally protected land (indigenous cover not protected, hereafter 'INP') in 2001/02. We then calculated the area of indigenous cover not protected in the first five land environment categories referred to as 'threatened environments' (hereafter 'INPTE'). Next, we calculated the area of INPTE in each of New Zealand's 73 district councils in DOC conservancies and areas, and in each threatened environment category. We also calculated the area of INPTE within the boundaries of the 304 pastoral leases remaining in the South Island High Country. Again, each of these analyses was performed twice, with land environment threat categories determined at Levels IV and II of LENZ, respectively.

3.2.3 The appropriate LENZ level to assess threatened environments

Next, we compared the effectiveness and efficiency of threat categories determined at Level II and Level IV. First, we illustrated effectiveness and efficiency by examining variability of protection and land clearance, of biodiversity pattern, and of current land cover types across Level IV environments within a given Level II environment (F1).

We then quantified, across all land environments, land areas affected by two issues arising from threat classification at Level II, rather than Level IV. First, we quantified the *less effective* protection that would arise because the areas are assigned to a lower category of threat, or to the 'Less Reduced and Better Protected' category. Second, we quantified the *less efficient* protection resulting from areas of indigenous cover being classified as 'threatened' when in fact they were less reduced and/or better protected.

3.2.4 Land-use capability in areas under indigenous cover, but not protected, in threatened environments

We calculated the area of indigenous cover not protected (INP) in each of eight LUC classes and each of the six land environment categories. This analysis was performed twice, with land environment categories determined at Level IV and Level II of LENZ.

3.2.5 Changes in indigenous cover from 1996/97 to 2001/02 and subsequent risk to remaining biodiversity

By comparing LCDB 1 and LCDB 2, we quantified the total change and net loss of indigenous cover from 1996/97 to 2001/02 by environment threat category and indigenous cover class. We calculated the rate of loss of indigenous cover from 1996/97 to 2001/02 in each land environment as a percentage of LCDB 1 (i.e. 1996/97) indigenous cover. We then calculated the change in SBL for each Level IV land environment from 1996/97 to 2001/02, based on the total area (and hence proportion) of indigenous cover remaining at each date.

We compared these changes across land environment threat categories determined at LENZ Level IV only. We quantified the contribution of each of the 73 council areas, and each DOC conservancy and area, to change in indigenous cover, and to summed change in SBL across New Zealand's land environments from 1996/97 to 2001/02, by threatened environment category.

3.3 DATA LIMITATIONS

Existing national large-scale environmental, biological and protection databases are surrogates for the pattern of environments, biota and protection across New Zealand. They all have limitations for application on the ground at the scale of individual properties and areas. Particular concerns, and some implications, are noted below.

3.3.1 Environmental information

LENZ is based on 15 environmental variables with known relevance (e.g. trees, ferns, land snails) for biodiversity pattern. It does not contain all of the environmental variables that affect biodiversity pattern. It is of limited use in identifying small-scale ecosystems and habitat types that are controlled by local, extreme environmental conditions such as limestone outcrops (karst), and geothermal and various wetland (and floodplain) ecosystems.

3.3.2 Land cover

In these analyses, we took the cover classes in LCDB 1 and LCDB 2 'at face value'. However, the cover data are not accurate. We know there are misclassifications and errors in both databases, but not their full magnitude or locations. Because of mapping/classification error, and the broad scope and qualitative nature of the cover classes (Grūner & Gapare 2004), LCDB 2 cover classes cannot and should not be relied upon to assess whether cover for a given location is in fact indigenous. Field inspection is needed to verify this.

Some cover classes are mixed and particularly problematic to categorise as either indigenous or non-indigenous. For example, Depleted Grassland ground cover is often dominated by the exotic flatweed *Hieracium pilosella*, but native species may dominate in number (e.g. Meurk et al. 2002). We assigned it to the Indigenous category based on expert opinion. Low-Producing Grassland includes some completely exotic cover (e.g. coastal marram grass, sweet vernal and browntop extensive pasture) but also grasslands of variable native and exotic composition dominated by indigenous short tussocks. Based on expert opinion that this class is primarily exotic across New Zealand, we have assigned it to the Non-indigenous category.

Only one cover class (Herbaceous Freshwater Vegetation) is provided for wetlands, and we have assigned it to the Indigenous category. Hence, our figures assume that all wetlands still support native cover, which is unrealistic. Consequently, some environments that support extensive wetlands that have been substantially modified by unsympathetic land use (e.g. Environment L3.1a on the Southland Plains, in the Less Reduced and Better Protected category) will incorrectly be assigned to less threatened categories.

3.3.3 Protection information

The protection dataset used for this analysis has several limitations, such as the inclusion of some Crown land managed by DOC for purposes other than conservation (e.g. buildings, gravel reserves, racecourses, cemeteries, marginal strips) (Walker et al. 2004) and inaccuracies associated with covenant boundaries (Rutledge et al. 2004). These sources of error will tend to increase estimates of protected land in threatened environments. On the other hand, council-protected areas (including regional parks such as the Hunua Ranges near Auckland) and certain types of privately protected land (including biodiversity sanctuaries such as the ecological island at Mt Maungatautari in the Waikato) are not included in the protected dataset. Consequently, the area of indigenous vegetation not protected in some districts will be overestimated.

4. Results

4.1 INDIGENOUS COVER AND THREATENED ENVIRONMENTS IN 2001/02

Approximately two-thirds of New Zealand's land environments were classified within one of the five categories of threatened environment (67% of environments if categories were determined at LENZ Level IV, and 63% of environments if categories were determined at Level II) (Table 2).

The five threat categories accounted for 54% or 53% (with categories determined at LENZ Levels IV and II, respectively) of the total land area of New Zealand. This implies greater environmental heterogeneity (and hence greater potential biodiversity) in threatened environments than across land not assigned to a threat category in our classification. In other words, past biodiversity loss has

been concentrated in the most environmentally diverse (and hence probably biologically diverse) regions of New Zealand.

Less than half of New Zealand's land area (12 632 214 ha, or 49%) was under some form of indigenous cover (Table 2). Acutely Threatened, Chronically Threatened and At Risk environments (i.e. those with < 30% indigenous cover remaining) represented 57% of Level IV environments and 42% of New Zealand's land area (Level IV), and 51% of Level II land environments and 41% of New Zealand's land area (Level II).

The two categories with the highest SBL (Acutely and Chronically Threatened environments, both with less than 20% of indigenous cover) together account for 46% of environments and 32% of New Zealand's land area (at Level IV), or 42% of environments and 26% of New Zealand's land area (at Level II). The area of indigenous cover that remains in Acutely and Chronically Threatened environments is 565 751 ha (6.9% of the total land area of these 232 Level IV environments), or 445 215 ha (6.8% of the total land area of the 42 Acutely and Chronically Threatened Level II environments).

The largest portion of New Zealand's threatened environments have less than 10% of indigenous cover remaining, and fall within the category of highest risk to remaining biodiversity (Acutely Threatened). Acutely Threatened environments account for 32% of Level IV land environments and 23% of total land area (at Level IV), or 29% of Level II environments and 19% of New Zealand's total land area (at Level II). The average percentage of indigenous cover that remains in Acutely Threatened environments is 3.8% (Level IV) or 4.5% (Level II), i.e. towards the lower end of the 0–10% range.

TABLE 2. NEW ZEALAND'S LAND ENVIRONMENT CATEGORIES IN 2001/02, SHOWING THE PERCENTAGE OF THE TOTAL NUMBER OF ENVIRONMENTS IN THE SIX LAND ENVIRONMENT CATEGORIES (% OF LENZ), THE PERCENTAGE OF THE TOTAL NEW ZEALAND LAND AREA THAT THIS AREA REPRESENTS (% OF NZ) AND THE PERCENTAGE OF LAND WITHIN THAT LAND ENVIRONMENT CATEGORY (% OF FULL EXTENT).

	LENZ LEVEL	TOTAL	ACUTELY THREATENED	CHRONICALLY THREATENED	AT RISK	CRITICALLY UNDER-PROTECTED	UNDER-PROTECTED	LESS REDUCED AND BETTER PROTECTED
Number of environments								
No. of	IV	500	158	74	52	33	18	165
LENZ	II	100	29	13	9	6	6	37
% of	IV	100.0	31.6	14.8	10.4	6.6	3.6	33.0
LENZ	II	100.0	29.0	13.0	9.0	6.0	6.0	37.0
Full extent of environments								
Area	IV	26 000 680	5 888 292	2 323 074	2 788 941	1 825 031	1 158 487	12 016 855
(ha)	II	26 000 680	4 983 260	1 674 228	4 090 474	772 143	2 138 778	12 341 796
% of	IV	100.00	22.65	8.93	10.73	7.02	4.46	46.22
NZ	II	100.00	19.17	6.44	15.73	2.97	8.23	47.47
Indigenous cover remaining in environments								
Area	IV	12 632 214	220 862	344 889	674 218	794 673	663 006	9 934 566
(ha)	II	12 632 214	223 886	231 329	1 125 322	328 852	1 056 026	9 666 799
% of	IV	48.58	3.75	14.85	24.17	43.54	57.23	82.67
full extent	II	48.58	4.49	13.82	27.51	42.59	49.38	78.33

Figure 4 illustrates the uneven distribution of threatened environments across New Zealand's 20 Level I environments. Level I environment N (Eastern South Island Plains) contains the highest number of Acutely Threatened Level IV environments (26), followed by environment B (Central Dry Lowlands) with 24. The three Level I environments F (Central Hill Country & Volcanic Plateau), J (Central Well-Drained Recent Soils) and A (Northern Lowlands) each contain 15 Acutely Threatened Level IV environments. In contrast, the least modified Level I environments (O, P, R, S and T) contain no Level IV environments with less than 30% indigenous cover remaining, and only one (S1.1a) has less than 20% of its land area protected.

The maps in Figure 5 show the distribution of threatened environments in New Zealand, and indicate that the categories of highest risk to indigenous biodiversity are in lowland environments.

4.2 INDIGENOUS COVER NOT PROTECTED IN THREATENED ENVIRONMENTS

Table 3 contains summary statistics for indigenous cover not within protected areas (INP).

Based on our Indigenous/Non-indigenous categorisation, 38% of New Zealand's indigenous cover (excluding reserves) was not legally protected (Table 3). In the five threatened environments categories, high percentages (c. 60–90%) of indigenous cover were not legally protected. In environments assigned to the sixth category (Less Reduced and Better Protected), lower percentages (c. 27–28%) of indigenous cover were not protected.

Acutely Threatened and Chronically Threatened environments contained smaller total areas of INP than At Risk environments at both LENZ levels (Table 3). The

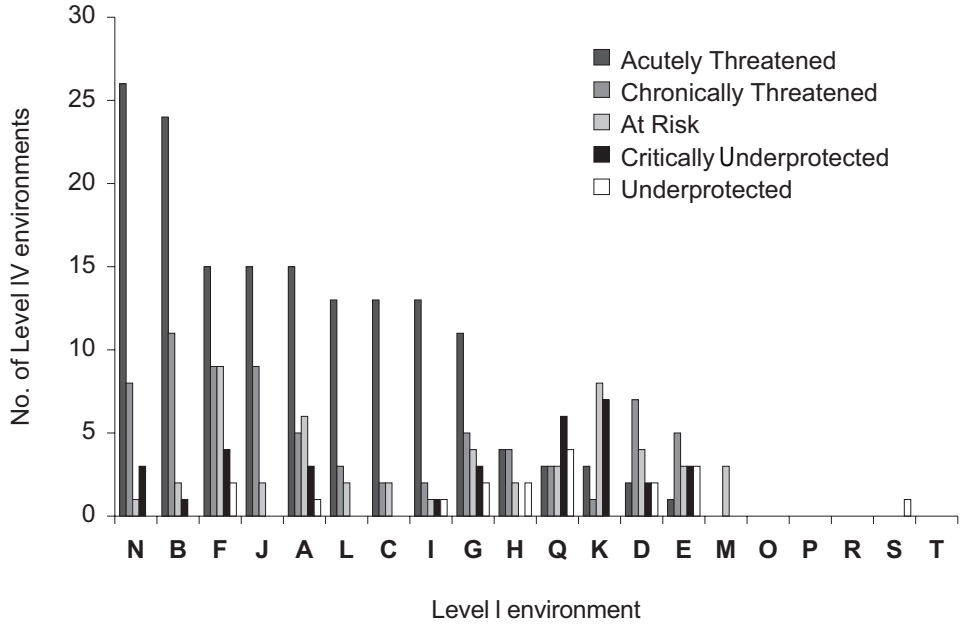

Figure 4. Number of threatened Level IV LENZ land environments in New Zealand's 20 Level I environments (A to T, arranged in order of decreasing threat to indigenous biodiversity).

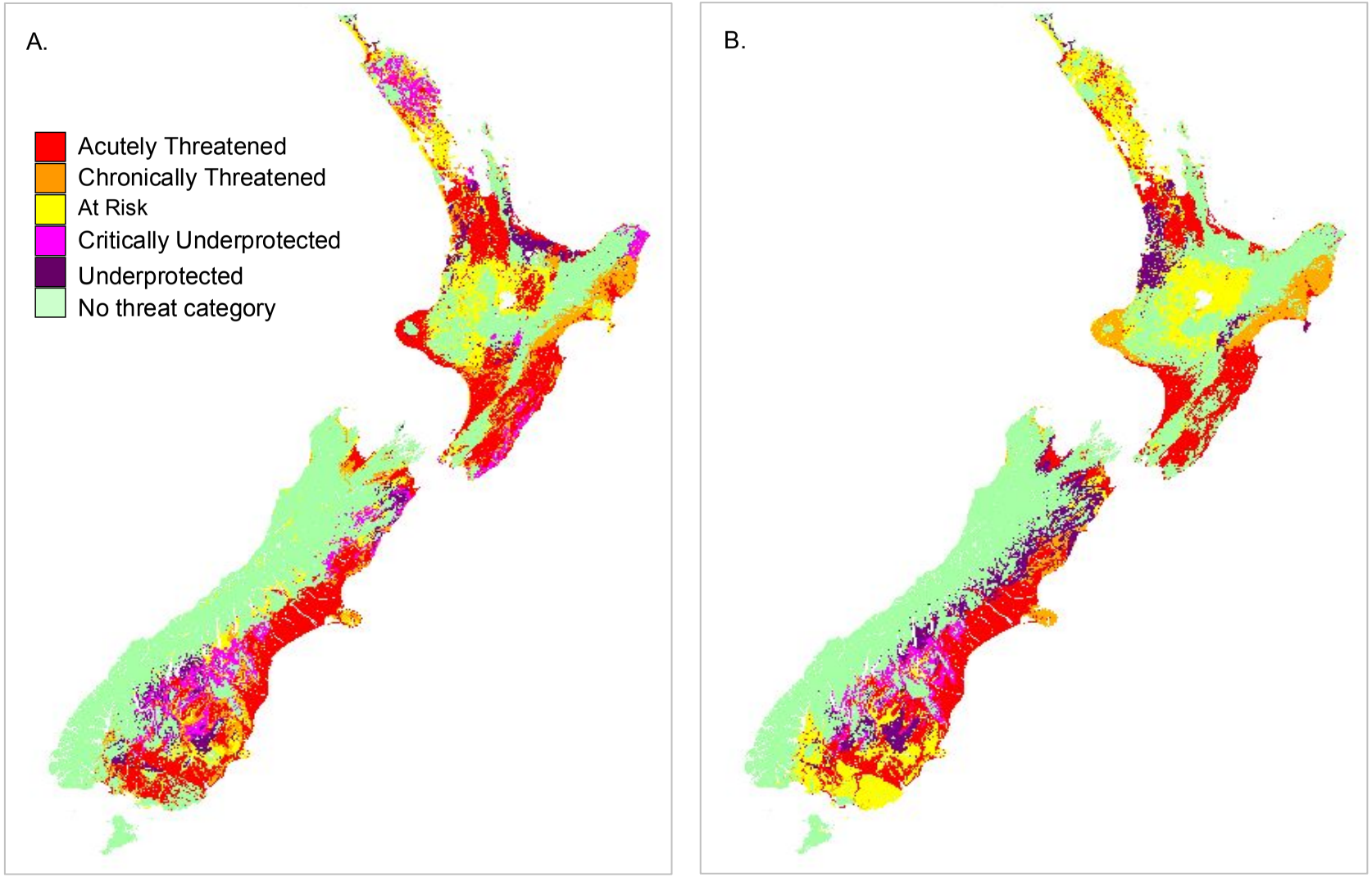

Figure 5. New Zealand's threatened environments. A: Level IV of LENZ. B: Level II of LENZ.

largest areas of INPTE were in environments in the Critically Underprotected and Underprotected categories, i.e. environments having more than 30% of indigenous cover remaining (at Level IV and Level II).

The areas covered by the LCDB 2 classes of INP in the five environment threat categories (i.e. INPTEs) are presented in Table 4 (at LENZ Level IV) and in Table 5 (Level II). In Acutely Threatened and Chronically Threatened environments, INPTE was dominated by forest and regenerating forest (Indigenous Forest, Manuka and/or Kanuka and Broadleaved Indigenous Hardwoods LCDB 2 classes). In contrast, in Critically Underprotected and Underprotected environments, INPTE was dominated by the Tall-Tussock Grassland class (34% and 54%, respectively, at LENZ Level IV). Manuka and/or Kanuka and Indigenous Forest also accounted for large portions of the INPTE in Critically Underprotected and Underprotected threat categories. Depleted Grasslands were a significant component of Critically Underprotected INPTE (17% at LENZ Level IV).

Tables 6 and 7 tabulate total INP and INPTE areas in each of 73 council areas across New Zealand. Figure 6 compares INPTE areas for the 25 councils with the greatest INPTE area. The four top-ranking councils (Central Otago, Queenstown Lakes, Waitaki and Mackenzie) contain 33% of the national total area of INPTE (at both LENZ levels). Level II of LENZ, which is less precise, shows Central Otago, Southland, Mackenzie and Hurunui districts as the top-ranking councils, containing 32% of INPTE.

Tables 8 and 9 tabulate total INP and INPTE areas in each of 13 DOC conservancies and 47 DOC areas across New Zealand. The four top-ranking DOC areas (Central Otago, Twizel, Gisborne and Coastal Otago) contain 35% of the national total area of INPTE, and the top seven (including Wanaka, South Marlborough and Wakatipu) contain 50%. The three highest ranked DOC conservancies are Otago (with 27% of the national area of indigenous cover not protected), Canterbury (with 18%), and East Coast/Hawke's Bay (with 9%).

In 2004, the 304 current and former Crown pastoral leases in the South Island high country contained 31% of New Zealand's INP, and 27% (c. 567 380 ha) of the remaining INPTE. The area of INPTE on pastoral leases may have been higher than this estimate, since indigenous short-tussock grasslands contained

TABLE 3. INDIGENOUS COVER NOT PROTECTED (INP) IN THE SIX LAND ENVIRONMENT CATEGORIES IN 2001/02, SHOWING THE AREA OF INP, THE PERCENTAGE OF THE TOTAL NEW ZEALAND LAND AREA THAT THIS AREA REPRESENTS (% OF NZ), AND THE PERCENTAGE THAT INP REPRESENTS OF ALL REMAINING INDIGENOUS COVER (% OF REMAINING) WITHIN EACH LAND ENVIRONMENT CATEGORY.

	LENZ LEVEL	TOTAL	ACUTELY THREATENED	CHRONICALLY THREATENED	AT RISK	CRITICALLY UNDER-PROTECTED	UNDER-PROTECTED	LESS REDUCED AND BETTER PROTECTED
Area	IV	4 794 636	182 573	285 416	468 195	708 816	497 697	2 651 940
(ha)	II	4 794 636	183 726	186 287	688 068	290 562	750 394	2 695 598
% of	IV	18.44	0.70	1.10	1.80	2.73	1.91	10.20
NZ	II	18.44	0.71	0.72	2.65	1.12	2.89	10.37
% of	IV	37.96	82.66	82.76	69.44	89.20	75.07	26.69
remaining	II	37.96	82.06	80.53	61.14	88.36	71.06	27.89

TABLE 4. INDIGENOUS COVER NOT PROTECTED (INP) IN 2001/02, BY INDIGENOUS COVER CLASS, IN ALL OF NEW ZEALAND'S ENVIRONMENTS, AND IN THE FIVE THREATENED ENVIRONMENT CATEGORIES. ALL CATEGORIES WERE DETERMINED AT LEVEL IV OF LENZ.

	TOTAL (ALL 500 ENVIRON-MENTS	ACUTELY THREATENED	CHRONICALLY THREATENED	AT RISK	CRITICALLY UNDER-PROTECTED	UNDER PROTECTED
Area (ha)						
Broadleaved Indigenous Hardwoods	348 214	31 197	48 706	52 436	36 960	20 533
Depleted Grassland	225 511	3702	21 524	26 737	118 190	9554
Fernland	43 188	1000	1675	1906	14 411	2616
Grey Scrub	63 624	3650	8079	8398	20 284	3840
Indigenous Forest	1 376 291	47 214	52 214	168 226	98 132	99 768
Manuka and/or Kanuka	834 453	48 671	102 089	132 558	144 537	64 265
Matagouri	26 432	3612	3157	6784	7913	490
Tall-Tussock Grassland	1 347 822	5212	23 055	38 657	237 179	267 834
Alpine[a]	137 602	14	100	263	5289	11 903
Rock[b]	300 354	14 228	12 273	19 335	17 360	11 516
Wetland/Water[c]	91 146	24 073	12 545	12 897	8562	5376
Total	4 794 636	182 573	285 416	468 195	708 816	497 697
Percentage (%)						
Broadleaved Indigenous Hardwoods	7.3	17.1	17.1	11.2	5.2	4.1
Depleted Grassland	4.7	2.0	7.5	5.7	16.7	1.9
Fernland	0.9	0.5	0.6	0.4	2.0	0.5
Grey Scrub	1.3	2.0	2.8	1.8	2.9	0.8
Indigenous Forest	28.7	25.9	18.3	35.9	13.8	20.0
Manuka and/or Kanuka	17.4	26.7	35.8	28.3	20.4	12.9
Matagouri	0.6	2.0	1.1	1.4	1.1	0.1
Tall-Tussock Grassland	28.1	2.9	8.1	8.3	33.5	53.8
Alpine[a]	2.9	0.0	0.0	0.1	0.7	2.4
Rock[b]	6.3	7.8	4.3	4.1	2.4	2.3
Wetland/Water[c]	1.9	13.2	4.4	2.8	1.2	1.1
Total	100.0	100.0	100.0	100.0	100.0	100.0

[a] Alpine = Alpine Grass/Herbfield, Permanent Snow and Ice, Subalpine Shrubland.

[b] Rock = Alpine Gravel and Rock, Coastal Sand and Gravel, Landslide, River and Lakeshore Gravel and Rock.

[c] Water/Wetland = Estuarine Open Water, Flaxland, Herbaceous Freshwater Vegetation, Herbaceous Saline Vegetation, Lake and Pond, Mangrove, River.

within the Low-Producing Grassland class in LCDB 2 are classified as 'exotic' and, therefore, not distinguished. Overall, indigenous cover on pastoral leases remained relatively high, probably because the Land Act 1948 and Crown Pastoral Land Act 1998 have constrained vegetation clearance activities, including soil cultivation, at least to some degree. Furthermore, pastoral leases contain high proportions of land of low value for agricultural production that does not lend itself to cultivation. Because South Island high country pastoral leases remained largely indigenous in character, much of the INPTE on pastoral leases was in the At Risk, Critically Underprotected and Underprotected categories, with less depleted indigenous cover (i.e. > 20% remaining). Pastoral leases contain just 5.5% (c. 25 500 ha) of the national INPTE in Acutely Threatened and Chronically Threatened environment threat categories, i.e. environments where indigenous cover has been reduced below 20% of original environment extent.

TABLE 5. INDIGENOUS COVER NOT PROTECTED (INP) IN 2001/02, BY INDIGENOUS COVER CLASS, IN ALL OF NEW ZEALAND'S ENVIRONMENTS, AND IN THE FIVE THREATENED ENVIRONMENT CATEGORIES. ALL CATEGORIES WERE DETERMINED AT LEVEL II OF LENZ.

	TOTAL (ALL 100 ENVIRON-MENTS	ACUTELY THREATENED	CHRONICALLY THREATENED	AT RISK	CRITICALLY UNDER-PROTECTED	UNDER PROTECTED
Area (ha)						
Broadleaved Indigenous Hardwoods	348 214	26 228	42 385	52 159	10 430	35 377
Depleted Grassland	225 511	6562	1022	36 709	68 030	64 608
Fernland	43 188	716	914	2623	13 944	4243
Grey Scrub	63 624	4169	1205	18 220	17 302	10 082
Indigenous Forest	1 376 291	35 749	32 992	267 319	10 506	139 394
Manuka and/or Kanuka	834 453	47 684	81 617	175 957	12 369	150 295
Matagouri	26 432	2678	2767	2136	7947	7319
Tall-Tussock Grassland	1 347 822	17 732	2651	101 430	133 427	289 851
Alpine[a]	137 602	32	37	3253	2652	17 322
Rock[b]	300 341	19 062	7827	13 554	7668	20 706
Wetland/Water[c]	91 145	23 103	12 871	14 708	6288	11 195
Total	4 794 636	183 726	186 287	688 068	290 562	750 394
Percentage (%)						
Broadleaved Indigenous Hardwoods	7.3	14.3	22.8	7.6	3.6	4.7
Depleted Grassland	4.7	3.6	0.5	5.3	23.4	8.6
Fernland	0.9	0.4	0.5	0.4	4.8	0.6
Grey Scrub	1.3	2.3	0.6	2.6	6.0	1.3
Indigenous Forest	28.7	19.5	17.7	38.9	3.6	18.6
Manuka and/or Kanuka	17.4	26.0	43.8	25.6	4.3	20.0
Matagouri	0.6	1.5	1.5	0.3	2.7	1.0
Tall-Tussock Grassland	28.1	9.7	1.4	14.7	45.9	38.6
Alpine[a]	2.9	0.0	0.0	0.5	0.9	2.3
Rock[b]	6.3	10.4	4.2	2.0	2.6	2.8
Wetland/Water[c]	1.9	12.6	6.9	2.1	2.2	1.5
Total	100.0	100.0	100.0	100.0	100.0	100.0

[a] Alpine = Alpine Grass/Herbfield, Permanent Snow and Ice, Subalpine Shrubland.

[b] Rock = Alpine Gravel and Rock, Coastal Sand and Gravel, Landslide, River and Lakeshore Gravel and Rock.

[c] Water/Wetland = Estuarine Open Water, Flaxland, Herbaceous Freshwater Vegetation, Herbaceous Saline Vegetation, Lake and Pond, Mangrove, River.

TABLE 6. INDIGENOUS COVER NOT PROTECTED (INP), AND TOTAL INDIGENOUS COVER NOT PROTECTED IN THE FIVE THREATENED ENVIRONMENT CATEGORIES (INPTE) IN 73 DISTRICT COUNCIL AREAS IN 2001/02. ALL CATEGORIES WERE DETERMINED AT LEVEL IV OF LENZ.

COUNCIL (DISTRICT OR CITY)	TOTAL DISTRICT/CITY COUNCIL AREA (ha)	AREA OF INP (ha)					INP IN FIVE THREATENED ENVIRONMENT CATEGORIES (INPTE)			
		ACUTELY THREATENED	CHRONICALLY THREATENED	AT RISK	CRITICALLY UNDERPROTECTED	UNDERPROTECTED	TOTAL AREA (ha)	PERCENTAGE AREA OF DISTRICT	PERCENTAGE OF TOTAL NATIONAL AREA	
									%	RANK
Ashburton	588 482	1898	838	8513	2075	2	13 325	2.3	0.6	36
Auckland	62 303	446	480	1264	3835	0	6024	9.7	0.3	47
Banks Peninsula	96 989	2841	4863	4970	0	0	12 674	13.1	0.6	37
Buller	788 090	0	711	2465	21	0	3198	0.4	0.1	58
Carterton	119 784	2266	1630	50	4706	0	8652	7.2	0.4	44
Central Hawke's Bay	327 393	6458	4261	492	3417	0	14 627	4.5	0.7	34
Central Otago	986 431	5282	28 006	19 917	145 511	111 973	310 689	31.5	14.5	1
Christchurch	42 445	471	167	26	0	0	663	1.6	0.0	70
Clutha	629 464	9859	5151	12 440	512	10 510	38 471	6.1	1.8	17
Dunedin	325 742	4290	6694	17 034	1108	21 982	51 108	15.7	2.4	12
Far North	666 822	3643	8561	33 787	58 010	5711	109 712	16.5	5.1	5
Franklin	215 041	4192	6145	4210	972	18 242	33 761	15.7	1.6	21
Gisborne	831 520	3815	47 601	5836	43 485	3728	104 464	12.6	4.9	6
Gore	123 454	743	83	926	2	2503	4256	3.4	0.2	52
Grey	338 118	0	0	2004	0	0	2004	0.6	0.1	64
Hamilton	9762	285	7	0	0	0	292	3.0	0.0	71
Hastings	514 892	3363	17 195	744	418	58	21 779	4.2	1.0	28
Hauraki	117 082	1603	179	1638	4	2564	5987	5.1	0.3	48
Horowhenua	105 152	1556	1166	553	0	0	3276	3.1	0.2	57
Hurunui	845 910	7226	10 219	10 002	27 561	4384	59 393	7.0	2.8	9
Invercargill	38 896	274	126	790	0	0	1190	3.1	0.1	68
Kaikoura	201 337	770	1994	1262	11 019	23 481	38 525	19.1	1.8	16
Kaipara	307 552	1675	4397	10 655	7946	0	24 673	8.0	1.2	27
Kapiti Coast	73 055	1270	300	1312	16	0	2897	4.0	0.1	59
Kawerau	2432	78	58	0	0	54	190	7.8	0.0	73
Lower Hutt	37 486	596	310	3382	399	0	4687	12.5	0.2	50
Mackenzie	685 329	2440	8834	22 176	76 555	1739	111 744	16.3	5.2	4
Manawatu	258 852	4594	5311	522	1	1	10 429	4.0	0.5	41
Manukau	53 186	403	163	1379	3433	3533	8911	16.8	0.4	43
Marlborough	1 032 287	3183	9080	10 724	28 649	21 929	73 566	7.1	3.4	8
Masterton	227 643	4621	4808	297	8893	0	18 618	8.2	0.9	30
Matamata-Piako	175 210	1392	114	1470	0	900	3876	2.2	0.2	53
Napier	9948	216	0	0	0	0	216	2.2	0.0	72
Nelson	42 101	398	213	921	0	74	1605	3.8	0.1	67
New Plymouth	221 207	3960	147	4797	0	479	9383	4.2	0.4	42
North Shore	12 743	51	63	1873	28	0	2015	15.8	0.1	63
Opotiki	309 775	2228	1099	236	1443	2969	7974	2.6	0.4	46
Otorohanga	200 714	744	773	10 414	0	6064	17 995	9.0	0.8	31
Palmerston North	32 537	356	1147	524	2	0	2029	6.2	0.1	61
Papakura	12 023	113	5	1116	3	469	1705	14.2	0.1	66
Porirua	17 648	494	136	992	273	0	1894	10.7	0.1	65

Continued on next page

Table 6—continued

COUNCIL (DISTRICT OR CITY)	TOTAL DISTRICT/CITY COUNCIL AREA (ha)	AREA OF INP (ha)					INP IN FIVE THREATENED ENVIRONMENT CATEGORIES (INPTE)			
		ACUTELY THREATENED	CHRONICALLY THREATENED	AT RISK	CRITICALLY UNDERPROTECTED	UNDERPROTECTED	TOTAL AREA (ha)	PERCENTAGE AREA OF DISTRICT	PERCENTAGE OF TOTAL NATIONAL AREA	
									%	RANK
Queenstown Lakes	856 396	1471	2913	2714	53 095	99 483	159 676	18.6	7.5	2
Rangitikei	445 780	11 128	4929	2701	16 337	4276	39 372	8.8	1.8	14
Rodney	232 172	1006	2111	25 119	2125	3	30 364	13.1	1.4	23
Rotorua	238 205	1339	1470	2902	0	6836	12 548	5.3	0.6	38
Ruapehu	669 819	743	2709	43 762	3906	3718	54 838	8.2	2.6	10
Selwyn	604 810	1940	746	8660	2254	0	13 601	2.2	0.6	35
South Taranaki	357 185	6003	146	4083	0	401	10 633	3.0	0.5	40
South Waikato	179 445	849	164	504	0	508	2025	1.1	0.1	62
South Wairarapa	233 337	6377	5804	670	21 762	1	34 614	14.8	1.6	19
Southland	2 905 381	9132	12 146	10 425	12 104	46 513	90 320	3.1	4.2	7
Stratford	213 951	1089	133	14 767	0	0	15 990	7.5	0.7	33
Tararua	435 552	11 237	8189	552	10 400	0	30 379	7.0	1.4	22
Tasman	953 487	3277	6232	7338	166	72	17 086	1.8	0.8	32
Taupo	629 332	3715	284	32 766	757	848	38 369	6.1	1.8	18
Tauranga	12 872	628	1	60	19	0	707	5.5	0.0	69
Thames–Coromandel	219 700	1275	1366	1436	2110	2295	8481	3.9	0.4	45
Timaru	258 233	2263	1132	1012	6320	0	10 727	4.2	0.5	39
Upper Hutt	54 024	675	343	2398	10	0	3426	6.3	0.2	55
Waikato	305 697	6124	4921	3229	0	14 832	29 106	9.5	1.4	24
Waimakariri	213 075	1558	408	295	1609	0	3870	1.8	0.2	54
Waimate	346 519	2373	2630	7193	39 874	216	52 286	15.1	2.4	11
Waipa	144 427	2436	287	1342	0	1157	5223	3.6	0.2	49
Wairoa	403 830	1453	19 804	13 330	1	7	34 595	8.6	1.6	20
Waitakere	36 396	251	210	1327	2361	112	4261	11.7	0.2	51
Waitaki	698 635	4145	14 735	16 392	68 130	28 543	131 945	18.9	6.2	3
Waitomo	350 843	1437	192	27 531	0	10 142	39 302	11.2	1.8	15
Wanganui	234 469	1995	2614	20 104	0	71	24 783	10.6	1.2	26
Wellington	28 742	446	15	2020	920	0	3401	11.8	0.2	56
Western Bay of Plenty	196 035	2910	4	184	1104	21 469	25 671	13.1	1.2	25
Westland	1 145 206	0	0	2233	0	0	2233	0.2	0.1	60
Whakatane	440 625	1628	2395	1783	0	12 842	18 649	4.2	0.9	29
Whangarei	269 661	1575	3351	7655	33 159	2	45 742	17.0	2.1	13
Total	26 000 680	182 573	285 416	468 195	708 816	497 697	2 142 696		100.0	

TABLE 7. INDIGENOUS COVER NOT PROTECTED (INP), AND TOTAL INDIGENOUS COVER NOT PROTECTED IN THE FIVE THREATENED ENVIRONMENT CATEGORIES (INPTE) IN 73 DISTRICT COUNCIL AREAS IN 2001/02. ALL CATEGORIES WERE DETERMINED AT LEVEL II OF LENZ.

		AREA OF INP (ha)					INP IN FIVE THREATENED ENVIRONMENT CATEGORIES (INPTE)			
									PERCENTAGE OF TOTAL NATIONAL AREA	
COUNCIL (DISTRICT OR CITY)	TOTAL DISTRICT/CITY COUNCIL AREA (ha)	ACUTELY THREATENED	CHRONICALLY THREATENED	AT RISK	CRITICALLY UNDERPROTECTED	UNDERPROTECTED	TOTAL AREA (ha)	PERCENTAGE AREA OF DISTRICT	%	RANK
Ashburton	588 482	2719	167	25	1434	28 555	32 900	5.6	1.6	22
Auckland	62 303	801	187	5029	0	0	6017	9.7	0.3	42
Banks Peninsula	96 989	340	12 334	0	0	0	12 674	13.1	0.6	31
Buller	788 090	7	993	1171	21	28	2220	0.3	0.1	57
Carterton	119 784	3696	0	162	0	0	3859	3.2	0.2	46
Central Hawke's Bay	327 393	8794	16	303	0	367	9480	2.9	0.5	36
Central Otago	986 431	15389	2725	31 485	55 861	167 163	272 623	27.6	13.0	1
Christchurch	42 445	301	358	4	0	0	663	1.6	0.0	67
Clutha	629 464	7395	504	44 430	333	10 970	63 631	10.1	3.0	10
Dunedin	325 742	5672	154	22 895	1842	20 912	51 475	15.8	2.5	15
Far North	666 822	6183	4214	91 873	0	5711	107 981	16.2	5.1	5
Franklin	215 041	5572	360	5186	0	22 091	33 209	15.4	1.6	21
Gisborne	831 520	1400	57 389	223	4258	43	63 313	7.6	3.0	11
Gore	123 454	332	10	5258	2	89	5691	4.6	0.3	43
Grey	338 118	0	0	0	0	3	3	0.0	0.0	72
Hamilton	9 762	264	4	0	0	7	274	2.8	0.0	69
Hastings	514 892	5313	14 938	1171	0	17 117	38 539	7.5	1.8	18
Hauraki	117 082	1442	60	1617	0	247	3366	2.9	0.2	49
Horowhenua	105 152	2428	0	498	0	0	2926	2.8	0.1	55
Hurunui	845 910	3497	21 198	8	526	87 195	112 423	13.3	5.4	4
Invercargill	38 896	790	171	878	0	0	1838	4.7	0.1	59
Kaikoura	201 337	513	2017	5769	1	42 344	50 643	25.2	2.4	16
Kaipara	307 552	2481	1339	20,821	0	0	24 641	8.0	1.2	26
Kapiti Coast	73 055	1332	0	1149	0	0	2481	3.4	0.1	56
Kawerau	2 432	30	48	0	0	0	78	3.2	0.0	71
Lower Hutt	37 486	837	2	773	0	0	1612	4.3	0.1	61
Mackenzie	685 329	4873	1749	10 322	68 604	50 301	135 849	19.8	6.5	3
Manawatu	258 852	2881	5	439	0	0	3325	1.3	0.2	50
Manukau	53 186	540	27	4811	0	3533	8911	16.8	0.4	37
Marlborough	1 032 287	4838	2225	16 649	399	82 514	106 625	10.3	5.1	6
Masterton	227 643	7,321	0	437	0	0	7758	3.4	0.4	39
Matamata–Piako	175 210	1161	38	1470	0	468	3136	1.8	0.1	53
Napier	9 948	178	38	0	0	0	216	2.2	0.0	70
Nelson	42 101	398	50	0	74	1083	1604	3.8	0.1	62
New Plymouth	221 207	16	5852	5271	0	295	11 434	5.2	0.5	33
North Shore	12 743	104	0	1911	0	0	2015	15.8	0.1	58
Opotiki	309 775	1230	701	1241	217	440	3828	1.2	0.2	47
Otorohanga	200 714	98	284	7123	0	14 744	22 249	11.1	1.1	27
Palmerston North	32 537	932	0	524	0	0	1456	4.5	0.1	63
Papakura	12 023	114	0	1119	0	472	1705	14.2	0.1	60
Porirua	17 648	622	0	76	0	0	698	4.0	0.0	66

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Table 7—continued

COUNCIL (DISTRICT OR CITY)	TOTAL DISTRICT/CITY COUNCIL AREA (ha)	AREA OF INP (ha)					INP IN FIVE THREATENED ENVIRONMENT CATEGORIES (INPTE)			
		ACUTELY THREATENED	CHRONICALLY THREATENED	AT RISK	CRITICALLY UNDERPROTECTED	UNDERPROTECTED	TOTAL AREA (ha)	PERCENTAGE AREA OF DISTRICT	PERCENTAGE OF TOTAL NATIONAL AREA	
									%	RANK
Queenstown Lakes	856 396	860	938	2979	47 807	15 644	68 228	8.0	3.3	9
Rangitikei	445 780	4238	404	23 579	0	7996	36 218	8.1	1.7	20
Rodney	232 172	2205	730	27 391	0	3	30 329	13.1	1.4	24
Rotorua	238 205	91	205	3272	0	39	3607	1.5	0.2	48
Ruapehu	669 819	306	1 449	69 621	0	405	71 781	10.7	3.4	8
Selwyn	604 810	1532	1194	0	584	27 967	31 278	5.2	1.5	23
South Taranaki	357 185	1063	4774	3959	0	51	9847	2.8	0.5	35
South Waikato	179 445	50	122	539	0	83	794	0.4	0.0	64
South Wairarapa	233 337	11301	0	277	0	0	11 578	5.0	0.6	32
Southland	2 905 381	6930	3129	100 843	10 680	38 299	159 881	5.5	7.6	2
Stratford	213 951	60	1245	9558	0	336	11 199	5.2	0.5	34
Tararua	435 552	8062	0	745	0	0	8807	2.0	0.4	38
Tasman	953 487	3417	1827	1068	238	8122	14 672	1.5	0.7	29
Taupo	629 332	6	1633	48 592	0	1538	51 769	8.2	2.5	14
Tauranga	12 872	685	0	22	0	0	707	5.5	0.0	65
Thames–Coromandel	219 700	2665	81	3326	27	215	6314	2.9	0.3	41
Timaru	258 233	3239	302	141	6466	5027	15 175	5.9	0.7	28
Upper Hutt	54 024	532	119	2302	0	0	2952	5.5	0.1	54
Waikato	305 697	4174	481	3291	0	19 827	27 773	9.1	1.3	25
Waimakariri	213 075	1558	408	0	156	11 951	14 072	6.6	0.7	30
Waimate	346 519	3771	183	8502	38 959	575	51 990	15.0	2.5	13
Waipa	144 427	892	214	770	0	1989	3864	2.7	0.2	45
Wairoa	403 830	1710	30 343	40	0	5030	37 123	9.2	1.8	19
Waitakere	36 396	292	14	3843	0	112	4261	11.7	0.2	44
Waitaki	698 635	10 900	1375	23 156	51 924	9166	96 521	13.8	4.6	7
Waitomo	350 843	134	1275	12 109	0	39 317	52 835	15.1	2.5	12
Wanganui	234 469	3878	255	3168	0	0	7301	3.1	0.3	40
Wellington	28 742	488	0	31	0	0	519	1.8	0.0	68
Western Bay of Plenty	196 035	3073	22	3	151	1	3250	1.7	0.2	52
Westland	1 145 206	0	0	0	0	0	0	0.0	0.0	73
Whakatane	440 625	315	1211	1760	0	2	3288	0.7	0.2	51
Whangarei	269 661	2467	2206	41 065	0	2	45 740	17.0	2.2	17
Total	26 000 680	183 726	186 287	688 068	290 562	750 394	2 099 038		100.0	

TABLE 8. INDIGENOUS COVER NOT PROTECTED (INP), AND TOTAL INDIGENOUS COVER NOT PROTECTED IN THE FIRST FIVE THREATENED ENVIRONMENT CATEGORIES (INPTE) IN 13 DOC CONSERVANCIES IN 2001/02. ALL CATEGORIES WERE DETERMINED AT LEVEL IV OF LENZ.

		AREA OF INP (ha)					INP IN FIVE THREATENED ENVIRONMENT CATEGORIES (INPTE)			
									PERCENTAGE OF TOTAL NATIONAL AREA	
CONSERVANCY	TOTAL AREA OF CONSERVANCY (ha)	ACUTELY THREATENED	CHRONICALLY THREATENED	AT RISK	CRITICALLY UNDERPROTECTED	UNDERPROTECTED	TOTAL AREA (ha)	PERCENTAGE AREA OF CONSERVANCY	%	RANK
Auckland	544 209	4 680	5 600	35 948	12 755	18 219	77 202	14	4	10
Bay Of Plenty	1 052 894	8 110	4 763	6 754	1 129	42 690	63 446	6	3	11
Canterbury	3 987 916	23 899	34 595	69 225	217 364	30 792	375 876	9	18	2
East Coast/Hawke's Bay	2 739 103	21 640	90 766	20 633	62 239	6 382	201 661	7	9	3
Nelson/Marlborough	2 307 820	7 700	17 741	21 366	43 112	47 715	137 634	6	6	5
Northland	1 245 377	6 893	16 308	52 011	99 116	5 714	180 042	14	8	4
Otago	3 051 847	23 097	52 464	58 724	205 066	243 774	583 125	19	27	1
Southland	3 195 728	11 135	12 409	14 403	11 003	51 122	100 073	3	5	9
Tongariro/Taupo	629 232	2 820	227	32 886	6 368	812	43 114	7	2	12
Waikato	1 833 584	17 402	11 613	62 413	2 126	41 429	134 982	7	6	7
Wanganui	2 100 197	30 512	17 646	75 120	3 652	9 046	135 976	6	6	6
Wellington	1 114 977	24 683	20 574	11 998	44 866	1	102 121	9	5	8
West Coast Tai Poutini	2 210 642	0	711	6 713	21	0	7 445	0	0	13

4.3 WHAT IS THE MOST APPROPRIATE LENZ LEVEL?

Level IV environments represent a finer partitioning of LENZ Level II environments. The habitat loss and protection status of Level IV environments within a single LENZ Level II environment may vary quite widely. This reflects their different environmental characteristics, and hence differences in their value for agricultural production, as well as their biodiversity. Appendix 3 presents a case study of differences among Level IV environments in patterns of protection and land clearance, biodiversity pattern and current land cover types within one Level II land environment (F1). The conclusions we drew from this example were that:

- Environmental differences that drive patterns of biodiversity, and both present and past land clearance, are at a finer scale than the environmental pattern evident at Level II of LENZ.
- Of the four LENZ levels, Level IV best depicts patterns of biodiversity and reflects patterns of past clearance. Level IV also relates most strongly to scales at which people perceive and use the landscape.
- Level IV is the most appropriate LENZ level to assess the vulnerability of remaining biodiversity.

TABLE 9. INDIGENOUS COVER NOT PROTECTED (INP), AND TOTAL INDIGENOUS COVER NOT PROTECTED IN THE FIRST FIVE THREATENED ENVIRONMENT CATEGORIES (INPTE) IN 49 DOC AREAS IN 2001/02. ALL CATEGORIES WERE DETERMINED AT LEVEL IV OF LENZ.

		AREA OF INP (ha)					INP IN FIVE THREATENED ENVIRONMENT CATEGORIES (INPTE)			
									PERCENTAGE OF TOTAL NATIONAL AREA	
AREA	TOTAL AREA OF AREA (ha)	ACUTELY THREATENED	CHRONICALLY THREATENED	AT RISK	CRITICALLY UNDERPROTECTED	UNDERPROTECTED	TOTAL AREA (ha)	PERCENTAGE AREA OF AREA	%	RANK
Aniwaniwa	171 942	73	290	219	0	62	643	0	0	45
Aoraki	67 469	0	0	0	0	0	0	0	0	47
Auckland	312 085	3 565	3 655	12 748	10 350	18 219	48 537	16	2	18
Bay of Islands	292 961	1 812	5 248	16 448	39 478	0	62 986	21	3	12
Buller–Kawatiri	428 996	0	711	1 319	21	0	2 051	0	0	41
Central Otago	801 512	4 047	22 418	18 382	117 171	77 643	239 660	30	11	1
Coastal Otago	1 167 457	16 639	23 320	36 332	7 086	45 326	128 702	11	6	4
Franz Josef–Waiau	226 459	0	0	865	0	0	865	0	0	44
Gisborne	1 128 863	5 324	67 067	19 109	44 016	3 735	139 251	12	6	3
Golden Bay	248 703	17	1 719	1 190	166	0	3 092	1	0	37
Great Barrier Island	29 204	260	81	323	302	0	966	3	0	42
Greymouth–Mawheranui	655 607	0	0	3 025	0	0	3 025	0	0	38
Hauraki	271 822	1 571	1 537	1 586	2 126	4 692	11 511	4	1	31
Hokitika	292 586	0	0	947	0	0	947	0	0	43
Kaitaia	298 010	1 385	3 030	16 904	10 896	5 708	37 923	13	2	20
Kapiti	166 981	2 799	1 022	2 927	296	0	7 043	4	0	33
Kauri Coast	264 662	1 843	2 981	7 278	9 394	0	21 496	8	1	24
Maniapoto	743 367	2 048	318	51 360	0	14 000	67 725	9	3	10
Motueka	437 002	3 658	3 999	6 271	0	146	14 073	3	1	29
Murihiku	1 800 185	11 068	8 763	14 249	11 001	49 565	94 645	5	4	8
Napier	1 059 640	14 082	22 386	1 157	17 311	59	54 994	5	3	17
New Plymouth	263 489	3 781	150	9 715	0	346	13 991	5	1	30
North Canterbury	1 207 001	11 135	15 120	13 853	22 935	2 225	65 268	5	3	11
Opotiki	378 658	2 162	1 022	148	913	2 527	6 773	2	0	34
Palmerston North	721 133	16 184	13 838	3 649	3 652	6 908	44 231	6	2	19
Poneke	119 641	1 713	677	7 734	1 326	0	11 450	10	1	32
Rangitaiki	433 067	2 559	2 405	3 220	18	12 525	20 727	5	1	25
Rotorua Lakes	369 859	1 609	2 295	3 264	0	9 404	16 572	4	1	28
Ruakapuka	1 257 077	7 630	3 966	14 464	34 211	16	60 287	5	3	14
Ruapehu	138 095	1	13	2 032	3 403	24	5 473	4	0	35
Solander Island	95	0	0	0	0	0	0	0	0	48
Sounds	248 684	152	1 307	62	271	1 122	2 914	1	0	39
South Marlborough	972 878	3 873	9 984	12 886	42 295	46 447	115 485	12	5	6
SouthWestland Weheka	606 994	0	0	557	0	0	557	0	0	46
Southern Islands	174 358	0	0	0	0	0	0	0	0	48
St Arnaud	400 554	1	732	958	379	0	2 070	1	0	40
Stratford	363 402	4 823	222	10 952	0	687	16 683	5	1	26
Tauranga	249 970	3 941	63	270	1 111	20 760	26 146	10	1	23
Te Anau	1 221 091	67	3 646	154	3	1 557	5 428	0	0	36
Turangi	492 097	2 821	244	31 021	2 965	788	37 839	8	2	21
Twizel	923 781	2 415	14 449	33 014	155 308	28 551	233 736	25	11	2
Waikato	817 411	13 781	9 727	9 301	0	22 737	55 546	7	3	16
Waimakariri	532 588	2 720	1 061	7 894	4 910	0	16 585	3	1	27
Wairarapa	828 350	20 171	18 874	1 337	43 244	1	83 627	10	4	9
Wakatipu	514 340	616	2 355	1 425	31 592	58 916	94 903	18	4	7
Wanaka	568 538	1 796	4 373	2 586	49 217	61 889	119 859	21	6	5
Wanganui	752 172	5 724	3 436	50 805	0	1 106	61 071	8	3	13
Warkworth	202 921	856	1 863	22 878	2 102	1	27 699	14	1	22
Whangarei	389 743	1 852	5 050	11 382	39 348	6	57 637	15	3	15

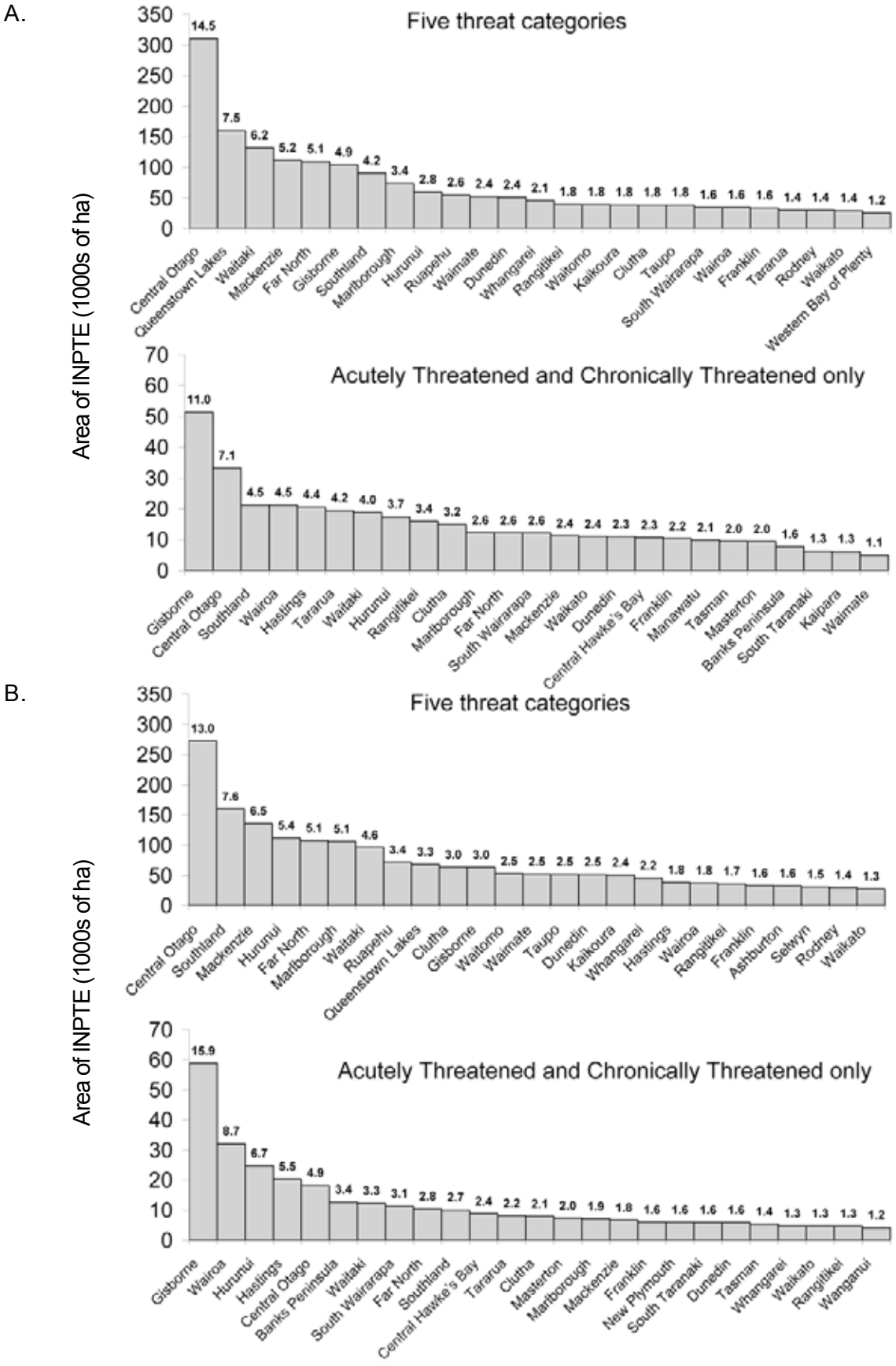

Figure 6. The 25 councils with the greatest area of INPTE (indigenous cover not protected in threatened environments). A: Level IV of LENZ. B: Level II of LENZ. Figures associated with each district are the percentage of the total national INPTE represented.

It is also intuitively obvious to land managers and administrators that Level IV better distinguishes variation in the environment, loss of indigenous cover and threat to biodiversity at the regional, district and local (e.g. property) scales at which they work. For example, a biodiversity officer in Tararua District Council would find little credibility in Level II information classifying remaining indigenous cover in environment F1.1g within the Less Reduced and Better Protected category (see Appendix 3), since it would be obvious to that officer that there was negligible indigenous cover of its type left in the area, and that it was poorly protected. Clearly, Level IV would be the better choice for identifying vulnerable biodiversity and prioritising future protection needs in this local authority area.

Having established that it was more appropriate to assess the vulnerability of remaining biodiversity at local, district and regional scales at Level IV than Level II, we were able quantify two issues resulting from less effective identification of threatened biodiversity that arise through threat classification at Level II. Less effective identification of areas containing much reduced or poorly protected biodiversity can result either in *less effective* protection, because the areas are assigned to a lower category of threat, or to the Less Reduced and Better Protected category (e.g. remaining areas of indigenous vegetation in environment F1 in central Rangitikei District; Appendix 3). Less effective identification of areas containing much reduced or poorly protected biodiversity can also result in *less efficient* protection, because some areas of INP will be classified as 'threatened' that are, in fact, less reduced and/or better protected.

Overall, the bias will be towards the former—less effective identification resulting in less effective protection—rather than the latter because a few well-protected or relatively intact Level IV environments will weight Level II environment totals and averages towards the Less Reduced and Better Protected category. Again, drawing on the example of F1 (Appendix 3), 12 of the 19 Level IV environments are threatened, but when categories are defined at LENZ Level II, the whole area is classified as Less Reduced and Better Protected.

The magnitude of these drawbacks can be quantified. Table 10 shows that threat classification at Level II assigned between 38% and 62% of the area of INP identified in the five threatened environment categories at Level IV (hereafter 'Level IV

TABLE 10. NUMBER OF ENVIRONMENTS AND AREA OF INDIGENOUS COVER NOT PROTECTED (INP) IN THE SIX LAND ENVIRONMENT CATEGORIES DETERMINED AT LEVEL IV (ROWS), BUT ASSIGNED TO THE SAME LAND THREAT ENVIRONMENT CATEGORIES DETERMINED AT LEVEL II.

	NUMBER OF ENVIRONMENTS		INP		
THREAT CATEGORIES DETERMINED AT LENZ LEVEL IV	TOTAL, LEVEL II	PERCENTAGE, LEVEL II (%)	TOTAL AREA, LEVEL IV (ha)	TOTAL AREA, LEVEL II (ha)	PERCENTAGE, LEVEL II (%)
Acutely Threatened	117	74.1	182 573	113 435	62.1
Chronically Threatened	24	32.4	285 416	115 230	40.4
At Risk	18	34.6	468 195	273 390	58.4
Critically Underprotected	13	39.4	708 816	270 033	38.1
Underprotected	9	50.0	497 697	204 827	41.2
Less Reduced and Better Protected	143	86.7	2 651 940	2 191 702	82.6

INPTE') to the same threat category. The lowest correspondence (38%) was in Critically Underprotected environments identified with a threat classification at Level IV. Of total Level IV INPTE (i.e. across the five threatened environment categories), 503 896 ha (24%) were not assigned to a threat category when Level II was used; in other words, identification of threatened biodiversity was 24% less effective with a Level II threat classification. Furthermore, the cost of less efficient identification was that 17% of INP (460 239 ha) that was not within a threatened Level IV environment was included in one of the five threatened environment categories when classification was performed at Level II (Table 11). We note that using Level IV rather than Level II to more effectively and efficiently target vulnerable biodiversity did not result in very large increases in the area identified as under threat: total area of INPTE increased only by 43 657 ha nationally (or less than 0.2% of New Zealand's total land area).

Of the 467 988 ha of Level IV INPTE in Acutely Threatened and Chronically Threatened environments, only 69% (322 078 ha) of INPTE area was assigned to one of these two threat categories when classification was performed at Level II. Thus 31% of threatened, unprotected indigenous cover in these two highest categories of threat was not identified as highly threatened through less effective targeting. Level II classification was less efficient by 47 936 ha (13% of total INP); this was the area of indigenous cover identified as threatened when a finer level of detail indicated that it was in a better-protected or less-reduced environment.

In 42 district councils (58% of the 73), more than 10% of the total area of Level IV INPTE was not included when threat classification was performed at Level II, 19 (26% of the 73) district councils had more than half of the area of Level IV INPTE not included, and three (4% of the 73) had more than 90% of the

TABLE 11. COMPARISON OF AREAS OF INDIGENOUS COVER NOT PROTECTED (INP) IN THE SIX LAND ENVIRONMENT CATEGORIES DETERMINED AT LENZ LEVELS IV (ROWS) AND II (COLUMNS).

Numbers are the area of INP (Level IV classification) not identified by classification at Level II. **Bold** numbers show the area assigned to the same threat category. Numbers in the 'less reduced and better protected' category (right column) show INP determined at LENZ Level IV, but not assigned to any one of the five threat categories by Level II classification, and not identified as within a threatened environment.

	LENZ LEVEL II					
LENZ LEVEL IV	ACUTELY THREATENED	CHRONICALLY THREATENED	AT RISK	CRITICALLY UNDER-PROTECTED	UNDER-PROTECTED	LESS REDUCED AND BETTER PROTECTED
Acutely Threatened (182 573 ha)	**113 435**	29 543	14 353	1	1924	23 316
Chronically Threatened (285 416 ha)	63 870	**115 230**	55 197	2609	23 339	25 171
At Risk (468 195 ha)	6338	34 247	**273 390**	16 109	73 093	65 020
Critically Under-protected (708 816 ha)	0	1938	175 161	**270 033**	126 326	135 358
Under-protected (497 697 ha)	0	0	36 029	1810	**204 827**	255 031
Less Reduced and Better Protected (2 651 940 ha)	84	5330	133 939	0	320 886	**2 191 702**

area of Level IV INPTE not included (Fig. 7A). Queenstown Lakes (106 534 ha), Central Otago (69 493 ha), Gisborne (41 172 ha) and Waitaki (37 139 ha) districts contained the largest areas of Level IV INPTE not identified as threatened when threat classification was undertaken at Level II (Fig. 7B).

In Acutely Threatened and Chronically Threatened environments only (Fig. 7B), Central Otago (16 832 ha), Southland (12 250 ha), Rangitikei (11 635 ha), Tararua (11 415 ha) and Clutha (7846 ha) districts had the greatest areas of Level IV INPTE not identified as threatened when threat classification was undertaken at Level II (these areas accounted for more than half of the INP in Acutely Threatened and

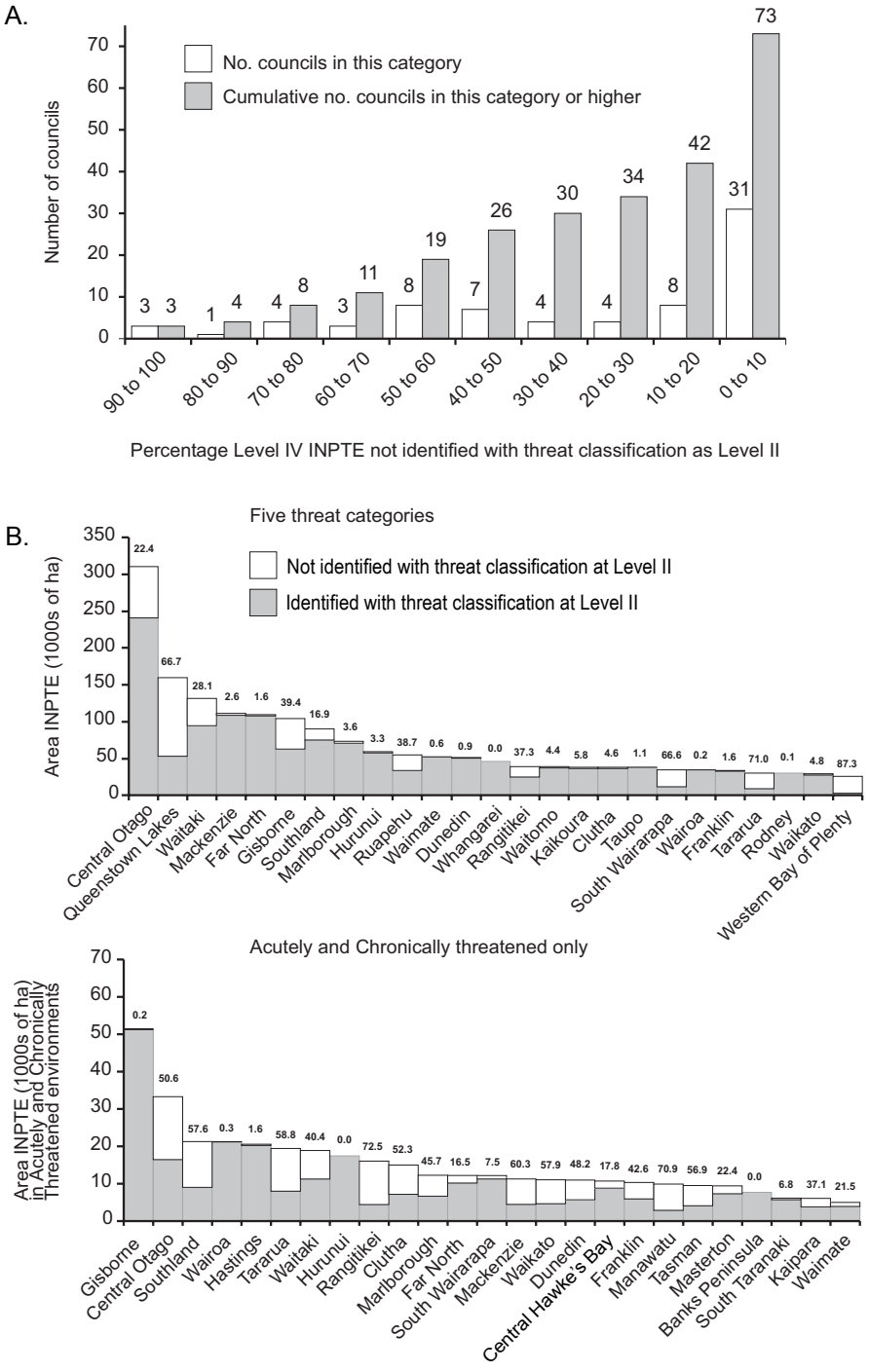

Figure 7. Less effective identification of threat through Level II threat classification. A: Percentage Level IV INPTE (indigenous cover not protected in threatened environments) not identified when threat classification was carried out at Level II. B: Area of Level IV INPTE identified or not in threatened environments in the 25 top-ranking councils when threat classification was carried out at Level II. Figures associated with columns show the percentage area of Level IV INPTE not identified.

Chronically Threatened environments in those districts, and included some of New Zealand's most threatened ecosystems and species).

Figure 8 illustrates the inefficiency costs of Level II classification for individual districts. The area of INPTE estimated with Level II threat classification substantially exceeded the Level IV INPTE area in Mackenzie, Southland, Marlborough, Hurunui, Ruapehu, Dunedin, Waitomo, Kaikoura, Clutha, Taupo and Wairoa districts (Fig. 7A). The largest excesses were in Southland (c. 70 000 ha) and Hurunui (c. 53 000 ha) districts. In environments identified at Level IV as Acutely and Chronically Threatened alone, the area of Level II INP was greater than the actual area in 17 districts, with largest excesses in Gisborne, Wairoa, Hurunui and Banks Peninsula districts.

In summary, although a Level II analysis provides a simpler framework for an overview of national data, it is less suitable than Level IV for assessing (and hence facilitating protection of) vulnerable biodiversity at local and regional scales (Leathwick et al. 2003b; MfE, DOC & LGNZ 2004).

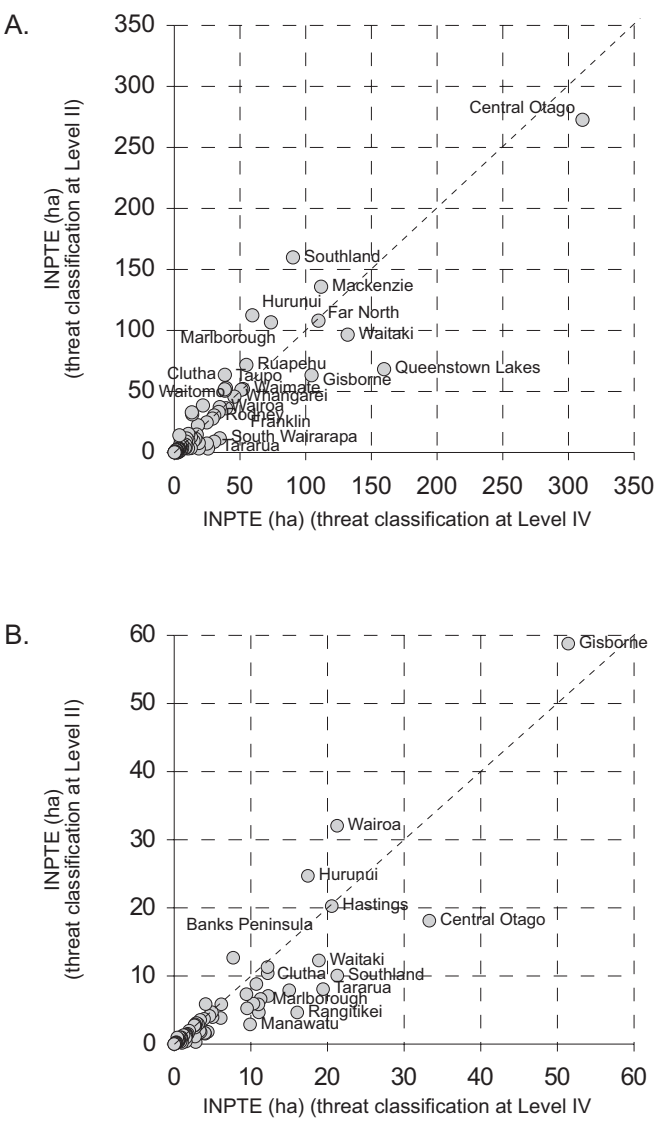

Figure 8. The consequences for districts (each represented by a dot) of less efficient targeting through Level II threat classification. A: All threatened environments. B: Acutely Threatened and Chronically Threatened environments only.

4.4 LAND-USE CAPABILITY OF INDIGENOUS COVER NOT PROTECTED

The characteristics of the eight land-use capability (LUC) classes of the NZLRI are summarised in Table 12.

Figure 9 illustrates that indigenous vegetation clearance in New Zealand has historically been concentrated in high-versatility LUC classes and that high proportions of indigenous cover on versatile soils lie within threatened environments. Consequently, there may be a high risk of loss of what little indigenous biodiversity remains in higher LUC classes today.

TABLE 12. SUITABILITY OF THE EIGHT LAND-USE CLASSES IN THE NZLRI FOR DIFFERENT LAND-USE TYPES (REPRODUCED FROM MINISTRY OF WORKS AND DEVELOPMENT (1979)).

Increasing limitations to use	CLASS	CROPPING SUITABILITY	PASTORAL & PRODUCTION FORESTRY SUITABILITY[a]	GENERAL SUITABILITY	Decreasing versatility
	I	High	High	Multiple use	
	II				
	III	Medium			
	IV	Low			
	V	Unsuitable	Medium	Pastoral or forestry	
	VI				
	VII		Low		
	VIII		Unsuitable	Catchment protection land	

[a] LUCs 4–7 that have wetness as the major limitation, and those units in very low rainfall areas or on shallow soil, are normally not suited to production forestry.

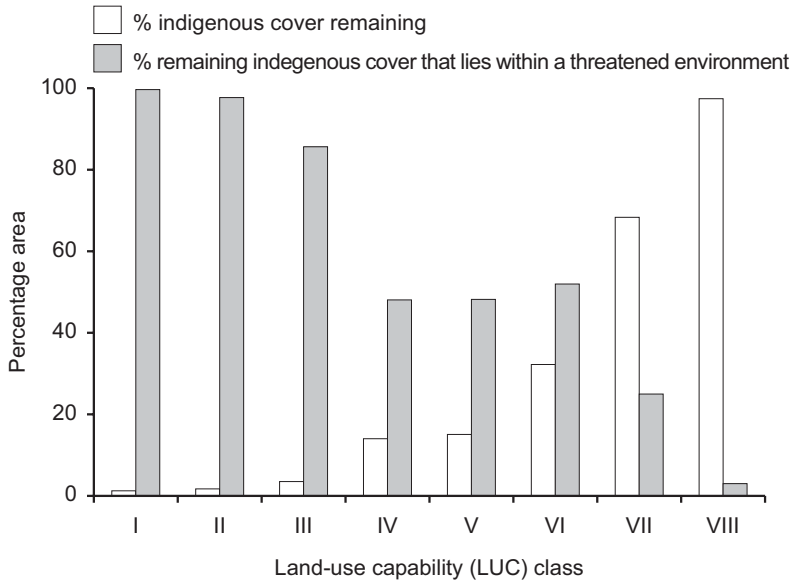

Figure 9. Indigenous cover and percentages of it in threatened environments, across Land-use capability classes in 2001/02.

Tables 13 and 14 show the areas of INP in all environments, and in each threat category (INPTE), across the eight LUC classes of the NZLRI. The great majority of INPTE area was on land with low value for agricultural production. Just 0.1% of INPTE was on elite soils (Class I). We inspected the relevant pixels in a GIS, and found some of this 'elite' land was on river scarps or floodplains under forest or shrubland (e.g. in Manawatu District) or in gullies (e.g. around Hamilton City). Because these places present severe hazards for productive use, we suggest misclassification error in the NZLRI may account for some of this land area.

Soils in Classes I to IV together accounted for 11% (at Level IV) or 12% (at Level II) of the total INPTE area (Tables 13 & 14). The highest portion of INPTE was in LUC Class VI ('non-arable land with moderate limitations and hazards'), which accounted for 51% (at Level IV) or 47% (at Level II) of the total INPTE area (Tables 11 & 12). Although some of this Class VI land supporting INPTE was listed as relatively stable (i.e. with a low erosion hazard), a large amount (c. 65%) of it has wetness, low rainfall, shallow soil or erosion limitations. Over one-third of INPTE was in the lowest LUC Classes VII and VIII; these classes accounted for 37% (at Level IV) or 41% (at Level II) of the total INPTE area. Therefore, the greatest opportunity for protection of INPTE lies in land that has the lowest suitability for cropping, pastoral production and forestry.

TABLE 13. INDIGENOUS COVER NOT PROTECTED (INP) IN THE EIGHT NZLRI LAND-USE CAPABILITY CLASSES, WITHIN EACH OF THE SIX LAND ENVIRONMENT CATEGORIES DETERMINED AT LEVEL IV OF LENZ.

LUC CLASS	TOTAL	ACUTELY THREATENED	CHRONICALLY THREATENED	AT RISK	CRITICALLY UNDER-PROTECTED	UNDER-PROTECTED	LESS REDUCED AND BETTER PROTECTED
Area (ha)							
I	2222	2042	165	3	6	0	7
II	19 168	12 881	3443	702	1318	424	400
III	71 199	31 645	13207	9857	4321	3693	8476
IV	213 363	35 716	29182	44 834	18 299	10 611	74 721
V	22 311	2027	1431	4186	4134	275	10 258
VI	1 497 129	61 389	136 387	298 201	356 544	151 580	493 029
VII	1 989144	25 960	88 223	87 168	296 708	278 776	1 212 311
VIII	943202	5749	11 472	18 511	23 292	51 716	832 462
Misc.[a]	10206	2780	905	2813	2844	358	507
Unclass.[b]	27424	2871	1143	1935	1378	296	19 802
Subtotal	4 795 368	183 058	285 556	468 209	708 843	497 728	2 651 973
NIRD[c]	732	485	140	14	27	31	33
Total	4 794 636	182 573	285 416	468 195	708 816	497 697	2 651 940
Percentage area of INP in first five threat categories (%; INPTE; 2142696 ha)							
I		0.1	0.0	0.0	0.0	0.0	
II		0.6	0.2	0.1	0.0	0.0	
III		1.2	0.7	0.9	0.1	0.1	
IV		1.6	0.8	3.9	0.2	0.8	
V		0.0	0.1	0.5	0.2	0.1	
VI		3.5	3.7	21.5	7.3	14.6	
VII		1.3	2.9	4.5	5.6	17.0	
VIII		0.2	0.3	1.2	0.3	3.2	

[a] Miscellaneous = towns, water, etc.

[b] Unclassified = Stewart Island/Rakiura and other offshore islands not included in the NZLRI.

[c] NIRD = non-indigenous vegetation recently disturbed, not included as indigenous cover in this work.

TABLE 14. INDIGENOUS COVER NOT PROTECTED (INP) IN THE EIGHT NZLRI LAND-USE CAPABILITY CLASSES, WITHIN EACH OF THE SIX LAND ENVIRONMENT CATEGORIES DETERMINED AT LEVEL II OF LENZ.

LUC CLASS	TOTAL	ACUTELY THREATENED	CHRONICALLY THREATENED	AT RISK	CRITICALLY UNDER-PROTECTED	UNDER-PROTECTED	LESS REDUCED AND BETTER PROTECTED
Area (ha)							
I	2222	1470	561	32	0	112	48
II	19 168	12 654	3610	1338	158	70	1338
III	71 199	25 078	13 950	18 387	2108	1624	10 052
IV	213 363	33 607	17 266	82 196	4578	16 157	59 559
V	22 311	669	2649	10 071	4804	1307	2810
VI	1 497 129	72 865	78 473	451 656	153 335	307 102	433 699
VII	1 989 144	26 944	60 801	93 813	117 294	356 267	1 334 025
VIII	943 202	4821	7338	25 564	6002	67 231	832 246
Misc.[a]	10 206	2664	1053	2632	2082	60	1714
Unclass.[b]	27 424	3457	708	2423	226	466	20 144
Subtotal	4 795 368	184 229	186 410	688 111	290 588	750 395	2 695 635
NIRD[c]	732	503	122	43	26	2	37
Total	4 794 636	183 726	186 287	688 068	290 562	750 394	2 695 598
Percentage area of INP in first five threat categories (%; INPTE; 2 099 038 ha)							
I		0.1	0.0	0.0	0.0	0.0	
II		0.6	0.2	0.0	0.1	0.0	
III		1.5	0.6	0.5	0.2	0.2	
IV		1.7	1.4	2.1	0.9	0.5	
V		0.1	0.1	0.2	0.2	0.0	
VI		2.9	6.4	13.9	16.6	7.1	
VII		1.2	4.1	4.1	13.8	13.0	
VIII		0.3	0.5	0.9	1.1	2.4	

[a] Miscellaneous = towns, water, etc.

[b] Unclassified = Stewart Island and other offshore islands not included in the NZLRI.

[c] NIRD = non-indigenous vegetation recently disturbed, not included as indigenous cover in this work.

At the time of writing, pastoral leases in the South Island high country contained more than a quarter (c. 552 000 ha or 29%) of the total area of INPTE in low versatility LUC Classes V to VIII, but a far smaller percentage (7%) of New Zealand's INPTE on more versatile soils (c. 15 500 ha in LUC Classes I–IV). Much of the INPTE on pastoral leases was in At Risk, Critically Underprotected and Underprotected threat categories, because there has been a tendency for pastoral leases to retain mainly indigenous cover. Pastoral leases contained just 5.5% of the total national INPTE in the Acutely Threatened and Chronically Threatened threat categories (c. 25 500 ha). Of INPTE in the Acutely Threatened and Chronically Threatened categories on pastoral leases, c. 21% (c. 5300 ha) was in the more versatile LUC Classes I–IV.

4.5 CHANGES IN INDIGENOUS COVER FROM 1996/97 TO 2001/02 AND THEIR CONSEQUENCES TO REMAINING BIODIVERSITY

In this section, we present data for threatened environments from threat classification at Level IV of LENZ only.

4.5.1 Nature of indigenous cover lost

Broadleaved Indigenous Hardwoods (6745 ha), Manuka and/or Kanuka (5609 ha), Tall-Tussock Grassland (2482 ha) and Indigenous Forest (2232 ha) were the indigenous cover types that experienced the largest conversion to non-indigenous cover types nationally from 1996/97 to 2001/02 (Table 15). Harvesting or felling of c. 2000 ha of Indigenous Forest (Forest – Harvested LCDB 2 class) accounted for 11% of the change, conversion to exotic forestry accounted for c. 13 500 ha or 66% of the total change, conversion to High-Producing Grassland (i.e. pasture) or cropland for 6%, and conversion to Low-Producing Grassland for 16%.

TABLE 15. LAND AREA THAT CHANGED FROM INDIGENOUS TO NON-INDIGENOUS COVER TYPES (ha) FROM 1996/97 TO 2001/02 BY LCDB 2 CLASS.

	BUILT-UP AREA	SURFACE MINE	SHORT-ROTATION CROPLAND	HIGH-PRODUCING EXOTIC GRASSLAND	LOW-PRODUCING GRASSLAND	GORSE AND/OR BROOM	AFFORESTATION (NOT IMAGED)	AFFORESTATION (IMAGED, POST LCDB 1)	FOREST–HARVESTED	OTHER EXOTIC FOREST	TOTAL
Coastal Sand and Gravel	0	0	0	0	32	0	0	22	0	1	55
River and Lakeshore Gravel and Rock	0	0	0	0	0	3	0	0	0	0	3
Landslide	0	0	0	0	172	6	0	0	0	0	178
Tall-Tussock Grassland	0	0	0	0	0	0	54	1196	0	1236	2486
Herbaceous Freshwater Vegetation	0	2	0	55	0	0	38	6	0	0	101
Herbaceous Saline Vegetation	0	0	0	86	0	0	0	0	0	0	86
Fernland	0	0	0	0	0	0	0	90	0	0	90
Manuka and/or Kanuka	0	8	0	565	2052	0	797	2148	3	42	5615
Matagouri	0	0	0	0	0	0	6	0	0	0	6
Broadleaved Indigenous Hardwoods	2	1	3	361	490	227	1802	3815	46	0	6748
Subalpine Shrubland	0	0	0	0	0	0	0	46	0	0	46
Indigenous Forest	3	4	0	0	34	0	0	259	1934	0	2233
Total change	5	16	3	1067	2779	236	2697	7582	1982	1278	17 646
Percentage of 17 646 ha (%)	0.0	0.1	0.0	6.0	15.7	1.3	15.3	43.0	11.2	7.2	100
Total in first five threatened environment categories	5	3	3	801	1765	222	1079	2947	1368	1238	9431
Percentage of 9431 ha (%)	0.0	0.1	0.0	5.6	15.8	1.3	15.4	43.2	11.3	7.3	100

The patterns of net loss of indigenous cover were very similar to those seen in the changes from indigenous to exotic land cover types. This is because the databases showed that, nationally, only 347 ha changed from a non-indigenous cover class to an indigenous cover class; of this, 270 ha was succession to Manuka and/or Kanuka shrubland, and much of the remainder was a change to Broadleaved Indigenous Hardwoods. The same indigenous cover types that showed the largest changes to non-indigenous cover across all environments accounted for the most loss in threatened environments (Table 16): 47% of the total loss of Broadleaved Indigenous Hardwoods, 53% of the total loss of Manuka and/or Kanuka, 66% of the total loss of Tall-tussock Grassland and 65% of the total loss of Indigenous Forest were in threatened environments.

TABLE 16. INDIGENOUS COVER LOSS (ha) FROM 1996/97 TO 2001/02 IN EACH OF THE SIX LAND ENVIRONMENT CATEGORIES, WHICH WERE DETERMINED AT LEVEL IV OF LENZ.

	TOTAL	ACUTELY THREATENED	CHRONICALLY THREATENED	AT RISK	CRITICALLY UNDER-PROTECTED	UNDER-PROTECTED	LESS REDUCED AND BETTER PROTECTED
Change from indigenous cover to non-indigenous cover							
Coastal Sand and Gravel	55	0	0	53	2	0	0
River and Lakeshore Gravel and Rock	2	1	0	0	0	0	1
Landslide	177	0	0	0	0	1	177
Tall-Tussock Grassland	2482	47	462	7	478	655	833
Herbaceous Freshwater Vegetation	101	16	35	25	0	0	24
Herbaceous Saline Vegetation	4	1	0	3	0	0	0
Fernland	90	0	0	25	2	0	63
Manuka and/or Kanuka	5609	371	1154	551	798	81	2654
Matagouri	6	6	0	0	0	0	0
Broadleaved Indigenous Hardwoods	6745	552	635	1303	598	98	3559
Subalpine Shrubland	46	7	2	0	1	1	35
Indigenous Forest	2232	145	249	313	534	210	781
Total change	17 550	1147	2537	2281	2413	1046	8126
Change from non-indigenous cover to indigenous cover							
All non-indigenous cover classes	347	20	8	74	6	0	238
Net loss of indigenous cover							
Net loss of indigenous cover	17 204	1127	2529	2207	2407	1046	7888
Net loss of indigenous cover not protected	16 271	1121	2483	2201	2360	956	7151
(% of net loss of indigenous cover)	(94.6%)	(99.5%)	(98.2%)	(99.7%)	(98.1%)	(91.4%)	(90.7%)
Change from low-producing grassland to other non-indigenous cover							
Low-Producing Grassland	29 338	3157	9135	6840	1287	3510	5409

Indigenous cover loss in threatened environments was also due to very similar activities: harvesting or felling of Indigenous Forest accounted for 11% (1368 ha) and exotic forestry for 66% (5264 ha) of the total change in threatened environments, conversion to High-Producing Exotic Grassland (i.e. pasture) or cropland for 6% (804 ha), and conversion to Low-Producing Grassland for 16% (1765 ha).

Table 16 (final row) also highlights that 29 338 ha changed from Low-Producing Grassland cover (classified as 'Non-indigenous') to other non-indigenous classes between 1996/97 and 2001/02. A large portion of this change (29 160 ha) was conversion to exotic forestry, and much of this conversion (c. 81%) occurred in threatened environments, particularly in Chronically Threatened and At Risk environments (9135 and 6840 ha, respectively). The land area of Low-Producing Grassland affected by these changes (29 338 ha) was greater (i.e. 1.67 times) than the total national decrease in indigenous cover classes (17 204 ha). Since many areas of Low-Producing Grassland contain mixtures of indigenous and exotic species, significant further loss of indigenous biodiversity may have been incurred owing to these changes.

4.5.2 Indigenous cover loss across land environments and threat categories

There was a net loss of indigenous cover in almost half (245, or 49%) of New Zealand's 500 Level IV land environments between 1996/97 and 2001/02 (Table 17). One Level IV environment (F1.3d, in central Rangitikei District) changed threat category from Chronically Threatened to Acutely Threatened owing to indigenous cover loss. Of the 500 Level IV environments, 251 (50%) showed no change in indigenous cover, and indigenous cover increased in just four (0.8%)

TABLE 17. PERCENTAGE LOSS AND RATE OF LOSS OF INDIGENOUS COVER FROM 1996/97 TO 2001/02 IN EACH OF THE SIX LAND ENVIRONMENT CATEGORIES, WHICH WERE DETERMINED AT LEVEL IV OF LENZ.

	TOTAL	ACUTELY THREATENED	CHRONICALLY THREATENED	AT RISK	CRITICALLY UNDER-PROTECTED	UNDER-PROTECTED	LESS REDUCED AND BETTER PROTECTED
Probability of loss in 5 years (% of environments with a net loss of indigenous cover)							
Probability	49.0	48.1	64.9	50.0	39.4	55.6	43.6
Five-year change (% of whole environment area)							
All environments							
Average	–0.07	–0.02	–0.10	–0.11	–0.09	–0.16	–0.07
Changed environments only							
Average	–0.13	–0.04	–0.16	–0.21	–0.22	–0.28	–0.15
Median	–0.04	–0.02	–0.08	–0.08	–0.13	–0.07	–0.05
Maximum	–2.39	–0.34	–1.86	–1.68	–1.00	–1.79	–2.39
Five-year rate of change (% of indigenous cover)							
All environments							
Average	–0.37	–0.49	–0.73	–0.42	–0.22	–0.41	–0.11
Changed environments only							
Average	–0.74	–1.00	–1.13	–0.81	–0.55	–0.74	–0.25
Median	–0.27	–0.51	–0.47	–0.30	–0.36	–0.16	–0.07
Maximum	–14.77	–11.06	–14.77	–5.86	–2.91	–5.53	–6.39

environments. These four net increases were relatively small in area (i.e. 1, 3, 6 and 35 ha, respectively).

Approximately 54% of the total area that changed from indigenous to non-indigenous cover from 1996/97 to 2001/02 (9316 ha) was in threatened environments. Of the five threat categories, the largest total decrease was in Chronically Threatened environments (2537 ha), but total losses in At Risk and Critically Underprotected environments were almost as large. Most of the indigenous cover lost had not been legally protected (95% of total loss). In threatened environments, 98% of indigenous cover lost was on land not legally protected (according to our database), whereas within environments assigned to the Less Reduced and Better Protected category, 91% of indigenous cover lost had had no legal protection status.

There was no significant relationship between the area of indigenous cover lost within a given land environment and the percentage of indigenous cover remaining in that environment in 1996/97 (Fig. 10A). However, it is very likely that a relatively small total area of indigenous cover was lost in the 158 Acutely Threatened Level IV environments (only 6.5% of the total area of indigenous cover lost from 1996/97 to 2001/02) because relatively little indigenous cover was left to lose in those environments, and because clearance occurs more rapidly in environments where more indigenous cover remains. Loss of indigenous cover in New Zealand's most intact environments (i.e. those with more than 90% indigenous cover remaining) also accounted for a relatively small portion of the total area lost, probably because these environments are remote, well protected and have few alternative land uses.

Although there is less indigenous cover to lose in threatened environments, rates of loss of indigenous cover (expressed as a percentage of indigenous cover remaining in 1996/97) were higher in most threatened environments than in environments that are Less Reduced and Better Protected (Fig. 10B; Table 17). Median rates of loss were highest in Critically Underprotected environments, but were also relatively high in Chronically Threatened, At Risk and Underprotected environments. The percentage of environments in which indigenous cover decreased was higher in Chronically Threatened environments than in other threat categories; loss occurred in almost 65% of Chronically Threatened environments, whereas in other threat categories probability of loss was between 39% and 50%. Figure 11A shows the geographic distribution of the rate of indigenous cover change within New Zealand's Level IV land environments.

4.5.3 SBL across land environments and threat categories

Change in the index SBL allowed us to identify those environments and districts where the loss of indigenous cover from 1996/97 to 2001/02 resulted in the greatest increase in risk to remaining biodiversity.

Table 18 shows that the majority (78%) of the summed increase in SBL was in the 158 Acutely Threatened Level IV environments. A further 15% of that increased risk to indigenous biodiversity was in the 74 Chronically Threatened environments.

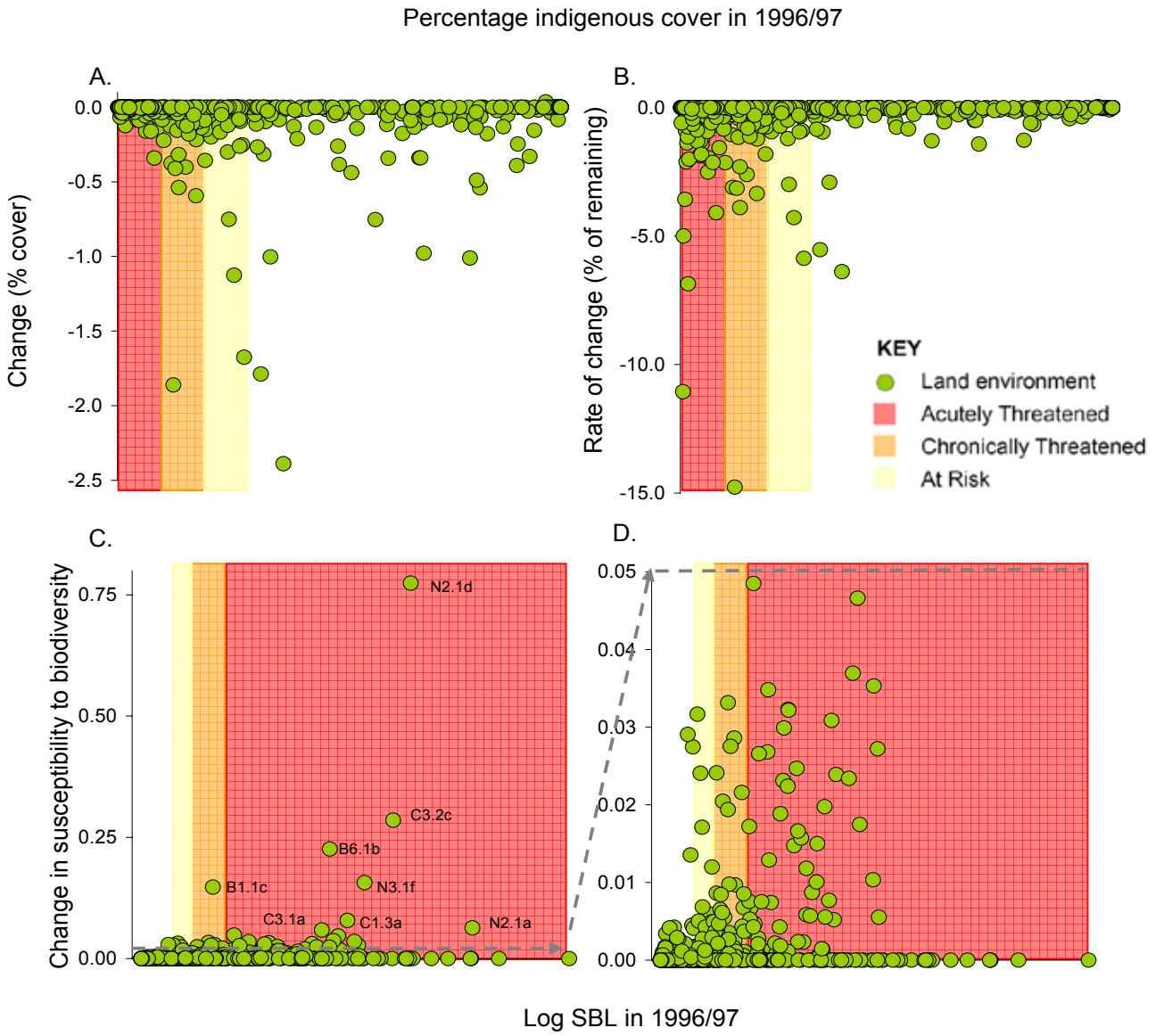

Figure 10. Change from 1996/97 to 2001/02 in New Zealand's Level IV land environments (represented by green circles). A: Change in indigenous cover (as a percentage of whole environment). B: Rate of change in indigenous cover (as a percentage of indigenous cover in 1996/97). C & D: Change in susceptibility to biodiversity loss (SBL; note different *y*-axis scales). A few environments that showed large increases in SBL are labelled and referred to in the text.

TABLE 18. SUMMED, AVERAGE AND MAXIMUM CHANGE IN SUSCEPTIBILITY TO BIODIVERSITY LOSS (SBL) FROM 1996/97 TO 2001/02 ACROSS LEVEL IV LAND ENVIRONMENTS, IN THE SIX LAND ENVIRONMENT CATEGORIES, WHICH WERE DETERMINED AT LEVEL IV OF LENZ.

	TOTAL	ACUTELY THREATENED	CHRONICALLY THREATENED	AT RISK	CRITICALLY UNDER-PROTECTED	UNDER-PROTECTED	LESS REDUCED AND BETTER PROTECTED
No. Level IV environments	500	158	74	52	33	18	165
Summed change	3.202	2.483	0.465	0.122	0.031	0.034	0.066
Percentage of total	100.0	77.5	14.5	3.8	1.0	1.1	2.1
Average change	0.006	0.016	0.006	0.002	0.001	0.002	<0.001
Maximum change		0.774	0.147	0.032	0.014	0.027	0.029

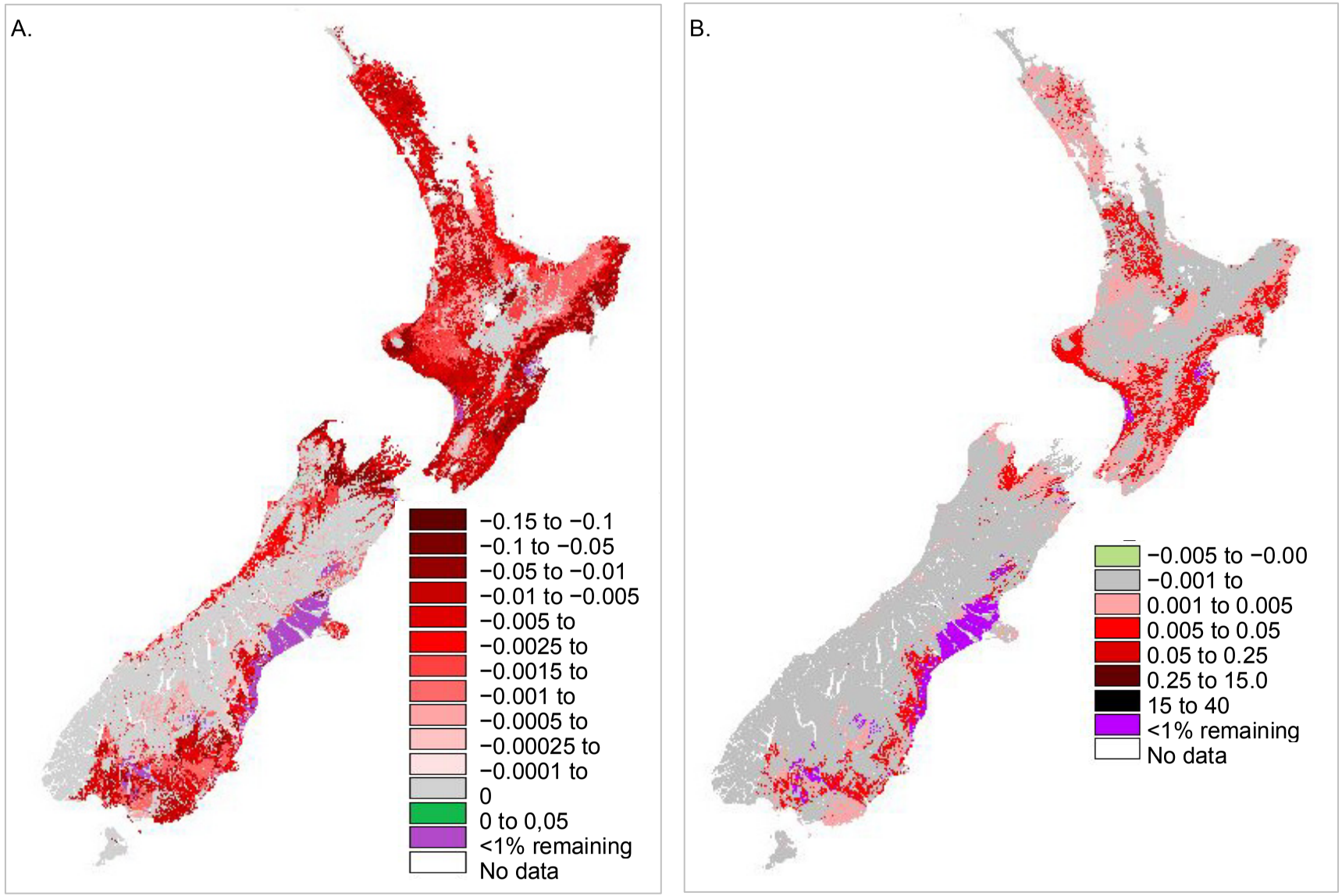

Figure 11. A: Rate of change in indigenous cover (as a percentage of remaining indigenous cover in 1996/97). B: Change in susceptibility to biodiversity loss (SBL) in Level IV land environments from 1996/97 to 2001/02.

The general pattern of increase in SBL (shown in Fig. 10C & D) was:

- Large increases in SBL in a few, Acutely Threatened environments (e.g. N2.1d – South Canterbury Plains, C3.2c – Coastal Rangitikei and Manawatu, B6.1b and B1.1c – terraces of the Awatere and Wairau Valleys in Marlborough, N3.1f – upper Maniototo and Strath Taieri Plains in Otago).
- Somewhat smaller increases in several Acutely Threatened, Chronically Threatened and At Risk environments.
- Minor increases in SBL in a high percentage of environments across all threat categories.

Figure 11B shows the geographic distribution of change in SBL within New Zealand's Level IV land environments.

4.5.4 Loss of indigenous cover and change in SBL across council areas

In our final analysis, we calculated change in indigenous cover from 1996/97 to 2001/02 in each council area, and the contribution of the indigenous cover loss in each to the total change in SBL across the 500 Level IV land environments nationally. These statistics are tabulated for councils and DOC conservancies and areas (Tables 19–22). The loss and change in those councils contributing most to total indigenous cover loss and to summed change in SBL is illustrated in Figure 12.

Tables 19 to 21 and Figure 12 show that the high proportions of the total loss of indigenous cover, the loss of indigenous cover not protected in threatened environments (INPTE) and the summed change in SBL occurred in a relatively small number of districts and DOC conservancies and areas.

More than 50% of the total loss of indigenous cover occurred in six council districts (Marlborough, Far North, Tasman, Central Otago, Southland and Gisborne), and more than 50% of loss of INPTE occurred in five council districts (Far North, Central Otago, Gisborne, Marlborough and Southland). Hastings, Marlborough and Horowhenua council districts contributed 57% of the summed increase in SBL across all land environments, with Central Otago, South Taranaki and Tasman districts together contributing another 17%. In 13 districts or cities (Auckland, Christchurch, Franklin, Gore, Hamilton, Kaikoura, Kawerau, Napier, Papakura, Queenstown Lakes, Selwyn, Tauranga, Waitakere), no indigenous cover loss at all was recorded (and, therefore, no increase in SBL).

Among DOC conservancies (Table 20), East Coast/Hawke's Bay contributed 37% of the summed increase in SBL (Napier Area alone accounted for 33%; Table 21), Nelson/Marlborough contributed 21% (South Marlborough Area accounted for 15%) and Wanganui contributed 17% (Palmerston North Area accounted for 15%).

Table 22 shows that Masterton, South Taranaki and Tararua districts had the largest area losses of indigenous cover from Acutely Threatened environments, while Central Otago, Far North and Gisborne districts lost the largest areas of indigenous cover in Chronically Threatened environments. Among DOC conservancies (Table 23) Wellington and Wanganui lost the largest area of indigenous cover from Acutely Threatened environments, while East Coast/ Hawke's Bay and Otago lost the largest area of indigenous cover in Chronically Threatened environments.

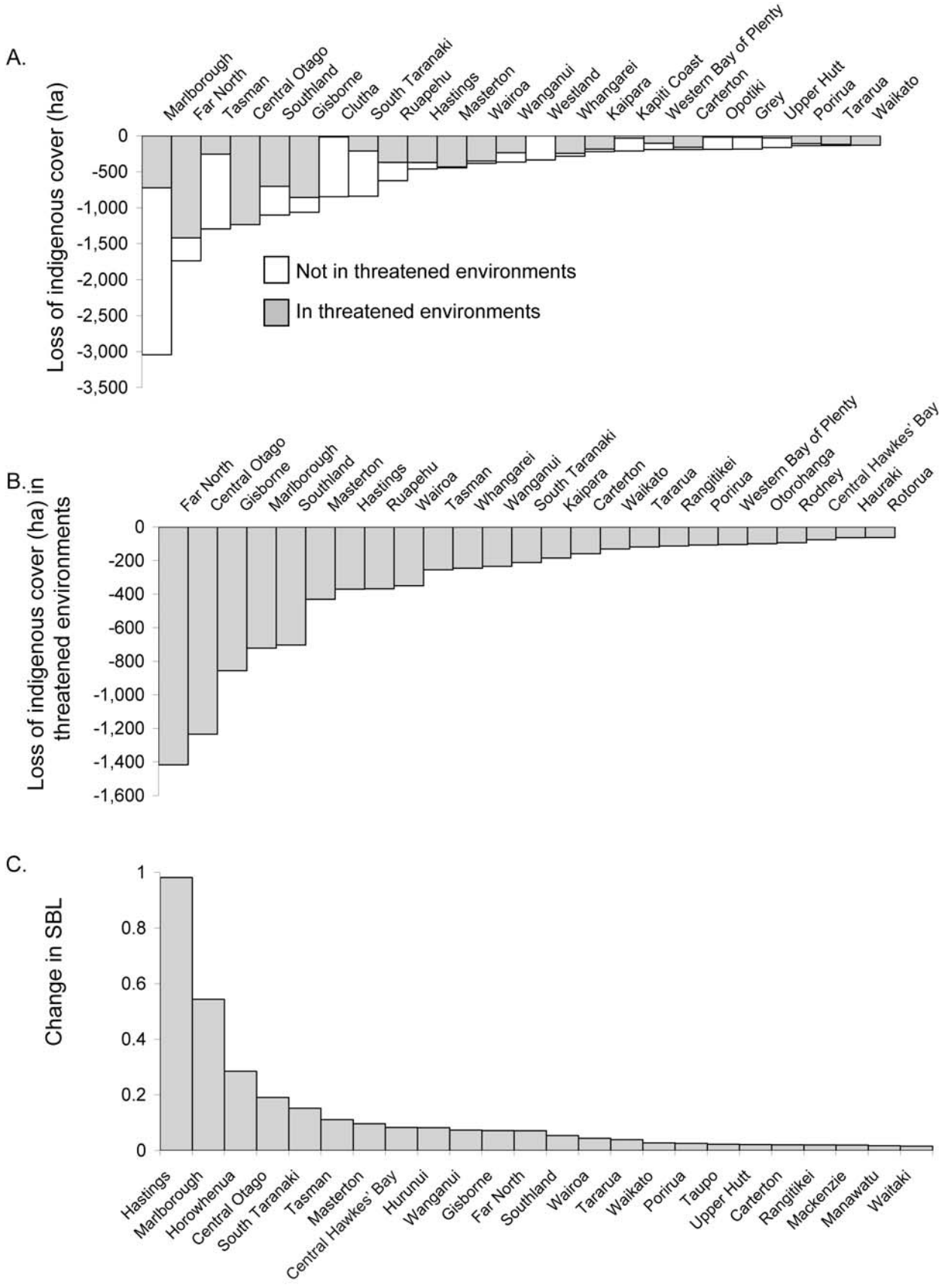

Figure 12. Contribution of top-ranking district and city council to national loss of indigenous cover and increase in susceptibility to biodiversity loss (SBL), in rank order. A: Loss of indigenous cover. B: Loss of indigenous cover in threatened environments only. C: Summed change in SBL due to loss of indigenous cover in that district.

TABLE 19. LOSS OF INDIGENOUS COVER BY COUNCIL AREA, AND CONTRIBUTION TO SUMMED NATIONAL CHANGE IN SUSCEPTIBILITY TO BIODIVERSITY LOSS (SBL) ACROSS ALL LEVEL IV LAND ENVIRONMENTS (ALL) AND THE FIVE THREATENED ENVIRONMENT CATEGORIES (THREATENED), FROM 1996/97 TO 2001/02. COUNCIL RANK (RK) INDICATES A COUNCIL'S CONTRIBUTION TO EACH LOSS STATISTIC, WHICH WERE DETERMINED AT LEVEL IV OF LENZ.

	LOSS OF INDIGENOUS COVER				LOSS OF INP				CHANGE IN SBL		
	ALL		THREATENED		ALL		THREATENED				
COUNCIL	AREA (ha)	RK	AREA (ha)	RK	AREA (ha)	RK	AREA (ha)	RK	CHANGE	PERCENTAGE OF SUMMED CHANGE	RK
Ashburton	9	55	1	55	9	54	1	55	0.002	0.07	45
Auckland	0	61	0	58	0	60	0	58	0.000	0.00	61
Banks Peninsula	16	51	16	44	16	50	16	43	0.004	0.14	37
Buller	29	42	21	37	49	35	20	37	0.002	0.07	43
Carterton	191	19	159	15	191	18	159	15	0.021	0.64	20
Central Hawke's Bay	81	31	75	23	80	30	74	22	0.083	2.60	8
Central Otago	1234	4	1234	2	1233	3	1233	2	0.191	5.95	4
Christchurch	0	61	0	58	0	60	0	58	0.000	0.00	61
Clutha	847	7	16	45	839	7	16	44	0.006	0.18	31
Dunedin	55	34	55	27	54	33	54	25	0.006	0.18	32
Far North	1737	2	1418	1	1695	2	1389	1	0.072	2.23	12
Franklin	0	61	0	58	0	60	0	58	0.000	0.00	61
Gisborne	1063	6	856	3	1035	6	839	3	0.072	2.25	11
Gore	0	61	0	58	0	60	0	58	0.000	0.00	61
Grey	186	21	20	39	129	23	20	38	0.002	0.07	46
Hamilton	0	61	0	58	0	60	0	58	0.000	0.00	61
Hastings	460	10	370	7	458	10	369	7	0.982	30.66	1
Hauraki	84	30	63	24	83	29	62	23	0.003	0.10	40
Horowhenua	24	44	14	46	24	44	14	46	0.285	8.90	3
Hurunui	38	39	36	29	38	39	36	28	0.082	2.57	9
Invercargill	6	57	0	58	6	56	0	58	0.000	0.00	59
Kaikoura	0	61	0	58	0	60	0	58	0.000	0.00	61
Kaipara	219	16	185	14	219	15	185	14	0.008	0.24	29
Kapiti Coast	213	17	35	30	213	16	35	29	0.008	0.25	28
Kawerau	0	61	0	58	0	60	0	58	0.000	0.00	61
Lower Hutt	42	38	3	54	42	38	3	54	0.001	0.03	53
Mackenzie	17	49	17	42	17	49	17	42	0.020	0.62	22
Manawatu	43	37	43	28	43	37	43	27	0.018	0.56	23
Manukau	17	50	17	43	16	51	16	44	0.000	0.00	58
Marlborough	3044	1	722	4	2972	1	699	4	0.544	16.98	2
Masterton	446	11	431	6	443	11	428	6	0.096	3.00	7
Matamata-Piako	1	60	1	57	1	59	1	57	0.000	0.01	55
Napier	0	61	0	58	0	60	0	58	0.000	0.00	61
Nelson	7	56	7	50	7	55	7	50	0.003	0.08	41
New Plymouth	36	40	9	49	36	41	9	49	0.002	0.08	42
North Shore	6	57	6	51	6	56	6	51	0.000	0.00	60
Opotiki	188	20	19	40	185	19	19	39	0.005	0.14	36
Otorohanga	122	28	99	21	121	26	99	21	0.002	0.05	47
Palmerston North	1	59	1	56	1	58	1	56	0.000	0.01	56
Papakura	0	61	0	58	0	60	0	58	0.000	0.00	61
Porirua	138	23	107	19	138	21	107	19	0.026	0.81	17
Queenstown Lakes	0	61	0	58	0	60	0	58	0.000	0.00	61
Rangitikei	129	26	113	18	114	27	111	18	0.020	0.63	21

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Table 19—continued

COUNCIL	LOSS OF INDIGENOUS COVER				LOSS OF INP				CHANGE IN SBL		
	ALL		THREATENED		ALL		THREATENED				
	AREA (ha)	RK	AREA (ha)	RK	AREA (ha)	RK	AREA (ha)	RK	CHANGE	PERCENTAGE OF SUMMED CHANGE	RK
Rodney	98	29	93	22	107	28	102	20	0.002	0.07	44
Rotorua	79	32	62	25	64	31	49	26	0.015	0.48	25
Ruapehu	623	9	368	8	623	8	368	8	0.006	0.18	30
Selwyn	0	61	0	58	0	60	0	58	0.000	0.00	61
South Taranaki	839	8	212	13	532	9	208	13	0.152	4.75	5
South Waikato	30	41	25	32	30	42	25	32	0.005	0.16	34
South Wairarapa	122	27	24	33	122	25	24	33	0.005	0.15	35
Southland	1101	5	703	5	1093	5	694	5	0.054	1.68	13
Stratford	44	36	18	41	44	36	18	41	0.000	0.01	54
Tararua	136	24	119	17	135	22	117	17	0.039	1.22	15
Tasman	1294	3	255	10	1221	4	251	10	0.111	3.47	6
Taupo	52	35	56	26	51	34	54	24	0.023	0.71	18
Tauranga	0	61	0	58	0	60	0	58	0.000	0.00	61
Thames–Coromandel	58	33	5	52	58	32	5	52	0.002	0.05	48
Timaru	23	47	23	35	23	47	23	35	0.011	0.35	26
Upper Hutt	163	22	30	31	163	20	30	30	0.021	0.67	19
Waikato	131	25	130	16	126	24	126	16	0.027	0.85	16
Waimakariri	20	48	20	38	19	48	19	40	0.011	0.33	27
Waimate	11	53	11	47	11	52	11	47	0.006	0.17	33
Waipa	23	45	22	36	23	45	22	36	0.004	0.14	38
Wairoa	383	12	350	9	383	12	350	9	0.044	1.38	14
Waitakere	0	61	0	58	0	60	0	58	0.000	0.00	61
Waitaki	11	53	11	47	11	52	11	47	0.016	0.49	24
Waitomo	23	46	23	34	23	46	23	34	0.001	0.04	50
Wanganui	366	13	234	12	365	13	234	12	0.073	2.29	10
Wellington	24	43	5	53	24	43	5	53	0.000	0.01	57
Western Bay of Plenty	191	18	105	20	37	40	26	31	0.001	0.03	52
Westland	335	14	0	58	194	17	0	58	0.001	0.04	51
Whakatane	11	52	–3	73	–3	73	–3	73	0.001	0.05	49
Whangarei	284	15	245	11	279	14	240	11	0.004	0.12	39

TABLE 20. LOSS OF INDIGENOUS COVER BY DOC CONSERVANCY, AND CONTRIBUTION TO SUMMED NATIONAL CHANGE IN SUSCEPTIBILITY TO BIODIVERSITY LOSS (SBL) ACROSS ALL LEVEL IV LAND ENVIRONMENTS (ALL ENV.) AND THE FIVE THREATENED ENVIRONMENT CATEGORIES (THREATENED), FROM 1996/97 TO 2001/02. RANK (RK) INDICATES A CONSERVANCY'S CONTRIBUTION TO EACH LOSS STATISTIC.

	LOSS OF INDIGENOUS COVER				LOSS OF INP				CHANGE IN SBL		
	ALL		THREATENED		ALL		THREATENED				
CONSERVANCY	AREA (ha)	RK	AREA (ha)	RK	AREA (ha)	RK	AREA (ha)	RK	CHANGE	PERCENTAGE OF SUMMED CHANGE	RK
Auckland	121	13	116	11	129	13	124	9	0.003	0.1	13
Bay Of Plenty	299	11	191	9	130	12	99	11	0.024	0.8	10
Canterbury	134	12	125	10	132	11	123	10	0.136	4.2	6
East Coast/Hawke's Bay	2241	2	1695	2	2181	3	1675	2	1.188	37.1	1
Nelson/Marlborough	4301	1	983	4	4160	1	957	4	0.657	20.5	2
Northland	2241	3	1848	1	2194	2	1814	1	0.083	2.6	7
Otago	2180	4	1319	3	2169	4	1316	3	0.218	6.8	4
Southland	1074	7	701	6	1066	7	692	6	0.053	1.7	8
Tongariro/Taupo	301	10	79	12	299	10	78	12	0.023	0.7	11
Waikato	890	8	676	7	884	8	670	7	0.044	1.4	9
Wanganui	1383	6	653	8	1074	6	649	8	0.552	17.2	3
Wellington	1445	5	888	5	1440	5	884	5	0.215	6.7	5
West Coast Tai Poutini	594	9	41	13	413	9	40	13	0.006	0.2	12

TABLE 21. LOSS OF INDIGENOUS COVER BY DOC AREA, AND CONTRIBUTION TO SUMMED NATIONAL CHANGE IN SUSCEPTIBILITY TO BIODIVERSITY LOSS (SBL) ACROSS ALL LEVEL IV LAND ENVIRONMENTS (ALL ENV.) AND THE FIVE THREATENED ENVIRONMENT CATEGORIES (THREATENED), FROM 1996/97 TO 2001/02. RANK (RK) INDICATES AN AREA'S CONTRIBUTION TO EACH LOSS STATISTIC. LAND ENVIRONMENT CATEGORIES WERE DETERMINED AT LEVEL IV OF LENZ.

	LOSS OF INDIGENOUS COVER				LOSS OF INP				CHANGE IN SBL		
	ALL		THREATENED		ALL		THREATENED				
DOC AREA	AREA (ha)	RK	AREA (ha)	RK	AREA (ha)	RK	AREA (ha)	RK	CHANGE	PERCENTAGE OF SUMMED CHANGE	RK
Aniwaniwa	14	37	1	38	2	39	1	38	0.000	0.0	39
Aoraki	0	40	0	39	0	40	0	39	0.000	0.0	40
Auckland	38	35	36	32	37	35	35	32	0.000	0.0	38
Bay of Islands	1345	3	1188	3	1316	3	1160	3	0.057	1.8	11
Buller–Kawatiri	–51	49	–5	49	–25	49	–5	49	0.000	0.0	49
Central Otago	1234	4	1234	1	1233	4	1233	1	0.191	6.0	4
Coastal Otago	946	8	85	19	936	7	83	19	0.028	0.9	18
Franz Josef–Waiau	0	40	0	39	0	40	0	39	0.000	0.0	40
Gisborne	1409	2	1205	2	1382	2	1188	2	0.116	3.6	7
Golden Bay	612	10	37	31	569	11	37	30	0.053	1.6	12
Great Barrier Island	0	40	0	39	0	40	0	39	0.000	0.0	40
Greymouth–Mawheranui	310	18	46	26	244	20	45	26	0.005	0.2	26
Hauraki	113	28	39	29	113	27	39	28	0.003	0.1	33

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Table 21—continued

DOC AREA	LOSS OF INDIGENOUS COVER				LOSS OF INP				CHANGE IN SBL		
	ALL		THREATENED		ALL		THREATENED				
	AREA (ha)	RK	AREA (ha)	RK	AREA (ha)	RK	AREA (ha)	RK	CHANGE	PERCENTAGE OF SUMMED CHANGE	RK
Hokitika	335	17	0	39	194	24	0	39	0.001	0.0	37
Kaitaia	114	27	108	18	113	26	107	17	0.004	0.1	31
Kapiti	360	15	142	15	360	14	142	15	0.034	1.1	17
Kauri Coast	361	14	169	14	348	15	169	14	0.017	0.5	22
Maniapoto	536	12	409	8	535	12	408	8	0.006	0.2	24
Motueka	296	19	183	13	274	17	180	13	0.043	1.3	14
Murihiku	982	6	661	5	977	6	656	5	0.049	1.5	13
Napier	594	11	469	7	577	10	467	7	1.067	33.3	1
New Plymouth	32	36	6	36	32	36	6	36	0.002	0.1	36
North Canterbury	65	32	63	22	64	31	62	21	0.092	2.9	9
Opotiki	225	24	19	34	221	23	19	34	0.005	0.2	29
Palmerston North	140	26	137	16	140	25	137	16	0.320	10.0	3
Poneke	229	23	38	30	229	22	38	29	0.023	0.7	19
Rangitaiki	3	39	3	37	3	38	3	37	0.004	0.1	32
Rotorua Lakes	80	31	63	22	65	30	50	24	0.016	0.5	23
Ruakapuka	60	33	52	24	59	33	52	22	0.039	1.2	15
Ruapehu	247	21	28	33	246	19	28	33	0.003	0.1	34
Solander Island	0	40	0	39	0	40	0	39	0.000	0.0	40
Sounds	1825	1	76	21	1776	1	76	20	0.062	1.9	10
South Marlborough	1219	5	645	6	1196	5	623	6	0.481	15.0	2
South Westland–Weheka	0	40	0	39	0	40	0	39	0.000	0.0	40
Southern Islands	0	40	0	39	0	40	0	39	0.000	0.0	40
St Arnaud	350	16	41	27	345	16	41	27	0.018	0.6	21
Stratford	254	20	195	12	253	18	194	12	0.132	4.1	6
Tauranga	216	25	125	17	62	32	45	25	0.005	0.2	28
Te Anau	93	29	40	28	89	29	36	31	0.005	0.1	30
Turangi	54	34	52	25	53	34	50	23	0.020	0.6	20
Twizel	0	40	0	39	0	40	0	39	0.000	0.0	40
Waikato	241	22	228	11	236	21	223	11	0.035	1.1	16
Waimakariri	9	38	9	35	9	37	9	35	0.005	0.2	27
Wairarapa	856	9	708	4	851	8	704	4	0.159	5.0	5
Wakatipu	0	40	0	39	0	40	0	39	0.000	0.0	40
Wanaka	0	40	0	39	0	40	0	39	0.000	0.0	40
Wanganui	957	7	315	10	649	9	311	10	0.097	3.0	8
Warkworth	83	30	80	20	92	28	88	18	0.002	0.1	35
Whangarei	421	13	382	9	416	13	377	9	0.005	0.2	25

TABLE 22. LOSS OF INDIGENOUS COVER, INCLUDING INDIGENOUS COVER NOT PROTECTED (INP) IN ACUTELY THREATENED AND CHRONICALLY THREATENED ENVIRONMENT CATEGORIES, BY COUNCIL AREA, FROM 1996/97 TO 2001/02. RANK (RK) INDICATES A COUNCIL'S CONTRIBUTION TO EACH LOSS STATISTIC. LAND ENVIRONMENT CATEGORIES WERE DETERMINED AT LEVEL IV OF LENZ.

	LOSS OF INDIGENOUS COVER				LOSS OF INP			
	ACUTELY		CHRONICALLY		ACUTELY		CHRONICALLY	
COUNCIL	AREA (ha)	RK	AREA (ha)	RK	AREA (ha)	RK	AREA (ha)	RK
Ashburton	1	42	0	34	1	43	0	34
Auckland	0	50	0	35	0	50	0	35
Banks Peninsula	3	37	6	23	3	37	6	23
Buller	0	50	0	35	0	50	0	35
Carterton	16	21	1	31	16	21	1	31
Central Hawke's Bay	36	9	26	12	35	9	26	12
Central Otago	9	29	461	1	9	29	460	1
Christchurch	0	50	0	35	0	50	0	35
Clutha	16	22	0	35	16	22	0	35
Dunedin	13	27	0	35	13	27	0	35
Far North	49	7	364	3	49	8	363	3
Franklin	0	50	0	35	0	50	0	35
Gisborne	27	14	450	2	27	14	450	2
Gore	0	50	0	35	0	50	0	35
Grey	0	50	0	35	0	50	0	35
Hamilton	0	50	0	35	0	50	0	35
Hastings	50	6	321	4	49	7	320	4
Hauraki	2	39	18	16	2	39	18	16
Horowhenua	14	26	0	35	14	26	0	35
Hurunui	9	28	27	11	9	28	27	11
Invercargill	0	50	0	35	0	50	0	35
Kaikoura	0	50	0	35	0	50	0	35
Kaipara	5	33	13	17	5	33	13	17
Kapiti Coast	34	11	0	35	34	11	0	35
Kawerau	0	50	0	35	0	50	0	35
Lower Hutt	1	46	0	32	1	46	0	32
Mackenzie	5	32	12	18	5	32	12	18
Manawatu	19	18	24	14	19	17	24	14
Manukau	0	50	0	35	0	50	0	35
Marlborough	34	10	267	5	34	10	245	5
Masterton	194	1	25	13	192	1	25	13
Matamata-Piako	1	47	0	35	1	47	0	35
Napier	0	50	0	35	0	50	0	35
Nelson	1	43	0	35	1	42	0	35
New Plymouth	4	35	0	35	4	35	0	35
North Shore	0	50	0	35	0	50	0	35
Opotiki	18	19	1	29	18	18	1	29
Otorohanga	1	40	0	35	1	40	0	35
Palmerston North	0	50	1	29	0	50	1	29
Papakura	0	50	0	35	0	50	0	35
Porirua	30	13	0	35	30	13	0	35
Queenstown Lakes	0	50	0	35	0	50	0	35
Rangitikei	72	4	37	9	70	4	37	9
Rodney	1	44	-5	73	1	44	-1	73
Rotorua	25	15	0	35	22	15	0	35
Ruapehu	0	50	0	72	0	50	0	72
Selwyn	0	50	0	35	0	50	0	35
South Taranaki	99	2	0	35	99	2	0	35
South Waikato	21	17	0	33	21	16	0	33

Continued on next page

Table 22—continued

	LOSS OF INDIGENOUS COVER				LOSS OF INP			
	ACUTELY		CHRONICALLY		ACUTELY		CHRONICALLY	
COUNCIL	AREA (ha)	RK	AREA (ha)	RK	AREA (ha)	RK	AREA (ha)	RK
South Wairarapa	8	30	3	26	8	30	3	26
Southland	44	8	201	6	53	6	184	6
Stratford	1	48	0	35	1	48	0	35
Tararua	74	3	6	24	73	3	5	24
Tasman	16	23	83	8	16	23	79	8
Taupo	53	5	0	35	53	5	0	35
Tauranga	0	50	0	35	0	50	0	35
Thames–Coromandel	1	40	1	28	1	40	1	28
Timaru	15	24	7	22	15	24	7	21
Upper Hutt	15	25	11	19	15	25	11	19
Waikato	21	16	2	27	18	19	2	27
Waimakariri	1	49	20	15	1	49	18	15
Waimate	6	31	0	35	6	31	0	35
Waipa	18	20	0	35	18	20	0	35
Wairoa	0	50	97	7	0	50	97	7
Waitakere	0	50	0	35	0	50	0	35
Waitaki	5	34	5	25	5	34	5	25
Waitomo	2	38	0	35	2	38	0	35
Wanganui	31	12	27	10	31	12	27	10
Wellington	0	50	0	35	0	50	0	35
Western Bay of Plenty	0	50	0	35	0	50	0	35
Westland	0	50	0	35	0	50	0	35
Whakatane	1	44	8	21	1	44	8	20
Whangarei	4	36	10	20	4	36	6	22

TABLE 23. LOSS OF INDIGENOUS COVER, INCLUDING INDIGENOUS COVER NOT PROTECTED (INP) IN ACUTELY AND CHRONICALLY THREATENED ENVIRONMENT CATEGORIES, BY DOC CONSERVANCY, FROM 1996/97 TO 2001/02. RANK (RK) INDICATES A CONSERVANCY'S CONTRIBUTION TO EACH LOSS STATISTIC. LAND ENVIRONMENT CATEGORIES WERE DETERMINED AT LEVEL IV OF LENZ.

	LOSS OF INDIGENOUS COVER				LOSS OF INP			
	ACUTELY		CHRONICALLY		ACUTELY		CHRONICALLY	
CONSERVANCY	AREA (ha)	RK	AREA (ha)	RK	AREA (ha)	RK	AREA (ha)	RK
Auckland	1	12	–5	13	1	12	–1	13
Bay Of Plenty	48	7	8	10	45	10	8	10
Canterbury	41	11	72	7	41	11	70	7
East Coast/Hawke's Bay	142	3	898	1	141	3	897	1
Nelson/Marlborough	51	5	350	4	51	5	324	4
Northland	58	4	387	3	58	4	383	3
Otago	45	9	466	2	45	9	465	2
Southland	42	10	201	5	51	6	184	5
Tongariro/Taupo	47	8	0	11	47	8	0	11
Waikato	50	6	21	9	47	7	21	9
Wanganui	240	2	89	6	238	2	89	6
Wellington	361	1	42	8	357	1	42	8
West Coast Tai Poutini	0	13	0	11	0	13	0	11

4.6 CHANGES DUE TO DATABASE REFINEMENTS AND/OR ACTUAL LOSS OF INDIGENOUS COVER?

Work completed in 2004 for MfE (i.e. Rutledge et al. (2004) and MfE et al. (2004)) pre-dated the release of LCDB 2 and LCDB 1 and is based on LCDB 1_2. Figures produced in our analyses for this work, therefore, differ from that previous work. Table 24 compares estimates from the three databases. It also shows the extent to which the different estimates based on LCDB 2 are due to improved classification (from 14 to 43 classes of cover) and to habitat loss.

5. Discussion

5.1 RISK TO REMAINING BIODIVERSITY IN NEW ZEALAND

New Zealand's indigenous biodiversity exists in a state of virtual extinction in some warm, flat, fertile eastern lowland environments, and is more intact and well protected in cold, wet, steep western environments. This variation reflects the uneven distribution of human development pressures (including

TABLE 24. AREAS (ha) OF REMAINING INDIGENOUS COVER NOT PROTECTED (INP) IN ACUTELY AND CHRONICALLY THREATENED ENVIRONMENT CATEGORIES, IDENTIFIED USING THE THREE DIFFERENT LAND COVER DATABASES: LCDB 1_2 (14 COVER CLASSES), LCDB 1 AND LCDB 2 (BOTH 43 COVER CLASSES).

				CHANGE IN ESTIMATED INP FROM LCDB 1 TO LCDB 2 AS A CONSEQUENCE OF:	
	LCDB 1_2* (1996/97)	LCDB 1 (1996/97)	LCDB 2 (2001/02)	IMPROVED CLASSIFICATION (LCDB 1_21 TO LCDB 1)	INDIGENOUS HABITAT CHANGE (1996/97 TO 2001/02)
Environment threat classification at LENZ Level IV					
Acutely Threatened	187 543	173 249	182 573	-14 294	9324
Chronically Threatened	282 757	298 343	285 416	15 587	-12 928
(Acutely Threatened + Chronically Threatened)	(470 300)	(471 592)	(467 988)	(1293)	(-3604)
All environments	5 936 173	4 810 907	4 794 636	-1 125 266	-16 271
Environment threat classification at LENZ Level II					
Acutely Threatened	179 564	185 476	183 726	5912	-1750
Chronically Threatened	261 412	187 756	186 287	-73 656	-1468
(Acutely Threatened + Chronically Threatened)	(440 976)	(373 232)	(370 014)	(-67 744)	(-3218)
All environments	5 936 173	4 810 907	4 794 636	-1 125 266	-16 271

* Data used in Rutledge et al. (2004) and MfE et al. (2004).

the pressure to clear indigenous cover), and legal protection for biodiversity for conservation purposes across New Zealand's land environments. Flat, warm, fertile environments have been almost entirely cleared of indigenous cover, and what little remains is poorly protected and threatened. Conversely, indigenous cover remains more intact and well protected in those environments that have been residual (or surplus) to productive uses, and hence under less threat from direct land clearance and the effects of fragmentation.

Remaining indigenous cover that is not protected in threatened land environments supports high proportions of New Zealand's threatened ecosystems and species. Its protection is, therefore, essential for halting the decline in indigenous biodiversity nationally, regionally and locally.

Advanced loss of habitat area is just one of many factors that may contribute to the high risk of loss to, and therefore vulnerability of, remaining indigenous biodiversity. Isolation, edge effects, co-extinctions and increased susceptibility to exotic pests and weeds are other factors that need to be considered in a comprehensive and realistic assessment of threat to the persistence of New Zealand's indigenous biota. These pressures and threats require active and ongoing management to halt the decline of biodiversity in most indigenous habitats (e.g. Perley et al. 2001). In the face of them, poor legal protection (associated with an absence of basic management inputs such as fencing and pest control) is the another major contributing factor to the vulnerability of biodiversity.

Poor legal protection is a particularly important risk factor in seral (successional) communities where percentage indigenous cover is an inadequate estimate of the extent of past habitat loss, and risk to remaining indigenous biodiversity. For example, tall-tussock grasslands in the eastern South Island were largely created by the intentional burning of diverse shrublands and forests by early Polynesians, and were subsequently depleted by fires set by Europeans and by mammalian grazing. Although still largely indigenous and, therefore, mainly classified as Critically Underprotected and Underprotected, environments supporting such seral communities probably now support only a fraction of their original biodiversity. Further clearance of their remnant shrublands, forests and wetlands and the loss of opportunities for their recovery and restoration would, therefore, pose severe risks to their remaining biodiversity. Recognition of threatened status in the future management of these land environments will be important to maintain their biodiversity and to secure a disproportionately large number of threatened species (Rogers et al. 2004).

5.2 PATTERN OF LOSS OF INDIGENOUS COVER

There was indigenous cover loss in almost half (49%) of the Level IV land environments in the 5 years from 1996/97 to 2001/02. More than 95% of this loss was of indigenous cover not legally protected (INP); in other words, lack of legal protection appears to a very strong predictor of loss. However, there appears to be some randomness in the pattern of recent loss of INP across land environments. We anticipate that in many environments, INP not cleared in this 5-year period may have suffered loss in the next 5 years (ending 2006/07). Similarly, some environments where loss occurred in this 5-year period may not lose indigenous cover in the next.

Indigenous cover that is not protected in the most threatened environments (e.g. Acutely Threatened and Chronically Threatened) now remains mainly on soils and landscape types of relatively low value for agricultural production. However, comparison of cover in 1996/97 and 2001/02 suggests that the trend is now for indigenous cover clearance on more marginal land. Overall, the greatest increase in risk to indigenous biodiversity (measured as change in SBL) in that 5-year period was in Acutely Threatened environments. However, the highest rates of loss of indigenous cover were in Chronically Threatened, At Risk, Critically Underprotected and Underprotected environments, where there was more indigenous cover left to lose than in Acutely Threatened environments.

Exotic afforestation was the major cause of indigenous cover loss in the period from 1996/97 to 2001/02, accounting for about 66% of it. Of the total increase in exotic afforestation across New Zealand in this period (c. 139 600 ha), at least 8.3% (c. 11 500 ha) involved clearance of indigenous cover. At least 3.8% (c. 5300 ha) of new afforestation involved clearance of remaining indigenous cover types in threatened environments. The future land use of an additional c. 2000 ha of cleared indigenous forest (c. 11% of total loss) is unknown. A proportion of this indigenous forest loss occurred in logging coupes within indigenous forest tracts that may slowly regenerate (e.g. in the Longwoods in Southland). However, some of the remainder may have been felled in preparation for planting in exotic forestry species or for pastoral use.

A further 29 198 ha of exotic forestry was established in vegetation classed in 1996/97 as Low-Producing Grassland (e.g. large areas in Southland, Clutha, Waitaki, Timaru, Hurunui and Marlborough districts). The Low-Producing Grassland cover class is a mixture of indigenous and non-indigenous vegetation types, and we expected, therefore, that indigenous cover loss due to forestry would be greater than the minimum estimate of c. 11 500 ha, perhaps considerably greater. Clearance for low-production pasture was a secondary cause of indigenous cover loss, intensive pasture development was a relatively minor contributor (< 6%), and loss to invasive weeds was minor (c. 1%).

Much of the remaining indigenous vegetation that was cleared (both in threatened environments and in those not classified as 'threatened') was forest or seral shrubland, or tall-tussock grassland. The greatest loss in a single class was in the Broadleaved Indigenous Hardwoods cover class (principally in Marlborough, South Taranaki and Ruapehu districts)—comprising broadleaved hardwood species, such as wineberry (*Aristotelia serrata*), mahoe (*Melicytus ramiflorus*), *Pseudopanax* spp., *Pittosporum* spp., *Fuchsia* spp., ngaio (*Myoporum laetum*) and titoki (*Alectryon excelsus*), together with tutu (*Coriaria* spp.) and tree ferns (Thompson et al. 2003). This vegetation type is usually in an advanced seral stage back to indigenous forest, but also includes primary coastal broadleaved forest. Loss of vegetation classed as Manuka and/or Kanuka Shrubland (principally in Marlborough, Gisborne, Tasman and Far North districts), Primary Indigenous Forest (principally in Far North and Southland districts), and Tall-Tussock Grassland (principally in Central Otago, Clutha and Southland districts) also accounted for significant portions of the total loss. In the past, seral (regenerating) woody vegetation may have been dismissed as insufficiently pristine to warrant protection. However, successional shrubland is probably of high importance for biodiversity in New Zealand. For example, Perley et al. (2001) highlighted general observational and quantified comparative studies that suggest that in

New Zealand late-successional shrubland communities are richer in insects than are tall, undisturbed forest (e.g. Dugdale & Hutcheson 1997; Hutcheson & Jones 1999).

We caution that because Low-Producing Grassland is a mixture of indigenous and non-indigenous vegetation types, we cannot estimate the extent of indigenous vegetation loss (e.g. short-tussock grassland) from this class. Our estimate of total loss and, therefore, increased SBL within New Zealand environments is probably an underestimate.

5.3 THE MOST APPROPRIATE LENZ LEVEL

As mentioned earlier, Leathwick et al. (2003a, b) suggested that LENZ Level II is useful for providing overview information at a national scale, but is less useful and relevant for applications at local, district and regional scales than Levels III and IV. Our work strongly supports this suggestion. We also advise that regional, district and local protection for biodiversity should be directed by a threat classification at Level IV rather than Level II.

First, we consider that a national threat classification to guide local authority protection for biodiversity should be relevant at the appropriate scale. Patterns of biodiversity, as well as of present and past land clearance, occur and are perceived at regional, district and local scales that are better depicted at Level IV than at Level II. A threat classification at Level II, therefore, is less appropriate for identifying vulnerable biodiversity at regional, district and local scales than a Level IV threat classification.

Second, we show that substantial areas of INPTE identified by threat classification at Level IV are *not* identified as threatened if classification is performed at Level II. Almost a third (31.2%) of INPTE area in Acutely Threatened and Chronically Threatened environments and almost a quarter (23.5%) of INPTE area in all five threatened environment categories are not classified as threatened if classification is carried out at Level II. In three of the 73 districts, the proportion of INPTE not identified is over 90%, and in more than a quarter of council areas it is greater than 50%. These underestimates are substantial and concerning, firstly, because the threat categories we assign are conservative (i.e. understated) rather than precautionary estimates of risk to remaining biodiversity, and, secondly, because indigenous biodiversity associated with environments not identified as threatened at Level II is known to contain some of New Zealand's most threatened species and ecosystems. These underestimates will also diminish the credibility of LENZ-based protection guidelines, especially in those districts where the error is large.

It has been suggested that the inefficiency cost of poorer targeting at Level II could be reduced by identifying only those areas of INP within environments classified as 'threatened' at Level II that are also within Level IV environments classified as 'threatened' at Level IV. This approach would:

- Introduce greater conceptual and computational complexity than is involved in undertaking a threat classification at Level IV of LENZ directly
- Nullify any perceived or actual advantage to implementation associated with the comparative simplicity of Level II threat classification

- Fail to mitigate the serious primary drawbacks of poor targetin—substantially less plausible and less effective identification of the biodiversity protection need

We, therefore, strongly recommend that Level IV is the most appropriate level of LENZ at which to classify threatened environments for the protection of vulnerable indigenous biodiversity at local, district and regional scales.

Level II of LENZ may be an appropriate level at which to present national and regional summaries of INPTE. However, it is more appropriate to summarise a threat classification performed at Level IV (cf. Walker et al. 2004) than to carry out a separate threat classification based on percentage indigenous cover remaining at Level II. For example, summarising areas of Level IV INPTE up to Level II both maintains constant estimates of national, regional and district INPTE areas and removes the considerable problems of less plausible, effective and efficient identification of threatened unprotected indigenous cover that arise from Level II threat classification. An example of such a summary is presented in Table A2.3.

5.4 DISSEMINATION OF THREAT CLASSIFICATION INFORMATION

Threat classification information is equally straightforward to disseminate and apply whether environments are classified at Level IV or Level II (all LENZ users have all four levels at their disposal).

The threat classification information can be tabulated and distributed to end-users such as council planners and ecological consultants in the form of a small (40KB for Level IV) ASCII text file (and, if desired, an associated GIS legend file of 4KB). The table can be joined to the LENZ grid table in a GIS (an operation that takes a few seconds at most). This converts the information to a national map (25-m resolution at LENZ Level IV) that can be accessed interactively and used for a wide variety of purposes such as consents processing, significance assessment, reserve planning, prioritising pest control.

We distributed Level IV threat classification information as described above to a small group of DOC, environmental NGOs, and regional council staff in October and November 2004 for testing. These end-users successfully trialled the LENZ Level IV threat classification across a variety of applications. It was used by DOC staff to inform policy and significance assessment for tenure review, by environmental NGOs for information, advocacy and resource consent hearings, and by regional council staff to inform priorities for pest control, and in submissions on proposed protected areas. A sample application of the interactive map is depicted in Appendix 4.

Our feedback from this trial suggests that (1) Level IV is an appropriate scale at which to assess the vulnerability of indigenous cover at a regional, district and local (i.e. property) scales and (2) the technical complexity of disseminating threat classification information at Level IV of LENZ (rather than Level II) is more perceived than actual: the threat classification was readily taken up and adopted by trial end-users with a range of skill levels and needs. The major

limitation to use that we saw is the use and uptake of LENZ by end-users; however, LENZ is now widely distributed across local authorities (Cieraad 2007; Walker et al. 2007), and remaining software constraints to uptake (e.g. conversion of LENZ for MapInfo users) are being resolved.

5.5 LIMITATIONS OF THE ENVIRONMENT THREAT CATEGORIES FOR IDENTIFYING SIGNIFICANT INDIGENOUS VEGETATION

Indigenous vegetation may be significant for its contribution to maintaining a wide range of different value types (i.e. not only biodiversity, but also landscape, recreation, public access, ecosystem services, etc.), and is usually identified by applying a range of criteria (e.g. representativeness, rarity, distinctiveness). Significance is not given only to inherent values that are threatened or rare. For example, the definition of significant inherent values in the Crown Pastoral Lands Act 1998 uses the terms 'importance', 'nature' and 'quality' as well as 'rarity'. An area may also be considered significant at a range of scales (e.g. national, regional, local).

Land environment threat categories can help to identify indigenous cover that is significant (i.e. deserves protection) for the maintenance of indigenous biodiversity (a single value set) at a national scale. Specifically, the environment threat categories can assist by improving the objectivity of the assessment of representativeness. Representativeness (i.e. contribution to the maintenance of the full range) is generally used as the primary criterion for the assessment of significance of ecological values. High representative value (i.e. high significance on the basis of the representativeness criterion) is given to a community or ecosystem that exhibits one of the following:

1. Has large overall areas in a region or district
2. Has been reduced from their former extent
3. Is poorly represented in reserves (Myers et al. 1987)

Therefore, the representativeness criterion includes communities or ecosystems that have been significantly reduced and/or are poorly protected, but extends beyond these.

Remaining indigenous ecosystems, habitats and species in the five categories of threatened land environments are parts of the full range of biodiversity that have been significantly reduced and/or are poorly protected and, therefore, meet conditions 2 and 3 of the representativeness criterion above. Consequently, indigenous vegetation in threatened environments, although typically highly modified, would certainly be considered significant. However, there will be many areas of indigenous vegetation important for maintaining indigenous biodiversity in land environments that are not assigned to any of our five threat categories. For example:

- Some large areas of remaining indigenous vegetation (i.e. communities or ecosystems that have large overall areas in a region or district;1, above) will not typically be located in threatened environments. High representative value is given to large areas because these are needed to maintain indigenous

species, habitats and ecological processes that require large areas to persist (e.g. species that are: large-bodied; host-dependent; habitat-specialist, or dependent on large contiguous habitats; or that have a narrow range).

- Remaining small-scale ecosystems and habitat types such as limestone outcrops (karst), geothermal and various wetland and floodplain ecosystem types are much reduced and/or poorly protected, but are not consistently identified by LENZ or other databases. These special habitats would meet conditions 2 and 3 of the representativeness criterion, but are not yet consistently mapped in New Zealand.
- An environment may not have lost more than 70% of its indigenous cover nationally, but remaining cover may be highly modified or disproportionately reduced within a particular region. In these cases, the cover may be judged to be significant, since its protection will contribute to the maintenance of the full range of biodiversity within that region.

6. Conclusions

New Zealand's coastal, lowland and montane environments have experienced substantial indigenous habitat loss, and what indigenous cover remains in these environments today has little legal protection.

The much-reduced and highly modified areas of indigenous cover in these threatened environments support a disproportionately large percentage of New Zealand's most seriously threatened species, habitats and ecosystems. The protection of what remains in these environments is essential to halt the decline of New Zealand's indigenous biodiversity.

Clearance and loss of indigenous cover and associated indigenous biodiversity continues across New Zealand, including in those environments where past loss has been extreme. Because the consequences of continued indigenous cover clearance for biodiversity (i.e. biodiversity loss and increased risk to what remains) are most severe in environments where little indigenous cover remains, the current pattern of clearance greatly exacerbates the status of biodiversity in New Zealand.

Although, historically, clearance of indigenous cover has been concentrated on land of high value for agricultural production, it appears that the trend is now for clearance of indigenous cover on more marginal land (i.e. Land-use Capability Classes VI, VII and VIII), notably for exotic forestry.

This evidence suggests that public awareness and education, voluntary protection, provisions of the Resource Management Act 1998 and formal legal protection of remaining indigenous biodiversity have not halted the clearance of vulnerable indigenous biodiversity in much reduced and poorly protected ecosystems and habitats.

7. Recommendations

Two characteristics of land environments can help to identify '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…' (DOC & MfE 2000: 41). These characterics are (1) poor legal protection (reflected by low percentages of areas being legally protected) and (2) past habitat loss (reflected by low percentages of indigenous cover). This work led to the following recommendations:

- Based on these two characteristics, we recommend five categories of threatened environments to identify environments containing indigenous biodiversity that is at most risk of loss from land clearance and the effects of fragmentation. The biodiversity that remains in these threatened environments is some of the most severely threatened in New Zealand.
- Note that threatened environments do not identify places where biodiversity is most vulnerable to pressures that damage ecosystem processes (e.g. predators, feral and domestic herbivores, weeds, pollution, fire, drainage, and/or extractive land uses such as selective logging). These pressures threaten biodiversity processes in all environments in New Zealand, not just in those environments that are much reduced and poorly protected. Spatially explicit measures and estimates of process disruption are not yet available to reveal how these other risks to biodiversity are distributed across the landscape.
- We recommend that Level IV of LENZ is the most appropriate level to identify environments that are most vulnerable to biodiversity loss, in order to effectively protect biodiversity at district and local (property) scales. Information based on a Level IV classification of threatened environments may be summarised to higher levels (e.g. Level I or II) for national or regional summaries.
- Existing databases (e.g. LENZ, LCDB) do not identify many rare and distinctive ecosystems and habitats that also have reduced indigenous vegetation cover and are poorly represented in the network of protected natural areas. We, therefore, recommend that such rare and distinctive habitats and ecosystems also be regarded as threatened.
- We recommend the investigation and comparison of the social, economic and regulatory drivers of indigenous vegetation protection and loss in councils where most loss (e.g. Far North, Central Otago and Marlborough districts) and least loss (e.g. Kaikoura District, Waitakere City, Queenstown Lakes District) have occurred. This may help policy makers to understand some of the key factors for successful biodiversity conservation on private land.
- This analysis cannot be repeated in the future, unless further full national updates of the Land Cover Database are produced, using satellite imagery taken over as short a time period as possible (e.g. a single summer). We recommend that the interval between releases of comprehensive national land cover database updates be no more than 5 years, so that progress towards halting the decline in biodiversity can be monitored within relevant time frames. It is time to initiate work on LCDB 3.

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Appendix 1

INDIGENOUS ('1') AND NON-INDIGENOUS ('0') COVER CLASSES (LCDB 1 AND LCDB 2)

CLASS NO.	CLASS NAME	COVER TYPE
1	Built-up Area	0
2	Urban Parkland/Open Space	0
3	Surface Mine	0
4	Dump	0
5	Transport Infrastructure	0
10	Coastal Sand and Gravel	1
11	River and Lakeshore Gravel and Rock	1
12	Landslide	1
13	Alpine Gravel and Rock	1
14	Permanent Snow and Ice	1
15	Alpine Grass/Herbfield	1
20	Lake and Pond	1
21	River	1
22	Estuarine Open Water	1
30	Short-rotation Cropland	0
31	Vineyard	0
32	Orchard and Other Perennial Crops	0
40	High-Producing Exotic Grassland	0
41	Low-Producing Grassland	0
43	Tall-Tussock Grassland	1
44	Depleted Grassland	1
45	Herbaceous Freshwater Vegetation	1
46	Herbaceous Saline Vegetation	1
47	Flaxland	1
50	Fernland	1
51	Gorse and/or Broom	0
52	Manuka and/or Kanuka	1
53	Matagouri	1
54	Broadleaved Indigenous Hardwoods	1
55	Subalpine Shrubland	1
56	Mixed Exotic Shrubland	0
57	Grey Scrub	1
60	Minor Shelterbelts	0
61	Major Shelterbelts	0
62	Afforestation (not imaged)	0
63	Afforestation (imaged, post LCDB 1)	0
64	Forest–Harvested	0
65	Pine Forest–Open Canopy	0
66	Pine Forest–Closed Canopy	0
67	Other Exotic Forest	0
68	Deciduous Hardwoods	0
69	Indigenous Forest	1
70	Mangrove	1

Appendix 2

AREA OF INDIGENOUS VEGETATION NOT PROTECTED IN LENZ ENVIRONMENTS

TABLE A2.1. AREA OF INDIGENOUS VEGETATION NOT PROTECTED (INP) IN THE 42 LENZ LEVEL II ENVIRONMENTS WITH LESS THAN 20% INDIGENOUS VEGETATION REMAINING NATIONALLY, BY DISTRICT.

Bold type represents environments with < 10% indigenous vegetation remaining. 0–10% = Acutely Threatened environments, 10–20% = Chronically Threatened environments, 0–20% = Acutely and Chronically Threatened environments. Figures in parentheses are district totals when threat categories are determined as level IV of LENZ (see Table A2.3).

Table A2.1

LEVEL II ENVIRONMENT	PERCENTAGE REMAINING	ASHBURTON DISTRICT	AUCKLAND CITY	BANKS PENINSULA DISTRICT	BULLER DISTRICT	CARTERTON DISTRICT	CENTRAL HAWKE'S BAY DISTRICT	CENTRAL OTAGO DISTRICT	CHRISTCHURCH CITY	CLUTHA DISTRICT	DUNEDIN CITY	FAR NORTH DISTRICT	FRANKLIN DISTRICT	GISBORNE DISTRICT	GORE DISTRICT	GREY DISTRICT	HAMILTON CITY	HASTINGS DISTRICT	HAURAKI DISTRICT
A5	**7.5**		**393**									**3149**	**722**	**517**			**44**	**37**	**1145**
A7	**5.6**		**408**									**3034**	**4480**	**423**			**220**		**162**
B1	**6.3**						**2254**											**1993**	
B2	**6.3**						**1568**							**10**				**1286**	
B3	13.0	154		5															
B4	**4.5**																		
B5	**1.5**						**5**							**199**				**380**	
B6	**1.4**			**4**					**6**										
B7	**3.6**						**0**							**0**				**783**	
B9	**6.9**								**9**										
C1	12.1				302								6	18					
C2	**4.0**					**139**	**93**											**71**	
C3	**2.1**					**84**	**1156**											**17**	
D3	16.3						15						17	51946			0	14781	55
E3	**6.6**	**790**		**0**				**90**											
F3	15.0	3		11954					308										
F4	**7.9**					**3044**	**3255**											**290**	
F5	10.3				691														
G3	11.6		187				1					4214	337	3568			4	136	4
G4	**8.0**		**0**										**370**	**4**					**135**
G6	10.2													1857				21	2
H3	**8.9**				**7**														
I2	**3.2**					**97**	**167**											**27**	
I3	10.5	9		376					50										
I4	**7.8**																		
I5	**1.4**						**2**							**218**				**210**	
I6	**7.5**													**29**				**26**	
J1	**6.5**																		
J2	**6.0**	**894**		**331**					**211**										
J3	12.6																		
J4	**7.7**					**333**	**293**											**193**	
K3	18.5	1						1766											
L1	**7.5**	**120**						**101**		**533**	**485**				**132**				
L2	11.8									445	154								
L4	**2.8**							**118**		**6792**	**2678**				**201**				
L5	13.0									59					10				
N1	**0.8**	**267**		**4**				**0**	**75**										
N2	**0.7**	**638**						**5**		**54**	**108**				**0**				
N3	**5.3**	**11**						**11286**		**15**	**2401**								
N5	**2.6**							**1946**											
N7	14.0							959											
N8	**5.6**							**1843**											
District totals: 0–10%																			
		2719	801	340	7	3696	8794	15389	301	7395	5672	6183	5572	1400	332	0	264	5313	1442
		(1898)	(446)	(2841)	(0)	(2266)	(6458)	(5282)	(471)	(9859)	(4290)	(3643)	(4192)	(3815)	(743)	(0)	(285)	(3363)	(1603)
District totals: 10–20%																			
		167	187	12334	993	0	16	2725	358	504	154	4214	360	57389	10	0	4	14938	60
		(838)	(480)	(4863)	(711)	(1630)	(4261)	(28006)	(167)	(5151)	(6694)	(8561)	(6145)	(47601)	(83)	(0)	(7)	(17195)	(179)

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Table A2.1—continued

LEVEL II ENVIRONMENT	HOROWHENUA DISTRICT	HURUNUI DISTRICT	INVERCARGILL DISTRICT	KAIKOURA DISTRICT	KAIPARA DISTRICT	KAPITI COAST DISTRICT	KAWERAU DISTRICT	LOWER HUTT CITY	MACKENZIE DISTRICT	MANAWATU DISTRICT	MANUKAU CITY	MARLBOROUGH DISTRICT	MASTERTON DISTRICT	MATAMATA-PIAKO DISTRICT	NAPIER CITY	NELSON CITY	NEW PLYMOUTH DISTRICT	NORTH SHORE CITY	OPOTIKI DISTRICT
A5					**2084**						**131**			**227**			**12**	**8**	**180**
A7					**397**		**30**				**347**			**410**			**4**	**96**	**1050**
B1										**160**		**691**				**212**			
B2																			
B3		21064		506					40			439							
B4												**60**				**13**			
B5															**25**				
B6		**7**		**18**								**356**							
B7				**159**								**931**			**4**				
B9				**291**								**797**							
C1	0					0				5	6			12			512		49
C2	**369**					**453**		**595**		**1139**			**240**						
C3	**595**					**552**		**77**		**403**			**443**						
D3														11	25				21
E3		**149**							**828**			**5**							
F3												11							
F4	**1**					**12**		**7**		**41**			**6187**						
F5								2				1355				50	5295		
G3					1339		48				21			15	13		45		631
G4											**61**			**524**					
G6														0					
H3												**141**				**56**			
I2	**133**					**6**				**53**			**77**						
I3		9										418							
I4				**9**								**25**							
I5															**36**				
I6															**113**				
J1				**7**								**1530**				**118**			
J2		**1344**		**20**					**1552**			**287**							
J3		124		1511								1							
J4	**1329**					**310**		**157**		**1086**			**375**						
K3									1394										
L1			**790**						**219**										
L2																			
L4																			
L5			171																
N1		**1861**		**9**					**62**			**2**							
N2		**122**		**0**					**599**			**14**							
N3		**15**							**913**										
N5									**699**										
N7									315										
N8									**0**										
District totals: 0–10%																			
	2428	3497	790	513	2481	1332	30	837	4873	2881	540	4838	7321	1161	178	398	16	104	1230
	(1556)	(7226)	(274)	(770)	(1675)	(1270)	(78)	(596)	(2440)	(4594)	(403)	(3183)	(4621)	(1392)	(216)	(398)	(3960)	(51)	(2228)
District totals: 10–20%																			
	0	21198	171	2017	1339	0	48	2	1749	5	27	2225	0	38	38	50	5852	0	701
	(1166)	(10219)	(126)	(1994)	(4397)	(300)	(58)	(310)	(8834)	(5311)	(163)	(9080)	(4808)	(114)	(0)	(213)	(147)	(63)	(1099)

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Table A2.1—continued

LEVEL II ENVIRONMENT	OTOROHANGA DISTRICT	PALMERSTON NORTH CITY	PAPAKURA CITY	PORIRUA CITY	QUEENSTOWN LAKES DISTRICT	RANGITIKEI DISTRICT	RODNEY DISTRICT	ROTORUA DISTRICT	RUAPEHU DISTRICT	SELWYN DISTRICT	SOUTH TARANAKI DISTRICT	SOUTH WAIKATO DISTRICT	SOUTH WAIRARAPA DISTRICT	SOUTHLAND DISTRICT	STRATFORD DISTRICT	TARARUA DISTRICT	TASMAN DISTRICT	TAUPO DISTRICT	TAURANGA DISTRICT
A5	**68**		**18**				**564**	**16**			**45**	**18**						**0**	**238**
A7	**29**		**73**				**1642**	**75**				**31**							**408**
B1						**1258**			**0**		**25**		**19**				**1818**	**1**	
B2						**43**			**51**									**5**	
B3					17					449							1		
B4																	**45**		
B5																			
B6																			
B7																			
B9																			
C1	260					220		172	1449		248	0			10		223	1632	
C2		**750**		**439**		**1345**			**30**		**261**		**482**			**1389**			
C3		**22**		**45**		**599**					**239**		**609**			**263**			
D3	2					182		1				89						0	
E3					**6**					**226**									
F3					21					288									
F4				**117**		**109**					**4**		**9129**			**5726**			
F5						2					4519				1235		1602		
G3	23						729	32			7	33						1	
G4			**23**				**0**					**1**							**39**
G6							0												
H3											**44**				**60**		**77**		
I2		**30**		**6**		**14**							**331**			**15**			
I3										457									
I4																			
I5																			
I6																			
J1																	**1477**		
J2										**622**									
J3																			
J4		**130**		**16**		**871**			**226**		**445**		**731**			**670**			
K3					895														
L1					**172**									**5733**					
L2																			
L4														**989**					
L5														3129					
N1					**3**					**207**				**3**					
N2					**30**					**478**				**105**			**1**		
N3					**31**									**98**					
N5					**584**														
N7					5														
N8					**33**														
District totals: 0–10%																			
	98	932	114	622	860	4238	2205	91	306	1532	1063	50	11301	6930	60	8062	3417	6	685
	(744)	(356)	(113)	(494)	(1471)	(11128)	(1006)	(1339)	(743)	(1940)	(6003)	(849)	(6377)	(9132)	(1089)	(11237)	(3277)	(3715)	(628)
District totals: 10–20%																			
	284	0	0	0	938	404	730	205	1449	1194	4774	122	0	3129	1245	0	1827	1633	0
	(773)	(1147)	(5)	(136)	(2913)	(4929)	(2111)	(1470)	(2709)	(746)	(146)	(164)	(5804)	(12146)	(133)	(8189)	(6232)	(284)	(1)

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Table A2.1—continued

LEVEL II ENVIRONMENT	THAMES–COROMANDEL DISTRICT	TIMARU DISTRICT	UPPER HUTT CITY	WAIKATO DISTRICT	WAIMAKARIRI DISTRICT	WAIMATE DISTRICT	WAIPA DISTRICT	WAIROA DISTRICT	WAITAKERE CITY	WAITAKI DISTRICT	WAITOMO DISTRICT	WANGANUI DISTRICT	WELLINGTON CITY	WESTERN BAY OF PLENTY DISTRICT	WESTLAND DISTRICT	WHAKATANE DISTRICT	WHANGAREI DISTRICT	TOTAL INDIGENOUS COVER NOT PROTECTED
A5	**387**			**1688**			**285**	**659**	**9**		**114**			**255**		**104**	**1164**	**14 281**
A7	**1125**			**1690**			**529**	**1048**	**279**		**0**			**2675**		**140**	**1302**	**22 108**
B1												**2341**						**10 770**
B2												**276**						**3239**
B3		17			360													23 051
B4																		**117**
B5												**9**						**618**
B6					**2**													**392**
B7												**0**						**1877**
B9																		**1097**
C1			119				60				1214	6		4		214		6741
C2			**449**									**512**	**324**					**9080**
C3			**73**									**339**	**62**					**5577**
D3	77			32			31	29 858				0				5		97 148
E3		**758**			**687**	**87**												**3626**
F3					24													12 610
F4			**2**									**123**	**40**					**28 085**
F5											61	248						15 059
G3				448			122	451	14		0			18		991	2206	15 637
G4	**1153**			**796**			**79**		**4**					**144**		**71**		**3403**
G6	5							33										1918
H3												**6**						**390**
I2													**28**					**984**
I3		46			25	62												1451
I4																		**34**
I5																		**467**
I6																		**168**
J1																		**3132**
J2		**346**			**302**					**4**								**5913**
J3																		1637
J4			**9**					**2**			**20**	**273**	**34**					**7502**
K3		133				117				1070								5376
L1		**265**				**334**				**194**								**9077**
L2		106				2				70								777
L4										**172**								**10 951**
L5																		3368
N1		**24**			**204**	**100**												**2821**
N2		**204**			**363**	**364**				**179**								**3264**
N3		**1642**				**2840**				**9489**								**28 741**
N5						**47**				**843**								**4118**
N7						2				235								1515
N8						**0**				**19**								**1895**
District totals: 0–10%																		
	2665	3239	532	4174	1558	3771	892	1710	292	10 900	134	3878	488	3073	0	315	2467	183 726
	(1275)	(2263)	(675)	(6124)	(1558)	(2373)	(2436)	(1453)	(251)	(4145)	(1437)	(1995)	(446)	(2910)	(0)	(1628)	(1575)	(182 573)
District totals: 10–20%																		
	81	302	119	481	408	183	214	30 343	14	1375	1275	255	0	22	0	1211	2206	186 287
	(1366)	(1132)	(343)	(4921)	(408)	(2630)	(287)	(19 804)	(210)	(14 735)	(192)	(2614)	(15)	(4)	(0)	(2395)	(3351)	(285 416)

TABLE A2.2 AREA OF INDIGENOUS VEGETATION NOT PROTECTED (INP) IN THE 42 LENZ LEVEL II ENVIRONMENTS WITH LESS THAN 20% INDIGENOUS VEGETATION REMAINING NATIONALLY, ACROSS 16 REGIONS.

Bold type represents environments with < 10% indigenous vegetation remaining. Figures in brackets are district totals when threat categories are determined at Level IV of LENZ (see Table A2.3). 0–10% = Acutely Threatened environments, 10–20% = Chronically Threatened environments, 0–20% = Acutely and Chronically Threatened environments.

LEVEL II ENVIRONMENT	AUCKLAND	BAY OF PLENTY	CANTERBURY	GISBORNE	HAWKE'S BAY	MANAWATU-WANGANUI	MARLBOROUGH	NELSON CITY	NORTHLAND	OTAGO	SOUTHLAND	TARANAKI	TASMAN	WAIKATO	WELLINGTON	WEST COAST	TOTAL INP
A5	**1252**	**790**		**517**	**697**				**6398**			**57**		**4572**			**14281**
A7	**5875**	**4375**		**423**	**1048**				**4734**			**4**		**5648**			**22108**
B1					**4279**	**3727**	**691**	**212**				**25**	**1818**	**1**	**19**		**10770**
B2				**10**	**2873**	**351**								**5**			**3239**
B3			22594				439			17			1				23051
B4							**60**	**13**					**45**				**117**
B5				**199**	**410**	**9**											**618**
B6			**37**				**356**										**392**
B7			**159**		**787**		**931**										**1877**
B9			**300**				**797**										**1097**
C1	12	467		18	10	1680						770	223	3140	119	302	6741
C2					**165**	**5534**						**261**			**3121**		**9080**
C3					**1173**	**2189**						**239**			**1976**		**5577**
D3	1	27		51946	44862									312			97148
E3			**3526**				**5**			**96**							**3626**
F3			12577				11			21							12610
F4					**3544**	**5419**						**4**			**19118**		**28085**
F5						263	1355	50				11036	1602	61	2	691	15059
G3	1132	1721		3568	601				7758			52		805			15637
G4	**157**	**253**		**4**										**2988**			**3403**
G6				1857	54									6			1918
H3						**12**	**141**	**56**				**98**	**77**			**7**	**390**
I2					**194**	**244**									**545**		**984**
I3			1033				418										1451
I4			**9**				**25**										**34**
I5				**218**	**249**												**467**
I6				**29**	**139**												**168**
J1			**7**				**1530**	**118**					**1477**				**3132**
J2			**5626**				**287**										**5913**
J3			1636				1										1637
J4					**488**	**4532**						**446**		**20**	**2016**		**7502**
K3			2708							2668							5376
L1			**1009**							**1413**	**6655**						**9077**
L2			107							669							777
L4										**9761**	**1190**						**10951**
L5										59	3310						3368
N1			**2813**				**2**			**3**	**3**						**2821**
N2			**2771**				**14**			**372**	**105**		**1**				**3264**
N3			**6505**							**22137**	**98**						**28741**
N5			**1588**							**2530**							**4118**
N7			552							963							1515
N8			**20**							**1876**							**1895**

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Table A2.2—continued

LEVEL II ENVIRONMENT	AUCKLAND	BAY OF PLENTY	CANTERBURY	GISBORNE	HAWKE'S BAY	MANAWATU–WANGANUI	MARLBOROUGH	NELSON CITY	NORTHLAND	OTAGO	SOUTHLAND	TARANAKI	TASMAN	WAIKATO	WELLINGTON	WEST COAST	TOTAL INP
Region totals: 0–10%																	
	7284	5418	24368	1400	16047	22017	4838	398	11131	38189	8052	1133	3417	13234	26794	7	183726
	(3464)	(8636)	(25077)	(3815)	(12128)	(30883)	(3183)	(398)	(6893)	(23748)	(10149)	(11034)	(3277)	(22484)	(17404)	(0)	(182573)
Region totals: 10–20%																	
	1146	2214	41207	57389	45527	1943	2225	50	7758	4398	3310	11858	1827	4325	120	993	186287
	(5299)	(5027)	(36836)	(47601)	(41481)	(25878)	(9080)	(213)	(16308)	(52494)	(12355)	(307)	(6232)	(12161)	(13434)	(711)	(285416)
Region totals: 0–20%																	
	8430	7632	65575	58788	61574	23960	7062	448	18890	42586	11362	12992	5244	17558	26914	1000	37 014
	(8763)	(13663)	(61913)	(51416)	(53609)	(56761)	(12263)	(611)	(23202)	(76242)	(22504)	(11341)	(9509)	(34645)	(30838)	(711)	(467988)

TABLE A2.3 AREA OF INDIGENOUS VEGETATION NOT PROTECTED (INP) IN THE 232 LEVEL IV ENVIRONMENTS WITH LESS THAN 20% INDIGENOUS VEGETATION REMAINING NATIONALLY, ACROSS 16 REGIONS.

The data are grouped within the 61 Level II environments represented. No. Lvl IV = number of Level IV environments; 0–10% = Acutely Threatened environments, 10–20% = Chronically Threatened environments, 0–20% = Acutely and Chronically Threatened environments.

LEVEL II ENVIRONMENT	NO. LEVEL IV	AUCKLAND	BAY OF PLENTY	CANTERBURY	GISBORNE	HAWKE'S BAY	MANAWATU–WANGANUI	MARLBOROUGH	NELSON CITY	NORTHLAND	OTAGO	SOUTHLAND	TARANAKI	TASMAN	WAIKATO	WELLINGTON	WEST COAST	TOTAL AREA
A1	1	42								1733								1776
A4	1														1			1
A5	9	1118	650		312	697				6397			57		4288			13519
A6	2	303	75		16					2782					174			3350
A7	7	5875	4375		423	290				4734			4		5644			21345
B1	8					4279	3727	691	212				25	1818	1	19		10770
B2	4				10	2873	351								5			3239
B3	4			15814				439			17			1				16271
B4	2							60	13					45				117
B5	5				199	410	9											618
B6	4			37				356										392
B7	4			159		787		931										1877
B8	1			6				1563						1				1569
B9	3			300				797										1097
C1	3	12	263		18		3						594	223	1545	103	302	3063
C2	5					165	5534						261			3121		9080
C3	7					1173	2189						239			1976		5577

Continued on next page

Table A2.3—continued

LEVEL II ENVIRONMENT	NO. LEVEL IV	AUCKLAND	BAY OF PLENTY	CANTERBURY	GISBORNE	HAWKE'S BAY	MANAWATU–WANGANUI	MARLBOROUGH	NELSON CITY	NORTHLAND	OTAGO	SOUTHLAND	TARANAKI	TASMAN	WAIKATO	WELLINGTON	WEST COAST	TOTAL AREA
D2	1	41	73			3							94		10216			10427
D3	8	1	27		46361	34764									295			81448
E1	2			256				3663	163					3422				7503
E2	1							11						925				937
E3	2			3526				5			96							3626
E4	1			5046				363										5408
F1	6					2203	29147						33		278	3623		35283
F3	3			7569				3			21							7593
F4	6					3544	5419						4			19118		28085
F5	4						263	1355	50				8835	535	44	2	56	11139
F6	2	5	5172		2	42									5069			10289
F7	3		1155		7	660	4699						1		3133			9655
G1	1	93																93
G3	8	1115	1718		1856	601				7552			52		805			13699
G4	3	157	63		4										2988			3212
G6	4				1857	54									6			1918
H1	4					15	633			4			599	1061	127	438	354	3231
H2	2		93		104	2									6			203
H3	2						12	141	56				98					307
I2	4					194	244									545		984
I3	5			1033				75										1108
I4	1			9				15										24
I5	3				218	249												467
I6	2				29	139												168
J1	6			7				1530	118					1477				3132
J2	6			3173				250										3423
J3	3			1636				1										1637
J4	9					465	4532						446		20	1895		7358
K3	3			1113							970							2083
K5	1			1														1
L1	9			1009							1178	4913						7099
L2	2			107							36							143
L4	3										9761	1190						10951
L5	2											3155						3155
N1	6			2813				2			3	3						2821
N2	6			2771				14			372	105		1				3264
N3	9			6505							22137	98						28741
N4	3			4366							17806							22172
N5	4			1588							2530							4118
N6	1			2255							354							2609
N7	2			552							963							1515
N8	3			20							1876							1895
Q3	1										257	1668						1924
Q4	5			245							17864	11371						29480

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Table A2.3—continued

LEVEL II ENVIRONMENT	NO. LEVEL IV	AUCKLAND	BAY OF PLENTY	CANTERBURY	GISBORNE	HAWKE'S BAY	MANAWATU–WANGANUI	MARLBOROUGH	NELSON CITY	NORTHLAND	OTAGO	SOUTHLAND	TARANAKI	TASMAN	WAIKATO	WELLINGTON	WEST COAST	TOTAL AREA
Region totals: 0–10%																		
	No. Lvl IV	18	17	46	31	45	36	28	7	7	40	16	20	9	27	27	0	158
	Area	3464	8636	25 077	3815	12 128	30 883	3183	398	6893	23 748	10 149	11 034	3277	22 484	17 404	0	182 573
Region totals: 10–20%																		
	No. Lvl IV	12	13	25	15	25	15	13	2	6	17	6	7	9	18	14	3	74
	Area	5299	5027	36 836	47 601	41 481	25 878	9080	213	16 308	52 494	12 355	307	6232	12 161	13 434	711	285 416
Region totals: 0–20%																		
	No. Lvl IV	30	30	71	46	70	51	41	9	13	57	22	27	18	45	41	3	232
	Area	8763	13 663	61 913	51 416	53 609	56 761	12 263	611	23 202	76 242	22 504	11 341	9509	34 645	30 838	711	467 988

Appendix 3

LEVEL IV ENVIRONMENTS COMPARED WITH LEVEL II ENVIRONMENT F1

This appendix illustrates differences among Level IV environments within one Level II environment. Environment F1 extends from the western Waikato through inland Taranaki and northern Manawatu to the ranges of Hawke's Bay and Wairarapa, through Wellington and southward to the Marlborough and Tasman regions. On average, 48.4% (886 270 ha) of the total 1 832 582 ha in environment F1 remains in indigenous cover, and 22.8% of the total area is protected (Table A3.1). Therefore F1 is assigned to 'no threat category' if threat classification is carried out at Level II.

If threat classification is carried out at Level IV, 12 of the 19 Level IV environments in F1 are classified as threatened, and all five threat categories are represented (Fig. A3.1, Table A3.1). Three environments are Acutely Threatened (F1.3d in central Rangitikei District, F1.1f in northwestern Manawatu, Tararua and northern Masterton districts, F1.1g in Tararua District). Indigenous cover in Level IV environments varies between 4.5% (F1.1g in Tararua District) and 78.5% (F1.1a in Tasman District). The percentage of a Level IV environment protected is positively correlated with indigenous cover remaining (R^2 = 0.69, P < 0.001), and ranges from 1.4% to 58.4%.

Figure A3.2 shows the distribution across environment F1 of broad potential natural vegetation cover classes (20 potential forest types defined using statistical modelling techniques to combine extensive plot data with environmental data layers: Leathwick et al. 2004). This figure shows the likely variation in one component of the undisturbed biodiversity pattern across F1 (i.e. the forest canopy). Table A3.1 shows wide variation in the percentage of each predicted forest type across Level IV environments. For example, Rimu-matai-miro-totara/kamahi forest was previously most abundant in the now almost entirely deforested environments F1.1g (Acutely Threatened, 1.1% of indigenous forest cover today) and F1.4d (Chronically Threatened, 4.9% indigenous forest cover) in Central Tararua District. A high proportion of Kahikatea-matai/tawa-totara forest was in environment F1.2c (Critically Underprotected, with 4.9% remaining in indigenous forest cover today).

Figure A3.3 shows the distribution of the major present LCDB 2 cover classes across F1. Table A3.1 shows the percentage areas of LCDB 2 in each cover class, as well as a selection of environmental characteristics. The land cover on the most fertile soils (indicated by high acid-soluble phosphate in F1.1g), and on sites with little slope (e.g. F1.1e and F1.1f) have generally been converted to pasture. Areas of less fertile soils where early attempts at pastoral farming were frustrated by soil nutrient deficiencies support regenerating forests and scrub (e.g. F1.2d in South Wairarapa). Extensive areas of indigenous forest still survive, mostly on steeper slopes and in more topgraphically challenging and remote areas (e.g. F1.1d in Ruapehu, South Taranaki and Wanganui districts).

These data demonstrate that environmental differences driving patterns of biodiversity as well as present and past land clearance, occur at finer scales than Level II of LENZ (represented here by F1), and that biodiversity and clearance patterns are better depicted at Level IV than at Level II. These patterns also vary considerably between different district council areas containing parts of a Level II environment.

Figure A3.1. LENZ Level IV environment threat categories within Level II environment.

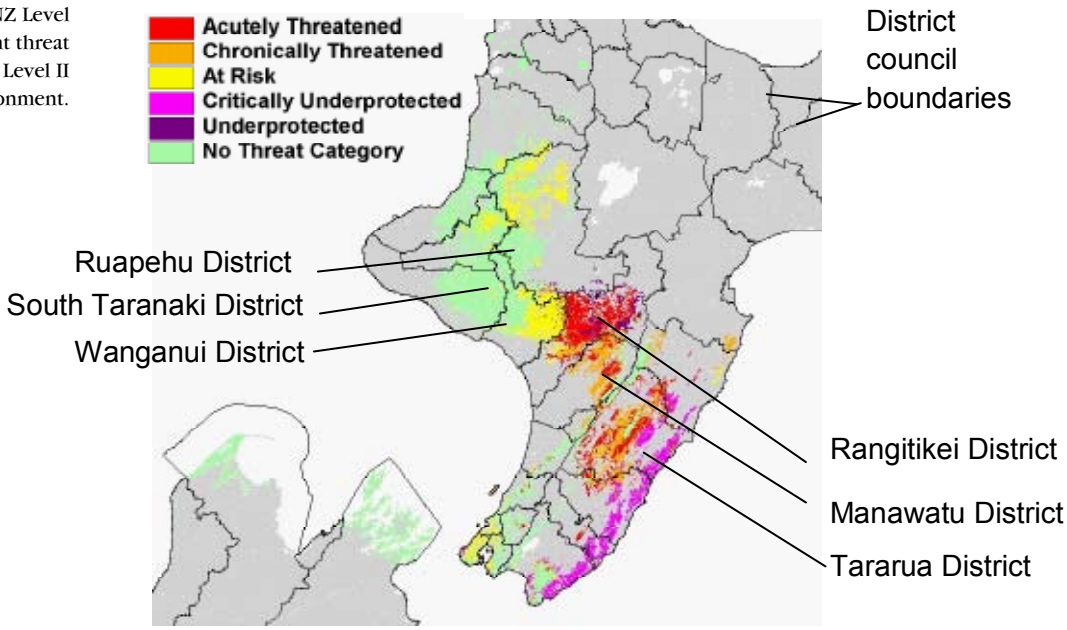


Figure A3.2. Potential forest types (from Leathwick et al. 2004) within Level II environment F1.

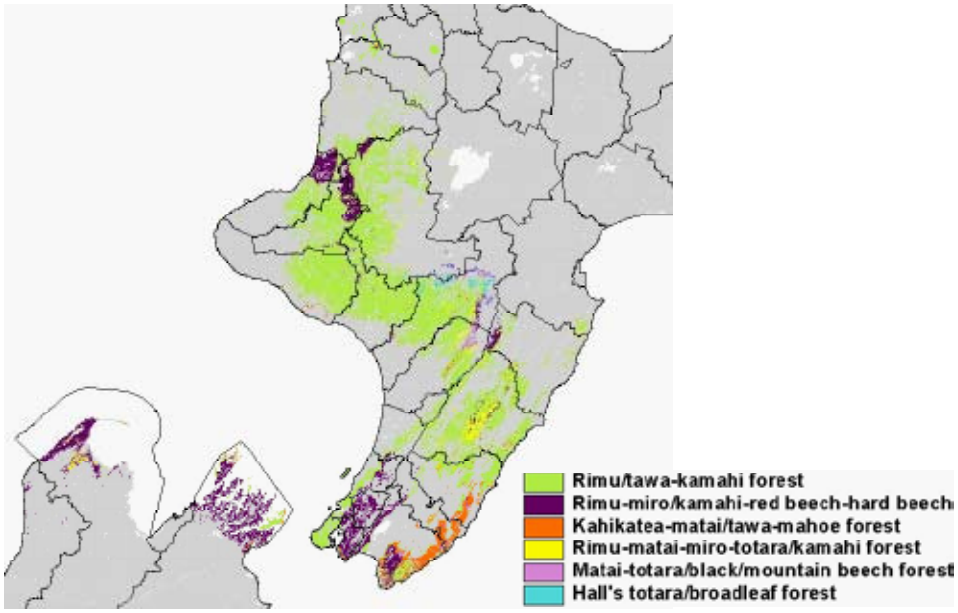


Figure A3.2. Present cover (LCBD 2 classes) within Level II environment F1.

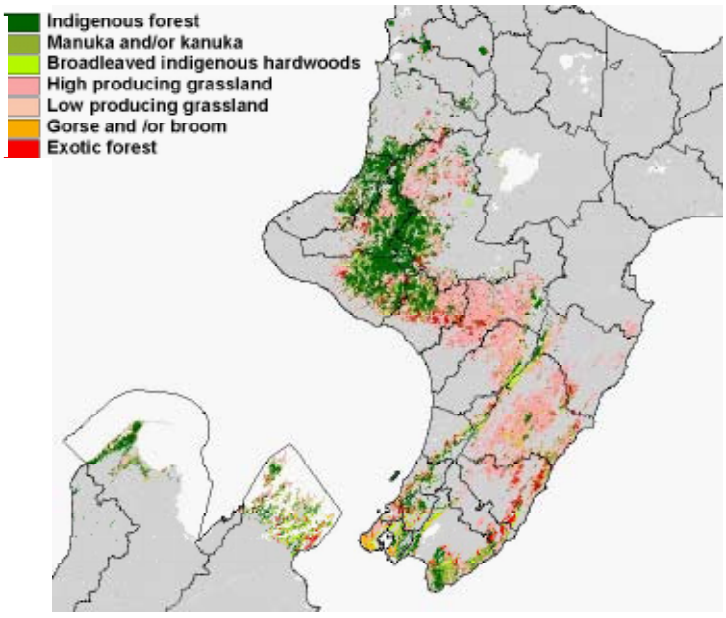


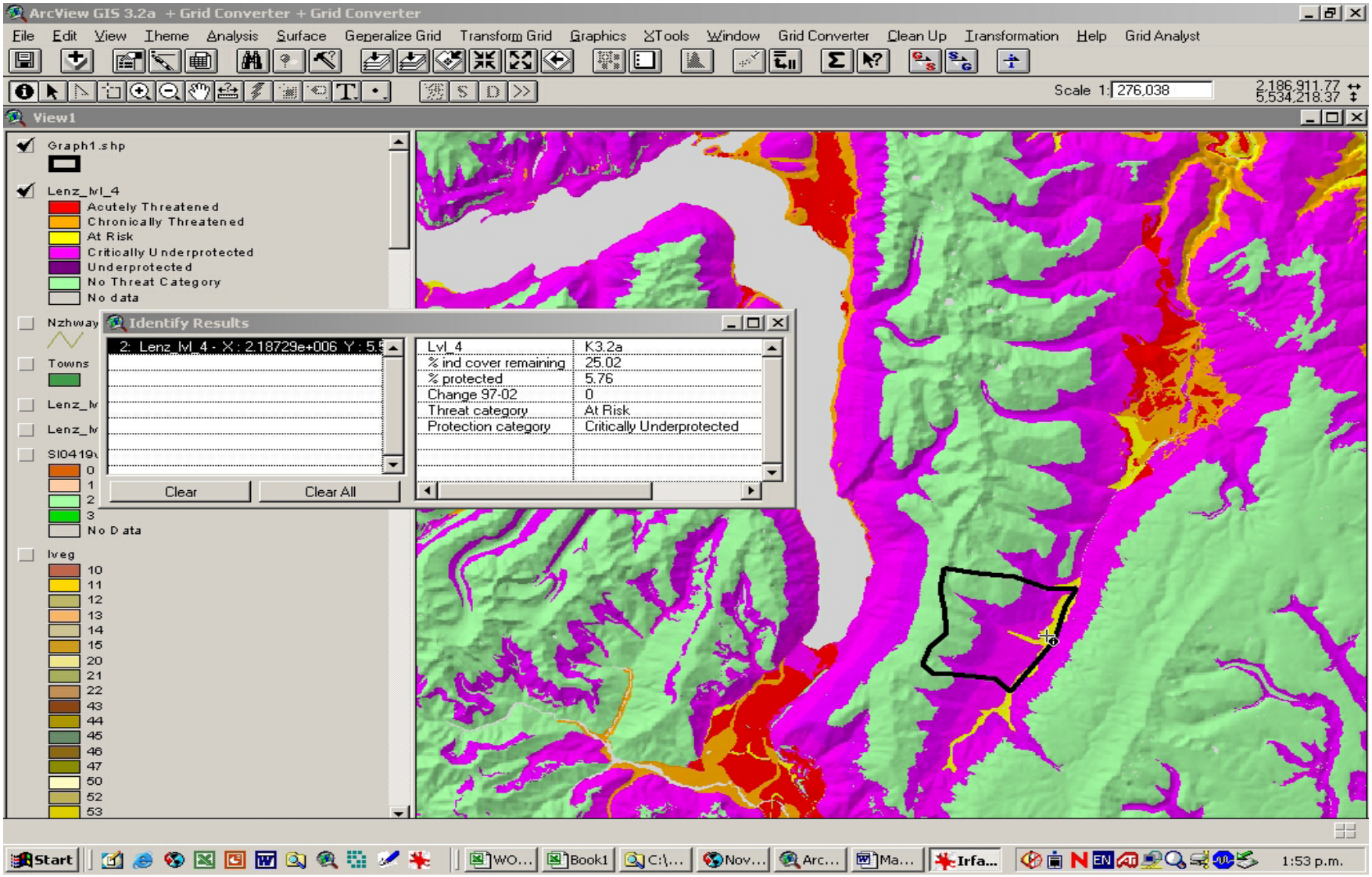
TABLE A3.1. DISTRIBUTION OF PERCENTAGE OF INDIGENOUS COVER, PERCENTAGE OF LEGALLY PROTECTED INDIGENOUS COVER, ENVIRONMENT THREAT CATEGORIES, POTENTIAL DOMINANT NATURAL VEGETATION, AND PRESENT LCDB 2 COVER CLASSES ACROSS THE 19 LEVEL IV ENVIRONMENTS WITHIN LEVEL II ENVIRONMENT F1.

THREAT STATISTICS AND CATEGORY					POTENTIAL NATURAL VEGETATION (6 MOST WIDESPREAD FOREST TYPES) (% OF ENVIRONMENT)						PRESENT LCDB 2 COVER CLASSES (5 MOST WIDESPREAD AMALGAMATED CATEGORIES) (% OF ENVIRONMENT)					ENVIRONMENTAL CHARACTERISTICS			
LEVEL IV	TOTAL AREA (ha)	INDIGENOUS COVER (%)	LEGALLY PROTECTED (%)	THREAT CATEGORY (THREAT CLASSIFICATION AT LENZ LEVEL IV)	RIMU/TAWA-KAMAHI	RIMU-MIRO/KAMAHI-RED BEECH-HARD BEECH	KAHIKATEA-MATAI/TAWA-TOTARA	RIMU-MATAI-MIRO-TOTARA/KAMAHI	MATAI-TOTARA/BLACK/MOUNTAIN BEECH	HALL'S TOTARA/BROADLEAF	INDIGENOUS FOREST	SCRUB (MANUKA, KANUKA, BROADLEAVED INDIGENOUS HARDWOODS)	PASTURE (HIGH + LOW PRODUCING)	GORSE AND/OR BROOM	EXOTIC FORESTRY	SLOPE (°)	MEAN ANNUAL TEMPERATURE (°C)	ANNUAL WATER DEFICIT (mm)	ACID SOLUBLE PHOSPHATE (1 = LOW, 5 = HIGH)
F1.1a	50099	78.5	58.4	No Threat category	3	83	0	11	0	0	51	25	18	1	2	12.3	12.1	0.1	1.7
F1.1b	131322	70.0	31.9	No Threat category	77	23	0	0	0	0	57	12	26	1	3	17.5	12.7	1.3	1.7
F1.1c	118124	29.9	14.2	At Risk	90	6	0	3	0	0	25	5	64	0	5	13.8	12.1	2.4	2.9
F1.1d	411537	77.9	50.1	No Threat category	80	11	0	5	2	1	63	14	18	0	4	19.7	11.2	0.5	1.1
F1.1e	18012	16.8	5.0	Chronically Threatened	90	3	0	4	2	0	11	5	79	0	2	8.7	11.3	13.5	1.7
F1.1f	84281	9.0	2.4	Acutely Threatened	85	2	3	6	4	0	3	6	85	1	5	9.6	11.3	24.3	1.7
F1.1g	19451	4.5	1.4	Acutely Threatened	40	9	2	46	0	3	1	3	94	1	1	12.3	10.5	8.9	3.6
F1.2a	126850	67.7	30.4	No Threat category	22	69	6	0	1	0	23	43	16	3	12	22.6	11.6	14.8	2.4
F1.2b	16582	53.9	23.5	No Threat category	36	46	19	0	0	0	10	38	35	3	7	17.6	12.4	52.6	2.6
F1.2c	154454	31.3	3.1	Critically Underprotected	62	0	36	0	1	0	5	25	49	3	16	14.8	12.1	78.7	1.0
F1.2d	10225	68.6	5.0	Critically Underprotected	75	3	21	0	0	0	6	59	29	0	0	12.7	12.5	26.1	1.1
F1.3a	108210	22.9	4.2	At Risk	95	0	1	1	0	1	13	10	62	2	12	17.5	11.5	33.0	1.8
F1.3b	138464	68.0	20.2	No Threat category	97	0	2	0	0	0	43	24	21	1	9	19.6	12.2	18.4	1.0
F1.3c	36060	34.2	12.2	Underprotected	27	5	0	12	1	30	20	11	62	0	3	16.1	9.4	23.8	1.1
F1.3d	124070	10.0	2.1	Acutely Threatened	89	1	1	1	2	4	5	4	83	0	6	13.6	10.8	52.1	1.8
F1.4a	112505	12.0	2.2	Chronically Threatened	89	1	4	4	2	0	3	9	79	1	6	10.0	11.4	39.5	1.1
F1.4b	26695	27.3	4.5	At Risk	74	24	2	0	0	0	6	21	34	18	9	13.9	12.2	42.4	1.0
F1.4c	110676	60.7	27.2	No Threat category	39	53	2	2	2	0	32	28	21	7	10	19.3	11.1	6.4	1.0
F1.4d	34965	16.8	4.3	Chronically Threatened	62	9	1	25	2	0	5	12	77	3	3	15.2	11.1	18.1	2.0
F1 total	1832582	48.4	22.9	No Threat category	72	16	5	4	1	1	31	17	42	2	7	13.6	11.5	20.6	1.5

Appendix 4

EXAMPLE OF AN INTERACTIVE GIS APPLICATION OF THE THREAT CLASSIFICATION TABLE

This example assesses the threat status of remaining indigenous cover within an area of interest (bold black outline) and statistics for the yellow area are displayed by clicking the crosshair pointer. This area is in environment K3.2a, and in the At Risk threat category. The environment has 25.02% indigenous cover remaining, and 5.76% protected. No change in indigenous cover was recorded in this environment from 1996/97 to 2001/02. The inset box shows the five-column table of data joined to the LENZ Level IV attribute table.


ArcView GIS 3.2a + Grid Converter + Grid Converter
File Edit View Theme Analysis Surface Generalize Grid Transform Grid Graphics XTools Window Grid Converter Clean Up Transformation Help Grid Analyst
Scale 1: 276,038
2,186,911.77
5,534,218.37
View1
Graph1.shp
Lenz_lvl_4
Acutely Threatened
Chronically Threatened
At Risk
Critically Underprotected
Underprotected
No Threat Category
No data
Nzhway
Towns
Lenz_lv
Lenz_lv
SI0419
0
1
2
3
No Data
lveg
10
11
12
13
14
15
20
21
22
43
44
45
46
47
50
52
53
Identify Results
2: Lenz_lvl_4 - X: 2.18729e+006 Y: 5.5
Clear
Clear All
Lvl_4 K3.2a
% ind cover remaining 25.02
% protected 5.76
Change 97-02 0
Threat category At Risk
Protection category Critically Underprotected
Start
WO...
Book1
C:\...
Nov...
Arc...
Ma...
Irfa...
1:53 p.m.

What protection does our native vegetation need?

Land clearance and loss of indigenous cover and biodiversity continue across New Zealand. We define five categories of environments containing indigenous biodiversity that are at most risk of loss from land clearance. Highest rates of loss are occurring in the most threatened environments, where little cover remains. Moreover, these ecosystems support a disproportionately large proportion of New Zealand's most threatened species and habitats. We recommend that the Land Environments of New Zealand database (LENZ) be used to identify environments that are most vulnerable to loss.

Walker, S.; Price, R.; Rutledge, D. 2008: New Zealand's remaining indigenous cover: recent changes and biodiversity protection needs. *Science for Conservation 2##*. 82 p.