A potential network of permanent forest plots for the West Coast Conservancy

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Abstract

Permanent plots in indigenous forests administered by the Department of Conservation's West Coast Conservancy in the National Vegetation Survey (NVS) database were analysed to show which forest types were adequately sampled according to identifiable forest types, and within each type, in space and in time. From 404 permanent forest plots considered in analysis, eight forest types were determined, of which only one (southern rata - kamahi - Hall's totara) is adequately represented in total number of plots and in measurements over time. Even this type is inadequately represented in space. Permanent plot coverage in Westland is overall very patchy, with the Whitcombe Ecological District having more than half the total number of permanent forest plots. There are no permanent forest plots in the NVS database in most Ecological Districts in the West Coast Conservancy, and coverage of major protected natural areas is often either scant (e.g., in Paparoa National Park), or absent entirely (the West Coast Conservancy parts of Kahurangi National Park). This report recommends a network of 287 plots to be retained for long-term monitoring of forest condition and trend. Good long-term data sets exist from some plots (3 and rarely 4 measurements), and these plots should be accorded high priority for ongoing measurement. However, given the patchy coverage of plots, it is strongly recommended that other sources of permanent plot data outside NVS (e.g., from Crown Research Institutes and Universities) and from other administrators of indigenous forests (especially Timberlands West Coast Limited) be integrated with NVS plots so that a more complete and widespread assessment of forests can be obtained.

1. Introduction

New Zealand's recent international obligations under a range of international conventions require better knowledge about biodiversity within indigenous forests, and about changes in forest condition and composition over time. Most notably, New Zealand has obligations to report on:

- biodiversity under the Convention on Biodiversity;
- sustainable management of forests (including their biodiversity) under the Global Forest Resource Assessment 2000 and the Montreal Process;
- national carbon budgets under the Framework Convention on Climate Change.

In forests administered by the Department of Conservation (DoC), regional and national operations, for example against animal pests, require reporting under the philosophy of Quality Conservation Management.

New Zealand's existing network of permanent forest plots has enabled determination of several aspects of forest ecology, including change over time, and

can be used in future for a variety of purposes. Permanent plots have provided information on national estimates of carbon (Hall & Hollinger 1997), long-term forest condition and mortality patterns (e.g., Bellingham *et al.* 1996), changes in seedling regeneration over time (e.g., Stewart & Burrows 1989), changes in biodiversity over time (e.g., Stewart *et al.* 1987), and exotic invasions over time (Wiser *et al.*, in revision).

Permanent forest plots can therefore provide information on regional and national changes in forest condition using the following as indicators:

- tree death (and defoliation) by species as an indicator of forest health;
- regeneration by species as an indicator of forest maintenance;
- exotic plant species invasion as an indicator of intactness;
- browsing by introduced animals as an indicator of animal impacts;
- living and dead stem biomass as a habitat indicator;
- and rare and threatened plants as an indicator of maintenance of diversity.

To assist the West Coast Conservancy of DoC in devising a network of permanent plots for ongoing assessment of changes in forest condition, an assessment of permanent plots in indigenous forests held in the National Vegetation Survey (NVS) database was conducted by Landcare Research. Data from permanent plots were analysed so that various forest types were defined, and recommendations were made for a subset of the permanent plots to be maintained for onward monitoring of forest condition and trends. Work was contracted in April 1997 and completed in July 1997.

2. Objective

To recommend a network of permanent plots suitable for onward measurement to assess forest condition in indigenous forests administered by DoC's West Coast Conservancy.

3. Background

3.1 THE NATIONAL VEGETATION SURVEY

Several thousand permanent sample plots have been established in New Zealand in indigenous forests (Allen 1993). Many of these plots have been established using similar methods that allow comparisons among them in terms of

quantifying biomass and species composition. Repeated measurement of these plots allows assessments to be made of forest dynamics.

The great majority of permanent plots in indigenous forests were established on the basis of two historic rationales: (a) to assess timber volumes or forest structure and composition (mostly in lowland forests); and (b) to assess the effects of introduced browsing mammals on forest condition, structure, and composition (mostly in upland 'protection' forests). The dictates of these two management needs have direct consequences for where the present network of plots is sited. Most plots established to determine timber volumes were focused on 'merchantable' stands, and thus were not necessarily representative of the vegetation of an area. Moreover, as logging of indigenous forests declined, so the need to establish plots to determine timber volumes declined, and thus many of these plots are old (1940s to 1950s) and difficult to relocate. In contrast, most of the permanent plots established to determine the effects of browsing mammals are generally of more recent origin (1970s to 1980s). Since plot location was not dictated so much by a priori decisions about what vegetation was to be sampled, but more by the effects of browsing animals, the sampling effort tended to concentrate on where these animals were most common, i.e., in steeper montane areas usually within large forest tracts.

In the West Coast Conservancy, most forest plots in the National Vegetation Survey (NVS) database are from larger forested tracts. Most of these plots were established in the 1970s and most were designed to measure the effects of browsing mammals in indigenous forests. The complete set of data from permanent plots in forests administered by DoC in the West Coast Conservancy was examined to determine:

(a) where plots are located;

(b) what kinds of forest vegetation the plots sample, and on that basis, how well sampled are particular types of forest; and

(c) how frequently plots in particular areas and in particular kinds of forest have been resampled, in order to assist in determining long-term trends within these forests.

4. Methods

Data from permanent plots in forests administered by DoC West Coast Conservancy usually have been collected after the methods of Allen (1993), i.e., from 20x20 m (400 m^2) plots, although a few plots are of other sizes. Within these plots all stems 22.5 cm diameter at breast height (dbh: 1.35 m) have been identified, permanently tagged with aluminium tags nailed at the point of diameter measure, and their diameters recorded. Each plot is normally subdivided into 16 contiguous 5x5 m (25 m^2) subplots, within which counts of saplings are made and within which seedling subplots are sited (see details

in Allen 1993). A standard forest reconnaissance survey plot (Allen 1992) usually accompanies each permanent plot, along with site data, typically a map reference, and estimates of altitude, slope, and aspect.

The plots are normally semi-randomly located within catchments to be surveyed, i.e. at systematically assigned distances along transects following semi-random bearings from a base assigned randomly along major stream courses. A few of the plots were located on the basis of stratification of vegetation determined from aerial photographs.

Data from each permanent plot are recorded in a standard format in the NVS database. In this exercise, only data from the trees (i.e. stems 22.5 cm dbh) were used, and the analysis program converted data for each species to a total basal area per hectare, to render plots of different size comparable. Where plots had been measured more than once, the most recent survey data were used.

I did not use in the analysis data from 307 permanent 20 x 20 m plots established in the Taramakau and Otira catchments in 1987, of which 102 were remeasured in 1993, because in contrast to all other plots, only stems 210 cm dbh were tagged and recorded. Thus data from these plots were not comparable with those from other plots. Another data set in the NVS database omitted from analyses is 53 plots from Saltwater Forest. Because I have limited the focus of this study to forests administered by DoC, these data were excluded because they were collected on land administered by Timberlands West Coast Limited (hereafter Timberlands); moreover, the data were collected from trees 210 cm dbh and thus are not readily comparable with other data.

All the most recent information collected from 404 permanent plots in the NVS database from the West Coast Conservancy were combined into a standard format. Site information exists from each of the plots, typically its map grid reference (either NZMS 1 or NZMS 260), elevation, slope, and aspect. Some of the plots lacked information on slope and aspect, so these variables were not included in the data analysis. To assist in determining how ecologically representative a sample of the Conservancy was contained in the NVS database, each of the permanent plots was assigned to its Ecological District (MacEwen 1987).

5. Analysis

The 404 permanent plots in forest in Westland were classified into vegetation types using the multivariate analysis program TWINSPAN (two-way indicator species analysis) (Hill 1979). Classification was based on a plot by species data matrix of basal area values. The third level of division in TWINSPAN was chosen to give eight recognisable vegetation types. The key features of each of the vegetation types defined by TWINSPAN were summarised using the program PCDIAM (Hall 1994).

6. Results

6.1 TWINSPAN CLASSIFICATION

Eight forest types were recognised from TWINSPAN classification (Fig. 1). The first division separated 266 plots distinguished by the presence of kamahi *(Weinmannia racemosa)* and *Quintinia acutifolia.* The second division within this group segregated 36 plots characterised by silver beech *(Nothofagus menziesii),* then split at the third level of division into a group of 27 plots, characterised by silver beech and horopito *(Pseudowintera colorata)* (Type 1), and a group of 9 plots (Type 2) with hard beech *(Nothofagus truncata),* rimu *(Dacrydium cupressinum)* and kamahi. The remaining 230 plots at the second level of division were characterised by the presence of southern rata *(Metrosideros umbellata),* which was then split at the third division into 56 plots where rimu was characteristic (Type 3) and 174 plots characterised by the presence of horopito and *Griselinia littoralis* (Type 4).

The second group distinguished at the first TWINSPAN division (138 plots) was characterised by the near absence of kamahi, and the presence of *Coprosma ciliata, Coprosma pseudocuneata, Griselinia littoralis,* and *Myrsine divaricata.* At the second level of division a group of 104 plots was separated by the presence of three tree species, southern rata, Hall's totara *(Podocarpus hallii)* and kaikawaka *(Libocedrus bidwillii),* and also *Coprosma pseudocuneata* from 34 plots where *Olearia ilicifolia* was the characteristic species. The group of 104 plots was subdivided at the third level into a group of 77 plots (Type 5) with a high frequency of horopito and *Hoheria glabrata* from a group of 27 plots where high-altitude small trees were common, i.e., *Archeria traversii, Dracophyllum longifolium, Dracophyllum traversii, Halocarpus biformis* and *Phyllocladus alpinus* (Type 6). The group of 34 plots recognised at the second division plots was further split into a group of 30 plots (Type 7), in which *Coprosma ciliata, Hoheria glabrata* and *Myrsine divaricata* were characteristic and 4 plots (Type 8) in which *Coprosma rugosa* was a characteristic species.

6.2 THE FOREST TYPES

Forest types are named with species that contribute 210 $m^2\ ha^{-1}$ ranked in descending order, for all types except type 8, named for the two species that contribute more than half the total basal area.

Type 1: silver beech
This forest type is not well sampled by the existing network of permanent plots (6.7% of 404 plots, Fig. 2). Silver beech overwhelmingly dominates (Table 1), with kamahi, black beech and red beech forming only minor components. Occurs at mid-altitude sites (342 + 49 m) in the North Westland and Aspiring Ecological Regions, with one plot at the northern edge of the Whataroa Ecological Region (Table 2).

Type 2: hard beech

Rarely represented within the plots (2.2% of 404 plots, Fig. 2) and occurs at rather low altitude (217 + 44 m). Characterised by hard beech (in only 78% of the plots) forming nearly half the total basal area, with silver beech, rimu and kamahi forming minor components (Fig. 3). Eight of the 9 plots are in the North Westland Ecological Region (Table 2), but one is in the Arawata Ecological District. In this last plot, hard beech is absent, but other floristic affinities place it with the plots dominated by hard beech. The plot is near some of the "outlier" stands of hard beech found in the adjacent Haast Ecological District (Mark & Lee 1985).

Type 3: rimu-kamahi

Inadequately represented by plots in the NVS database (13.9% of plots), this forest type is characteristic of low-altitude sites (200 + 27 m) including lower montane areas, moraines and fluvioglacial terraces. Rimu (89% of plots) and kamahi (all plots) dominate, with Quintinia acutifolia abundant but forming a much lesser proportion of total basal area. Most plots that sample this type are in the Harihari Ecological District, with other plots scattered in the lower montane parts of other Ecological Districts (i.e., Reefton, Punakaiki,Whitcombe and Arawata Ecological Districts).

Type 4: southern rata - kamahi - Hall's totara

By far the best represented forest type in West Coast Conservancy (43.1% of plots, Fig. 2), in montane areas (605 + 10 m). The canopy tree species, southern rata, kamahi and Hall's totara dominate the forest (Fig. 3) and all three species are found in over 80% of 174 plots (kamahi is found in nearly all plots, Table 1). Other widespread common species include *Quintinia acutifolia* (absent from 27% of plots, mostly those in the Glaciers Ecological District, beyond its southern limit) and *Griselinia littoralis*, although these species form only a small proportion of total basal area, and *Pseudowintera colorata* is found in most plots. The great majority of plots in this forest type are found in the Whataroa Ecological Region (especially in the Whitcombe Ecological District,Table 2), and a few in upper montane areas of the North Westland Ecological Region (Table 2).

Type 5: southern rata - Hall's totara - *Griselinia littoralis*

The second best represented forest type (19.1% of plots, Fig. 2). Hall's totara and *Griselinia littoralis* are the most widespread canopy trees (both found in 97% of 77 plots, Table 1); although southern rata forms the greatest proportion of total basal area it is less widespread (in 71% of plots). Kaikawaka is a locally important component (found in 65% of plots, forming 8.4% of total basal area). Kamahi is comparatively rare, and common elements of the understorey include *Pseudowintera colorata* and *Myrsine divaricata*. Occurs at high montane sites (738 ± 14 m), all in the Whataroa Ecological Region (Table 2).

Type 6: southern rata - *Archeria traversia* - Hall's totara.

A forest type poorly represented in the NVS permanent plots (6.7% of plots, Fig. 2), characteristic of very high montane sites (870 ± 11 m). Arcberia traversai and Hall's totara are the most widespread species (both in >90% of plots, Table 1), with southern rata less widespread (in only just over half the plots) but forming a greater proportion of total basal area (Table 1). Kaikawaka

is a widespread and common component (in 89% of plots, forming 10.7% of total basal area), as is *Halocarpus biformis* (in 59% of plots, 8.8% of total basal area), *Griselinia littoralis* (in 82% of plots, 8.7% of total basal area) and *Phyllocladus alpinus* (in 85% of plots, 6.2% of basal area). *Dracophyllum traversii* and *Pseudopanax simplex* are also common components. Almost all plots in this type are in the Whataroa Ecological Region, with one plot in the North Westland Ecological Region (Table 2).

Type 7: *Griselinia littoralis*
An uncommon forest type among the plots sampled (7.4% of 404 plots). *Griselinia littoralis* is a common component and the only constituent to form >10 $m^2 ha^{-1}$ (Table 1). *Hoheria glabrata* (70% of plots, forming 23.2% of total basal area) and *Olearia ilicifolia* (87% of plots, 14.7% of total basal area) are widespread and important components, with *Pseudowintera colorata*, *Myrsine divaricata* and *Coprosma ciliata* also important though forming less of the total basal area. Occurs at high altitude (785 ± 31 m), best sampled in the Whataroa Ecological Region, with a few in the Arawata Ecological District (Table 2).

Type 8: *Olearia ilicifolia - Dracophyllum longifolium*
The most poorly represented forest types (1.0% of 404 plots, Fig. 2), but with very low basal area compared with other forest types (Table 1) at very high altitude (912 + 83 m), these plots are located in penalpine shrub-heaths (*sensu* Wardle 1991) not normally sampled in most forest surveys. *Olearia ilicifolia* is found in 3 of the 4 plots that sample this type and *Dracophyllum longifolium* in 2 plots, with other species of *Olearia* and various *Coprosma* species forming minor components. All plots that sample this forest type are in the Whitcombe Ecological District (Table 2). The small total basal area and the presence of *Coprosma rugosa* suggests these plots may be in disturbed areas, e.g., arising on avalanche or landslide areas.

7. Choosing a representative sample

Choice of a subsample of the 404 existing permanent forest plots in West Coast Conservancy to maintain and monitor must inevitably be overlain with particular management imperatives. For example, high emphasis may be placed on maintaining plots in montane conifer-hardwood rain forest in two National Parks (Arthurs Pass and Westland) that receive high visitor numbers, to determine long-term trends and condition in these forests with respect to possum control efforts (e.g., Rose et al. 1988, Stewart 1992, Smale et al. 1993, Bellingham et al. 1996).

Permanent forest plots in the NVS database give a very patchy coverage on land administered by the DoC. There are no permanent forest plots on land administered by West Coast Conservancy in three Ecological Regions, i.e.

- North-west Nelson Ecological Region (including parts of Heaphy, Wangapeka and Matiri Ecological Districts, and all of Karamea Ecological District),

- Spenser Ecological Region (including parts of Rotoroa, Ella and Hope Ecological Districts), and

- Olivine Ecological Region (including most of Cascade Ecological District and about half of Pyke Ecological District).

In part, lack of coverage of these Ecological Regions is mitigated by coverage by permanent plots in adjacent DoC Conservancies, respectively Nelson-Marlborough, Canterbury and Southland Conservancies. For example, there are respectively 10 and 14 permanent forest plots in the portions of the Cascade and Pyke Ecological Districts in Southland Conservancy. However, in some of these Ecological Regions, permanent forest plots are absent from a number of Ecological Districts they contain, e.g., Heaphy, Karamea and Ella Ecological Districts.

In the remaining Ecological Regions wholly or partly contained within the West Coast Conservancy, coverage is patchy, and often with few permanent plots in the NVS database.

- Only 37 permanent forest plots are in the NVS database from land administered by DoC in the North Westland Ecological Region (Table 2), and those from only 2 of 11 Ecological Districts in that Ecological Region. Importantly, permanent forest plots are located in indigenous forests administered by Timberlands in Maimai, Totara Flat, and Hochstetter Ecological Districts in the North Westland Ecological Region, and also in Rotoroa Ecological District in the Spenser Ecological Region. Timberlands is currently putting in more permanent plots, and may put some in forests administered by DoC.

- In the Whataroa Ecological Region, where permanent forest plot coverage is best (Table 2), only three of eight Ecological Districts have permanent plots in the NVS database, with coverage especially poor in the southern portion of this region (e.g., no plots in Wilberg, Waiho, Karangarua and Mahitahi Ecological Districts).

- Coverage of the Aspiring Ecological Region is also especially poor, with only 20 plots, all of which are in one Ecological District (Arawata), with none in the Paringa, Mataketake, Landsborough, Haast and Okuru Ecological Districts.

It is noteworthy that coverage of permanent forest plots is very poor in some major protected natural areas, especially in Paparoa National Park (only 11 plots) and in the parts of Kahurangi National Park (no plots) and Te Wahipounamu World Heritage Area (20 plots in the NVS database) that the West Coast Conservancy administers. However, especially for the Te Wahipounamu World Heritage Area, there is an exhaustive survey of forests that would allow stratification of forests for future siting of permanent forest plots, as well as some detailed studies (e.g., Dickinson & Mark 1994).

The imperatives that dictated original sampling of forests neglected certain kinds, in particular fragments of lowland forest, thus certain Ecological Districts, especially those comprising mostly pastoral landscapes in West Coast Conservancy lack permanent forest plots of any kind or have a very poor sample. For example, there are no permanent forest plots in the NVS database in the Foulwind Ecological District (North Westland Ecological Region), or the Hokitika Ecological District (Whataroa Ecological Region).

I present here a first discussion to show how it is possible to develop a series of guidelines and recommendations for a network of permanent plots, based on those in the NVS database, which might be maintained in West Coast Conservancy. Additions must take into account at least the considerations listed above. Above all, in any new initiatives about placement and maintenance of permanent plots, a wider assessment of sources of information will be required. This should include integration of permanent plots established by Universities (e.g., from the School of Forestry research station at Harihari, and by staff and students of Canterbury, Lincoln, and Otago Universities), and extending coverage by integrating data collection and analysis with Timberlands from areas they administer (see below).

7.1 AN ADEQUATE SAMPLE OF A GIVEN FOREST TYPE

Large samples are needed to ascribe statistical confidence to conclusions drawn and predictions made about trends in forest condition and composition over time. Some studies have used subsamples of permanent plots from an existing network of plots. For example, Allen & Allan (1995) chose a subsample of thirty 20x20 m plots from an existing network in species-poor mountain beech forests of the Kaweka Range, central North Island, to assess changes in forest condition attributable to changes in deer density over time. I shall use a sample of 30 plots per forest type as an example of a possible minimum to maintain statistical confidence about changes in condition over time, but the actual number of plots required to give precise estimates of changes in forest condition in different forest types is unknown and is a topic that demands further research. Some components of selection of a number of plots to give statistical confidence will be addressed by Landcare Research and the New Zealand Forest Research Institute as part of determination of national carbon budgets, funded by the Ministry for the Environment. A pilot project within this research programme is likely to focus on a "Southern Alps Transect", evaluating permanent plots located between latitudes 42°50' and 43°10' south, including several permanent plots within the West Coast Conservancy. Should remeasurements take place, from DoC's perspective, remeasurement of plots could focus on biodiversity issues while the plots are also measured for above-ground biomass, a surrogate for carbon. Ideally any subsample of plots should also allow sufficient replication of particular site attributes, e.g., slope, altitude, physiography, drainage.

Four of eight forest types identified in the current evaluation of 404 permanent forest plots in West Coast Conservancy are represented by fewer than my own arbitrarily chosen subsample of 30 plots (Fig. 2), viz.

Type 1: silver beech (27 plots);

Type 2: hard beech (9 plots);

Type 6: southern rata - *Archeria traversii* - Hall's totara (27 plots);

Type 8: *Olearia ilicifolia* - *Dracophyllum longifolium* (4 plots).

To gain any worthwhile indication of trends through time in these four forest types it could well be necessary to maintain all existing plots, and even establish others in similar vegetation. Note also that major forest types, probably better represented in West Coast Conservancy than anywhere else in New Zealand, are unrepresented by permanent plots in the NVS database, e.g., lowland kahikatea dominant forest (Duncan 1993), and floodplain matai - totara forest (McSweeney 1982).

7.2 AN ADEQUATE SAMPLE IN TIME

The more frequently a forest type has been measured over time, the more confidence that can be attached to the conclusions; therefore those measured most frequently should be accorded the highest value. Plots have often been remeasured in response to particular management objectives. For example, plots in the Taramakau and Copland valleys have been measured repeatedly to determine the long-term fate of southern rata trees in stands where they were dominant. Areas of special interest to managers are thus likely to be areas with a history of remeasurement.

Of the 404 permanent forest plots in West Coast Conservancy, 148 plots (36.6%) have been measured more than once (Table 3). Applying the arbitrary minimum of 30 plots per forest type, only one forest type is above this threshold of confidence (Fig. 2), i.e. Type 4: southern rata - kamahi - Hall's totara (86 plots measured more than once), although Type 5 (southern rata - Hall's totara - *Criselinia littoralis*), with 29 plots remeasured more than once is close to the arbitrarily chosen minimum.

Of the 148 plots measured more than once, 84 plots (i.e., 20.8% of the total) have measurements from three periods, i.e., what might be considered an adequate baseline from which to deduce trends in forest condition. These plots are located in the Taramakau and Kokatahi valleys in the Whitcombe Ecological District, and from the Copland valley (Westland National Park) in the Glaciers Ecological District. Of the 84 thrice-measured plots, 52 are in forest type 4, i.e. still a sufficient sample compared with the arbitrarily chosen minimum number for confidence. A further 11 plots in the Taramakau valley have been measured four times, and can thus provide an even better basis for deduction of long-term trends, although they were last measured in 1979 (Table 3).

7.3 AN ADEQUATE SAMPLE IN SPACE

Other than types 4 (southern rata - kamahi - Hall's totara) and 5 (southern rata - Hall's totara *Griselinia littoralis),* all other forest types have inadequate sampling in total and over time. Thus for types 1, 2, 3, 6, 7, and 8 it is probably desirable to maintain all plots and thus give as widespread coverage as possible using existing plots. Only type 4 has more than 30 plots with at least two measurements. Thus it may be desirable to maintain a widespread sample of the 86 plots measured more than once in space, to represent variability detected in the current analysis arising from environmental gradients of altitude, latitude and longitude. The great majority of remeasured plots in Type 4 are in the Whataroa Ecological Region, and it would be desirable to at least maintain all plots measured more than once in this Ecological Region (Table 3). The only other plot in Type 4 remeasured more than once is in the Punakaiki Ecological District; this plot along with another plot measured only once in the Reefton Ecological District should probably be maintained in the longer term.

Forest type 5 lacks adequate sampling in time (Table 3), but from the total of 77 plots in this type (Table 2), at least all plots measured more than once should probably be retained. All plots in this type are in the Whataroa Ecological Region, and it may be desirable to extend geographic coverage of this type, at least to other Ecological Districts within the Ecological Region.

8. Further sampling and integration with other data sources

It may be desirable to extend the coverage of permanent plots to include forest types not represented in the existing network. Siting of additional plots should make use of other available databases (e.g., a literature review, Forest Class maps, reconnaissance surveys, the Ngakawau PNAP survey, and other permanent survey plots may be available; see Meurk & Buxton 1991). There are several important, and in some cases, long-maintained permanent plots not in the NVS database that should be integrated into long-term monitoring of forests administered by DoC in its West Coast Conservancy. Some examples are included in a list that is not exhaustive (Table 4).

As pointed out, coverage of West Coast Conservancy by permanent forest plots is geographically very patchy. Additional plots extend geographic coverage (Table 4), and using published literature and reconnaissance plots, it should be possible to identify areas where the 8 forest types of this exercise occur but are at present either not sampled by permanent plots or are poorly represented (e.g., hard beech forest and rimu - kamahi forest in the Aspiring Ecological Region).

Timberlands is a major administrator of indigenous forests in West Coast Conservancy. In forests administered by Timberlands there is a major source of information on forests, including several hundred reconnaissance and permanent plots. Data from many of these plots have been collected using either similar or identical methods to those analysed in this exercise, and include data on forests poorly represented in NVS plots from forests administered by DoC, e.g., beech forests (Table 1). Likewise other institutions, e.g. Landcare Research, the New Zealand Forest Research Institute and Universities (especially the School of Forestry at the University of Canterbury) have had a long and ongoing history of measurement of plots in these forests, including data from permanent plots. Data from Timberlands forests extends geographic coverage in Ecological Districts where there are few or no plots in forests administered by DoC, and can thus assist in assessing whether trends detected in NVS plots are local or widespread. Therefore it will be important to integrate collection of data by DoC with Timberlands, Crown Research Institutes and Universities; this integration could be achieved under the aegis of NVS.

In the Taramakau Valley, the 307 permanent 20x20 m plots that I excluded from analysis may also be valuable for onward monitoring (especially the subset of 102 plots remeasured twice), as they give extensive coverage of the Otira Valley, which has high significance for management because of its high visitor numbers. With minor modification, these plots could also conform to the standard used in measurement of other plots.

New initiatives from other government agencies present opportunities to remeasure existing permanent plots, and in some cases, to extend coverage to include forest types and areas inadequately covered at present. Most notably, the Ministry for the Environment needs to obtain a national carbon budget for New Zealand in 2000 to determine change from a 1990 baseline. This exercise is likely to entail use of existing permanent forest plots.

9. Summary

It is possible to choose from the existing network of forest plots in West Coast Conservancy a subsample which is probably a minimum from which to make confident assessments of past trends and to make predictions for the future. Of the existing 404 permanent plots, 287 (71.0%) (Table 5) could be considered for future monitoring to give adequate sampling of some of the 8 forest types identified. Note that this subsample is an arbitrary recommended minimum number. It would certainly be desirable to boost the sample of underrepresented forest types (1, 2, 6, and 8). It is also desirable scientifically to place strong emphasis on future measurement of all plots already remeasured at least twice. Integration of existing permanent forest plots not in the NVS database and from indigenous forests administered by Timberlands with those plots recommended for future remeasurement in Table 5 will be essential to obtain a regional overview of trends and condition in all indigenous forest types in the West Coast Conservancy.

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11. References

Allen, R.B. 1992. RECCE: an inventory method for describing New Zealand's vegetative cover. *Forest Research Institute bulletin no. 181.* 25 p.

Allen, R.B. 1993. *A permanent plot method for monitoring changes in indigenous forests.* Christchurch, Manaaki Whenua - Landcare Research, 35p.

Allen, R.B. & Allan, C. 1995. *Mountain beech forest dynamics in the Kaweka Range and the influence of browsing animals.* Landcare Research contract report no. LC9596/024 to the Department of Conservation.

Bellingham, PJ., Wiser, S.K., Hall, G.M.J.,Alley, J.C.,Allen, R.B. & Suisted, PA. 1996. Impacts of possum browsing on the long-term maintenance of forest biodiversity. Landcare Research Contract Report LC 9697/047 for Department of Conservation.

Dickinson, K.J.M. & Mark AT 1994. Forest-wetland vegetation patterns associated with a Holocene dune-slack sequence, Haast Ecological District, south western New Zealand. *Journal of Biogeography,* 21, 259-281.

Duncan, R.P. 1993. Flood disturbance and the coexistence of species in a lowland podocarp forest, south Westland, New Zealand. *Journal of Ecology,* 81, 403-416.

Hall, G.M.J. 1994 *PC-DIAM: stem diameter analysis.* Auckland, Manaaki Whenua - Landcare Research, 88p.

Hall, G.M.J. & Hollinger, D.Y. 1997. Do the indigenous forests affect the net C02 emission policy of New Zealand? *New Zealand Forestry,* 41, 24-31.

Hill, M.O. 1979. *TWINSPAN-A FORTRAN program for arranging multivariate data in an ordered two-way table by classification of the individuals and attributes.* Ecology and Systematics, Cornell University, Ithaca, U.S.A.

MacEwen, W.M. 1987. *Ecological Regions and Districts of New Zealand.* 3rd edition. Department of Conservation, Wellington.

McSweeney, G.D. 1982 Matai/totara flood plain forests in south Westland. *New Zealand Journal of Ecology,* 5, 121-128.

Mark, A.F & Lee, W.G. 1985. Ecology of hard beech (*Nothofagus truncata*) in southern outlier stands in the Haast Ecological District, south Westland, New Zealand. *New Zealand Journal of Ecology,* 8, 97-121.

Meurk, C.D. & Buxton, R.P. 1991: *A* register *of* permanent *vegetation* plots. DSIR Land Resources contract report to DoC no. 91/35. Christchurch, DSIR Land Resources.

Rose,A.B., Pekelharing, C.J. & Hall, G.M.J. 1988 Forest dieback and the impact of brushtail possums in the Otira, Deception and Taramakau catchments, Westland. Forest Research Institute Contract Report for West Coast Region, Department of Conservation.

Smale, M.C., Rose,A.B., Frampton, C.M. & Owen, H.J. 1993. The efficacy of possum control in reducing forest dieback in the Otira and Deception catchments, central West-

land. Manaaki Whenua - Landcare Research Contract Report LC 9293/110 for Department of Conservation.

Stewart, G.H. 1992. Forest structure and regeneration in conifer-broadleaved hardwood forests, Westland - Monitoring rata-kamahi forest canopy condition and stand dynamics, Copland Valley. Forest Research Institute Contract Report FWE 92/31 for Department of Conservation.

Stewart, G.H. & Burrows, L.E. 1989. The impact of white-tailed deer *Odocoileus virginianus* on regeneration in the coastal forests of Stewart Island, New Zealand. *Biological Conservation,* 49, 275-293.

Stewart, G.H., Wardle, J.A. & Burrows, L.E. 1987. Forest understorey changes after reduction in deer numbers, northern Fiordland, New Zealand. *New Zealand Journal of Ecology,* 10, 3542.

Wardle, P 1991. *Vegetation of New Zealand.* Cambridge University Press, Cambridge, United Kingdom.

Wiser, S.K.,Allen, R.B., Clinton, PW & Platt, K.H. In revision. Invasion of *Nothofagus* forest by an exotic perennial herb over 24 years. *Ecology*.

12. Appendices

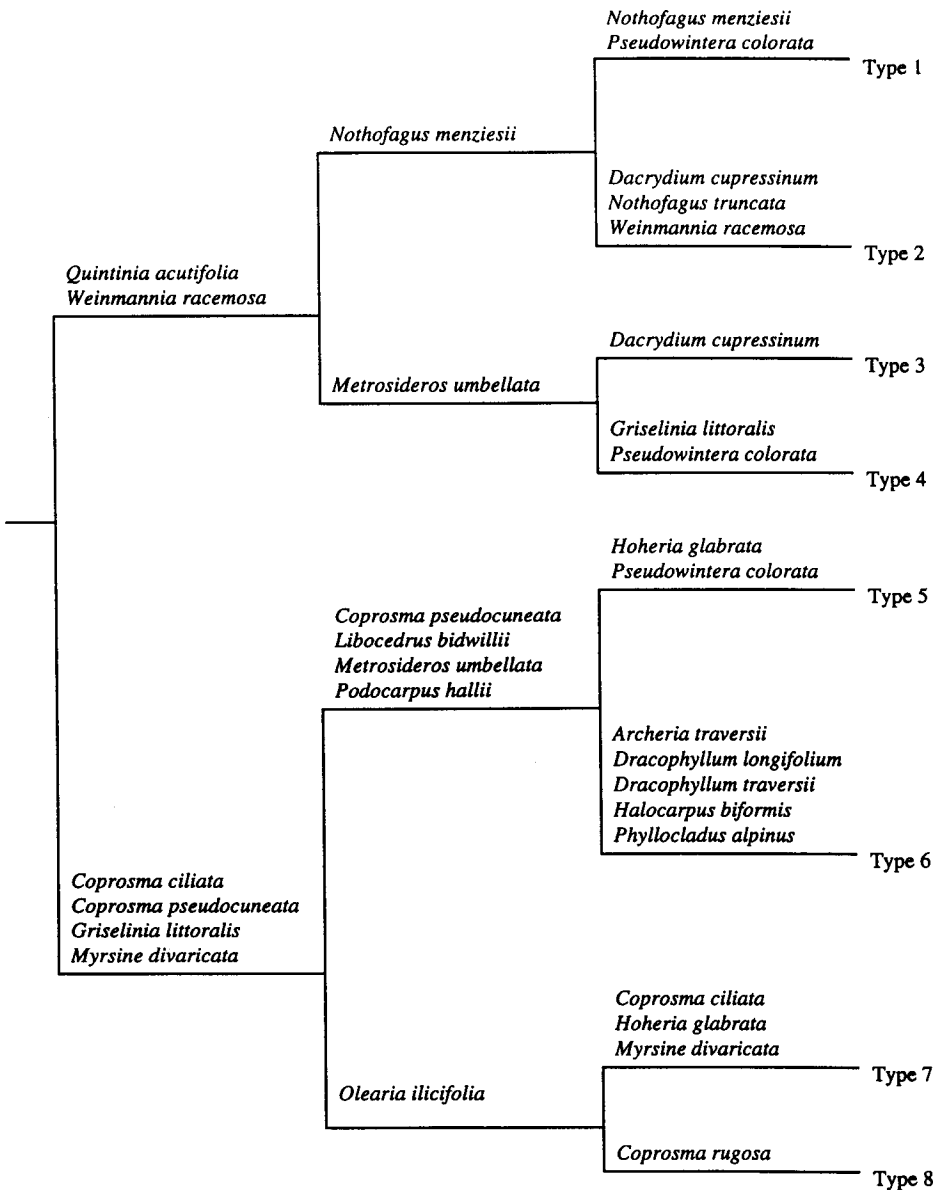

Figure 1: Dendrogram from TWINSPAN classification of 404 permanent forest plots from West Coast conservancy showing species used to distinguish eight forest types (1-8), recognised at the third level of division.

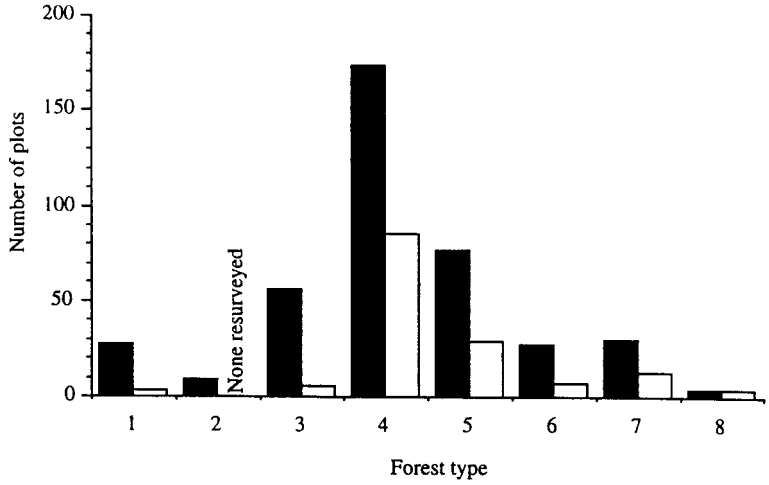

Figure 2: Number of plots in eight forest types in West Coast conservancy, based on 404 permanent plots in the NVS database. ■, total number of plots per forest type; □ number of plots resurveyed at least once since establishment.

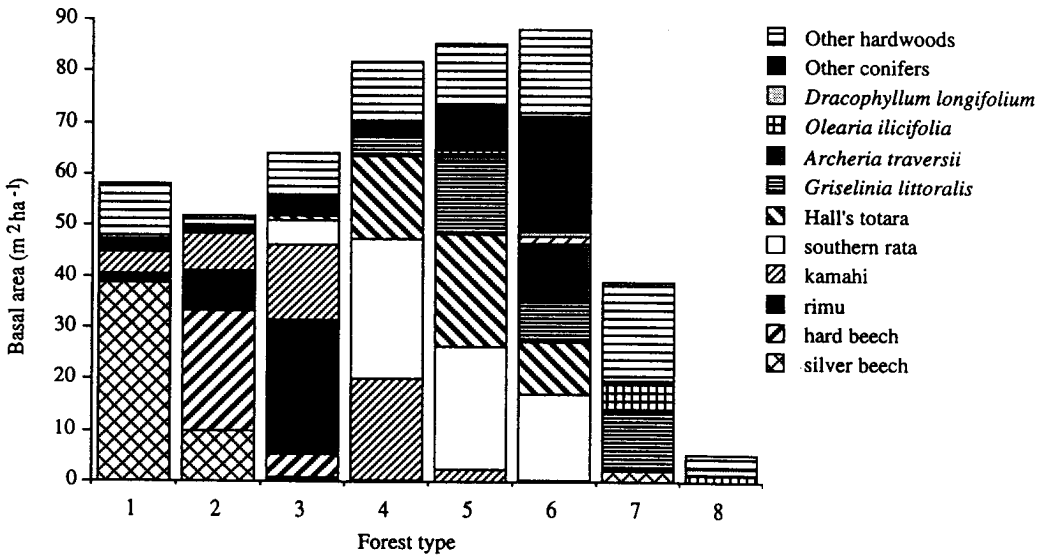

Figure 3: Basal area of dominant taxa in eight forest types in West Coast Conservancy, based on 404 permanent plots in the NVS database.

Table 1: Summary of forest types sampled by permanent plots in DoC West Coast Conservancy.

Forest type	Number of plots	Species	Basal area (m^2/ha)	% of plots in which species occurs
Type 1 : Silver beech	27	*Nothofagus menziesii*	38.75	100
		All species	58.30	
Type 2 : Hard beech	9	*Nothofagus truncata*	23.66	78
		All species	52.05	
Type 3 : Rimu-kāmahi	56	*Dacrydium cupressinum*	25.93	88
		Weinmannia racemosa	14.69	100
		All species	64.08	
Type 4: Southern rātā-kāmahi-Hall's tōtara	174	*Metrosideros umbellata*	27.21	80.5
		Weinmannia racemosa	19.81	97.1
		Podocarpus hallii	16.14	86.8
		All species	81.93	
Type 5 : Southern rātā-Hall's tōtara-*Griselinia littoralis*	77	*Metrosideros umbellata*	24.45	71
		Podocarpus hallii	21.88	97
		Griselinia littoralis	14.16	97
		All species	85.58	
Type 6 : Southern rātā-*Archeria traversii*-Hall's tōtara	27	*Metrosideros umbellata*	16.90	52
		Archeria traversii	11.37	96
		Podocarpus hallii	10.22	93
		All species	88.19	
Type 7 : *Griselinia littoralis*	30	*Griselinia littoralis*	10.93	77
		All species	39.13	
Type 8 : *Olearia ilicifolia-Dracophyllum longifolium*	4	*Olearia ilicifolia*	1.56	75
		Dracophyllum longifolium	1.20	50
		All species	5.42	

Table 2: Numbers of permanent forest plots in DoC West Coast Conservancy in 8 vegetation types assigned by TWINSPAN classification, and according to the ecological regions and districts in which each occurs.

Ecological Region	North Westland		Whataroa			Aspiring	Σ
Ecological District	Reefton	Punakaiki	Whitcombe	Harihari	Glaciers	Arawata	
Type 1: Silver beech	9	4	1			13	27
Type 2: Hard beech	6	2				1	9
Type 3: Rimu-kāmahi	10	3	8	33		2	56
Type 4: Southern rātā-kāmahi-Hall's tōtara	1	1	140		32		174
Type 5: Southern rātā-Hall's tōtara-*Griselinia littoralis*			60		17		77
Type 6: Southern rātā-*Archeria traversii*-Hall's tōtara		1	24		2		27
Type 7: *Griselinia littoralis*			25		1	4	30
Type 8 : *Olearia ilicifolia-Dracophyllum longifolium*			4				4
Total:	26	11	262	33	52	20	404

Table 3: Permanent plots surveyed in DoC West Coast Conservancy more than once since establishment, years in which surveys took place, and forest types (as in Table 1) represented in the survey areas.

			Forest types								
Survey area	**Survey years**	**Ecological Districts**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**Σ**
Paparoa Exclosure	1989 1995	Punakaiki	2		1	1		1			5
Taramakau	1978 1992	Whitcombe				2					2
Taramakau	1978 1984 1992	Whitcombe				8					8
Taramakau	1968 1975 1979	Whitcombe	1				1		3	4	9
Taramakau	1968 1975 1978 1979	Whitcombe				1	3	1	6		11
Kokatahi	1971 1979	Whitcombe			5	9			1		15
Kokatahi	1971 1979 1995	Whitcombe				17	2		2		21
Whitcombe	1971 1979	Whitcombe				16	6	3			25
Copland	1978 1984	Glaciers				5	1				6
Copland	1978 1984 1992	Glaciers				27	16	2	1		46
			3	0	6	86	29	7	13	4	148

Table 4: Some permanent plots in forests administered by DoC that are not included in the NVS database, but which should be integrated with NVS data and other sources in extending coverage of forest types and geographic coverage.

Location	Ecological District	Plot types	Years measured	Contact
Mt Harata	Tōtara Flat	1 exclosure plot	1995	Terry Farrell (DoC)
Station Creek	Rotoroa	Red/silver beech forest dynamics. *c.* 1 ha plots in each, and 164 "gap" plots.	1986-87, 1992-93, 1995-96	Glenn Stewart (Lincoln University)
Rough Creek				
Pell Stream				
Spring's Junction				
Mahinapua Forest	Hokitika	Lowland podocarp forest dynamics. 1 large plot	1920s onwards	Glenn Stewart (Lincoln University)
Saltwater Ecological Area	Harihari	Forest dynamics without possum control. 10, 20x20 m plots and 4, 500x20 m transects	1993-94	David Norton (University of Canterbury) and Craig Miller and Terry Farrell (DoC)
South Okarito Forest, Westland National Park	Harihari	Forest dynamics after possum control. 6, 500x20 m transects	1994	
Mt Hercules Scenic Reserve	Harihari	Forest dynamics without possum control. 2, 500x20 m transects	1994	
Wanganui River mouth	Harihari	Kahikatea forest dynamics. 1, *c.* 30 x 1200 m transect (podocarps only tagged)		Glenn Stewart (Lincoln University)
Welcome Flat, Copland Valley, Westland National Park	Glaciers	Regeneration dynamics of ribbonwood forests. 5, various-sized quadrats	1995	Glenn Stewart (Lincoln University) and Larry Burrows (Manaaki Whenua)
Ohinemaka Forest	Karangarua and Paringa	Kahikatea forest and mixed podocarp forest dynamics. 3, 60x60 plots, 1, 90x60 m plot. Plots marked; trees not tagged.	1988-90	Richard Duncan (Lincoln University)
Waitangi River	Harihari	Determination of cattle grazing effects at forest margins on river flats. 7 exclosures and controls (30 m x 20-40 m), reduced to 5 by river erosion	Established 1989, portions remeasured annually, and fully every 3-4 years.	Rowan Buxton and Peter Wardle, (Manaaki Whenua) and Craig Miller and Susan Timmins (DoC)
Cook River	Waiho			
Arawata River	Arawata			
Jackson River	Cascade			

Table 5 (below and opposite): A scenario for a possible network of permanent plots in forests in DoC West Coast Conservancy that might be maintained in an attempt to include adequate samples in 8 forest types, through time, and in space.

Vegetation type	Total number of plots	Ecological District and number of plots per district		Survey Area	Years surveyed
Type 1 : silver beech	27	Reefton	9	Coal Creek	1976
		Punakaiki	2	Paparoa Exclosures	1989
			2		1989, 1995
		Whitcombe	1	Taramakau	1968, 1975, 1979
		Arawata	13	Haast	1970
Type 2 : hard beech	9	Reefton	6	Coal Creek	1976
		Punakaiki	2	Paparoa Exclosures	1989
		Arawata	1	Haast	1970
Type 3 : rimu - kāmahi	56	Reefton	10	Coal Creek	1976
		Punakaiki	2	Paparoa Exclosures	1989
			1		1989, 1995
		Whitcombe	1	Whitcombe	1982/86
			2	Hokitika	1983/86
			5	Kokatahi	1971, 1979
		Harihari	33	Okarito	1983/84
		Arawata	1	Haast	1970
Type 4 : southern rātā - kāmahi - Hall's tōtara	87	Reefton	1	Coal Creek	1976
		Punakaiki	1	Paparoa Exclosures	1989, 1995
		Whitcombe	2	Taramakau	1978, 1992
			8		1978, 1984, 1992
			1		1968, 1975, 1978, 1979
			9	Kokatahi	1971, 1979
			17		1971, 1979, 1995
			16	Whitcombe	1971, 1979
		Glaciers	5	Copland	1978, 1984
			27		1978, 1984, 1992

Type 5 : southern rātā - Hall's tōtara - *Griselinia littoralis*	47	Whitcombe	1	Taramakau	1968, 1975, 1979
			3		1968, 1975, 1978, 1979
			2	Kokatahi	1971, 1979, 1995
			6	Whitcombe	1971, 1979
			18		1982/86
		Glaciers	1	Copland	1978, 1984
			16		1978, 1984, 1992
Type 6 : southern rātā - *Archeria traversii* - Hall's tōtara	27	Punakaiki	1	Paparoa Exclosures	1989, 1995
		Whitcombe	1	Taramakau	1968, 1975, 1978, 1979
			3	Whitcombe	1971, 1979
			16		1982/86
			4	Hokitika	1983/86
		Glaciers	2	Copland	1978, 1984, 1992
Type 7 : *Griselinia littoralis*	30	Whitcombe	3	Taramakau	1968, 1975, 1979
			6		1968, 1975, 1978, 1979
			1	Kokatahi	1971, 1979
			2		1971, 1979, 1995
			9	Whitcombe	1982/86
			4	Hokitika	1983/86
		Glaciers	1	Copland	1978, 1984, 1992
		Arawata	4	Haast	1970
Type 8 : *Olearia ilicifolia - Dracophyllum longifolium*	4	Whitcombe	4	Taramakau	1968, 1975, 1979
TOTAL	287				