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Indicator M8: Change in area under intensive land use

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Indicator M9: Habitat and vegetation loss

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Overview

In 2010, the Technical Group of the Regional Council Biodiversity Forum worked with Landcare Research to develop the Regional Council Terrestrial Biodiversity Monitoring Framework.[1]

This framework is designed as part of 'a national, standardised, biodiversity monitoring programme, focusing on the assessment of biodiversity outcomes, to meet regional council statutory, planning and operational requirements for sustaining terrestrial indigenous biodiversity'

The terrestrial biodiversity monitoring framework adopts the same approach as the ecological integrity framework designed by Landcare Research for the Department of Conservation (DOC) and consists of three components: (i) indigenous dominance, (ii) species occupancy, and (iii) environmental representation.[2] To inform the framework, there are four broad areas: (i) state and condition, (ii) threats and pressures, (iii) effectiveness of policy and management, and (iv) community engagement.

A standardised monitoring framework ensures that data for each measure are consistent among regional councils, which allows for reliable State of Environment reporting. Furthermore, to enable national reporting across public and private land, it is also desirable that where possible, measures can be integrated with those from DOC'sBiodiversity Monitoring and Reporting System (DOC BMRS).[3] The monitoring framework covers most categories of essential biodiversity variables[4] recommended for reporting internationally, addressing species populations, species traits, community composition, and ecosystem structure adequately, but does not address genetic composition and only in part ecosystem function.

This report contains descriptions of 18 terrestrial biodiversity indicators developed within this framework by scientists who worked with regional council counterparts and representatives from individual regional councils. Each indicator is described in terms of its rationale, current efforts to evaluate the indicator, data requirements, a standardised method for implementation as a minimum requirement for each council, and a reporting template. Recommendations are made for data management for each indicator and, for some, research and development needed before the indicator can be implemented.

The terrestrial biodiversity indicators in this report are designed to enable reporting at a whole-region scale. Some of the indicators are also suitable for use at individual sites of interest within regions. Each indicator is described in terms of a minimum standard for all

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[1] Lee and Allen 2011. Recommended monitoring framework for regional councils assessing biodiversity outcomes in terrestrial ecosystems. Lincoln, Landcare Research.

[2] Lee et al. 2005. Biodiversity inventory and monitoring: a review of national and international systems and a proposed framework for future biodiversity monitoring by the Department of Conservation. Lincoln, Landcare Research.

[3] Allen et al. 2013. Designing an inventory and monitoring programme for the Department of Conservation's Natural Heritage Management System. Lincoln, Landcare Research.

[4] Pereira et al. 2013. Essential biodiversity variables. Science 339, 277–278.

councils. If implemented by all councils, each measure can then be aggregated to allow national-scale reporting (e.g., for State of Environment reports, or for international obligations such as reporting on achievement of Aichi Targets for the Convention on Biodiversity). Individual councils could add additional measurements to supplement the minimum standards recommended.

Three of the 18 terrestrial biodiversity indicators – Measures 1 ‘Land under indigenous vegetation’, 11 ‘Change in temperature and precipitation’, and 18 ‘Area and type of legal biodiversity protection’ – were implemented and reported on for all regional councils in June 2014. An attempt to implement and report two others at that time – Measures 19 ‘Contribution of initiatives to (i) species translocations and (ii) habitat restoration’ and 20 ‘Community contribution to weed and animal pest control and reductions’ – was unsuccessful because the data needed for these indicators was either not readily available or not collected in a consistent way, and investment will be needed to remedy these issues before they can be reported successfully.

7 Indicator M8: Change in area under intensive land use & Indicator M9: Habitat and vegetation loss

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7.1 Introduction

Additional research and development is necessary before indicators M8 (‘Change in area under intensive land use’) and M9 (‘Habitat and vegetation loss’) can be standardised and used by regional councils. This will include augmentation of LCDB data, the estimation of disturbance intensities for land-cover classes, and additional calibration/sampling for both monitoring and reporting.This report describes the recommended methods and next steps for M8 and M9 before monitoring can be implemented to collect and report the necessary data.

Appendix 7-1 provides information on procedures for the estimation of disturbance intensities for land cover classes drawing from past work (Overton et al. 2010; Rutledge et al. 2004; Walker et al. 2006).

Appendix 7-2 provides notes from a 29 January 2014 workshop between Landcare Research and regional council representatives where methodology and next steps were discussed. Representatives at the workshop concluded that definition of intensive land-use, land-cover classification errors and the accuracy for estimates of land cover change will need to be resolved as part of next steps for M8 and M9, including for implementation.

Lee and Allen (2011) define M8 as a pressure indicator, with the element LCDB (Land Cover Database) cover classes within an agreed definition of ‘intensive land use’, for example, areas actively managed to the general exclusion of terrestrial native biodiversity (i.e. crops, roads, etc.). Data is identified as ‘LCDB and re-runs, while maintaining historical compatibility of cover classes’. Lee and Allen (2011) define M9 as an impact indicator, with the element based on changes in area of land-cover classes and naturally rare ecosystems. Data is identified as ‘LCDB and reruns, augmented by regional aerial mapping for habitat loss.’ Indicator M9 can be seen as an evaluation of change in the indicator M1 (‘Land area under indigenous vegetation’). This means both M8 and M9 are fundamental biodiversity indicators since they report on the patterns and amounts of remaining indigenous biodiversity and the patterns and rates of loss (or change). It makes sense for M9 to also report on indigenous biodiversity gain (negative loss).

Indicators M8 and M9 are addressed together in this report because of the considerable overlap between intensification and loss of habitat. While Lee and Allen (2011) consider M8 a pressure and M9 an impact, the two overlap heavily. Many types of intensification result in direct habitat loss and would be identified from the resulting land cover changes. In both cases the data is LCDB, although intensification is more of a land use issue than a land cover issue. Another area of overlap is that the data required to reliably estimate patterns and rates of loss (or gain) will require more intensive local studies to augment the LCDB and calibrate reporting.

Indicators M8 and M9 are also closely aligned with measure M1, which looks at amounts and patterns of remaining indigenous habitat types and M17, which looks at the distribution of indigenous habitats in water catchments.

7.2 Scoping and analysis

7.2.1 Inadequacy of comparisons of different versions of the LCDB to estimate loss and change

Successive iterations of the LCDB are the fundamental datasets required for M8 and M9, but there are **major research issues to be resolved to determine the circumstances where comparing different versions of the LCDB is fit for purpose as a tool to estimate biodiversity loss**. The primary purpose of LCDB is to monitor coverage of generalised land cover classes nationally; temporal trends in change in these classes and the uncertainty that attends estimates of change (i.e. between classes) require a general appraisal.

On average, the LCDB has been estimated to give good depiction of the amounts and rates of total change. Approaches for change detection implemented by Landcare Research have achieved approximately 90% overall accuracy for estimates of change. Much of this overall change is in cover classes that are relatively easy to define and detect (e.g. harvested and un-harvested exotic forest). However, a number of studies indicate that the estimates of change derived from the LCDB may be considerably less accurate for classes that are important for estimating the loss of indigenous biodiversity.

An evaluation of change in dry, indigenous grasslands using successive iterations of LCDB (Weeks et al. 2013a) found that comparisons between the LCDB1 and LCDB2 picked up very little (about 4%) of the observed loss in grasslands. However, later comparisons between the LCDB2 and LCDB3 resolved from ⅓to ⅔ of the loss. This improvement is due partly to the feedback from these studies to the LCDB methodology and resulting improvement in the way in which grassland change was depicted. These studies highlight that, at least for certain cover types, the LCDB is underestimating change and loss. The latest version of LCDB4 includes the estimates of change from the work of Weeks et al. (2013a).

Cieraad et al. (2014) provided updates of estimates of indigenous cover remaining and protection across Land Environments of New Zealand (LENZ) environments. The authors investigated the ability of the LCDB to detect changes in indigenous land cover and decided they could not provide reliable estimates. During the study, the LCDB was estimated to provide approximately 50% accuracy in detecting indigenous cover change (J. Shepherd, Landcare Research, pers. comm.).

Further, the LCDB has been shown to resolve particular land cover types poorly. For example, Davis et al. (2013) found that LCDB2 was poor at resolving wetlands, and that wetlands could only be accurately identified using other information. Since wetlands and other rare ecosystem types are important for biodiversity, this suggests a need for auxiliary information to augment the LCDB. Future iterations of LCDB may include mapped wetlands of national importance (included in the Freshwater Ecosystems geo-database; http://www.doc.govt.nz/our-work/freshwater-ecosystems-of-new-zealand/).

In the case of M8 and the intensification of land use, the LCDB cover classes will not identify many of the important types of intensification affecting indigenous biodiversity. For example, a conversion from sheep and beef to dairy may result in considerable intensification but not a change in LCDB pasture class. In fact, it is likely to be the types of intensification that do not directly lead to land cover change that are likely to be of most relevance for M8, simply because these changes will not be identified from land cover changes that are picked up in M9. As for biodiversity loss, such land cover classification issues can be addressed if more careful characterisation of intensification is done in a spatial sample of regions. These issues point to a need for a **national map of land use** in addition to a national map of land cover as a key means of interpreting change in vegetation.

Miminum mapping unit

LCDB is appropriate for 1:50,000 scale mapping and potentially to 1:25,000 scale (P. Newsome, Landcare Research, pers. comm., May 2015). There is a **research and development need** to determine a **suitable minimum mapping unit (MMU) for which to report change using the LCDB**. For example, reporting change in land cover at a 1-ha scale (one suggested MMU) is likely to be below the scale of resolution that LCDB can achieve (P. Newsome, Landcare Research, pers. comm., May 2015). Consensus is needed about desirable and feasible minimum mapping units for which to report this measure.

Measures of change at a scale below the level of resolution that LCDB can achieve leads to discrepancies in estimates of change. For example, Auckland Council conducted a study of loss from clearance in the Waitakere Ranges, west Auckland (C. Bishop, Auckland Council, pers. comm., 2014). Comparisons of the LCDB estimated an annual loss rate of indigenous vegetation of approximately 0.003% per year, whereas inspection of aerial imagery provided an estimate of 0.02% per year, about a seven times higher rate of loss. A major reason for this difference is that some of the change was occurring in small pieces less than 1 ha and therefore below the MMU of the LCDB. This pattern of lots of small change is likely to be more extreme in peri-urban areas such as the Waitakere ranges, but this pattern will occur throughout New Zealand such that there may be significant amounts of change in indigenous vegetation below the MMU of the LCDB. If reporting change at finer resolution than LCDB can achieve is a general issue across councils (rather than for reporting at fine scales within regions, such as the example from the Waitakere Ranges), there could be a **research and development need** to **evaluate the remote sensing tools most fit for purpose** (e.g. aerial imagery, LiDAR, etc.).

Together, the above issues mean that the different versions of the LCDB, and the accompanying estimates of cover class change are, by themselves, inadequate to provide reliable estimates of biodiversity loss due to land cover change or intensification. Either the LCDB must be augmented, or change estimated independently using a sample of the landscape. The two approaches are best done together to gain the benefits of each. There is considerable potential to improve the LCDB through augmentation.

7.2.2 M9 Next Steps: a sampling programme to estimate change, augment and calibrate the LCDB

It is important to note that regional or national estimates of biodiversity loss do *not* require an exhaustive nationwide depiction of observed land cover change and can in fact be achieved entirely without the LCDB or comparisons between LCDB versions. A representative sample (which may be a stratified sample) of a region or of New Zealand can be chosen and, within the sample locations (which may be points or study areas, e.g., 10 km ×10 km squares), a more careful depiction of change can be done using a wide range of information, including the LCDB, satellite and aerial imagery, consent information and local knowledge. This sample can then provide an unbiased estimate of the national change without the need to map observed change regionally or nationally. Investment in these data would contribute not only to the indicators, but more widely to the improvement of land cover and land use information that will be widely used for other purposes.

The most useful approach would be to use information derived from such a sampling program in conjunction with the extensive information from the LCDB. The estimates of change from the sampled area can then be used to:

- calibrate the LCDB;
- produce maps of estimated risk of change for all of New Zealand;
- provide statistically robust accuracy measures for change of indigenous vegetation in the LCDB;
- provide more structured and quantitative feedback to improve the LCDB.

Given successive iterations of the LCDB do not accurately estimate change in indigenous cover in some cover types, we suggest that a robust characterisation of change requires using such a sampling approach, preferably in conjunction with the LCDB. This would essentially be an extension of the approach used by Weeks and her collaborators in the grassland work described above (Weeks 2013a, b, c), and can be integrated with vegetation measures (e.g., Measure 2, Vegetation structure and composition). The choice of sample areas that are representative of regions or New Zealand will allow unbiased estimates of change across all land cover types for entire regions and New Zealand. There are opportunities to mobilise point-based measurements of vegetation to improve the accuracy of LCDB, to link the LCDB to classifications of vegetation, and to improve the capacity to resolve change. Existing data in the National Vegetation Survey databank (NVS) can improve spatial resolution beyond grid-based assessments (e.g., LUCAS and DOC's Tier One data from its Biodiversity Monitoring and Reporting programme, and data from regional councils from the implementation of M2).

Before embarking on these approaches, some initial work is required to scope the work and estimate characteristics such as the feasibility of such a sampling programme (e.g., calibration within 10 km ×10 km squares), the sample sizes required to achieve certain levels of change, and the desired sampling scheme.

We suggest that this could be achieved using a staged approach with the following:

1. A survey of existing more detailed information on land cover change held by councils. This together with the LCDB provides a first estimate of change, and information needed to assess sampling design and statistical power.

2. Estimates of sample sizes, stratification and methods required to adequately estimate change according to agreed criteria, under different sampling schemes and costs. From this a recommended approach would be chosen.

3. A pilot study that would trial the recommended approach in one or several regions.

4. Implementation of above, either by region or nationally.

7.2.3 M8 research and development needs: intensification as a measure of disturbance intensity

During the M8/M9 workshop (29 January 2014), extensive discussions were had on the meaning, definition and quantification of intensification (this discussion is recorded in the workshop notes). For example, intensification may refer to labour intensity, economic intensity, disturbance intensity and other sorts of intensity. Most pertinent to the biodiversity indicators is probably disturbance intensity, which incorporates a wide range of factors that displace, disrupt, remove or otherwise adversely affect indigenous animals and plants.

A range of difficulties exist in the definition and quantification of disturbance intensity. For example, different taxa or different characteristics would be affected differently by different factors, and combining these into one number would require a number of decisions. There was general consensus at the workshop that this work would focus on indigenous plants as the taxa to consider for this indicator. In addition, a current MBIE-funded project, Next Generation Biodiversity Assessment, is looking at differences in biotic composition between different land covers (sampled in 2014 and 2015; leader Robbie Holdaway, Landcare Research). Vegetation data has been collected using methods identical to M2 (stored in the NVS databank) at catchment and national scales and could provide an objective quantification of different land covers in relation to fully indigenous ones. The implementation of M2 by Greater Wellington Regional Council (since 2015) could likewise assist in an objective quantification.

Another approach is to use quantitative approaches to inform an expert estimation of disturbance intensity for land covers. This would result in a consensus table that contains the estimated disturbance intensity for each land cover class. Entries in the table would range from 0 (no disturbance) to 100 (complete disturbance). Consensus on the values in the table could be achieved by having a range of ecologists estimate the values, and then compare them to reach a consensus value for each land cover class. As with all things ecological, there are a number of complications that need to be considered:

- First, intensification is often driven by land use – if consistent information on land use becomes available, then this might supplement or replace the information on land cover for estimation of intensification.

- Second, the interpretation of land cover in terms of disturbance intensity depends on the land cover that would naturally be expected at a site. For example, whether native scrub is considered to indicate medium or low disturbance intensity will depend on whether that particular site/location would naturally have scrub or forest.

An example of how these issues have been addressed, drawn from past work, is given by Overton et al. (2010) and reproduced in Appendix 7-1.

Other options on determining intensification include qualitative information gained from consultation with landowners to determine the frequency and depth of soil disturbance, biomass removal, and use of external inputs (i.e. fertilizer, herbicide), which, in turn, influence vegetation complexity and the proportion of non-native species (Rader et al. 2014).

Finally, as noted above, disturbance factors influence different components of biodiversity differently. Choices will need to be made as to what components are being estimated.

In terms of next steps for M8, a quantitative approach for estimating disturbance intensity for land cover will be needed. To achieve this, we suggest that a number of ecologists from regional councils, Landcare Research, and universities convene and:

1. Are given a complete table with all combinations of current and potential land cover (see Appendix 7-1, Table A7-1-1, for an example partial table).

2. Independently score the land cover class combinations from 0 to 100 according to disturbance or 'percent native' (we suggest that a pragmatic choice of which biodiversity components to consider is to focus on impacts on vascular plants).

3. Compare their independent assessments to each other (either remotely via email or if resources exist in a targeted workshop) to compare the values and reach consensus values for a working (expert estimation) disturbance intensity table.

M8 could then be estimated from changes in land cover. Any site/ location or area would be considered to have undergone intensification if it changed land covers from a class with lower disturbance intensity to higher disturbance intensity. Furthermore, this intensification would have a continuous number from –100 to 100 that would indicate the amount and direction of intensification.

It is worth noting that this disturbance intensity table would essentially be a continuous generalisation of the tables used for M1 and M9 to estimate whether something is native or exotic. In the case of M1 and M9, land cover classes are estimated to be either exotic (0, equating to disturbance of 100) or native (1, equating to a disturbance of 0). The use of a continuous scale of native-ness has been signalled as a future possibility for M1. As more people become familiar and comfortable with such definitions and approaches, it may be that M8 and M9 are merged and use the same disturbance intensity table as does M1.

This is a step towards a more defensible and enduring national quantification of intensification that could be convened by consensus in the context of the "Biological Heritage" and "Our Land and Water" National Science Challenges.

7.3 Data requirements

7.3.1 Land cover and indigenous vegetation

The LCDB is the only nationally consistent source of information to measure extent of indigenous vegetation for M9. The reality is that the higher resolution land cover information needed is expensive to derive and data are not currently available for the whole country. This means that the LCDB is, at present, the only practical option for a national indigenous vegetation indicator. However, the difficulties in the use of LCDB for detecting indigenous change (detailed in section 2.2.1) lead us to conclude that further work (as detailed in section 2.2.2) is required to reliably estimate change in indigenous vegetation.

Many regional councils have more accurate/catchment scale digital maps of the spatial extent of indigenous vegetation or clearance of indigenous vegetation (e.g. from aerial photograph analysis and fieldwork). Where such information is available it should be used with the biodiversity indicators that require vegetation data (e.g. M1, M2, M5, M8, M9, M17). More accurate indigenous vegetation and/or vegetation clearance layer(s) can then be used to report indicators regionally. For comparative purposes nationally, however, LCDB data should still be reported for each region and the country as a whole. A good outcome of this work may be a better process by which more detailed information held by councils is made available to and incorporated into new versions of the LCDB.

7.3.2 Habitat types

Habitat types should align with M1, and preferably also align with those used by M5 and M17. Currently this is the Potential Vegetation of New Zealand augmented regionally with information on special habitats, e.g. naturally rare ecosystems.

7.3.3 Disturbance intensity for land cover classes

A consensus table of disturbance intensity for each land cover class would be generated according to the process described above.

7.4 Statistics to report and reporting indices and formats

The final choices of indices and formats to report should be made after further development of these indicators. Here we provide some indicative outputs, drawing upon past work.

7.4.1 Indicator M8

1. Tables or bar chart of per cent intensification (on scale of –100 to +100) by
    a. land cover type before intensification
    b. land cover type after intensification
    c. habitat type.

2. Table of the land cover transitions leading to the most estimated loss of indigenous biodiversity in the region
3. Map of risk of further intensification, as modelled from observed intensification over past period. A map of observed intensification is also possible, but likely to be hard to see the relatively small areas of intensification.

Text/narrative should provide information to explain the tables and map above (i.e., what the data are telling us). The text should explain the estimated overall loss in the region due to intensification. It should describe the spatial patterns of the intensification , and it should discuss any implications for biodiversity and policy.

7.4.2 Indicator M9

1. Tables or bar chart of area lost (ha) and percent remaining by
    a. land cover type .
    b. habitat type.
2. Scatterplot by habitats of per cent recent regional loss in remaining habitat versus regional total loss in original habitat. Regional total loss is from M1.
3. Map of risk of further loss, as modelled from observed loss over past period (e.g. past 5 years), and combined as needed with recent historical loss (e.g. past 20 years). See Figure 7-1 for an example. A map of observed loss can also be considered, but it is likely that it will be hard to see the relatively small areas of loss when mapped at a regional scale.

Accompanying text should discuss the above and the spatial patterns of the loss and report on the estimated overall loss in the region due to loss of native vegetation, and implications for biodiversity and policy. In particular, the scatterplot (2 above) is an excellent visual check of whether rates of loss of remaining habitat are continuing in the habitats that have already experienced the most loss. The map of risk of further loss (3 above) provides an excellent visualisation of spatial patterns of loss.

7.4.1 Reporting frequency

Overall, a 5-year reporting interval is appropriate for these indicators. If the LCDB is used, then the reporting frequency will depend on the timing of LCDB updates. A sampling approach (as defined here) would provide the possibility for other time intervals.

7.4.2 Data management and access requirements

Access to all versions of the LCDB is required. These datasets are publicly available. The information from the sampling scheme should be held both regionally and nationally.

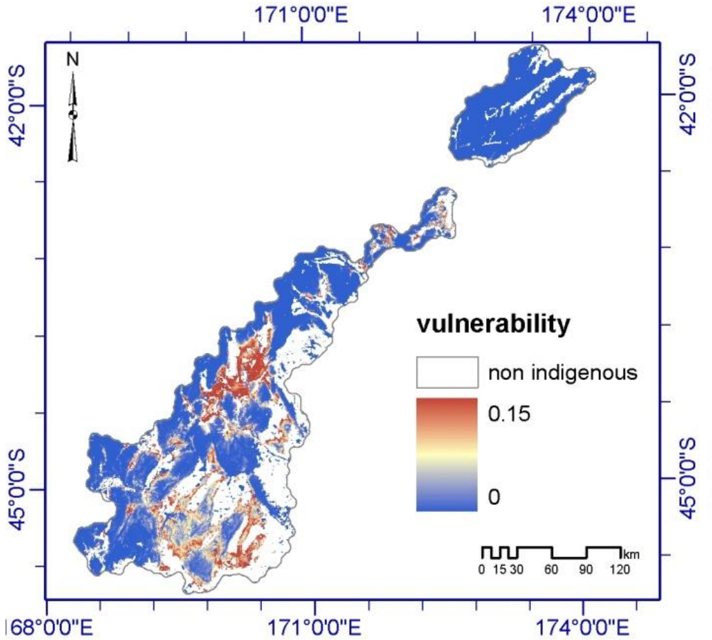

Figure 7-1 Example of estimated risk of further loss. This example is from Weeks et al. (2013a) and shows the estimated risk of loss of indigenous grasslands in dryland grasslands of inland South Island.

7.5 Conclusions

- Indicators M8 and M9 are related measures and are fundamental measures of loss of biodiversity due to changes in land use and land cover. They are dealt with here together because they are closely related and explore different aspects of the same issue.
- While the LCDB is the only nationally consistent data layer of land cover, there is considerable evidence to suggest that additional work and data will be needed to reliably estimate loss of biodiversity due to loss of native cover and intensification of land use, using the LCDB and other sources.
- In this methodology report, we outline a process to evaluate and calibrate the LCDB to enable estimates of loss of native vegetation. This involves a staged approach to further investigate rates of loss from existing information and to design a a national calibration and evaluation of the LCDB.
- We also outline a process to develop the information required to estimate intensification from changes in land cover.

7.6 References

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Appendix 7-1 – Estimation of naturalness or disturbance intensity

Here we adapt information from Overton et al. (2010) on the estimation of naturalness or disturbance intensity from a combination of current land cover and natural vegetation.

Potential-current naturalness table

This table gives the estimated proportion of native vegetation remaining for various combinations of potential vegetation and current vegetation. Each row contains a unique combination of potential and current land cover and the estimated proportion of native vegetation (native dominance) for that combination. The values in the table can be either defined or calibrated from data, or they can be assigned by expert opinion, as was done for this project. Some rows from the table used in this demonstration are shown in the table below.

To understand the logic of how and why the table was constructed, it is useful first to consider this table to be an elaboration of the simple, one-column table used in past studies to assess the amount of native vegetation remaining (e.g. Rutledge et al. 2004; Walker et al. 2006). These earlier tables assign each LCDB current land cover class to one of two possible categories ('native' or 'exotic'). Our potential-current naturalness table makes two refinements on this approach:

- We adopt a continuous measure of the proportion of native vegetation remaining, rather than a simple, binary, 'native'/'exotic' dichotomy. This allows for mixtures of native and exotic vegetation.
- We assign proportions of native vegetation remaining to a particular land cover type based on potential land cover type as well as the current type. This is done to represent the effects of human influences on a modern cover class. For example, native species-dominated non-forest land cover types such as scrub or tussock grassland that occur below treeline have often been induced by forest clearance. Elsewhere, scrub or tussock may be the natural undisturbed vegetation cover (e.g. above treeline or on valley floors subject to severe temperature inversions). In our table, areas of scrub or grassland in places where scrub or grassland would be the potential natural vegetation are considered to have higher proportions of native vegetation remaining than the same cover in areas that were predicted to be naturally (or potentially) forested.

In practice, this is simply done by finding all the unique combinations of potential cover and current cover and estimating the proportion of the original vegetation that remains by comparing the current vegetation cover to the potential vegetation cover. Many of the combinations are uncommon (see column 'count' in Table A7-1-1) and many constitute errors in either the potential vegetation or the current vegetation predictions. The values of proportion native vegetation remaining assigned to these combinations should be chosen to minimise the influence on the results.

Table A7-1-1 Example rows from the potential-current naturalness table. The complete table has many more rows. Each row shows a unique combination of predicted potential vegetation and current land cover from the LCDB2. The column Comb Val is simply an arbitrary (but unique) value assigned in the grid to a unique combination of the two covers. This value is used to link the value in the Percent Native column back into the grid. The count column gives the number of pixels (at 25-m resolution) that have a particular combination.

Comb Val	Count	Potential Vegetation	LCDB2 class	Percent Native
894	1196699	Scrub, shrubland and tussock grassland above treeline	Indigenous Forest	100
1135	18871	Scrub, shrubland and tussock grassland above treeline	Urban Parkland/ Open Space	0
970	28325	Scrub, shrubland and tussock grassland above treeline	Gorse and Broom	0
1151	30	Scrub, shrubland and tussock grassland above treeline	Flaxland	100
1146	37242	Scrub, shrubland and tussock grassland above treeline	Vineyard	0
915	6325988	Scrub, shrubland and tussock grassland above treeline	Tall Tussock Grassland	100
980	137953	Scrub, shrubland and tussock grassland above treeline	Alpine Grass/Herbfield	100
960	242228	Scrub, shrubland and tussock grassland above treeline	Sub Alpine Shrubland	100
1000	102	Alpine Gravel and Rock	Other Exotic Forest	0
992	5937	Alpine Gravel and Rock	Sub Alpine Shrubland	100
1063	1	Alpine Gravel and Rock	Fernland	100
994	240	Alpine Gravel and Rock	Mānuka and/or Kānuka	100
787	417228	Alpine Gravel and Rock	Tall Tussock Grassland	100
345	130639	Mataī–kahikatea–tōtara forest	Built-up Area	0
93	179007	Mataī–kahikatea–tōtara forest	Mānuka and/or Kānuka	30
676	33930	Mataī–kahikatea–tōtara forest	Grey Scrub	40
319	759091	Mataī–kahikatea–tōtara forest	Low Producing Grassland	5
150	3463	Mataī–kahikatea–tōtara forest	Estuarine Open Water	100
847	1071	Mataī–kahikatea–tōtara forest	Landslide	0
670	17646	Mataī–kahikatea–tōtara forest	Fernland	20
533	17151	Mataī–kahikatea–tōtara forest	Afforestation (not imaged)	0
525	28168	Mataī–kahikatea–tōtara forest	Vineyard	0
599	1152	Hall’s tōtara/broadleaf forest	Urban Parkland/ Open Space	0
659	10572	Hall’s tōtara/broadleaf forest	Herbaceous Freshwater Vegetation	100
853	10501	Hall’s tōtara/broadleaf forest	Major Shelterbelts	0

Comb Val	Count	Potential Vegetation	LCDB2 class	Percent Native
680	827	Hall’s tōtara/broadleaf forest	Transport Infrastructure	0
1066	109229	Hall’s tōtara/broadleaf forest	Short-rotation Cropland	0
868	2288	Kahikatea–mataī/tawa–māhoe forest	Herbaceous Freshwater Vegetation	100
661	5699	Kahikatea–mataī/tawa–māhoe forest	River	100
368	31782	Kahikatea–mataī/tawa–māhoe forest	Other Exotic Forest	0
363	1494	Kahikatea–mataī/tawa–māhoe forest	Surface Mine	0
387	104141	Kahikatea–mataī/tawa–māhoe forest	Built-up Area	0
370	16450	Kahikatea–mataī/tawa–māhoe forest	Deciduous Hardwoods	0
1101	16	Kahikatea–mataī/tawa–māhoe forest	Sub-Alpine Shrubland	100
863	1900	Kahikatea–mataī/tawa–māhoe forest	Alpine Gravel and Rock	100
864	16531	Kahikatea–mataī/tawa–māhoe forest	Vineyard	0
921	406	Lake and Pond	Landslide	0
802	17194	Lake and Pond	Tall Tussock Grassland	100
669	2514	Lake and Pond	Alpine Gravel and Rock	100
446	310	Lake and Pond	Surface Mine	0
119	3714	Lake and Pond	Pine Forest – Closed Canopy	0
214	5619	Lake and Pond	Deciduous Hardwoods	0
797	461	Lake and Pond	Permanent Snow and Ice	100

Appendix 7-2 – Workshop notes

Meeting notes from workshop 29 January 2014 at Landcare Research, Lincoln, to discuss proposed methods prepared by Jake Overton, Landcare Research Manaaki Whenua, for M8 and M9.

Discussion notes are written up under each agenda item below. Recommended actions are noted first.

Attendees:

- Nancy Willems, Bay of Plenty Regional Council
- Ellen Cieraad, Landcare Research
- Peter Bellingham, Landcare Research
- Robbie Holdaway, Landcare Research
- Jeromy Cuff, Canterbury Regional Council
- Mirella Pompei, Canterbury Regional Council
- Kirsty Johnston, Canterbury Regional Council (Convenor)
- Philip Grove, Canterbury Regional Council
- Zach Hill, Canterbury Regional Council
- David Pairman, Landcare Research
- Jake Overton, Landcare Research
- Peter Newsome, Landcare Research
- James Shepherd, Landcare Research

Apologies:

- Emily Weeks, Landcare Research
- Susan Walker, Landcare Research

Recommended actions:

- Complete M8 and M9 methodology paper incorporating discussion points/ recommendations from workshop participants. Paper then goes out for feedback/ review by participants and BDWG. Completion, including review, July 2014 (measure delivery date). (Jake Overton, Landcare Research; Kirsty Johnston, key regional council contact).
- Following completion of methodology paper, and discussion with BDWG, prepare a pilot study/candidate project for how ground-truthing of land cover images/data might be improved upon, including for determining appropriate sampling methods for M8 and M9. This would include a regional trial and step-wise implementation process for M8 and M9. (Jake, David, James and Robbie/Landcare Research with input and peer review from Workshop participants and BDWG).

- Develop a continuum of land cover types based upon intensity of use. This would entail scoring the land cover types contained in the LCDB from 0 to 100, with 0 being pristine (no use and un-impacted biodiversity) and 100 being the highest intensity land use (e.g. mining, urban, roading infrastructure). This ranking would be used to define intensification from land cover transition matrices. Different rankings could be done for different types of intensity (e.g. disturbance to biodiversity, labour, economic), but biodiversity is the main interest of this indicator.

Workshop agenda:

- Welcome/introductions

Overview:

- Purpose of meeting was to discuss

  1. a working definition of intensive land use for biodiversity (and council SOE) monitoring, including the data sources and cover classes for indicator M8

  2. estimating indigenous habitat loss (or gain) as a measure of any transition (+ or –) between cover classes, including those agreed for intensive land use (M8).

- Background to regional councils' biodiversity indicators project
  - EnviroLink Tools project: Purpose, process and people/agencies, framework and indicator set

    (Refer to May 2011 Landcare Research report for the regional council biodiversity working group: Recommended monitoring framework for regional councils assessing biodiversity outcomes in terrestrial systems)
- Any relevant givens for M8 and M9
  - e.g. we have agreed to use LCDB indigenous vegetation classes as surrogate for indigenous 'habitats'
  - scope – regional council biodiversity/ SOE monitoring programmes
- Overview of proposed M8 and M9 methods and approach (refer to Jake's PowerPoint)

M8: Change in area under intensive land use

A definition for intensive land use, including any limitations.

Discussion notes:

Workshop participants had a free-ranging discussion about methodologies for/the ability to define, measure and report changes in 'intensive' land use. Consensus was that, even internationally, objective methods have not been developed for a measure such as M8 because of the number of factors affecting classification of intensive land use – there are limitations. Discussion points included:

- Can be a lot of variability within a land use type – community composition and distance to 'natural'. Do you assume that because there is more intensification there is a loss in biodiversity? This isn't what data always show.

- Straightforward to go between obvious change in intensification (e.g. from not irrigated to irrigated land, from vegetation to roads or urban settlement) but not when dealing with already intensive use (e.g. sheep and beef to dairy vs. urban or dairy).
- Land use: need to know what it is and isn't. Not the same as land cover. Some land use classes are inferred from LCDB, others are not.
- Need to look at land-use change first, and then look at land cover.
- Will need to list land-use classes and agree these amongst agencies/end-users as a consistent set of classes/categories for monitoring and reporting purposes.
- Want to report spatial patterns of change including location, extent, type, total intensification, total loss (or gain) in types, transitions from one type to another.
- Presentation wanted in maps, and as numbers.

Workshop participants then discussed possibilities of developing an intensive land use classification. This could include regional councils making clear what land use classes they use and then having these ranked in more or less 'intensity' on 0–100 scale (distance to native X). Time series change could be used to estimate cover transitions by type. Discussion points/steps:

- Ranking land cover classes for a defined purpose and creating a gradient for more or less 'intensive' land use possible, but would have to be fit for purpose
- Plausible steps:
    - Create a transition matrix using LCDB
    - Assign transition; 0–100 exotic: native (NB: 0–1 scale only gets loss, not intensification. To get intensification, you need the 0–100 scale, or make a cut-off as to what you consider intense versus non-intense land use within the exotic land covers/uses)
    - Identify what we need to know beyond LCDB (other data/information), for example, particular cover classes omitted (e.g. grey scrub)
    - Habitat gains/losses (equivalent (or not) to loss of biodiversity) to be identified/assigned.

Data source(s) for monitoring, mapping and reporting M8

- ***LCDB***
- ***Other***

Discussion notes:

- LCDB currently not sufficient for estimating loss of native biodiversity
- Resolution issues of LCDB to be considered (reporting/sampling cut-offs), for example, if below resolution of LCDB (1 ha) then not considered for reporting change
- Accuracy assessment needed to give a total accuracy assessment and to adjust figures.

- A useful stratified design that is fit for purpose to biodiversity needs/regional council needs must be developed (i.e. strata to design a sampling scheme and answers standardised by sampling scheme).
- As part of LCDB3 checking, Landcare Research provided regional councils with a tool to look at change polygons within scrub class – feasible thing to do (with classes and ortho photos). Not all councils participated. Change is patchy/not random. All councils need to participate in this process.
- Looking at change polygons needs to be complemented with looking at areas of no change to be correct/catch omissions.

M9: Habitat and vegetation loss

- **Data sources for estimating habitat loss (or gain), including any limitations:**
    - **LCDB**
    - **Rare ecosystems**
    - **Other**

Discussion notes:

Participants didn't discuss data sources for M9 specifically. Discussion about the LCDB and issues with its use (scale, resolution, a fit for purpose sampling scheme and accuracy assessments) apply to M9. Rare ecosystems data sources include national priorities/threatened environments.

Next steps/close meeting/thanks

- **Completing the draft methodology**
- **Peer review process**

Discussion notes

Everyone agreed that Jake Overton's PowerPoint provided a good overview of M8 and M9 methodological issues and recommended sensible next steps (i.e. the pilot study to estimate change and patterns of change in several regions) and stepwise implementation. Bay of Plenty, Canterbury, Otago and Manawatū–Whanganui were suggested as possible pilot regions.

The need to rationalise/ have one scheme of sampling for biodiversity indicators/ measures, including for M8 and M9 and the use of the LCDB was noted – key Landcare Research scientists to discuss.

After the meeting, Jake looked at data more. A good first step might be to do a more careful look around to see which councils have higher resolution data that might be used to assess change and the accuracy of the LCDB. For example, Waikato Regional Council has done a mapping exercise at 0.5 ha MMU of native vegetation for years 2002, 2007 and 2012, although not the entire region for each year. Jake has looked at this data but not had a chance to assess its suitability.