Significance Assessment for Biodiversity in the South Island High Country

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Summary

Objectives

Land Information New Zealand asked Landcare Research to describe a standard, multi-scale (whole of high country, catchment or mountain range, individual property) approach to assess the significance of environments and indigenous vegetation. Specifically, we

1. Evaluate available existing criteria used to determine the significance of indigenous vegetation and environments for various purposes in New Zealand,.
2. Update significance criteria to accommodate the use of explicit, quantitative frameworks to assess representativeness.
3. Revise criteria in terms of Goal 3 of the New Zealand Biodiversity Strategy.
4. Describe the application of the revised criteria at three levels: (a) all pastoral lease lands and associated high country land; (b) catchment or mountain range; (c) individual property.

Methods

We undertook a review of key documents in the New Zealand and international literature related to assessments of the significance of biodiversity. We develop and recommend updated criteria to determine the significance of vegetation and environments to meet Government's high country objectives. Criteria that may be applied to features other than vegetation and environments (e.g. recreational or historic/cultural values) are not considered.

Results

Synoptic reviews are given of the criteria used to assess the significance of natural areas in New Zealand to date. Criteria previously applied to assessment of significance of vegetation and environments under Tenure Review incorporate PNAP ranking criteria, developed for a specific purpose in the 1980s. We recommend their replacement with modern criteria specific to Government objectives for the high country, that accommodate Goal 3 of *The New Zealand Biodiversity Strategy* and current international standards and conventions.

Conclusions and Recommendations

- There have been some significant shifts in emphasis in conservation goals through the latter part of the 20th century. Criteria used to assess significant inherent values need to be updated to reflect these changes.
- Revised criteria emphasise that simple static preservation of one or more samples is often inadequate for persistence, and that maintaining processes required to sustain ecosystems and species in healthy functioning states is a primary requirement.
- Persistence of biodiversity over time requires protection of both biodiversity pattern and the ecological processes that sustain this pattern.
- Modern criteria also recognise that a primary focus on relatively pristine areas will not fulfill the goal of maintaining a full range of indigenous biodiversity. For this to be achieved, priority and urgency should be accorded to protection of features with greatest likelihood of imminent loss or degradation under current and/or future land uses.
- Two types of significance criteria (ranking and binary) have been used in New Zealand. We suggests that binary criteria are consistent with the CPLA; i.e. a feature is assessed as either significant or not.

- Environments and vegetation may be significant inherent values for many different reasons. We comment on only three in this report: (1) natural character (2) ecosystem services, and (3) biodiversity. However, our primary focus is on the third category (biodiversity).
- We suggest two *ecological integrity* criteria for the assessment of environments and vegetation that are significant inherent values of natural character. These are (1) indigenous dominance, and (2) self-regeneration and potential species occupancy.
- Environments and vegetation may also be significant inherent values for the provision of ecosystem services. A full discussion of types and values of ecosystem services is beyond the scope of this report. We highlight water purification, water yield and flood mitigation as key ecosystem services provided by indigenous vegetation cover in the high country.
- Vegetation and environments may be considered significant inherent values is for their contribution to maintaining the full range of indigenous biodiversity. Biodiversity significant inherent values require a different definition from natural character and ecosystem services significant inherent values, and therefore different significance criteria.
- We suggest that an appropriate definition of biodiversity significant inherent values is those features *requiring protection in order to sustain the full range of indigenous biodiversity across the landscape*.
- Three criteria are used to assess whether environments and vegetation are biodiversity significant inherent values by the above definition. The first two criteria are to recognise features of biodiversity pattern requiring protection. They are:
    1) Representativeness and vulnerability, and
    2) Rarity or distinctiveness
- A third criterion is used to assess the ecological processes that must be protected if those features are to persist over time. This criterion,

    3) Sustainability requirements,

  is applied to each of the significant biodiversity pattern features identified by Criterion 1 or 2. The total area (identified feature and sustainability requirements) is the significant inherent value.
- These biodiversity significance criteria identify only those natural features (ecosystems, communities, species) that are at greatest risk of loss or degradation under current and/or future land uses. The criteria are therefore conservative rather than precautionary. Features meeting the criteria are priorities for protection to meet the goal of halting the decline of indigenous biodiversity.
- Many areas contributing to the maintenance of the full range indigenous biodiversity across the landscape will not meet the above criteria for biodiversity significance. Because these less imminently threatened features will typically be less modified, we anticipate that they should meet criteria for significant inherent values of natural character and/or of ecosystem services.
- Where possible, we recommend objective, quantitative assessment frameworks for determining biodiversity significance by these criteria. However, for some criteria, quantitative frameworks are not yet available, and assessment would therefore need to be based on the best available ecological knowledge.
- We suggest an explicit decision-making process that may be used in the assessment of biodiversity significance.
- We suggest a systematic application of the three biodiversity significance criteria within an explicit framework at three scales.

- We suggest that the assessment of significant inherent values using binary criteria be separated from their prioritisation for protection. The benefits of this are: consistency of identification, full scoping of the protection need, transparency of prioritisation, and the ability to objectively assessment and report progress towards the overarching objective.
- We advise that the prioritisation of biodiversity significant inherent values may be guided by the maximisation of biodiversity performance measures.

1. Introduction

1.1 Project objectives

In December 2003, the Department of Conservation reported to Cabinet on its evaluation of current methods by which it and the Commissioner identify significant inherent biodiversity values for protection (POL Min (03) 19/7, Appendix 1, Further work proposed, paragraph g). In February 2004, LINZ requested Landcare Research to build on the work completed by the Department of Conservation in its report to Cabinet. The task was to develop a framework and protocols to guide priority setting for protecting land environments and vegetation components of significant inherent values. Other components of significant inherent values (e.g. landscape, cultural and historic, and recreational) are outside the scope of the work. The framework and protocols developed were required to be suitable for operational application.

This report describes existing approaches, and recommends a standard approach to assess the significance of environments and vegetation in the high country.

1.2 Tenure review objectives

The purposes of tenure review (in the Crown Pastoral Land Act 1998) include 24(b): To enable the protection of the significant inherent values of reviewable land. Government objective c. for the high country (derived from the CPLA) is to "protect significant inherent values on reviewable land by the creation of protective measures…" (Table 1). Objectives g. and h. specify the protection of significant inherent values for particular conservation outcomes.

This report describes existing approaches, and sets out a standard approach to assess the significance of environments and vegetation in the high country. Three Government objectives for the high country (c, g and h) are relevant in the assessment of significance of environments and vegetation (Table 1).

Table 1 Government objectives for the high country relevant to this report

Objectives derived from the CPLA 1998
c. Protect significant inherent values on reviewable land by the creation of protective measures [CPLA S.24(b)(i)]; or preferably by the restoration of the land concerned to full Crown ownership and control [CPLA S.24(b)(ii)]
Complementary objectives from POL Min (03) 19/7
g. Ensure that conservation outcomes for the high country are consistent with the New Zealand biodiversity strategy (NZBS)
h. Progressively establish a network of high country parks and reserves

Significant inherent values (in CPLA S.24(b)(ii) and Government objective c. for the high country) are defined in the CPLA as follows:

- *"Significant inherent value"*, in relation to any land, means *inherent value* of such importance, nature, quality or rarity that the land deserves the protection of management under the Reserves Act 1977 or the Conservation Act 1987:

- *"Inherent value"*, in relation to any land, means a value arising from —
  (a) A cultural, ecological, historical, recreational or scientific attribute or characteristic of a *natural resource* in, on, forming part of, or existing by virtue of the conformation of, the land; or
  (b) A cultural, historical, recreational or scientific attribute or characteristic of a historic place on or forming part of the land:
- "Natural resources" means —
  (a) Plants and animals of all kinds; and
  (b) The air, water, and soil in or on which any plant or animal lives or may live; and
  (c) Landscape and landform; and
  (d) Geological features; and
  (e) Ecosystems; —
  and "natural resource" has a corresponding meaning:

1.3 Scope of the report

1) Inclusions
First (in Section 3), we provide a synoptic review of existing criteria for the assessment of significance of environments and indigenous vegetation, referring to the major applications in New Zealand to date. For convenience, we divide the criteria into two types: (A) ranking and (B) binary.

Second (in Section 4), our report sets out an approach for assessment of the significance of environments and indigenous vegetation in the high country. We recognise that environments and vegetation may be components of several '*value sets'* of significant inherent values [cf. PLA S.24(b)(ii)]. We comment on only three of these: (1) environments and vegetation that are significant inherent values of *natural character*, (2) those that may be significant inherent values for the *ecosystem services* they provide, and (3) those features that are significant inherent values because they are important for sustaining indigenous biodiversity.

Our focus is on the third category: biodiversity significant inherent values. We propose a definition of biodiversity significant inherent values that is specific to Government's biodiversity objectives for the high country, taking into account Goal 3 of the Zealand Biodiversity Strategy (Department of Conservation & Ministry for the Environment 2000) and its priority actions, and modern international conventions. Three criteria are proposed for their assessment. The quantitative assessment of the first of these proposed significance criteria (Representativeness and vulnerability) is detailed in an earlier report (Walker et al. 2004a).

2) Exclusions
We do not address many types of significant inherent values (e.g. landscape, access, amenity, cultural) that are not direct or sole properties of environments and vegetation.

2. Background

2.1 High country environments and vegetation

The pastoral high country covers some 25% of New Zealand's land area, encompassing a considerable altitudinal range from valley floors to mountain tops. Productivity follows altitudinal gradients, with factors such as steep relief, short growing season, high frost frequency, and low soil fertility all limiting primary production with increasing elevation. Indigenous species and communities also follow altitudinal gradients; for example, in the absence of human disturbance, shrublands and tall tussock grasslands would dominate above treeline (i.e. in the alpine zone), tall forests would cover mountain slopes (the montane zone), dry, frosty basin floors (the lowland zone) would be occupied by shrublands with diverse understorey herbs and smaller grasses (Leathwick et al. in press).

Lowland and montane areas of the high country have been more intensively developed by topdressing and oversowing with exotic pasture species, as well as by cultivation. This process removes indigenous species and replaces them with exotic species (mainly grasses and forbs). There has therefore been differential modification of indigenous vegetation and removal of indigenous biodiversity across 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. This altitudinal pattern of land use and habitat loss in the South Island high country is a feature it shares with all New Zealand (Leathwick et al. 2003a).

2.2 New Zealand conservation directives relevant to significant assessment

Three major directives are relevant to the identification and assessment of significant inherent values in the high country.

The Reserves Act (1977)

The Reserves Act (1977) expresses a national conservation goal as follows:

> 3 (1) (b) Ensuring, as far as possible, the survival of all indigenous species of flora & fauna, both rare and commonplace, in their natural communities and habitats, and the preservation of representative samples of all classes of natural ecosystems and landscapes, which in the aggregate originally gave New Zealand its own recognisable character

In 1983, the Protected Natural Areas Programme (PNAP) was established as a national initiative towards providing a network of reserves that would be representative of the natural diversity which in the aggregate originally gave New Zealand its own recognisable character, as expressed in the Reserves Act 1977 (Section 3 (1) (b)).

The Conservation Act (1987)

The Conservation Act (1987) defines conservation as follows:

> "Conservation" means the preservation or protection of natural and historic resources for the purposes of maintaining their intrinsic values, providing for their appreciation and

recreational enjoyment by the public, and safeguarding the options for future generations;
"Conservation area" means any land or foreshore that is—
(a) Land or foreshore for the time being held under this Act for conservation purposes; or
(b) Land in respect of which an interest is held under this Act for conservation purposes

***The New Zealand Biodiversity Strategy* (2000)**

New Zealand's indigenous biodiversity is globally distinctive and unique, a consequence of evolution through a long period of isolation after separation from other continents some 80 million years ago. This distinctiveness is seen in high levels of endemism (native only to New Zealand), presence of ancient and unusual forms, and in the different features of communities.

The loss and condition of indigenous biodiversity was described in the *State of New Zealand's Environment 1997* report (Ministry for the Environment 1997 p. 10.6) as the nation's most pervasive environmental issue. *The New Zealand Biodiversity Strategy* (DOC & MfE 2000) was prepared in response to the decline in New Zealand's native biodiversity. Goal 3 of the Strategy is to:

> *Halt the decline in New Zealand's indigenous biodiversity*
> Maintain and restore the full range[1] of remaining natural habitats and ecosystems to a healthy functioning state, enhance critically scarce habitats and sustain the more modified ecosystems in production and urban environments; and do what else is necessary to maintain and restore viable populations of all indigenous species and subspecies across their natural range and maintain their genetic diversity (p. 18)
> [1] a comprehensive and representative range that reflects the known diversity of habitats and ecological communities remaining in New Zealand

The Strategy also states (p. 20) that "maintaining viable populations of indigenous species across their natural range should largely be achieved by maintaining a full range of natural habitats and ecosystems."

2.3 The need to update biodiversity significance criteria

Through the latter part of the 20th century the conservation goals defined and elaborated in legislation have undergone a significant shift in emphasis, in part reflecting international changes in conservation perspectives in response to increasing biodiversity loss. There have also been developments in understanding of the structure and spatial patterns of biodiversity.

First, there has been an expansion in the focus of conservation. The emphasis has shifted from the survival and preservation of at least one representative "sample" of ecosystems and habitats to providing for the maintenance of healthy functioning states of ecosystems and viable populations of species across their natural range. While it remains important to protect the full range (i.e. all natural ecosystems and species, as expressed in the Reserves Act), it is now recognised that simple static preservation of one or more samples or examples of ecosystems in their present states will generally be inadequate to meet that aim: i.e. the survival of ecosystems and their component species in the future. Protecting and providing for the *processes* that are required to sustain those ecosystems and species in healthy functioning states is now recognised as a primary requirement. For example, the New Zealand Biodiversity Strategy states:

> There is a need for greater recognition and action to restore fragmented, degraded or scarce natural habitat, halt declining ecological condition, restore essential ecosystem functions, and extend the area of particular habitat types…
> (*The New Zealand Biodiversity Strategy* p. 38)

A second important distinction is the change in focus from "preserving" what is "original" to maintaining and restoring what is modified. This follows the recognition that there are few ecosystems in New Zealand that have not been substantially modified through extinctions, as a consequence of ongoing predation and herbivory by introduced animals and other anthropogenic disturbances. Importantly, "quality" and "naturalness" are difficult to define, and these criteria serve to focus protection effort on those natural ecosystems that are most intact. Although it remains important to protect relatively pristine areas, it is now recognised that an exclusive focus on such areas will not fulfill the goal of maintaining a full range of indigenous biodiversity (i.e. representative samples of all ecosystems and habitats).

3. Review of Criteria

3.1 Introduction

Many sets of criteria have been developed over the years in an attempt to determine significance (conservation values) for areas of indigenous ecosystems. We make no attempt to review comprehensively all sets of significance criteria in this report; we provide instead synoptic reviews (focusing on the context and intent) of those of that have been most widely applied to date.

3.2 Types of criteria used to assess significance in New Zealand

We divide criteria that have been used to assess the significance of biodiversity into two categories, based on the purpose for which they were developed:
Ranking criteria: these have evolved out of a need to prioritise remaining areas of indigenous vegetation and fauna habitat in the face of continued decline in the extent and quality of natural areas, and in response to new environmental and conservation legislation. Prioritisation is required because there are limited resources for conservation and these must be put to best possible use. Key examples are the criteria used in the Protected Natural Areas Programme and those applied by the Nature Heritage Fund.
Binary criteria: these have been developed for situations where it is necessary to determine whether indigenous vegetation and fauna habitat are significant or not. An example is the assessment of significance for Resource Management Act (1991) purposes.

3.2.1 Ranking criteria

Criteria used in the Protected Natural Areas Programme (PNAP)

In 1983, the Protected Natural Areas Programme (hereafter PNAP) was established as a national initiative towards providing a network of reserves representative of the natural diversity that in the aggregate originally gave New Zealand its own recognisable character, as expressed in the Reserves Act 1977 (Section 3 (1) (b)). This initiative was a major progression in formally recognising the significance of areas then outside the formal protection network (Kelly & Park 1986).

The aim of the PNAP was to "focus attention on, and secure protection in some form for, the natural ecosystems and landscapes that were originally typical or commonplace in each Ecological District" (McEwen 1987; Myers et al. 1987). PNAP surveys therefore identified and recommended areas for protection (as RAPs) that represented the highest quality or best condition examples of the remaining indigenous biological and landscape features within each ecological region or district.

A set of criteria was developed for the evaluation of priority natural areas for protection (RAPs):

1. representativeness
2. diversity and pattern
3. rarity and special features
4. naturalness
5. long-term ecological viability
6. size and shape
7. buffering, surrounding landscape and boundaries.

It is noted that "other considerations" for significance assessment within the PNAP include the vulnerability of, and threats to, the features themselves, with importance attached to those species, habitats and communities most reduced by past human influence and most likely to disappear if no remedial action was taken, or those least readily replaced once lost or badly damaged (Technical Advisory Group, PNA Programme 1986).

The seven different PNAP criteria share many component attributes (e.g. diversity is related to size, since larger areas usually contain more habitats and therefore variety of species).

The PNAP criteria also contain some internal conflicts. In particular: four criteria (4. naturalness; 5. long-term ecological viability; 6. size and shape; and 7. buffering, surrounding landscape and boundaries) all serve to reduce the significance rank accorded to modified areas that are vulnerable to imminent loss. This is in conflict with the note that highlights consideration of vulnerability and threats, which would tend to rank more vulnerable features more highly.

Nature Heritage Fund criteria

Criteria have been developed to assist the Nature Heritage Fund (hereafter "NHF") with the assessment of priorities for further protection or restoration of indigenous ecosystems (Harding 1999). Like other such agencies, the NHF recognises they are constrained financially in their ability to purchase indigenous ecosystems, or to assist with their protection. Therefore, for the NHF, consideration of protection or restoration proposals is nearly always an exercise in determining relative priorities. Harding (1999) has developed and refined the three key criteria and three secondary criteria:

Key criteria	Secondary criteria (selected to refine the key criteria)
1. Representativeness	Distinctiveness
2. Sustainability	Condition
3. Landscape integrity	Amenity

For significance assessment by the NHF, Representativeness is defined in terms of estimates of original extent of ecosystems. Definition of these ecosystems relies on estimates generated by expert opinion, and a complete ecosystem classification has been performed for Southland only. While we believe this classification is of high quality, it remains subjective, would probably not be repeatable, and is difficult to transfer consistently to other areas of New Zealand.

The rationale behind the sustainability and condition criteria used by the NHF is that a feature will be ranked as less significant if it is in poor condition or if there is ecological opinion that its present values are not likely to persist in the long term. However, there is inconsistency in this criterion, because an area will be ranked more highly if it is judged to contribute to the sustainability of *other* protected areas.

3.2.2 Binary criteria

Resource Management Act (1991)

Several unpublished documents offer criteria for defining significance under Section 6(c) of the Resource Management Act 1991 (RMA), which provides for the protection of areas of significant indigenous vegetation and significant habitats of indigenous fauna as a matter of national importance. We mention a few of these only.

Whaley et al. (1995) reviewed existing significance criteria for Environment Waikato and recommended nine criteria to be applied for RMA purposes. In 1985, Dr BD Clarkson (one of the authors of Whaley et al. 1995) presented evidence before the Environment Court, recommending the same nine criteria:

1. Representativeness
2. Diversity and pattern
3. Rarity and/or special features
4. Naturalness/intactness
5. Size and shape
6. Inherent ecological viability/long-term sustainability
7. Buffering/surrounding landscape connectivity
8. Fragility and threat
9. Management input

The Royal Forest and Bird Protection Society have used 13 criteria for defining significance under Section 6(c) of the RMA. These do not attempt to rank values (Appendix 1).

In a draft discussion document, Norton and Roper-Lindsay (1999) suggested four criteria for the assessment of significance under Section 6(c) of the RMA:

1. Representativeness
2. Rarity /distinctiveness
3. Ecological context
4. Sustainability

The above four criteria are binary, i.e. an area is assessed as either significant or not significant.

3.2.3 Department of Conservation Tenure Review criteria

Appendix 5 of the Department of Conservation *Tenure Review Manual* lists seven standards (abbreviated below) to be applied as guidelines in the identification and assessment of significant inherent values:

1. Areas that alone or collectively sustain the special natural quality and integrity of the high country landscape, especially the indigenous component.
2. Areas that sustain the most culturally valued attributes (e.g. scenic, aesthetic, recreational and historic) and their context within a natural high country landscape.
3. Areas that would currently meet the PNAP criteria for selection as priority natural areas (e.g. RAPs), or sites of special wildlife significance ranking as “outstanding” to “moderate/high”, or wetlands of ecological and representative importance included in the WERI inventory (see Appendix 6 of the manual).
4. Habitats of threatened species (including those regionally threatened).
5. Type localities and habitats of species and communities that are at their distributional limits and/or endemic or that have specialised habitat requirements in the high country, and species, communities, habitats or ecosystems that are uncommon and/or endemic in the ecological district.
6. Key breeding or feeding sites of fully protected wildlife or sites that are important for other life-cycle stages of indigenous or migratory species, or support species that contribute significantly to the ecological functioning of off-site protected areas.
7. Areas that make a special contribution to the overall quality, natural functioning and ecological integrity of significant values (e.g. linkages, buffers), in their present or potential state.

Standard point 3. above is elaborated in a further appendix (Department of Conservation *Tenure Review Manual* Appendix 6), which lists seven PNAP criteria and selected criteria for ranking sites of special wildlife interest (adapted from standard criteria used by the former NZ Wildlife Service). In other words, the standards used by the Department of Conservation to assess significance for tenure review to date expand on and supplement PNAP criteria, special wildlife significance criteria, and WERI criteria. Department of Conservation criteria for the assessment of significance in tenure review are therefore an amalgam of ranking and binary criteria.

Along with the PNAP and WERI criteria (Point 3, Appendix 5 of the Department of Conservation *Tenure Review Manual*) tenure review has inherited significance criteria designed to identify highest-quality sites. Specifically, the secondary significance criteria (4. Naturalness, 5. Long-term ecological viability, 6. Size and shape, or 7. Buffering, surrounding landscape and boundaries) will tend to downgrade the final significance ranking of more modified areas that are most vulnerable to imminent loss.

Davis (2002) reviewed the criteria used to assess significance for tenure review and suggested that four criteria should be used:

1. Diversity and pattern
2. Rarity and distinctiveness
3. Naturalness
4. Size, shape and buffering.

Examples of ratings (high, medium or low, but for rarity and distinctiveness, simply present) are suggested for each criterion. These suggested criteria make many modifications to previous criteria along the lines needed to meet Goal 3 of the New Zealand Biodiversity Strategy. For example, the importance of modified areas is emphasised. However, in the guidelines for applying the criteria, it is suggested that lower-significance rankings should be attributed to more modified and vulnerable environments (e.g. those that are less natural and less well buffered) than to those areas that are more intact and less vulnerable. These criteria are therefore principally of the ranking type.

We note that both the tenure review manual and the criteria of Davis (2002) recognise the significance of areas that require protection for the long-term sustainability of natural features that might not themselves be considered significant by criteria such as representativeness or rarity. Standards 6 and 7 of the *Tenure Review Manual* accord significance to areas that contribute, for example, to the “overall quality, natural functioning and ecological integrity of significant values (e.g. linkages, buffers etc.), in their present or potential state”. Davis (2002) suggests that requirements for sustainable long-term viability should be considered, including provision of buffers, corridors and networks of smaller sites with linkages between them.

We have not had the opportunity to rigorously review a new draft revision of significance criteria for Tenure Review by Connell (2004). Key points appear to be:

- The guidelines recommend continued reliance on qualitative judgements in significance assessment, pointing out that systems development in DOC has not reached the point where quantitative assessments can be made.
- The guidelines recommend that features are ranked along a subjectively defined significance spectrum from ‘highest significance’ to ‘not significant at all’. Therefore, significance is seen as a continuum, and the criteria are ranking rather than binary criteria. However, in this case, apparently arbitrary levels of significance are recommended to replace the explicit scoring system used in the application of PNAP-type criteria. There seems to be no rigorous basis for the level of significance accorded to different features.
- Guidelines appear imprecise in some respects e.g. Point 67 “significance may be accorded to places that connect other places…”. There is no guidance given as to when this criterion will or will not be applied.
- The guidelines accord higher levels of significance to species, habitats or ecosystems that are closer to extinction. In this, they are more explicit than significance criteria previously applied in Tenure Review.
- The guidelines are not related to biodiversity conservation targets or performance measures.

4. Framework for the Assessment of Significance of Environments and Vegetation in the High Country

4.1 Introduction

In this section we describe and recommend a standard, multi-scale approach to guide identification of land environments and vegetation components of significant inherent values. To ensure that conservation outcomes for the high country are consistent with Government objectives, it is intended that the approach should be suitable for operational application.

Environments and vegetation may be significant inherent values for many reasons. They may be components of several '*value sets'* (*sensu* Connell 1994), i.e. cultural, historical, ecological (including biodiversity), recreation, science, landscape and scenery, and ecosystem services. In this report, we comment on only three of these, i.e.

- for their natural character
- for the provision of ecosystem services, and
- for the maintenance of indigenous biodiversity.

Consistent with our brief, we focus our work on the third of the above bullet points.

We use the word 'protection' in this report in a very broad sense. A variety of conservation management activities may be required to sustain the significant inherent values associated with those areas of land that are identified as significant (i.e. requiring protection). A range of protection mechanisms might be used to give effect to these different management activities, and we do not attempt to address these in any detail here.

4.1.1 Natural character

We define 'natural character' as a property that arises from the predominantly indigenous nature of the vegetation within an environment. Areas that have significant inherent values of natural character would require protection to maintain this intrinsic value (the predominantly indigenous state that is unique to New Zealand) for its own sake, providing for its appreciation and recreational enjoyment by the public, and safeguarding the options for future generations (cf. Conservation Act 1987). Our definition of natural character is very close to the first criterion (Standard 1) in Appendix 5 of the Department of Conservation Tenure Review Manual: '*Areas that alone or collectively sustain the special natural quality and integrity of the high country landscape, especially the indigenous component'*.

We consider that natural character cannot be rigorously or consistently assessed by comparing the current state of an feature with an original state at some nominated time in the past, because reconstructions of past ecosystem states necessarily draw on imprecise and inconsistent interpretation and opinion. We suggest instead that two *ecological integrity* criteria may be used to assess natural character. An area would be significant for its natural character if it would meet the following criteria given practical protection from land use and invasion pressures (e.g. cultivation, drainage, pollution, fire, grazing, browsing, oversowing and topdressing, invasion by ecosystem-transforming pests and weeds).

Criterion 1: Indigenous dominance: indigenous species dominate the ecosystem structure (e.g. vegetation cover) and function (e.g. grazing and browsing).

Criterion 2: Self-regeneration and potential species occupancy: the indigenous species present have the capacity to regenerate, and the community retains successional potential. Indigenous species that have been eliminated or reduced by past human disturbances (e.g. fire, herbivory, predation) will be able to recolonise the area in time.

We use three examples to illustrate the application of the criteria:

- Scenario 1: An area in a wetter, western area of the high country dominated by indigenous bracken fern vegetation that would revert to indigenous shrubland and forest communities within several decades in the absence of fire. Some elements of the fauna that have been eliminated (e.g. birds, lizards, and invertebrates) will recolonise in time.
  Assessment: the area is significant by natural character criteria.
- Scenario 2: An area of indigenous-dominated tussock grassland persists in an environment that formerly supported beech forest. With cessation of grazing and burning, tussock density and stature may increase, with associated changes in litter, stream water quality and composition of terrestrial and freshwater invertebrate fauna. However, shrubland and forest vegetation (especially beech forest) is unlikely to establish within several centuries.
  Assessment: the area is significant by natural character criteria.
- Scenario 3: An area that has been cultivated and fertilised, and is dominated by exotic pasture species. Removal of grazing is unlikely to result in reversion to indigenous vegetation because the substrate has been considerably modified, and because seed sources of potential colonisers are distant and few.
  Assessment: the area is not significant by the natural character criteria.

The protection of significant inherent values of natural character appears to be consistent with the Government's high country objective (h) (Progressively establish a network of high country parks and reserves). We consider that criteria to determine the significance for the creation of high country *parks* to meet this high country objective (listed in Cabinet Policy Committee Report Back on Government Objectives for the High Country, paragraph 50) may be appropriate additional criteria to identify environments and vegetation requiring protection to maintain intrinsic values that stem principally from their indigenous character (i.e. significant inherent values of natural character).

4.1.2 Ecosystem services

Ecosystem services are the processes by which natural ecosystems perform fundamental life-support services upon which humans depend. Ecosystems provide 'services' that:

- moderate weather extremes and their impacts
- disperse seeds
- mitigate drought and floods
- protect people from the sun's harmful ultraviolet rays
- cycle and move nutrients
- protect stream and river channels and coastal shores from erosion
- detoxify and decompose wastes
- control agricultural pests
- maintain biodiversity
- generate and preserve soils and renew their fertility
- contribute to climate stability
- purify the air and water
- regulate disease carrying organisms

• pollinate crops and natural vegetation (Goodland & Daly 1996; Costanza et al. 1997).

Many of these ecosystem services contribute directly to production and consumption in the market economy, but come under pressure from economic and social activities.
They may be threatened by growth in the scale of human enterprise (population size, per-capita consumption, and effects of technologies to produce goods for consumption) and a mismatch between short-term needs and long-term societal well-being (Costanza et al. 1997). Specific examples of processes that that disrupt, impair or re-engineer ecosystems and the services they provide include: runoff of pesticides, fertilisers, and animal wastes; pollution of land, water, and air resources; introduction of non-native species; overharvesting fisheries; destruction of wetlands; erosion of soils; deforestation; and urban sprawl.

We suggest that an appropriate definition of significant inherent values of ecosystem services would be *those features requiring protection in order to maintain the ecosystem services provided by the landscape*.

A full discussion of ecosystem services is beyond the scope of this report. However, we highlight water purification, water yield, and flood mitigation as key ecosystem services provided by indigenous vegetation cover in the high country. Water purification depends on filtration and absorption by soil particles and living organisms in the water and soil (Stapleton 1997). Human activities that compact soil, contaminate the water, or alter the composition of organisms degrade the purification process and can accelerate movement of unfiltered water into water supplies. Wetland vegetation can remove metals in the water, trap and retain sediment from runoff, and eliminate much of the entering nitrogen (Barbier et al. 1993). Riparian (streamside) vegetation acts as a living filter that intercepts and absorbs sediments, and stores and transforms excess nutrients and pollutants carried in runoff from adjacent lands. There are many examples that illustrate these services internationally (e.g. Stapleton 1997) and in New Zealand. Long- term monitoring indicates that loss of tussock or shrubland and indigenous forests, an increase in planted forests, and an increase in areas used primarily for pastoral agriculture is associated with a decrease in Lake Taupo's water quality (Environment Waikato 2003). Large areas of tussock grassland have been retired from pastoral use in the Deep Stream catchment near Dunedin to retain the city's water supply and quality. The establishment of exotic plantations in tussock grassland areas has been shown to significantly reduce catchment water yields (e.g. Fahey & Jackson 1997).

4.1.3 Maintenance of indigenous biodiversity

In this report, we focus on criteria to assess whether environments and vegetation are significant inherent values for the maintenance and restoration of indigenous biodiversity. We see that there are two Government's high country objectives that are consistent with this subset of significant inherent values, i.e.:

1. High country objective g. (Ensure that conservation outcomes for the high country are consistent with the New Zealand Biodiversity Strategy (NZBS)),

2. High country *reserves* for the purposes of biodiversity protection within high country objective h. (Progressively establish a network of high country parks and reserves)

We suggest that an appropriate definition of biodiversity significant inherent values would be those features requiring protection in order to sustain the full range of indigenous biodiversity across the landscape.

We recommended three criteria would be needed to assess biodiversity significant inherent values as defined above:

1. Representativeness and vulnerability
2. Rarity and distinctiveness
3. Sustainability requirements

These criteria are binary, so that a feature would be assessed as either significant (‘*requiring protection in order to sustain the full range of indigenous biodiversity across the landscape*’) or not. The criteria rely on current information and best available knowledge to identify environments, vegetation, and species that are either severely reduced or in decline in the landscape, and the ecological requirements to sustain threatened indigenous biodiversity in the landscape. It follows logically that the loss of a feature identified as significant would result in failure to halt the decline in indigenous biodiversity. In other words, features meeting our biodiversity significance criteria are the minimum set required to achieve the goal of halting the decline of indigenous biodiversity.

These criteria identify as significant only *threatened* indigenous biodiversity features, i.e. those that are known to be severely reduced or in decline (along with the requirements for their long-term sustainability). The criteria are therefore conservative rather than precautionary. There will be environments, vegetation, and species that contribute to the maintenance of the full range indigenous biodiversity across the landscape that have not reached such an advanced state of decline. We recognise that such features might be (wrongly) considered insignificant or valueless for maintaining biodiversity because they are less threatened. Less threatened features will typically be more pristine and supply higher-quality ecosystem services than the more threatened biodiversity. We therefore anticipate that these less imminently threatened biodiversity features should be identified as significant in other categories (e.g. they may be significant inherent values of natural character or ecosystem services).

We are able to suggest objective, quantitative, repeatable systems for assessing biodiversity significance by the criteria of 1. (Representativeness and vulnerability) and the threatened species component of 2. (Rarity or distinctiveness).

However, knowledge is insufficient, and appropriate frameworks are not yet available to quantitatively define all aspects of Criterion 2 (Rarity or distinctiveness) and Criterion 3 (Sustainability requirements for all features that are significant by Criteria 1 and 2). For these criteria, the precautionary application of best ecological knowledge will be required. In the elaboration of each criterion below, we suggest how present qualitative criteria may be updated to use quantitative frameworks in the future.

4.2 Biodiversity Criterion 1: Representativeness and vulnerability

Representativeness has been a major goal of conservation in New Zealand (e.g. Reserves Act 1977) and the primary criterion in the most commonly used significance assessment systems in New Zealand to date.

Representativeness has usually been assessed by comparing the current extent of an ecological element with its “original” extent at some time in the past. Often, the immediate pre-European datum (i.e. 1840; e.g. O’Connor et al. 1990) has been used as the baseline against which to compare the extent of the present ecosystem. However, complex changes and biodiversity losses occurred in natural ecosystems throughout the era of Polynesian occupation before 1840, and were continuous with those that occurred once Europeans arrived (e.g. Walker et al. 2003a; McGlone 2003). Consequently, ecosystem patterns were not at equilibrium at the time of European settlement, and the assumption that the 1840 date represents "natural" or "original" climax ecosystems is false. Moreover, non-equilibrium states that existed in 1840 are difficult to define: there is scant sub-fossil evidence from that time, and little consensus among expert ecologists interpreting that evidence.

Application of the criterion of representativeness relative to hypothetical 1840 ecosystem states (or indeed a prehuman ecosystem state) necessarily draws on imprecise, subjective interpretations and interpolations of scant evidence. Published reconstructions of dominant cover types have been attempted in some areas (Molloy et al. 1963; Harding 1999; McGlone 2001; Hall & McGlone 2001; Walker et al. 2003a; 2004b) but these vary in methodology, resolution, assumptions, associated statistical error, and in the range of biotic groups considered. We consider that it is not possible at present (given the scarcity of evidence) to provide accurate, quantitative predictions of the prior extent of ecosystems (either pre-European or prehuman) in the high country at scales (typically 1:50 000) that are useful for assessing representativeness in tenure review. In summary, we believe the standard previously used for the assessment of representativeness (estimating the extent of a pre-European ecosystems) to be subjective and inconsistently interpreted. Its application reduces the rigour and defensibility of significance assessment and resulting land allocation outcomes.

Land Environments of New Zealand (LENZ) identifies climatic and landform factors likely to influence the distribution of plant and animal species, and uses these factors to define a landscape classification that groups together sites that have similar environmental character. Each land environment would be expected to have supported similar potential natural vegetation, and contained a similar suite of ecosystems and biodiversity, in the absence of human disturbance. LENZ therefore provides an objective basis for assessing representativeness.

The most imminent threats to the persistence of the indigenous ecosystems and species are generally in those land environments where land-use changes (principally intensive agricultural development and urbanisation) and pest and weed invasions are leading to the most rapid loss of indigenous habitats, communities and species, and therefore the most rapid retreat of options and opportunities for biodiversity protection (e.g. Lee & Walker 2004). If representativeness goals are to be met, priority and urgency must be accorded to the protection of remaining indigenous ecosystems in the most vulnerable land environments.

In an earlier report (Walker et al. 2004a), we recommended definitions of representativeness and vulnerability to meet high country biodiversity objectives and describe applications to assess the significance of indigenous high country vegetation. Using theoretical predictions of species richness against habitat area (Rosenweig 1995), we suggest indigenous vegetation within an environment will be significant if <20% of that environment is currently protected (Walker et al. 2004a). For areas that are significant by the representativeness criterion, vulnerability represents protection urgency.

Definitions of indigenous vegetation used in New Zealand vary widely. Consistent with our definition of significance for biodiversity objectives, we suggest indigenous vegetation for survey purposes be defined as *vegetation supporting indigenous species*. This recognises that the physiognomic (structural) or numeric dominance (richness) of indigenous species on the ground is not the critical issue; what determines significance for biodiversity is whether or not the vegetation of an area (whether predominently native or exotic) contributes to the maintenance of indigenous biodiversity across the landscape.

4.3 Biodiversity Criterion 2: Rarity and distinctiveness

4.3.1 Rarity

In this criterion, the term “rarity” encompasses both the naturally uncommon and the threatened. Conceptually, rarity can be applied at several levels of biodiversity, i.e. species, communities, habitats, or ecosystems.

Naturally uncommon (i.e. range-restricted or sparse) plant and animal taxa (hereafter “species”), communities, habitats or ecosystems occur sparsely across the landscape, so the loss of a population or example typically translates into a relatively large proportional reduction in the total remaining (the same magnitude of loss would account for a smaller proportional reduction in a common or widespread species or ecosystem).

Species, communities, habitats, or ecosystems that are threatened with extinction may be naturally uncommon, or they may be naturally widespread. However, if they are classified as threatened, they are judged to be most at risk of extinction in the wild, on the basis of combined criteria such as low total population size or number, small or significantly reduced area of occupancy, fragmentation of populations or advanced degradation, declines in total population, habitat area, number of sites or area of occupancy, and/or predicted declines due to existing or anticipated threats.

A rare species classification system

The Department of Conservation has recently adopted a system for classifying species according to threat of extinction, designed specifically to list taxa that occur in New Zealand. The international organisation IUCN (International Union for the Conservation of Nature) periodically publishes "Red Lists" of globally threatened taxa. The IUCN Red List system has seven threatened categories ranging from Extinct to Least Concern. The categories and criteria of the New Zealand threat classification system bear some resemblance to those of the IUCN system, but differ in that they take account of the relatively small size of New Zealand, the period over which recent declines have occurred, and the large number of taxa with naturally restricted ranges and small population sizes.

The classification system has been designed so that any taxon that exists in the wild in New Zealand can potentially be listed. Categories for both introduced and non-introduced (native) taxa have been included as well as categories for both threatened and non-threatened taxa (Fig. 1). Seven categories of threat are provided for threatened taxa, and one for non-threatened taxa. The classification system has been developed to apply equally to marine, terrestrial and freshwater biota.

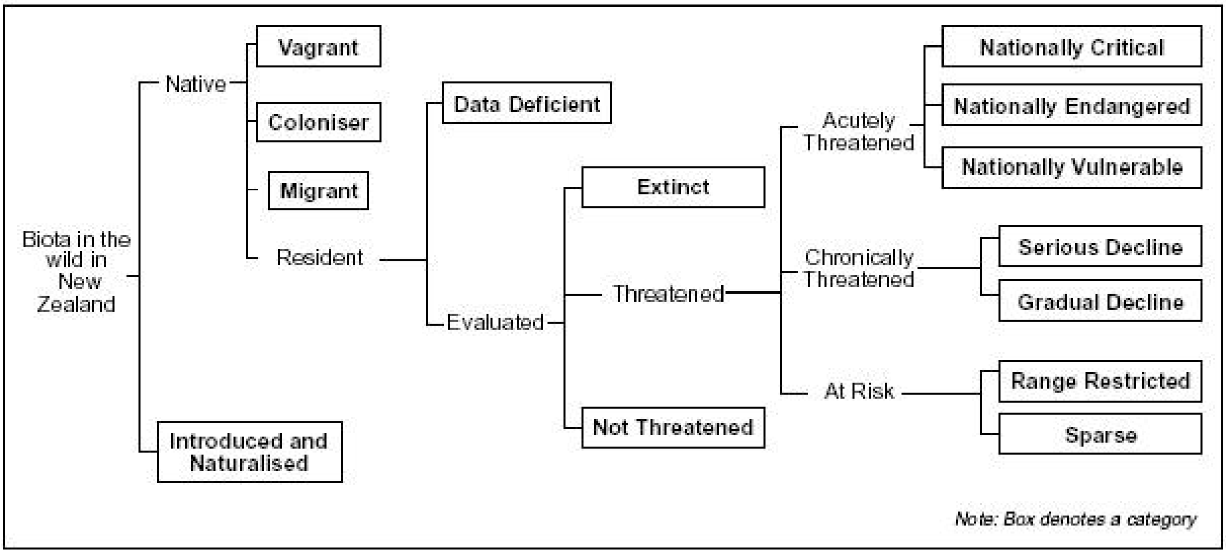

Fig. 1 Structure of the New Zealand threat classification system (Molloy et al. 2002).

Protection of terrestrial or freshwater species in all of the seven categories of threat is likely to be necessary to halt the decline in indigenous biodiversity. In other words, places containing species classified in any one of these categories would be significant. This is because further reduction of populations of Chronically Threatened species (i.e. those in serious and gradual decline categories) is likely to elevate the threat status of those species to Acutely Threatened. Likewise, truncation of current ranges of At Risk species (i.e. range restricted and sparse) will, in time, serve to elevate them to higher categories in the threat classification.

A draft rare habitat/community type classification system

While LENZ provides the best available framework for assessing environmental pattern, it accounts for only certain abiotic components of ecosystems, and at the scale enabled by the underlying data layers (statistical error estimates for the surfaces underlying LENZ are published in Leathwick et al. 2003b). LENZ does not, therefore, map either the biotic components of ecosystems, or some fine-scale features that define naturally uncommon (i.e. distinctive) habitats or communities. For convenience, we hereafter call these biotic features "rare habitat/community types".

For example, limestone outcrops are uncommon in parts of the high country, and may support distinctive, "basicolous" indigenous flora and fauna. Limitations in the substrate data underlying LENZ mean these are inconsistently distinguished by LENZ, although they will often be significant for indigenous biodiversity. Similarly, inland cliffs and bluffs, support disproportionately high proportions of indigenous species that are threatened with extinctions, yet, being vertical, they are seldom adequately depicted on maps. Similarly, caves are subterranean features that are poorly mapped.

Habitat/community types have not been formally classified by threat category in New Zealand, but we believe development of such a habitat/community classification would be useful. However, listing and ranking habitat/community types would have shortcomings, mainly related to the necessarily (at least given current knowledge) subjective nature of the habitat/community classification (definition of types and categories may be hard to justify with the current state of knowledge) and the subjectivity and likely inconsistency of thresholds for listing types as uncommon or significantly reduced. A list makes it very hard to argue for the protection of non-listed types, and this might in fact increase the vulnerability of types not listed. Nevertheless, the same limitations apply to the New Zealand threat classification system used for species. We believe that in the absence of appropriate quantitative frameworks there is a role for a regularly revised, updated, subjective but authoritative national classification of threatened habitat/community types, modelled on the protocols established for classifying threatened species (e.g. plants, de Lange et al. 2004).

In two draft tables (Tables 1 and 2) we suggest the form such a classification might take, based on informal discussion among ecologists. Tentative threat categories are attached (i.e. Threat category HIGH >> MODERATE–HIGH >> MODERATE >> Naturally Uncommon). We envisage that as for threatened species, all listed habitat/community types (i.e. either significantly reduced or naturally uncommon) will be significant.

We offer this as a draft model requiring wide consultation rather than as a definitive framework – for example, the classification below differs from the more detailed classification applied to Southland by Harding (1999). We suggest that a refined framework be developed at an appropriate scale, building on other such classifications that have been developed.

Table 1 Draft list of the most naturally uncommon and significantly reduced terrestrial habitat/community types in New Zealand (excluding wetlands and coastal habitat/community types). Note: this list is not intended to be definitive; it will require refinement and development. Question marks denote uncertainty.

Habitat/community type and category	Significantly reduced (Threat category)	Naturally uncommon
Alpine		
Fellfield		YES
Flush and bog		?
Snowbank		?
Forest or shrubland		
Upland conifer		YES
Alluvial floodplain	HIGH	
Alluvial terrace	MODERATE-HIGH	
Kauri	MODERATE-HIGH	
Dryland	HIGH	
Coastal	HIGH	
Swamp	?	
Lowland hill country	MODERATE	
Volcanic	?	
Wet/dry and frosty hollow and margin	MODERATE-HIGH?	YES
Inland non-forest (excluding wetland)		
Cliff and talus	HIGH	YES
Braided riverbed, stony river terrace, and fan	MODERATE-HIGH	YES
Seral shrubland/scrub (include orchid habitat)	MODERATE-HIGH	YES
Saline	HIGH	YES
Basin and plateau floor/maritime grassland/shrubland ablation hollow	HIGH	YES
Thermal	HIGH	YES

Table 2 Draft list of most naturally uncommon and significantly reduced freshwater habitat/community types in New Zealand. Note: this list is not intended to be definitive; it will require refinement and development. Question marks denote uncertainty.

Habitat/community type and category	Significantly reduced (Threat category)	Naturally uncommon
Wetlands		
Palustrine wetlands	HIGH	
Ephemeral wetlands (including ablation hollows, kettleholes)	?	
Wetland margins	?	
Lakes		
Dune lakes	MODERATE-HIGH	YES
Volcanic lakes	MODERATE-HIGH	YES
Dystrophic (peat) lakes	HIGH	YES
Deepwater lakes with bryophyte communities		YES
Karst lakes (surface)	?	YES
Riverine lakes and oxbows	HIGH	
Lakes with marginal charophyte/turf communities	MODERATE-HIGH or MODERATE	YES
Lakes with intact indigenous biota	HIGH	
Rivers		
Low-gradient floodplain streams with floodplain connectors	HIGH	
Braided river – aquifer systems and springs	MODERATE-HIGH	
Anastomising rivers	HIGH	YES
Streams/reaches with intact indigenous biota	HIGH	
Intact mountain headwaters to sea rivers	HIGH	
Groundwater and springs		
Cold freshwater springs and seepages	MODERATE-HIGH	YES
Geothermal springs	HIGH	YES
Gravel aquifers	MODERATE-HIGH	YES
Subterranean karst lakes, rivers and aquifers		YES

We recommend lists such as these should be replaced (in whole or part) with objective, quantitative classifications of habitat/community types in the future. For example:

- The Waters of National Importance (WONI) classification (draft due for release in June 2004) used an objective quantitative methodology to identify the 5% of New Zealand rivers that are most significant for the maintenance of the full range of indigenous aquatic biodiversity. WONI appears to offer an appropriate, quantitative and explicit system to replace the subjective classification and significance assessment for river habitat/community types in Table 2.
- A map of the predicted potential natural vegetation of New Zealand (Leathwick et al. in press) may offer an appropriate replacement for the forest habitat/ community types suggested in Table 2. The percentage of each of 20 potential forest types remaining can be estimated quantitatively, and used to explicitly assess threat category (Table 3). Forest (irrespective of present composition) growing within the zone of any significantly reduced or naturally uncommon potential forest type would be significant.

Table 3 List of 20 national potential forest types from Leathwick et al. (in press). Quantitative estimates are given for current land area and the historical area of forest within each type. We suggest a translation into explicit threat categories. Threat category criteria: <5% remaining = HIGH, 5–10% remaining = MODERATE-HIGH, 10–20% remaining = MODERATE. Question marks denote a datum close to the threshold for significance. Naturally uncommon criterion: Historical area <5000 km^2. Note: this translation into a threat classification is not intended to be definitive. It will require refinement and development.

No.	Potential forest type	Data from potential vegetation map (Leathwick et al. in press)			Suggested threat classification	
		Current (km^2)	Historical (km^2)	Percent remaining	Significantly reduced (Threat category)	Naturally uncommon
1	Kauri/taraire–kohekohe–tawa	4008	15100	26.5		
2	Rimu/tawa–kāmahi	8992	46653	19.3	MODERATE	
3	Kahikatea–pukatea–tawa	401	19119	2.1	HIGH	
4	Mataī–kahikatea–tōtara	51	14113	0.4	HIGH	
5	Kahikatea–mataī/tawa–tōtara	117	5028	2.3	HIGH	
6	Mataī–tōtara–kahikatea–rimu/broadleaf–fuchsia	449	9074	4.9	HIGH	
7	Hall's tōtara/broadleaf	444	11823	3.8	HIGH	
8	Hall's tōtara/silver beech–kāmahi–southern rātā	3032	3872	78.3		YES
9	Hall's tōtara–miro–rimu/kāmahi–silver beech–southern rātā	3755	4212	89.2		YES
10	Hall's tōtara–miro/kāmahi–southern rātā–broadleaf	1565	1769	88.5		YES
11	Kahikatea–tōtara	2	803	0.3	HIGH	YES
12	Rimu–miro/kāmahi–red beech–hard beech	10082	15721	64.1		
13	Rimu–miro/tawari–red beech–kāmahi–tawa	3691	5823	63.4		
14	Rimu–mataī–miro–tōtara/kāmahi	1738	8091	21.5	?	
15	Rimu–miro–tōtara/kāmahi	2908	7459	39.0		
16	Silver beech	10063	19223	52.4		
17	Red beech–silver beech	3319	4342	76.4		YES
18	Black/mountain beech–red beech	2071	3995	51.8		YES
19	Mountain beech	2051	11818	17.4	MODERATE	
20	Mataī–tōtara/black/mountain beech	253	5001	5.1	MODERATE-HIGH	

4.3.2 Distinctiveness

The notion of distinctiveness embodies "difference". Distinctiveness is sometimes referred to as "special features" in other systems of significance assessment.

New Zealand has many internationally distinctive plants and animals – families, genera and species that have evolved in isolation and occur nowhere else in the world. In mountainous regions of New Zealand, and particularly in the South Island (including the high country), many locally endemic plant and animal species have evolved from a small number of families and genera in the last 3–5 million years (i.e. the Pliocene and Pleistocene eras). This phenomenon (termed adaptive radiation) is thought to have been driven by:

- the development of new, steep, cold habitats (before the Pliocene, the New Zealand land mass had been low, flat and warm for tens of millions of years)
- the isolation of populations (either remnants or chance new-dispersers) by the periodic eastward advance and westward retreat of piedmont (sheet) glaciers led to the evolution of new species in isolation.

Thus, different mountain ranges in the high country support different species of native buttercups, daisies, weta, moths and so on. Although the species and subspecies in highly radiated genera and families are genetically quite similar, protecting those different forms is part of protecting the full range of biological diversity, and the future evolutionary potential of the fauna and flora. They are distinctive and therefore significant.

For assessing distinctiveness to meet high country biodiversity objectives, we define distinctiveness as an aspect of rarity, but with a frame of reference that is local (at the level of the ecological district or mountain range) rather than national. Distinctive natural features (species, communities, habitats, or ecosystems) are of value for maintaining the full range of indigenous biodiversity; not necessarily because they are nationally rare or threatened, but because they contribute to the maintenance of the full range of biological diversity *across its natural range* (Goal 3 of *The New Zealand Biodiversity Strategy*). An area of indigenous vegetation would be distinctive if it contained:

- a local or regionally endemic species
- a species that is regionally threatened (by the Molloy et al. 2002 criteria)
- a species at one of its known geographic distributional limits
- an unusual combination of commonplace attributes may make a feature distinctive, e.g.
    - species, communities, habitats or ecosystems that are rare or uncommon in an ecological district or on a mountain range, although they may be common elsewhere in New Zealand (e.g. mānuka on the Dunstan Mountains, bellbirds on the Pisa Range, a relict of bog pine – celery pine shrubland on terraces in Mackenzie Basin, small stands of mataī and kahikatea in the Lakes Ecological District)
    - a species that is commonplace in an ecological district but is found in an unusual situation or community (e.g. snow tussock on Blackstone Hill near the dry core of Central Otago).

The regional spatial framework required to assess distinctiveness currently provides no platform for repeatable quantitative assessment. Assessment will typically rely on authoritative expert information.

However, improvement is possible. For example, some Department of Conservation conservancies maintain lists of regionally threatened species that customise the national threat ranking criteria for the conservancy. The list used by Wellington Conservancy was drawn up in a meeting of local experts, who applied the criteria used in the national threat classification system to all plant taxa. This approach offers an explicit basis for identifying regionally threatened species by conservancy. Its wider use in conservancies dealing with the high country would improve the consistency of one aspect of the distinctiveness assessment.

4.4 Biodiversity Criterion 3. Sustainability requirements

We define significant inherent values to meet high country biodiversity objectives as features *requiring protection in order to sustain the full range of indigenous biodiversity across the landscape*. Protection requirements to sustain the complete spectrum of indigenous biodiversity are twofold. In addition to the protection of areas that represent biodiversity pattern (i.e. the "full range" of indigenous biodiversity, captured by representativeness and rarity/distinctiveness significance criteria), those areas that are necessary to maintain the ecological processes needed for the persistence of indigenous biodiversity must also be protected. Simply put:

Persistence = Pattern + Process

The ecological processes that affect a natural feature (be it a species, community, habitat, or ecosystem) inevitably extend beyond its obvious physical boundaries. For example, a patch of shrubland, a rock outcrop supporting native lizards, a river, and a wetland all depend upon resources and processes that lie beyond the physical boundaries of the features themselves. Processes that need to be considered are both short term (e.g. pollination, dispersal, migration, predation/herbivory, hydrology) and long term (evolution, migration with climate change).

So far, we have suggested two criteria for the identification of significant features contributing to biodiversity **pattern**:

1. Representativeness and vulnerability, and
2. Rarity or distinctiveness

However, persistence of these significant features over time depends on the maintenance of the ecological **processes** they require. Therefore, the protection of areas beyond the obvious physical boundaries of these features will often be needed. These additional areas will also be significant, being of such importance to require *protection in order to sustain the full range of indigenous biodiversity across the landscape*. This is consistent with the recognition in the New Zealand biodiversity strategy that:

> There is a need for greater recognition and action to restore fragmented, degraded or scarce natural habitat, halt declining ecological condition, restore essential ecosystem functions, and extend the area of particular habitat types…
> (New Zealand Biodiversity Strategy p. 38)

Sustainability requirements will generally be associated with features that are recognised as significant by one of the two pattern criteria (Criterion 1 or Criterion 2). For example:

- Scenario 1: a small area in a poorly represented and vulnerable environment (significant by Criterion 1) requires a buffer zone for sustainability.
  Assessment: The whole area (the indigenous portion of the environment plus the buffer zone) is significant.
- Scenario 2: An acutely threatened species (significant by Criterion 2) occurs in several small habitat patches. The survival of the species requires male and juvenile individuals' dispersal between populations in different habitat patches. Areas of shrubland recovering from fire in the vicinity will provide additional

habitat in the future, and these will be needed to secure the survival of the species by mitigating against inbreeding depression.

Assessment: The whole area (the habitat patches currently occupied, the land between those patches and areas of potential habitat that are not currently occupied) is therefore significant.

It is important to note that areas significant for biodiversity sustainability requirements may not be themselves support indigenous species. They may not necessarily be on the same property, nor directly adjacent to the natural feature identified as significant by the above criteria.

Current knowledge is inadequate to define the spatial requirements needed to sustain all biota and communities. However, empirical research suggests that the following principles (4.4.1 to 4.4.4) generally apply to the assessment of spatial requirements for the persistence of indigenous biodiversity, and should be assessed for each feature that is recognised as significant by one of the two pattern criteria.

4.4.1 Size, shape, buffers and island biogeography theory

Traditionally, island biogeography theory (McArthur & Wilson 1967) has been one of the major influences on reserve planning. It was typically applied to determining adequate size, shape and distance from sources for the maintenance of biodiversity (although these criteria were seldom quantitative). In general, island biogeography and associated ecological theories predict that larger areas, and those of more compact shape, will have greater life-supporting capacity or carrying capacity (Harrison & Bruna 1999). This is because larger areas hold, and may sustain, greater diversity of species (due to biological area effects, such as the loss of large-bodied or top predator species requiring large areas of habitat), and because large compact areas are less influenced by physical (e.g. wind) and biological edge effects (e.g. penetration of edge or open-dwelling nest predators or parasites) than small, non-compact ones. The general rule derived from these theoretical principles is "the larger and more connected the better".

It follows that for small and isolated features and populations to persist *in situ* over time, areas around those features may also require protection, e.g. to prevent extinctions as a result of physical edge effects and/or and to allow for the indigenous vegetation or population to expand to a viable state in the future. For example:

- The persistence of a small area of indigenous vegetation in a poorly represented and vulnerable environment may require the indigenous community to recolonise adjacent areas that would not be significant in their own right
- The long-term viability of an isolated population of a rare or distinctive species may require areas of surrounding habitat that would not be significant in their own right to be protected from clearance for future colonisation

These surrounding areas would therefore be significant.

Buffers are zones around either large or small core areas of ecological value that help to maintain their values over time. They do this largely by increasing the effective size or effective shape of the feature, thereby reducing biological area effects and physical or biological edge effects (e.g. they may reduce weed invasion or nutrient runoff from adjacent areas).

Areas that provide buffers to either large or small core areas of ecological value will therefore be significant for sustainability requirements. Buffers may be largely indigenous in character, or they may be exotic, e.g. riparian pasture from which stock is removed; an exotic plantation surrounding a forest or shrubland patch that buffers it against wind. Buffer areas may be very large when protective management over considerable areas will be needed for the persistence of indigenous biodiversity. For example, it may be necessary to eradicate distant upwind seed sources of pines (e.g. in the Mackenzie Basin) since their invasion into downwind ecosystems may cause local extinctions, reduce indigenous species richness, and prevent or slow regeneration and succession processes. For the conservation of rare lizards, rabbit control may be needed across large areas, since rabbit numbers are the principle driver of predators such as ferrets and cats, which have extensive home ranges and take native lizards as by-catch.

This interpretation of size and shape considerations differs from that used in PNAP significance criteria, in which areas that were small and non-compact were ranked as less significant than those larger ones. This probably reflects the requirement of the PNAP to rank and recommend “best” individual sites as RAPs. However, modern understanding is that small, non-compact areas can make vital contributions to the maintenance of indigenous genetic and species diversity. For example, plots in smaller forest remnants in coastal Otago have consistently higher species diversity than larger fragments (Ohlemuller 2003). Individual shrubs in paddocks adjacent to forest tracts in Southland support a greater diversity and biomass of invertebrates than shrubs within adjacent forest fragments (Walker et al. 2003b). This effect has been called the “crowding effect” (Lovejoy et al. 1986; Debinski & Holt 2000). This research indicates that very small fragments, and even single isolated specimens of indigenous trees or shrubs, can act as temporary reservoirs of indigenous biodiversity in modified landscapes. Furthermore, collectively small, discontinuous habitat patches may also sustain mobile and itinerant species, e.g. scattered small wetlands used by waterbirds. Therefore, small, non-compact areas of indigenous vegetation may be significant; in other words, they will require protection to sustain the full range of indigenous biodiversity across the landscape.

4.4.2 Metapopulation dynamics and metacommunity models

Island biogeography and associated early landscape ecological theory informed reserve planners principally about the desirable size and shape properties of individual areas or habitat patches. Research now demonstrates that, to maintain biodiversity over time (decades to centuries), multiple connections *between* habitat patches are also of critical importance. In particular, metacommunity dynamics (a subset of landscape ecology) considers species interactions between patches of indigenous habitat, and within the more modified matrix between habitat patches.

Metapopulation theory (e.g. Hanski & Simberloff 1997) recognises that populations do not exist in isolation, but as metapopulations (networks of local populations of a species linked by dispersal). A species that exists as a metapopulation will become extinct when the rate of extinction of local populations exceeds the rate of migration and colonisation. Most contemporary studies have progressed beyond single-species models. Instead, they now study interactions between species and how the spatial configuration of habitat patches affects multiple species persistence (“metacommunity dynamics”, e.g. van Nouhuys & Hanski 2002).

Metapopulation and metacommunity theories highlight the importance of *not* considering sites or indigenous habitat patches in isolation. It recognises that confining species to single small reserves (e.g. through vegetation clearance at other sites) is likely to produce population bottlenecks. Population bottlenecks increase the risk of local extinction through a catastrophic event (by eliminating sources of recolonisation) and will tend to increase the likelihood of inbreeding depression in both plants (Young et al. 1996) and animals (e.g. Cunningham & Moritz 1998; Hedrick & Kalinowski 2000; Kalinowski et al. 2000; Cassinello et al. 2001).

Research on animal populations suggests that lower immunity (through reduced histocompatibility complex variation) may be a principal driver of the many symptoms of inbreeding depression. Symptoms of inbreeding depression are therefore an effect of population decline, and a positive feedback contributor to decline. There is emerging evidence of inbreeding depression leading to increased hatching failure in New Zealand indigenous bird species recovering from population bottlenecks (Briskie & Mackintosh 2004). Heightened susceptibility to parasites in the now isolated grand skink population at Macraes in Otago may be attributable to inbreeding depression (Reardon & Norbury 2004) as suggested for small, inbred animal populations elsewhere (e.g. parasites of gazelle; Cassinello et al. 2001).

Protection of metapopulations therefore requires:

- Multiple populations and communities

Multiple populations retained across a species' natural range will spread the risk of extinction through single chance events, and reduce the likelihood of inbreeding decline. For example, all remaining remnant stands of forest and shrubland in an area may be needed if a present distinctive population of an indigenous bird (e.g. bellbirds on the Pisa Range) is to be maintained in the future (cf. North 2002; North et al. 2003).

- Linkages

For metapopulations to be maintained, links between habitat areas are needed to allow the dispersal and exchange of individuals between geographically separate populations across the landscape. Complete corridors and even discontinuous patches of habitat between larger, distant remnant patches may serve this purpose, providing either continuous routes or stepping-stones for migration, dispersal and the exchange of genetic material between sites. For example, research indicates minimum areas and configurations of suitable habitat are required to maintain populations of bellbirds in urban and peri-urban areas (North 2002; North et al. 2003).

- Sympathetic management of the matrix

Metapopulation and metacommunity theories also direct attention towards the importance of sympathetic management of the matrix (i.e. the areas between habitat patches and natural areas) for maintaining biodiversity (Wiens 1994). For example, areas between sites where threatened species are known to occur may require protection from burning and grazing, and application of intensive predator or weed control measures. Cultivation of tussock grassland between and around rocks tors in Otago is associated with reduced richness and cover of indigenous plants on rocks. This degrades lizard habitat by reducing fruit and invertebrate food sources, removing plant cover that protects lizards from predators, and constraining their ability to travel and disperse successfully between rocks. High levels of rabbit control will also be needed to maintain low cat and ferret numbers.

- Potential habitat

Maintaining species metapopulations also requires protection of unoccupied areas of suitable habitat that can be occupied in the future. For example, bracken- or kānuka-dominated communities regenerating after fire will in the future provide forest and shrubland habitat that will be needed to sustain regionally rare (i.e. distinctive) kererū, tūī and bellbird populations.

These metacommunity considerations are critical for the maintenance of indigenous biodiversity. However, they have yet to become well-established principles guiding land-allocation planning in New Zealand.

4.4.3 Landscape-scale natural processes

For some species, communities, habitats, ecosystems and requirements for sustainability need to be considered at the landscape scale. The following two examples illustrate this.

Example 1: Freshwater ecosystems (rivers, streams, wetlands, and lakes)

The biodiversity of aquatic communities (streams, rivers, lakes and wetlands) can be reduced or destroyed by land uses that alter flows and increase nutrient or sediment input in surrounding or upstream areas (e.g. Huryn et al. 2004). Extractive activities (e.g. irrigation or hydroelectric offtake, forestry plantations) will reduce or alter streamflow patterns. Stock grazing, trampling, defecation and death (i.e. decaying carcasses) lead to disturbance and nutrient enrichment of turf communities of wetlands.

Removal of riparian vegetation by grazing and burning has numerous inter-related local and downstream effects. It reduces shading, which buffers stream temperature and limits slime build up, and it reduces cover for fish. At the same time it also reduces nutrient capture and filtering, and lowers inputs of allochthanous organic matter that supports the in-stream decomposer community (complex/diverse recycling instream food webs rather than simple algal autochthanous ones). Simultaneously, riparian vegetation clearance reduces riverbank stability, leading to increased streambank collapse in low-flow periods. This reduces the quality of instream substrates for benthic invertebrates and fish by clogging gravels with silt. Sedimentation and eutrophication will also result from upstream catchment development activities such as cultivation, subdivision or roading.

Catchments of features that are significant for freshwater/aquatic biodiversity will therefore be significant since they require protection from antagonistic land uses to sustain the full range of indigenous biodiversity across the landscape.

Example 2: Successional communities and species dependent on landscape-scale natural disturbance

The persistence of certain successional species and communities of the high country may depend on maintaining indigenous vegetation across sufficiently large areas to allow for the colonisation of areas subject to infrequent large-scale natural disturbances.

For example, threatened, relatively fast-growing small tree species such as Hector's tree daisy (*Olearia hectorii*) and/or the subalpine *Pittosporum patulum* appear to regenerate infrequently in response to canopy gaps created by occasional catastrophic floods and/or landslides. They complete their life cycles before they are competitively suppressed by taller trees over timescales of decades or centuries. Clearly, protection of small discrete areas containing these small trees will not provide for their persistence in the long term.

Alluvial ecosystems also require landscape-scale processes for their maintenance. For example, in a braided river, a suite of small native herbs colonise the youngest floodplain gravels, and are succeeded by taller indigenous grasses and shrubs after a period of stability (again, from decades to centuries). Backswamp and oxbow wetlands develop as meanders and braids migrate downstream. Maintaining the biodiversity of an alluvial ecosystem depends upon maintaining natural flood disturbances that create this wide range of successional states.

4.4.4 Climate change

Climate change is inevitable with or without global warming, but it is likely that we are entering a period of rapid climate change as a result of human-induced global warming. Climate change causes the climatic components of environments to move across the landscape – in the case of human-induced global warming, there is likely to be a net upslope migration of temperature zones, and a shift in orographic rainfall patterns.

To persist in the changing landscape, species must be able to follow their environments. For this, they will require appropriate upslope habitat adjoining or in close proximity, and mechanisms for dispersal (e.g. birds in the case of bird-dispersed trees, lizards in the case of lizard-dispersed fruiting shrubs). It is therefore important to protect sequences of indigenous vegetation along representative major climatic gradients. Because of orographic differences across mountain ranges and valley floors, sequences on both sides of each range would be needed to cover the full range of environments.

We suggest that at the “whole of high country scale”, minimum targets for climate change would be to protect a complete catchment from valley floor to ridge crest on each side of each major mountain range. This is consistent with the approach and spatial targets recently proposed in systematic conservation planning for the Cape Floristic Region in South Africa (Pressey et al. 2003). Ideally, the protected catchments should be connected across the crest of the range. However, complete catchments on each side of the main ridge would be a compromise where connection was not possible due to the configuration of reviewable properties.

For efficient design of altitudinal corridors to provide migration routes for climate change, we suggest that planning for this spatial requirement should be undertaken once information on the full range of significant inherent values on a property are known, and placed in the context of other significant inherent values known within the region (ecological district or mountain range). For example, climate change spatial requirements for several individual significant inherent values (e.g. an area of vulnerable or underrepresented indigenous environment, a nationally threatened species, and distinctive features such as a locally endemic fish) could be provided for by protecting a catchment connecting to an area of indigenous vegetation on a range top that is significant for its contribution to a network of high country parks. Other types of significant inherent value (e.g. cultural/historical, recreational) could also be provided for.

4.5 Applying the criteria to determine biodiversity significance

Figure 2 provides an illustration of the assessment of biodiversity significance (i.e. the suggested application of our three criteria in a decision-making process).

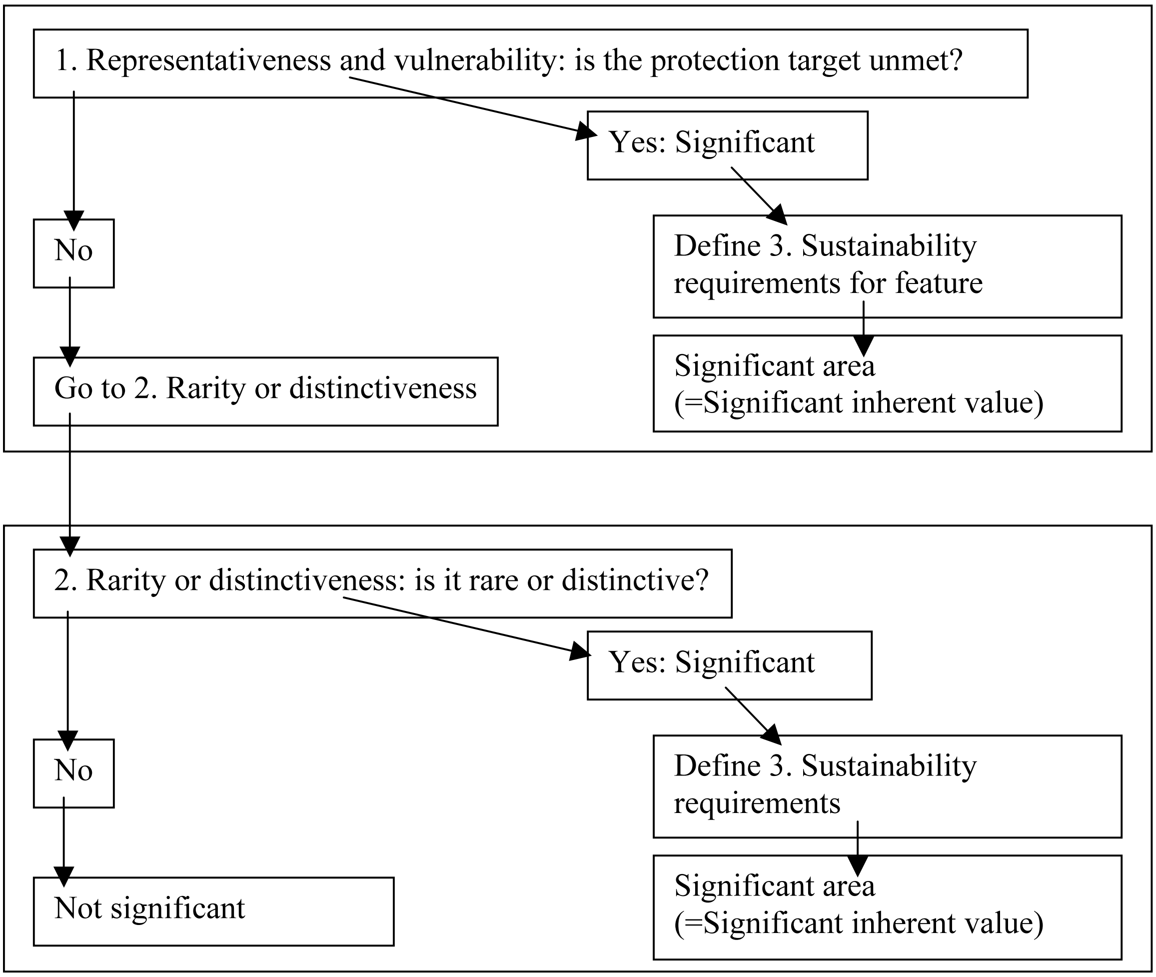

Fig. 2 Decision-making process: applying the criteria to determine biodiversity significance.

4.6 Framework for application of the biodiversity significance criteria

The application of our recommended criteria would depend upon explicit targets. We suggest that representativeness targets could be based on the method described in Walker et al. (2004a). Appropriate targets for 2. (Rarity or distinctiveness) and 3. (Sustainability requirements) would be the protection of all features recognised as significant, since this, by our definition, will be required to halt the decline of indigenous biodiversity.

Recommended conservation performance measures are based on these targets. Those suggested to assess the changes made to overall representativeness and vulnerability are described in Walker et al. (2004a). Performance measures for 2. Rarity or distinctiveness could be the percentage of significant inherent values recognised that are also protected.
We note that in contrast to our quantitative measures for representativeness and vulnerability and for rare species, distinctiveness and the definition of sustainability requirements would depend on subjective expert judgement.

Our brief was to describe how the criteria we suggest might be applied within the high country at three levels: (1) all pastoral lease lands and associated high country land; (2) catchment or mountain range; (3) individual property. We list below some of the iterative steps that might be involved in the application of our biodiversity criteria at three spatial scales. We envisage parallel planning could take place for other types of significant inherent value (e.g. landscape, recreation/access, historical) at each scale.

4.6.1 Whole of high country

Targets for representativeness and sustainability in the face of climate change would be best set at the scale of the whole of the high country. The process at this scale could include the following steps:

1. Assess representativeness and vulnerability using LENZ Level IV, High Country vegetation classes, and Public Conservation Land datasets
2. Set targets for representativeness based on Walker et al. (2004a)

4.6.2 Catchment or mountain range

A smaller, regional scale is appropriate to set targets to provide for landscape-scale sustainability requirements (C: Landscape-scale natural processes and D: Climate Change). Either ecological districts, catchments or mountain ranges would be appropriate planning units.

Steps of the process at this scale could include:

1. Collate existing information for the ecological district, catchment or mountain range, recognising that it will contain many gaps. Existing information will include existing property information, PNAP information (including RAPs), and threatened species locations.
2. Identify those known features that meet criteria for biodiversity significance 1. & 2. Assess and map their sustainability requirements (buffers, metacommunity considerations, landscape-scale process requirements).
3. Explicitly identify gaps. These may be geographic (wholly unsurveyed areas or properties) or biotic (e.g. vegetation data exist, but there is no information on invertebrates, birds or lizards).

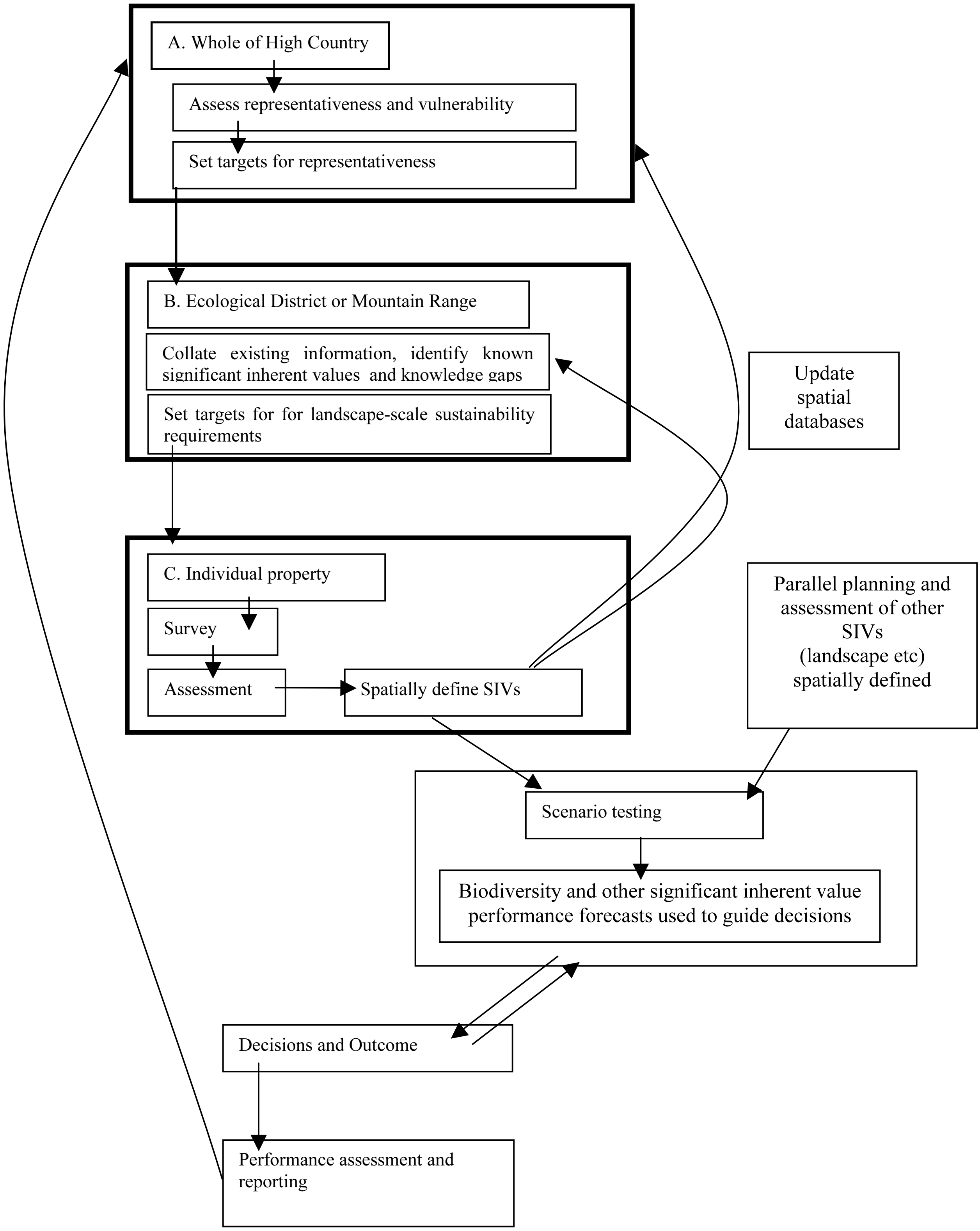

Fig. 3 Three-scale framework (bold boxes) for biodiversity significance assessment.

4.6.3 Individual property

Field survey

1. Determine the location of significant vegetation
2. Identify and locate rare species, rare habitat/community types and distinctive features.

Assessment

1. Determine and define the areas required to maintain ecological processes to sustain those features (sustainability requirements)
2. Map and enumerate significant inherent values.

Feedback to databases and planning

This iterative step is necessary to update the relevant databases using survey and assessment information

A. Whole of high country – refine targets for representativeness and estimates of vulnerability using indigenous vegetation information from survey
B. Catchment or mountain range – update regional overview (i.e. Section 4.6.2. steps 2 & 3).

Scenario testing and performance assessment

At this stage, there could be land allocation scenarios developed to assess potential contributions to biodiversity targets for the high country, which could be used to guide prioritisation. This could also be used to monitor progress towards targets as land allocation decisions are made, and to review strategies and guidelines.

5. Discussion

5.1 Environments and vegetation that are significant inherent values

We see several reasons that environments and vegetation may be significant inherent values [cf CPLA S.24(b)(ii)]. We comment on only three of these in this report.

Environments and vegetation may be significant inherent values for their natural character, or for the ecosystem services they provide to society. While providing other benefits, areas that are natural character or ecosystem services significant inherent values will also contribute to the maintenance of indigenous biodiversity.

The above two categories of significant inherent values are not discussed in depth in this report. Instead, our focus is on defining the biodiversity subset of significant inherent values and suggesting appropriate criteria for their identification.

We see two of Government's complementary high country objectives that are consistent with this subset of significant inherent values, i.e.:

1. High country objective g.: Ensure that conservation outcomes for the high country are consistent with the New Zealand biodiversity strategy (NZBS),

   and

2. High country *reserves* for the purposes of biodiversity protection within high country objective h.: Progressively establish a network of high country parks and reserves.

We suggest that an appropriate definition of "biodiversity significant inherent values" would be *those features requiring protection in order to sustain the full range of indigenous biodiversity across the landscape*. The purpose of the assessment of biodiversity significant inherent values is to identify those areas requiring additional protection because there is evidence that associated biodiversity is either significantly reduced or in decline.

5.2 Significance as a state

We suggest criteria that classify features as significant inherent values or not. In this, our criteria are similar to those suggested for application under the RMA, which provides for the protection of areas of significant indigenous vegetation and significant habitats of indigenous fauna as a matter of national importance.

Halting the decline of indigenous biodiversity (Goal 3 of *The New Zealand Biodiversity Strategy*) will require the maintenance of the full range of indigenous biodiversity that currently remains. Since all of the indigenous features meeting our criteria for biodiversity significance are those that are likely to be lost over time without protection (both of the features themselves and the areas required to sustain them), we might expect that failure to protect a significant area would not halt the decline, and would, in time, reduce the proportion of the full range remaining. It follows that significance (at least, by the definition we use in this report) is not a continuum but a state – an area is either significant, or it is not.

5.3 Prioritisation

We recommend that assessment of significance using binary criteria should be a separate exercise from the prioritisation of significant inherent values for protection.

This is necessary because the factors that make a feature a significant inherent value are not necessarily the same as those that would rank significant inherent values for protection priority. For example, the cost or achievability of protection in no way influences the significance or otherwise of a value for protection, whereas, clearly, these are matters that will be taken into account when prioritising significant inherent values for protection.

This approach is already used in threatened species management. All species that are currently recognised as being under threat of extinction are listed using the New Zealand threat classification system (Molloy et al. 2002). It is not feasible to meet the recovery requirements of all (~2000) of these species. Therefore, there is a subset list of threatened species that are considered priorities for recovery investment by the Department of Conservation. The prioritisation exercise is separated from the assessment of whether or not a species is threatened, and its assignment to a threat category. Prioritisation uses different criteria, which include imminence of threat, but also 'iconic' status, cost and achievability (including whether there is sufficient information to prescribe recovery action). Because funding is limited, only a fraction of the priority subset list of threatened species actually receive effective recovery investment. The benefits of this tiered approach are: consistency of identification (irrespective of cost, feasibility etc), full scoping of the protection need, transparency of prioritisation, and objective assessment and reporting of progress towards overarching objectives (i.e. improved security of threatened species).

We note that prioritisation is complex, and the science to support it is in early development (e.g. Stephens et al. 2002). For example, we do not as yet have capability to compare different kinds of contribution to the different components of the biodiversity goal (*halting the decline* across *the full range*). While we can measure some properties (e.g. change in representativeness or vulnerability) we *cannot* yet determine the trade-off between, for example, a change in representativeness and halting decline by some other means (e.g. improving biodiversity condition by reducing predation or removing grazing). Nor is it possible to directly compare contributions to different biodiversity targets (in other words, there is no basis to compare the contribution of improved security of a particular threatened species *vs* improved environment vulnerability *vs* protection of a distinctive feature). Because we cannot compare different types of contribution, a cost–benefit approach to prioritisation is not possible. Therefore, we would not be able to offer a comprehensive basis for prioritisation at this stage. However, we anticipate international research over the next decade will address some of these issues.

Notwithstanding that ecological science cannot yet provide comprehensive assistance, if all significant inherent values cannot be protected, then there will need to be some prioritisation. *Within* biodiversity significant inherent values, we suggest that prioritisation might be guided by the maximisation of specific biodiversity performance measures. Thus, the aims of prioritisation within biodiversity significant inherent values might be to maximise representativeness and rare feature protection, and to minimise vulnerability (the feasibility of measuring and forecasting changes in representativeness and vulnerability in an operational setting is demonstrated in our earlier report: Walker et al. 2004). As a general principle, biodiversity performance measures would be optimised by prioritisation of those significant features that most urgently require protection.

In practice, prioritisation of significant inherent values would entail the protection of the optimal protection of a combination of *all* categories of significant inherent values (i.e. not just biodiversity significant inherent values, and not only those different value sets in which environments and vegetation are a major component). This would need to be determined by comparing (and attempting to maximise) performance measures for the different significant inherent values for a range of scenarios. However, advice on performance measures for other subsets of significant inherent values, and prioritisation across these subsets, is beyond the scope of this report.

5.4 Advances in conservation science and biodiversity significance criteria

Advances in conservation science since the development of significance assessment criteria for the PNAP in the 1980s have considerable bearing on the selection and design of significance criteria for biodiversity significant inherent values. In particular, the last two decades has seen the development (largely overseas) of systematic conservation planning, the classification of land environments (Land Environments of New Zealand), revised classifications of New Zealand's threatened species, and the emergence of metapopulation and metacommunity dynamics and landscape ecology as major research themes.

Key advances for significance assessment from systematic conservation planning include the use of quantitative targets and performance measures to direct conservation effort, and the quantitative estimation of the representativeness and vulnerability of terrestrial land environments. These advances are discussed in greater detail in Walker et al. (2004a).

Systematic conservation planning has also informed ecosystem classification and prioritisation processes that are relevant to significance assessment. For example, the draft WONI (Waters of National Importance) classification draws on systematic conservation planning concepts to identify priority-rivers that are significant for aquatic biodiversity. This classification will be able to be used to recognise those catchments that are significant for biodiversity in the future.

The development of the New Zealand threat classification system (Molloy et al. 2002) provides a consistent, authoritative basis to classify species on the basis of extinction threat. We incorporate this system in our biodiversity significance Criterion 2: Rarity, distinctiveness and special features.

Significance assessment is contentious because of competing interest and land-use demands. The procedure for significance assessment therefore needs to be as rigorous as possible (i.e. objective, explicit, and repeatable). In developing this framework, we have taken the opportunity to draw on the advances above to recommend explicit, quantitative criteria as far as is currently possible, and to link these to similarly quantitative conservation performance measures. However, science is currently inadequate to support the development of quantitative criteria for distinctiveness and sustainability requirements.

Metapopulation and metacommunity dynamics and landscape ecology have brought about a key shift in the focus of conservation effort that is extremely relevant for the development of modern biodiversity significance criteria. The change in emphasis has been from "stamp collecting” – i.e. from providing for the survival and preservation of at least one representative “sample” or “example” – to providing for the maintenance and restoration of healthy functioning states (ecosystems) or viable populations (species) across their natural range, following recognition that the static preservation of one or a few representative samples or examples of present states will be inadequate for the survival of many ecosystems and species into the future. The focus has therefore shifted to the requirements to sustain the essential processes that maintain the full range of ecosystems and species. In other words, the aim is now to retain a network of indigenous communities (with links and corridors) that is sufficient to maintain (and restore) native biodiversity throughout the landscape.

This understanding requires modern significance criteria to direct attention away from individual sites or areas. Instead, these criteria will need to take into full account the spatial context and configuration of features, and the mobility requirements of elements of indigenous biodiversity. The importance of some spatial requirements (e.g. buffers and linkages) have traditionally been considered in the assessment of significance (e.g. Standards 6 and 7 of Appendix 5 of the Department of Conservation *Tenure Review Manual*). However, we describe four aspects of sustainability requirements (Criterion 3) that are designed to ensure spatial requirements for persistence are fully considered, and recommend that spatial requirements for persistence are integral to the spatial definition of biodiversity significant inherent values.

5.5 Criteria not suggested for assessment of biodiversity significance

Criteria that were used in the PNAP to give priority for protection to the most natural or intact features are not appropriate in biodiversity significance criteria. It has been recognised for at least three decades (e.g. Sullivan & Shaffer 1975) that representativeness is less likely to be achieved when priority for protection is accorded to the least modified areas (Pressey 1994; Pressey & Taffs 2001a, b). This is because realistic opportunities for protection are narrowed down over time to a diminishing set of features that are safest from clearance or pest invasion pressures (Pressey & Taffs 2001a, b; Rouget et al. 2003a, b). Achieving representativeness (i.e. protecting representatives of the full range of biological diversity) is therefore a retreating option. If representativeness goals are to be met, international research indicates that priority and urgency should be accorded to the protection of the most rapidly retreating opportunities, i.e. those natural features (ecosystems, communities, species) for which there is the greatest likelihood of imminent loss or degradation under current and/or future land uses (World Resources Institute 1992; Pressey 1994; Pressey & Taffs 2001b). Prioritising the protection of those environments that are under little threat has real biodiversity costs, in that opportunities for better overall biodiversity outcomes will be missed, and there will be an increase in vulnerability (i.e. the likelihood and/or imminence of biodiversity loss).

The central purpose of the biodiversity significance criteria we propose is to identify those features under the most imminent threat of loss or degradation, i.e. the most urgent priorities for protection if the full range of biodiversity is to be retained. It follows that these features will seldom be either predominantly natural in character, or exhibit symptoms that point to excellent prospects of long-term viability! Specifically, for these reasons, PNAP criteria “naturalness” and “long-term ecological viability” are not relevant for the assessment of biodiversity significance. However, we do suggest that aspects of both naturalness (indigenous dominance) and viability (self regeneration and potential species occupancy) are relevant for identifying environments and vegetation that are natural character significant inherent values.

The PNAP criterion "diversity and pattern" is also omitted as a biodiversity significance criterion . This criterion was usually used to recognise the variability that occurs within an area, and to rank more diverse areas as more significant. However, while some communities are naturally diverse and others are not, both are important for maintaining the full range of indigenous biodiversity. We therefore agree with Norton & Roper-Lindsay (1999) who also conclude that this criterion is not appropriate for significance assessment.

6. Conclusions and Recommendations

- There have been some significant shifts in emphasis in conservation goals through the latter part of the 20th century. Criteria used to assess significant inherent values need to be updated to reflect these changes.

- Revised criteria emphasise that simple static preservation of one or more samples is often inadequate for persistence, and that maintaining processes required to sustain ecosystems and species in healthy functioning states is a primary requirement.

- Persistence of biodiversity over time requires protection of both biodiversity pattern and the ecological processes that sustain this pattern.

- Modern criteria also recognise that a primary focus on relatively pristine areas will not fulfill the goal of maintaining a full range of indigenous biodiversity. For this to be achieved, priority and urgency should be accorded to protection of features with greatest likelihood of imminent loss or degradation under current and/or future land uses.

- Two types of significance criteria (ranking and binary) have been used in New Zealand. We suggests that binary criteria are consistent with the CPLA; i.e. a feature is assessed as either significant or not.

- Environments and vegetation may be significant inherent values for many different reasons. We comment on only three in this report: (1) natural character (2) ecosystem services, and (3) biodiversity. However, our primary focus is on the third category (biodiversity).

- We suggest two *ecological integrity* criteria for the assessment of environments and vegetation that are significant inherent values of natural character. These are (1) indigenous dominance, and (2) self-regeneration and potential species occupancy.

- Environments and vegetation may also be significant inherent values for the provision of ecosystem services. A full discussion of types and values of ecosystem services is beyond the scope of this report. We highlight water purification, water yield and flood mitigation as key ecosystem services provided by indigenous vegetation cover in the high country.

- Vegetation and environments may be considered significant inherent values for their contribution to maintaining the full range of indigenous biodiversity. Biodiversity significant inherent values require a different definition from natural character and ecosystem services significant inherent values, and therefore different significance criteria.

- We suggest that an appropriate definition of biodiversity significant inherent values is those features *requiring protection in order to sustain the full range of indigenous biodiversity across the landscape*.

- Three criteria are used to assess whether environments and vegetation are biodiversity significant inherent values by the above definition. The first two criteria are to recognise features of biodiversity pattern requiring protection. They are:
    1) Representativeness and vulnerability, and
    2) Rarity or distinctiveness

- A third criterion is used to assess the ecological processes that must be protected if those features are to persist over time. This criterion,
    3) Sustainability requirements,

  is applied to each of the significant biodiversity pattern features identified by Criterion 1 or 2. The total area (identified feature and sustainability requirements) is the significant inherent value.

- These biodiversity significance criteria identify only those natural features (ecosystems, communities, species) that are at greatest risk of loss or degradation under current and/or future land uses. The criteria are therefore conservative rather than precautionary. Features meeting the criteria are priorities for protection to meet the goal of halting the decline of indigenous biodiversity.

- Many areas contributing to the maintenance of the full range indigenous biodiversity across the landscape will not meet the above criteria for biodiversity significance. Because these less imminently threatened features will typically be less modified, we anticipate that they should meet criteria for significant inherent values of natural character and/or ecosystem services.

- Where possible, we recommend objective, quantitative assessment frameworks for determining biodiversity significance by these criteria. However, for some criteria, quantitative frameworks are not yet available, and assessment would therefore need to be based on the best available ecological knowledge.

- We suggest an explicit decision-making process that may be used in the assessment of biodiversity significance.

- We suggest a systematic application of the three biodiversity significance criteria within an explicit framework at three scales.

- We suggest that the assessment of significant inherent values using binary criteria be separated from their prioritisation for protection. The benefits of this are: consistency of identification, full scoping of the protection need, transparency of prioritisation, and the ability to objectively assessment and report progress towards the overarching objective.

- We advise that the prioritisation of biodiversity significant inherent values may be guided by the maximisation of biodiversity performance measures.

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Appendix 1 Forest & Bird Criteria for Significant Vegetation and Habitat

Criteria developed for the purpose of section 6(c) of the Resource Management Act 1991.

Any area meeting one or more of the following criteria will be considered a significant area of indigenous vegetation and a significant habitat for indigenous fauna:

1. Indigenous vegetation or habitat that has been specifically set aside by statute or covenant for protection and preservation.

2. Indigenous vegetation or habitat recommended for protection under the PNAP programme, or recommended in a report for protection by the Forest Heritage Fund or Nga Whenua Rahui committees, or in reports of a CRI, DOC, conservation board or authority, or national parks and reserves authority. This includes areas recommended for protection by organisations which preceded those above, such as Forest Service, DSIR, and National Parks and Reserves Board.

3. Indigenous vegetation or habitat that supports indigenous species that are uncommon, in decline, or threatened with extinction (rare, threatened, or endangered) within an ecological district, ecological region, or nationally.

4. Indigenous vegetation or habitat that is important in the maintenance and recovery of a species that is uncommon, in decline, or threatened within the ecological district, ecological region, e.g. provide linking corridor, size of habitat, altitudinal sequence, riparian shading or buffering.

5. Indigenous vegetation or habitat type that can restore depleted representative values or is underrepresented within the district, or an ecological district, or nationally.

6. Indigenous vegetation that contains associations of indigenous species that are rare, representative, or usually abundant within an ecological district or nationally.

7. Unusual indigenous vegetation or habitat being influenced by factors such as geothermal activity, historical cultural practices, altitude, water table, or soil type.

8. Wetland or aquatic habitat for indigenous vegetation or fauna.

9. Indigenous vegetation or habitat that protects a freshwater fishery in terms of section 6(a) and section 7(d) (h) of the RMA, or section 6(a)(b) and section 39 (4) (5) of the Conservation Act.

10. Indigenous vegetation significant for its size and habitat potential, being 40 ha or more.

11. Native forest, which is an area of woody indigenous vegetation containing naturally occurring tree species, which attain 30 cm at breast height at maturity, and is either:
    - over 1 ha, and with an average canopy height 6 m or taller
    - over 5 ha of any height.

12. Indigenous vegetation that contributes to a designated landscape feature such as a regional walkway, or a tourist scenic route, or a distinctive landscape of the region.

13. Indigenous vegetation identified in a regional or district plan as catchment protection vegetation protecting soil or water values, or which functions in hazard mitigation.