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COMPARATIVE ASSESSMENT OF SOME NATIONAL FOREST SURVEY TYPES

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ABSTRACT

Physiognomic importance of each plant species was estimated at 49 stratified random locations in the proposed Taunoa Biological Reserve, an area of podocarp, hardwood and beech forests in the Longwood Range, Southland. Agglomerative grouping, direct and indirect gradient analyses revealed that an ordination using the Euclidean distance **D** provided the most informative treatment of the field data. Vegetation in the reserve is best described as part of a forest continuum varying in composition and structure chiefly along an altitudinal gradient.

Agglomerative groups distinguished nine forest communities, six of which were described in the National Forest Survey (N.F.S.) Type classification of the area. Forest communities derived from N.F.S. typing and agglomerative grouping were found to be closely related to the pattern of locations displayed by the two dimensional ordination. Quantitative treatment thus confirms the validity of N.F.S. Types in this area at least and supports their use in planning Biological Reserves. The more sensitive ordination techniques are considered to have value for analysis and interpretation of the detailed biological information being gathered in ecological surveys of indigenous forests.

INTRODUCTION

During the past decade there has been increasing interest in and attention given to the reservation of indigenous forest for the preservation of definitive communities and wildlife habitats. A high degree of protection for such areas is provided by designation as "Forest Sanctuaries". In addition, the 1973 Amendment to the Forest Act 1949, makes provision for further areas with scientific interest to be designated as "Biological Reserves", protecting them from any use inconsistent with the purpose of their dedication. Thompson and Nicholls (1973) and Nicholls (1974; 1975) provide details of N.Z. Forest Service progress in setting aside areas of forest with scientific value.

For some biological reserves being mapped in State indigenous forests there is a wealth of ecological information available for foresters to decide areas, boundaries and management. But in most intended reserves they must rely on the National Forest Survey (N.F.S.) Type maps. These resource unit maps are based on prominent trees, landscape and ecological information collected during the 1945-55 National Indigenous Forest Survey of merchantable timber volumes. That broad assessment has been invaluable in tree species zonation and mapping (Holloway, 1954; McKelvey and Nicholls, 1957; Masters *et al.,* 1957). Subsequent ecological surveys are leading to regional maps of forest classes such as that of the Grey River Catchment by Franklin and Nicholls (1974), and more refined definitions of cover types (Nicholls, 1976). More detailed analyses of some forests have been made by McKelvey (1963, 1973) in West Taupo and the Urewera and by Franklin (1967) for the Tararua and Ruahine Mountains. However, when N.F.S. Types are used in the definition and delimiting of biological reserves, forests are assumed to display essentially discrete patterns of spatial variation. Their use also assumes uniformity within type boundaries. Discrete patterns do exist, but there are many extensive tracts of forest where spatial variation has a merging character and where changes in composition follow essentially continuous environmental gradients. The broad grouping inherent in the N.F.S. types may tend to mask the presence of those gradients otherwise expressible as a forest continuum. McKelvey (1973) displayed such patterns in forests of the Urewera, while P. Wardle (1974) has noted considerable variation within N.F.S. Types mapped in the Fletcher Creek.

The investigation described here attempted to test the validity of N.F.S. typing as the main mapping criterion for the designation of biological reserves in State forests by comparing it with results of alternative methods of forest community analysis.

Study Area

The proposed Taunoa Biological Reserve is an area of about 500 ha surrounding the headwaters of the Taunoa Stream, situated in the south-west of the Longwood Range in western Southland. Terrain is easy rolling, characterised by mature rounded slopes and spurs. Most of the Longwoods are gazetted State forest and have been included in Forest Service proposals for beech forest utilisation. Much logging for rimu and silver beech has already occurred, particularly on the south-western lowlands, and valleys and slopes of the eastern and northern sectors of the Longwoods (Holloway, 1953). The forested slopes range in altitude from approximately 100 m to 765 m above sea level. Within this range there occurs a complex mosaic of podocarp/hardwood, podocarp/

beech and pure beech forest communities. There is a gradual altitudinal zonation in tree species. In addition, the most significant podocarp stands are confined to the western flanks of the hills. Extensive logging and fire over the last century has severely modified most of the forested area. The proposed Taunoa Biological Reserve contains one of the few remaining unlogged podocarp areas in the Longwoods (Nicholls, 1974).

Using results of the Primary Forest Survey, Holloway (1946, 1953, 1954) described the Longwood forests and commented on their past and present relationships with climate. Most of the podocarp/mixed hardwood stands occur on easy slopes below 460 m. They consist of rimu (*Dacrydium cupressinum**) with Hall's totara (*Podocarpus hallii*) and miro (*Podocarpus ferrugineus*) while kamahi (*Weinmannia racemosa*) and southern rata (*Metrosideros umbellata*) occur commonly as sub-canopy species. On the upper slopes and in the valley floors the podocarp-dominated stands merge with silver beech (*Nothofagus menziesii*). On riparian sites silver beech may become dominant.

The unusually depressed bushline changes abruptly to open alpine meadow in which thickets of leatherwood (*Olearia colensoi*) are prominent. Red tussock (*Chionochloa rubra*) is often dominant on the open tops. At lower elevations the silver beech is of good form, but malformation increases with altitude. Tree stature decreases until at bush line (730 m) canopy height is no more than 8 m and all branches are festooned with moss and lichen.

METHODS

Sampling Procedure

A random sampling pattern was adopted in order that variations in the data could be substantiated by standard statistical tests (Kershaw, 1973). The reserve, fairly uniform in topography, has two access tracks which traverse from farmland to the upper limit of the forest. These were used as base lines from which plot centres were offset. Distances between sampling points were established by random numbers and the appropriate distance measured upslope. At each sample point, the elevation, aspect, slope and topography were recorded. Visual estimation of species dominance and presence within a minimal area surrounding the sample point was selected as the most appropriate descriptive method. Minimal area estimates made previously, showed that a search area of radius 15 m included most species present in any one forest stand. The vegetation was divided into the following strata by height:

Canopy trees	generally over 10.5 m tall
Sub-canopy trees	approximately 4.5 m-10.5 m
Tree saplings	approximately 2.0 m-4.5 m
Shrubs	approximately 10 cm-2.0 m
Herbs and seedlings	less than 30 cm

Presence/absence records were made for vascular species in each tier at all 49 sampling points. One to three species per tier were recorded as dominant. Time limitations precluded inclusion of the many forest bryophytes and lichens.

Analysis of Data

Ordination techniques were chosen as a preliminary method for the analysis of data. However, to interpret the ordering of stands and evaluate the N.Z.S. type designations,

* Species names and authorities follow Allan (1961).

there was a need to have an objective system of classification. In order to provide such a system, a modified agglomerative grouping technique previously used by J. Wardle (1970), was adopted.

In both ordination and agglomerative methods it was necessary to assign a numerical importance value, reflecting the species' importance within the sample. The score was based on the presence of the species in each of the five tiers, and its dominance in each tier. Within a scale of 10-100 the highest individual species score was 90 for *N. menziesii.*

THE ORDINATION

The method adopted by Bray and Curtis (1957) was used initially in ordering the 49 samples, with modifications concerning axis construction suggested by Beals (1965). Sample comparison was based on an Index of Dissimilarity (100-*C*) calculated from

$$C = \frac{2w}{a + b}$$

where C = coefficient of similarity, a = the sum of the quantitative values of all species of one stand, b = the sum of quantitative values in the other stand and w = the sum of values of the two stands which are common to both.

Orloci (1966) and Austin and Orloci (1966) argued that interstand distances based on the 100-*C* coefficient were non-Euclidean under certain circumstances and that axes when constructed were not truly perpendicular to each other. The latter can be readily corrected, as for example, in Beals (1973) but the first problem remains. Hence, the Pythagorean or Euclidean distance, *D*, as derived by Orloci (1966), was calculated and a matrix established. As previously, the interstand distance was calculated from the species scores for the two stands, i.e., the importance values X_{ij} and X_{ih} by the formula:

$$D_{jh} = \left[\sum_{i=1}^{N} (X_{ij} - X_{ih})^2 \right]^{\frac{1}{2}}$$

For any individual axis in the ordination it was necessary to show that its construction contributed new and meaningful separation of the sample points. 'F' values were calculated for regressions of *X* and *Y, Y* and *Z* and *X* and *Z* co-ordinates using 50 random pairs of sample points. In the 100-*C* ordination the *X* and *Y* axes were shown to be uncorrelated but a third or *Z* axis was correlated and did not contribute any further information. In the ordination using the coefficient *D,* no such correlation was evident between the *X, Y* or *Z* axes.

Correlation coefficients were calculated for the relationship between interstand distances and original matrix values again for the two parameters 100-*C* and *D.* Swan (1970) considered that such a value would illustrate how well the two and three dimensional ordination had displayed the coefficient of community values of the matrix. A value of +0.804 was obtained for the Euclidean distance *D* and +0.722 for 100-*C.* Thus for further analytical work the interstand distance *D* was used.

RESULTS AND DISCUSSION

A sharp reduction in diversity of vascular plants was recorded in forests at higher altitude (Fig. 1).

The agglomerative or clustering technique was applied to species-importance values

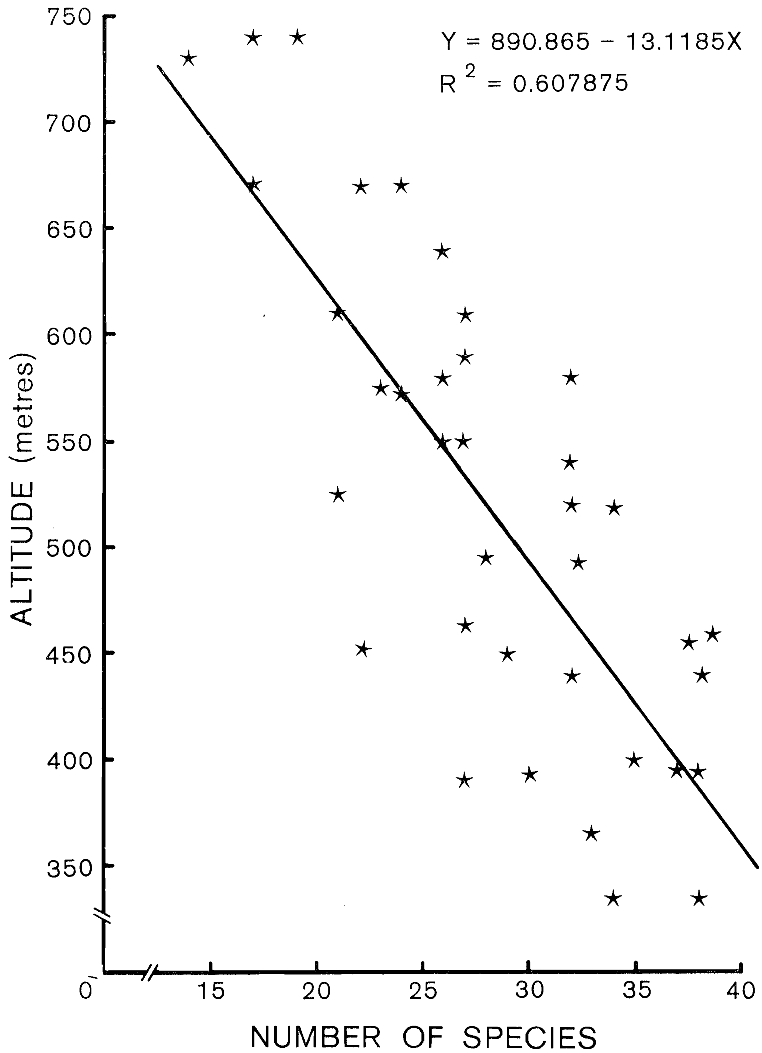

FIG. 1—Reduction in number of species at each sampling point with increasing altitude.

in the 49 sample plots. Each sample plot was compared with all others, the two most similar plots were then fused and compared as a unit with all those remaining, and so on. Gradual fusion of plots and construction of a dendrogram led to the illustration of relationships between all sample plots. Forest communities were then identified as those groups of plots having a very close relationship. For some of the nine recognisable groups, personal judgment was necessary to assign plots. This difficulty was caused by the merging or gradual change in species and communities with changing altitude and near gullied streams in the reserve. Each forest community is described in

Appendix 1 while all vascular plants encountered in the study are listed in Appendix 2.

Our field sampling noted forest structure as well as species diversity in each vegetation tier. Forest structure was most complex in podocarp/hardwood stands and contributed greatly to the high number of species per community at low altitude. Though not assessed numerically, distribution of passerine birds appeared to follow the same pattern in abundance and diversity (*c.f.* Crook and Best, 1974).

Accompanying the general reduction of plant diversity several species increase in abundance in the simpler silver beech forests higher on the Longwoods. Histograms of species importance for trees, and shrubs and herbs together (Fig. 2), show a gradual

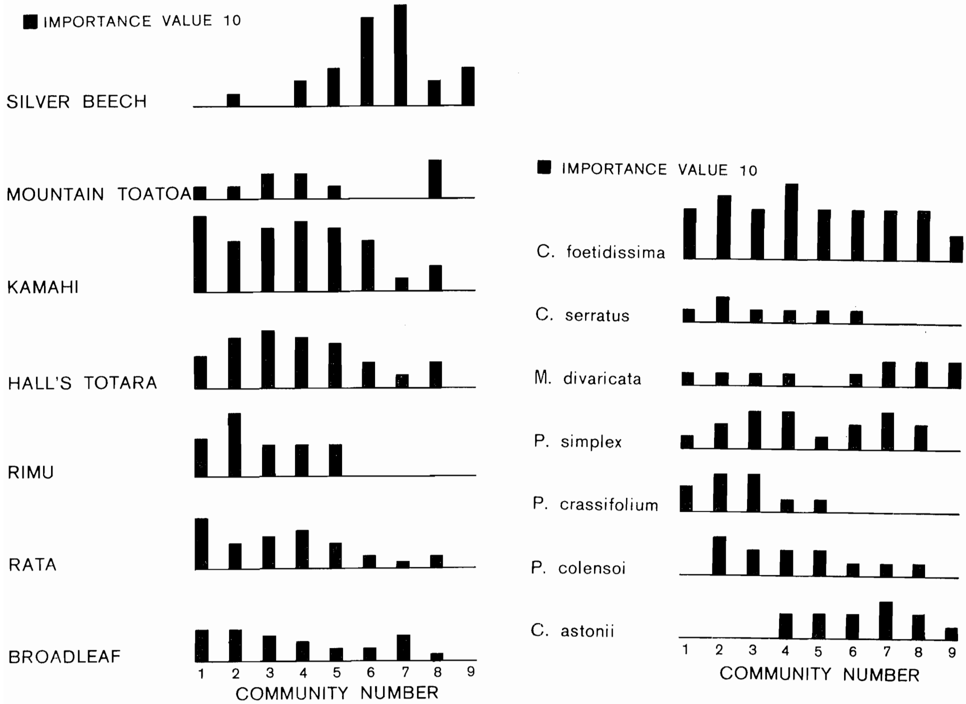

FIG. 2—Mean importance values within communities of major canopy species (left) and of major shrub species (right). **C. astonii** should read **C. pseudocuneata.**

merging but changing composition, such that lowland and bushline forests have little similarity. These estimates of species importance plotted on, in effect, an altitudinal gradient are complemented by the two-dimensional ordination (Figs. 3 and 4); the method for which, Whittaker (1973) describes as a form of indirect gradient analysis.

All nine forest communities recognised from the agglomerative grouping of field plots were assigned a symbol and plotted on the ordination in Fig. 3. The distribution of plots in the ordination space is considered to display ecological relationships within and between these community types. Forest interpretation by ordination was then compared with the original National Forest Survey typing for the south-west Longwood

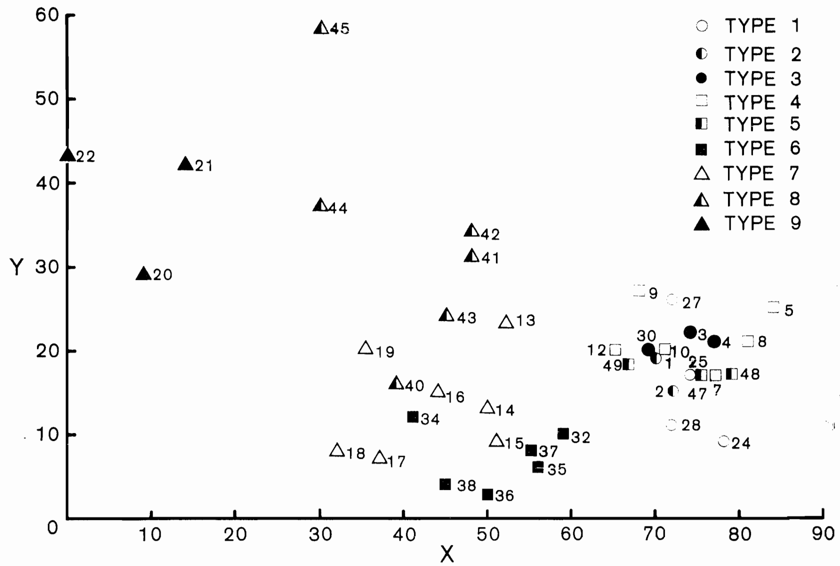

FIG. 3—Forest communities recognised by grouping shown within the ordination.

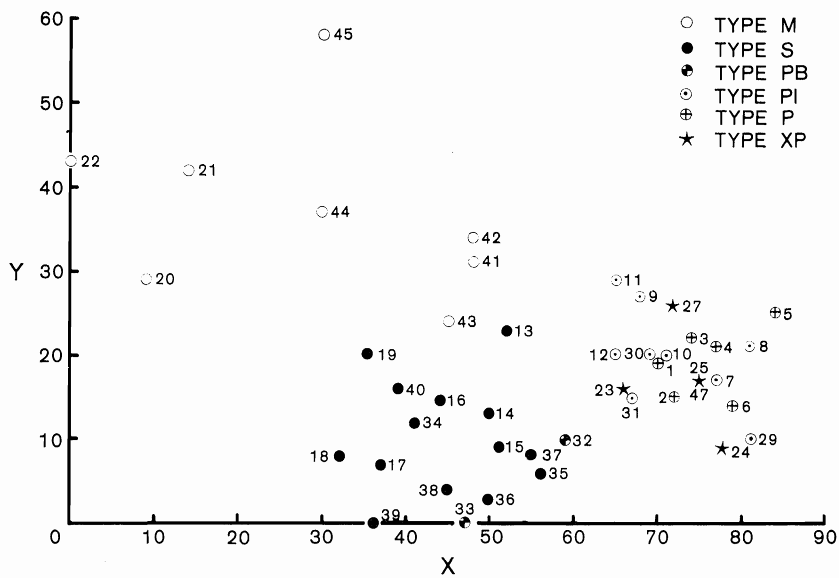

FIG. 4—National Forest Survey types shown within the ordination.

unit carried out by Holloway (1953a). Six N.F.S. types were mapped within the Taunoa area and when plotted on the ordination in Fig. 4 they bear a very close resemblance to the communities as set out in Fig. 3. The resurvey and ordination displayed further forest variation but substantially confirms the descriptions given by Holloway (1946, 1953a, 53b) and later by Masters, Holloway and McKelvey (1957) who state:

> "The rimu-rata-kamahi stands grade imperceptibly into mixed silver beech-rimu stands at altitudes exceeding 1200 ft; and from this point to the timberline about 2500 ft . . . . are pure silver beech stands, their quality decreasing rapidly with gain in altitude."

Forests within the reserve appear to be part of a continuum of changing composition and structure generally along an altitudinal gradient. Whilst this gradient is the most obvious in its effect on the forest composition it is more than likely an expression of several interlocked environmental gradients. However, as noted by McKelvey (1973) in his description of the altitudinal gradation in forests of the Ureweras, subjective forest class or community boundaries tend to follow contours but are at best arbitrary and concerned with the modal frequency maxima of prominent canopy species. This arbitrary grouping of communities within a continuum is effectively illustrated in Figs. 3 and 4. Clearly, there is a very strong grouping between types with a substantial podocarp element, whilst the silver beech-dominated communities are more scattered along the first two axes of the ordination. This indicates that the primary forest survey of the area was sufficiently detailed to allow classification into types reflecting quite subtle ecological variation. In addition, there appear to be small-tree, shrub and herbaceous species with a degree of positive or negative association with particular physiognomic dominants. Where this occurs the community could be ecologically characterised largely from density and dimensions of the canopy trees and soil profile descriptions. Several profiles of forest soils were excavated and described in the present study. Though broadly relating to altitude and forest type, soils in the proposed Taunoa reserve also strongly reflect local relief and age of parent material; such as younger, fertile soil on stream gully alluvium.

Almost 30 years has passed since the National Forest Survey of the Longwood Range, a short time in the life of undisturbed indigenous forest. The only discernible difference today may be a reduction in browsing by deer and opossums leading to improved density and vigour of palatable, broadleaved species and younger age-classes of canopy trees. Despite the separation of years it is considered that the quantitative results of this study can be used to evaluate N.F.S. typing of the unlogged and lightly logged forests in the proposed Taunoa Biological Reserve. Both clustering-ordination and N.F.S. typing-mapping fit the same basic pattern. Thus, despite earlier doubts about the ecological validity of the National Forest Survey types, the analysis presented here supports their use in the initial planning of scientific reserves in indigenous forests. Indeed, Holloway (1947) noted that the primary survey was not an end in itself but it mapped and recorded the distribution of the forest types. Moreover, it should indicate the inter-relationships of the various forest-types in order to provide a starting point for a more detailed study. Kirkland (1975) has recently indicated the progress being made toward that objective in State indigenous forests. From the work of Nicholls (1974, 1975), Franklin (1975), Beveridge (1975), Beveridge and Franklin (1975), McKelvey (1963, 1973) and Kelly (1975) among others, it is clear that ecological criteria are being widely used in deciding appropriate management for particular indigenous forests.

The analyses used in this small study are more sensitive than the original forest survey approach but can be considered to complement forest typing. The ordination presented here is particularly useful when analysing the variations and relationships of forest communities, together with their soils and animal populations within resource units. More detailed field measurements would, after ordination, indicate the full range of variation, and the adequacy of proposed scientific reserves and their boundaries could then be assessed. Reserves often have actual boundaries along easily-identified landscape features and even artificial boundaries caused by previous logging, or fires. However, this should not rule out the scientific value of including all available ecosystems on continuous ecological gradients when biological reserves are designated where unbroken tracts of forest remain, especially in the southern beech and podocarp/hardwood forests.

Forest ordination provides an excellent framework upon which other field surveys and environmental data can be established and studied as a whole system. Quantitative assessments of beech forest bird diversity by Crook and Best (1974), and McLay (1974), gradients in forest composition in the Charleston reserve by Herbert (1973) and of forest soils in the Inangahua Depression by Mew *et al.* (1975) provide first class data which can be fitted to ordinations. It would then be seen more clearly that biological reserves are whole ecosystems, which provide preservation of flora and vegetation, soil sequences, fauna and food chains. Ordination techniques are thus considered to have value in the final synthesis of multi-disciplinary surveys currently occurring in many areas of indigenous forest.

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Appendix 1 — Description of Plant Communities

COMMUNITY 1: Podocarp Cutover

Open canopy dominated by kamahi (**Weinmannia racemosa**), rata (**Metrosideros umbellata**) together with rimu (**Dacrydium cupressinum**) Hall's totara (**Podocarpus hallii**) and miro (**Podocarpus ferrugineus**).

The shrub layer is dense and dominated by stinkwood (**Coprosma foetidissima**) together with **Pseudopanax simplex**, **P. colensoi**, **P. crassifolius** and **Carpodetus serratus**. Hook sedge (**Uncinia** sp.) is common among dense bryophytes on the ground.

The podocarps which remain are of poor form and unmerchantable. Rimu and miro regeneration is common in many areas but of the canopy species kamahi is regenerating most vigorously.

COMMUNITY 2: Mixed Podocarp

This is the most complex community within the reserve. The main canopy tree species is rimu with miro and Halls totara. Kamahi and occasional rata occur as sub-canopy trees. A notable feature of the community is occasional silver beech (**Nothofagus menziesii**) which may indicate upslope riparian invasion. A moderately thick shrub layer of stinkwood, putaputaweta, **Dicksonia squarrosa** and mapou (**Myrsine australis**) is present.

Ground cover is usually **B. discolor**, **Nertera dichondraefolia** and **N. depressa** with **Uncinia** species. Bush Lawyer (**Rubus cissoides**) is present throughout the community.

COMMUNITY 3: Midslope Podocarp

This community is the upland facies equivalent of Community 2. It is associated with generally better-drained slopes with wide interfluves and benches. The absence of silver beech is of interest, the physiographic position of the community being too high for invasion from riparian stands but too low for invasion from beech stands at higher altitude.

Rimu with Hall's totara are still dominant canopy species but kamahi and rata are generally common. The shrub layer is more open but with stinkwood still dominant. **Myrsine australis**, **Pseudopanax simplex** and **P. colensoi** commonly occur with occasional **P. edgerleyii**. The ferns **Blechnum discolor**, **B. minus**, **Asplenium bulbiferum**, **A. flaccidum** and **Phymatodes diversifolium** are all important components of the ground flora together with the ubiquitous **N. dichondraefolia**.

COMMUNITY 4 — Upland Podocarp

The upland podocarp community marks generally the upper altitudinal limit of rimu and miro. Canopy is relatively open and stem form is generally poor. The community is an important interface between podocarp and beech communities. Silver beech occurs throughout as a result of downslope invasion. Mountain toatoa (**Phyllocladus alpinus**) is a dominant component of the subcanopy and sapling tiers. Occasional pink pine (**Dacrydium biforme**) are a feature of the community. Shrub layer is fairly open with **Coprosma astonii** and **C. foetidissima**.

COMMUNITY 5 — Riparian Beech/Podocarp

This community forms relatively narrow strips within the reserve and along streams where water-borne seed originating in higher pure beech areas eventually becomes established. These sites are very often optimal in terms of soil nutrients and moisture availability so that tree growth rate and form is impressive in both silver beech and podocarps. The silver beech has a good representation of age-classes. Tree ferns **Cyathea smithii** and **Dicksonia squarrosa** are major components of the sapling tier together with broadleaf. Once again stinkwood is the dominant shrub species with pepperwood (**Pseudowintera colorata**) and **Pseudopanax simplex**. Heavy ground cover of **B. discolor**, **B. fluviatile** and **A. flaccidum** is a feature of the community. So too is a luxuriant ground and lower tree bark cover of forest bryophytes and foliose lichens.

COMMUNITY 6 — Silver Beech/Kamahi

Silver beech dominated community with a high percentage of kamahi in the canopy. Hall's totara still occurs spasmodically in the sub-canopy with some rata and broadleaf. The silver beech is of good form and has suffered little from climatic factors, such as snow and high wind. **Coprosma foetidissima** is still a dominant shrub species but **C. linariifolia** and **C. astoni** are also present. **Pseudopanax simplex** and **P. colensoi** with occasional **P. edgerleyii** and **Myrsine divaricata** are important components of this layer. Ground cover is heavy, of crownfern and **Asplenium flaccidum** with **Nertera dichondraefolia** and less commonly **N. depressa.**

Rubus cissoides is the common climber. This particular community would represent a zone which occurs at the interface of the Pl and S Forest Survey types.

COMMUNITY 7

A silver beech community without the kamahi component of community 6. Considerable snow and wind damage has occurred in the beech canopy, such that light gaps have in many cases allowed grouped regeneration to develop. There is little or no rata and the upper limit for broadleaf. Shrub layer is fairly open with **Coprosma foetidissima, C. linarifolia** and **C. astonii. Blechnum discolor** and **Polystichum vestitum** are an important component of the ground cover but not as dense as further downslope. Interspersed among the bryophyte cover, **Lagenophora petiolata** is a characteristic ground species.

COMMUNITY 8

A simple structured community of silver beech and mountain toatoa. Occasional pink pine of poor form appear but no kamahi or broadleaf. There is an open shrub layer of stinkwood and **C. linarifolia. Blechnum** cover is very sparse though there is some **Polystichum vestitum**. Soil profiles are strongly podzolised with iron pans and deep mottling.

COMMUNITY 9 — Montane silver beech community

A community which occurs on the more gentle slopes before forest gives way to open grassland. Stunted silver beech no more than 8 m high dominates the community with few other species. **Coprosma pseudocuneata** is a characteristic shrub species, often forming dense thickets. Leatherwood (**Olearia colensoi**) occupies the bush edge and enters the forest for some way. No **B. discolor** or **P. vestitum** occurs but ground cover is largely **Hymenophyllum** species, liverworts and mosses.

APPENDIX 2 — List of plant species

TREES

Aristotelia serrata	wineberry	**Leptospermum scoparium**	manuka
Carpodetus serratus	putaputaweta (marble leaf)	**Metrosideros umbellata**	southern rata
Dacrydium biforme	pink pine	**Nothofagus menziesii**	silver beech
Dacrydium cuppressinum	rimu	**Phyllocladus alpinus**	mountain toatoa
Elaeocarpus hookerianus	pokaka	**Podocarpus ferrugineus**	miro
Fuchsia exorticata	konini (fuchsia)	**Podocarpus hallii**	Hall's totara
Griselina littoralis	puka (broadleaf)	**Weinmannia racemosa**	kamahi

SMALL TREES AND SHRUBS

Coprosma astonii		**Myrsine australis**	mapou
Coprosma foetidissima	stinkwood	**Myrsine divaricata**	
Coprosma linarifolia		**Olearia colensoi**	leatherwood
Coprosma lucida	shining Karamu	**Pseudopanax colensoi**	mountain five-finger
Coprosma propinqua	mikimiki	**P. crassifolius**	lancewood
Coprosma pseudocuneata		**P. edgerleyi**	
Coprosma rhamnoides		**P. simplex**	
Cyathodes juniperina	mingi mingi	**Pseudowintera colorata**	pepperleaf
Dracophyllum longifolium	terpentine wood	**Rubus australis**	bush lawyer
Gaultheria sp.	snowberry	**R. cissoides**	bush lawyer
Lophomyrtus obcordata			

HERBS

Astelia spp.	native lily	**Libertia pulchella**	
Celmisia gracilenta	grassland daisy	**Luzuriaga parviflora**	
Collospermum hastatum		**Microlaena avenacea**	bush rice grass
Chionochloa rubra	red tussock	**Nertera depressa**	
Corybas rivularis	native orchid	**N. dichondraefolia**	
Dendrobium cunninghamii	native orchid	**Pterostylis** spp.	native orchid
Earlina autumnalis	native orchid	**Uncinia silvestris**	hook sedge
E. mucronata	native orchid	**U. uncinata**	hook sedge

FERNS AND FERN ALLIES

Asplenium bulbiferum	hen and chickens	**Dicksonia squarrosa**	weki
Asplenium flaccidum		**Grammitis billardieri**	
Blechnum capense		**Hymenophyllum** spp.	
Blechnum discolor	crown fern	**Lycopodium australianum**	
Blechnum fluviatile		**Phymatodes diversifolium**	stagshorn fern
Blechnum minus		**Polystichum vestitum**	
Ctenitis sp.		**Tmesipteris tannensis**	
Cyathea smithii	soft tree fern		