RESUMES OF CONFERENCE PAPERS

Resumés of papers read at the Ecological Society Conference, 1979, are presented (except those presented in full elsewhere in this volume). For the complete programme of papers given at this Conference please refer to the Annual Report at the back of the Journal.

THE POSSIBLE DEVELOPMENT OF A MAJOR FORESTRY INDUSTRY IN NORTHERN MARLBOROUGH

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During the late nineteenth century, there was a rapid change in land use over a substantial area of Marlborough north of the Wairau River, including the Sounds, from mixed hardwood, podocarp and beech forests to pasture. Much of the hill country has been unable to sustain an economic level of pastoral farming and is currently in varying stages of reversion.

A land use survey over an estimated 288 700 hectares of North Marlborough showed that about 50 % of the area is under an indigenous cover of high forest or advanced regeneration (see Table 1). Much of this land is owned by the Crown and lies within Mt Richmond State Forest Park or the Marlborough Sounds Maritime Park. Pastoral farming continues on 48500 hectares (17%) and exotic forests occupy 19300 hectares (7%). Reverted hill country occupies 73300 hectares (25%) and this is the land base on which most exotic forests will continue to be established.

Recent planting rates have been as high as 2000 hectares per annum, and if this continues for another two decades, there would be a total exotic forest resource of approximately 60000 hectares. Present and possible future land uses in twenty years time are shown in Table 1, assuming there are no changes in area of other land uses during this period.

In terms of area, exotic forests will remain a relatively minor land use in Northern Marlborough and less than 6 % of the total area of Marlborough County.

The total area of commercial exotic forests in Marlborough is estimated (at 31 March 1979) to be about 20460 hectares; this is predominantly *Pinus radiata* (93 %), predominantly planted north of the Wairau River (94%), mostly planted since 1971 (73 %) and mostly privately owned (63 %).

The volume of sawlog quality roundwood is forecast to rise dramatically by the turn of the century to around 990 000 cubic metres per annum, with an additional 240 000 cubic metres per annum of lower quality roundwood. Local requirements for sawn timber are unlikely to exceed 6% of future sawlog production and regional requirements in Wellington and Canterbury are likely to be met by other regions, thus releasing the majority of this roundwood for export. This will represent about 3% of New Zealand's future roundwood production of 35 million cubic metres per annum which would be less than 1 % of the total world consumption, estimated as being 4500 million cubic metres per annum. Future markets appear to be readily available, particularly for high quality sawntimber and plywood.

TABLE 1. *A summary of current and possible future land use in Northern Marlborough.*

	Present (1979)		Future (1999)	
	Area		Area	
Land Use	(ha)	(%)	(ha)	(%)
Pastoral farming	48 500	17	48 500	17
Indigenous forest and advanced regeneration	144 700	50	144 700	50
Exotic forest	19 300	7	59 300	20
Reverted hill country	73 300	25	33 300	12
Other uses	2 900	1	2 900	1
Total	288 700	100	288 700	100

A wide range of processing alternatives are available particularly if a policy of maximum local processing is pursued. The final choice could involve a mixture of log export and local processing. On current scales of operation, there would not be sufficient low quality roundwood and sawmill residues available locally to establish a chemical pulp mill unless augmented by wood supplies from outside the region. The Marlborough wood resource is adequate to sustain a thermo-mechanical pulpmill from forest and sawmill residues.

Overseas earnings could bring in $46 million per annum from log exports or $68 million per annum from processed exports of sawn timber and woodpulp by the year 2000. Direct employment would involve 570 in the log export option and 970 in the processed option.

Attention is drawn to the relatively low nutrient requirements of *Pinus radiata* in comparison with other common agricultural crops. A literature survey by Will and Ballard (1976) concluded that there appeared to be no justification for the popular belief that successive crops of conifers produce irreversible changes in the soil when normal forest operations were carried out; any problems that had arisen occurred largely as a result of practices such as litter removal, charcoaling or regular understorey burning. Site productivity could be maintained by fertilising.

There are extensive areas of privately owned land in Northern Marlborough which are well suited for exotic afforestation. The extent of the development of an exotic forest industry depends to a large extent on local and national land use policies over the next decade.

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THE MARLBOROUGH CATCHMENT BOARD EAST COAST SURVEY: EFFECTS OF CLIMATIC EXTREMES

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Cyclone Alison, of tropical origin, manifested itself on the Kaikoura coast in March 1975 as a rainfall event with a return period of one in more than 200 years. Road and rail links of national importance were devastated. The Marlborough Catchment Board initiated the East Coast Survey to assess the condition of catchments and stream channels influenced by the cyclone, and to make appropriate recommendations. A land inventory survey. in which the soils, slopes, vegetation and erosion were mapped, was carried out on an 80 000 hectare area. A Potential Land Use classification was made in terms of the physical limitations for a particular use; arable, non-arable, production forestry, or watershed protection. A Recommended Land Use classification which introduced social and economic constraints to the Potential Land Use, was then implemented. The values related to primary production, recreation, scenery, science, transport and energy were also considered.

A survey of 116 streams was conducted. Detritus volume was estimated, the sources investigated (be they slip feeders, stream banks, gully heads, or bed workings), and assessed for importance. Possible treatments were considered and ranked in terms of desirability. A priority was set on each stream depending on its importance to national transport artery, county road, or farmland.

Land use recommendations and stream channel proposals were influenced by a number of recent changes in emphasis:

i. Channel form and behaviour are the product of a number of factors most of which are not manipulable by man.
ii. Sediment commonly derives from sources where it has been held in temporary storage in the valleys and channels themselves rather than the upper catchments.
iii. Many spectacular erosion features do not actually feed into any channel.
iv. Flood waters derive from the lands immediately adjacent to the stream channel and the bed of the channel itself.
v. Water quality degradation by nutrient run-off from aerial fertilizer spreading and livestock depasturage in riparian areas can be a serious problem.

The change in emphasis resulting from the above considerations meant that recommendations tended to be concerned with the riparian zone rather than the upper catchments or the channels themselves. In point of fact, on only 11 of the 116 streams investigated was any debris retention recommended. The common proposal would be reinforcement of the stream banks with poplar *(Populus* spp.) or willow *(Salix* spp.) plantings, or retirement of the riparian zone, this latter almost inevitably involving a difficult fence line.

Catchment proposals centred around the stability to be achieved by trees. Unstable mudstone soils were recommended to be space-planted. Production forest recommendations varied from planting *Pinus radiata* at 2m X 2m spacing, through the use of long rotation species on steep untracked slopes, to enrichment planting of moderately high altitude unproductive beech *(Nothofagus)* forest.

Appropriate areas were set aside as reserves for scenic, scientific, and recreational purposes as well as for the protection of soil and water values. Almost 20 % of the surveyed area was assigned a non-productive role.

The conclusion was that the Kaikoura coast includes much high, steep, earthquake-riven country that continues to be uplifted comparatively rapidly. It is subject to high intensity storms, and part of the price of retaining the tenuous national transport arteries along it is that from time to time they will be disrupted.

NEAR-SHORE SEA WATER QUALITY, MARLBOROUGH SOUNDS

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In January 1978 the New Zealand Forest Service initiated a seawater sampling programme to provide a broad indication of the seawater quality near the foreshores of selected areas under forestry development in Pelorus and Queen Charlotte Sounds. At 8 near-shore sites, ranging between Wet Inlet and the mouth of the Pelorus River in Pelorus Sound, 1 litre samples of surface seawater were collected on a two week basis, mainly during fine weather periods. At 2 near-shore sites in the Bay of Many Coves, Queen Charlotte Sound, samples were collected at very irregular intervals during storm periods. Sample salinities were determined by gravimetry, and suspended solid concentrations were determined by filtration methods.

Salinities at the Pelorus Sound sites excluding a site near the Pelorus River mouth averaged between 27 and 33 p.p.t. but individual samples ranged from 13 p.p.t. to 35 p.pt. At near-shore sites in Crail Bay and Four Fathoms Bay salinities appear to be closely related to the antecedent rainfall. During storm periods fresh water masses, derived from storm streamflows, cause seawater dilution and unpredictably low salinity values. Salinities at Cullens Point, which is heavily influenced by the Kaituna and Pelorus River inflows, averaged 13 p.p.t. and ranged between 2 and 25 p.p.t.

Seawater suspended solid concentrations during fine weather conditions usually remained between 0 and 10 p.p.m. However, between January and June 1978 concentrations were generally higher, averaging about 15 p.p.m. The higher concentrations may have been related to a period of high biologic activity because a large part of the suspended solids consisted of algal fragments and diatoms. Over most of the sampling period suspended solids consisted of platey clay minerals, silt-sized mineral fragments and diatoms.

During heavy storms in April and August 1978 the near-shore seawater at the Bay of Many Coves was influenced by a flooded stream carrying high suspended sediment loads from a recently clearfelled and tracked catchment. Contamination was restricted to the vicinity of the stream mouth. In the April and August storms seawater sediment concentrations 10 m offshore from the stream mouth averaged 560 and 156 p.p.m. respectively, but turbidities decreased quickly after cessation of rainfall.

Laboratory flocculation tests in seawater, using Kenepuru soils collected in the Crail Bay region, showed that flocculation and settlement of suspended soil materials occurs rapidly in seawater. These tests combined with the results of the seawater sampling programme, suggest that suspended sediment derived from small freshwater streams or coastal erosion is likely to precipitate and settle rapidly in the proximity of the foreshore region. Fluctuations in salinity and turbidity appear to be most pronounce:! within 50 m of the shoreline.

SUSTAINABILITY OF RESOURCE USE IN MARLBOROUGH SOUNDS

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Nine main types of land and water use (pastoral agriculture, horticulture, *Pinus* forestry, native forestry, native vegetation reserves, commercial fishing, aquafarming, tourism and recreation, retirement and self-employment) were compared in tabular form as to sustainability. Sustainability was defined as the sum of our estimates of the renewability of each land use and its compatability with the other land uses. The resource uses which depend on maintaining the original land and water ecosystems, like native forestry, fishing and tourism, we judge to have a higher sustainability, whereas monocultures like *Pinus* forestry and mussel farming we judge to have a lower sustainability, all depending to a large extent on management. We consider a mix of the more sustainable systems the most desirable.

MYCORRHIZAS AND THE SPREAD OF BEECH

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It has always seemed important to biogeographers to understand the dispersal of *Nothofagus,* the southern beeches. Darlington (1965) for example, in his book on the biogeography of the Southern Hemisphere suggested that it could be the key to the history of all terrestrial life in the southern lands.

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There are two features of beech dispersal in New Zealand which have always seemed odd. One is its failure to cross Foveaux Strait and take its proper place in the Post-Pleistocene forests of Stewart Island. The other is the narrow band of seedlings along the margin of a beech forest that is expanding into its neighbouring community-normally seedlings establish only in a belt about equal in width to the height of the parent trees. Both these situations have been attributed simply to the poor dispersal of the wind borne seeds (Holloway, 1954). But this is windy country, and beech seeds have wings and are so light that it may take nearly half a million to weigh a kilogram (Preest, 1961). McQueen (1951) was indeed puzzled at the ease with which he found not only seeds but whole full cupules 15 times the distance from the forest edge that he could find seedlings.

I contend that what has been lacking in our understanding of beech dispersal is an appreciation of the part mycorrhizal fungi play in its spread. My basic assumption is that plants in their natural soils are normally mycotrophic for phosphorus. They obtain phosphorus from the soil via the mycelium of symbiotic fungi that extend from the root cortex into the soil, converting the root into mycorrhiza. Other nutrients and water will of course enter this way, but it is usually only phosphorus for which mycorrhizas are essential (Baylis, 1967).

Silver beech *(Nothofagus menziesii')* seedlings raised in podocarp soil that had been steamed to kill mycorrhizal fungi ceased growth with about six leaves and a dry weight below 50 mg. They were limited by the phosphorus stored in the seed. Though steaming slightly increases the phosporus available in the soil (Baylis, 1967) they could obtain none without mycorrhizas. In contrast seedlings raised in pots of untreated beech forest soil, provided that mycorrhizas were quickly established, had two or three branches at the end of their first growing season and a dry weight about 500 mg.

Morrison (1956) and June (pers. comm.) have also found that beech seedlings fail in podocarp soil just as consistently as if the soil has been steamed. This demonstrates that the distribution of is mycorrhizal fungi determines where beech can grow. Beeches have ectomycorrhizal symbionts; the rest of the flora, with few exceptions, have endomycorrhizal symbionts, an entirely different group.

Thus, natural soils in New Zealand usually lack fungi to assist the growth of beech. An essential step in ecesis for most species is linking with the mycorrhizal mycelium dominating their patch of soil. Through it they derive what is in limiting supply (usually phosphorus but perhaps even water at times) not only from the soil but possibly also from established plants nearby (Read, Malibari and Whittingham, 1979). Insofar as beech symbionts are active only in association with beech roots, beech seedlings are normally restricted to the rooting zone of beech trees, a zone about as wide as the trees are tall.

Where will beech seedlings escape these limits? Most obviously where soil contains enough phosphorus to be absorbed directly. To take up phosphorus from poor soils roots must produce abundant hairs a millimetre or more long. Hairs were plentiful on non-mycorrhizal roots of silver beech in forest loam, but their average length was only 0.2 mm. Wardle (1980) estimates a prevailing length of 0.5 mm on similar roots in stream gravels. In a preliminary experiment (ct. Baylis, 1972) studying response to increasing doses of phosphate by silver beech, black nightshade *(Solanum nigrum)*, and karamu *(Coprosma robusta)*, beech and karamu gave parallel results, both being less responsive than black nightshade. Beeches thus appear to be about as mycotrophic as tea tree *(Leptospermum scoparium)*, karamu and kamahi *(Weinmannia racemosa)*, beginning growth without mycorrhizas in the range 15-30 p.p.m. available phosphorus (Baylis, 1975). It is where there are slips, windthrows and new alluvium that available phosphorus is likely to be high enough to be absorbed directly by beech root hairs.

The second possibility is that a beech seedling will share a mycorrhizal fungus established in the roots of another host species. The only other widespread New Zealand genus that can be ectomycorrhizal is *Leptospermum* but, unlike beech, teatree also forms efficient endomycorrhizas (Baylis, 1971). John Wardle (1970) and Peter Wardle (1980) observed that beech seedlings extend further into shrubland than into grassland which suggests that the ectomycorrhizal fungi of tea tree can cross to beech. It would be interesting to discover what happens to beech seedlings planted where teatree seems to be taking the place of beech, e.g. on Stewart Island. Perhaps all Stewart Island teatree is endomycorrhizal.

The third possibility is that beech seed and fungus spore will germinate together and claim sufficient phosphorus and any other essentials for growth. This might happen on a slip or in a wind throw but it seems most likely where a stream deposits seed and inoculum along with new soil. This links with seed dispersal in explaining why beech migrates most readily downstream.

Dispersal of and competition between endo- and ecto-mycorrhizal symbionts must also playa part when pole stands of beech thin sufficiently to admit an understorey, and may do more than feral deer to explain why beech forest interiors often seem to offer unexploited resources of light and moisture. Ferns can form ectomycorrhizas but these are probably inefficient since endomycorrhizas are formed where shrub and herb layers are well developed under beech (Cooper, 1976). Both mycorrhizal systems must also co-exist where beeches are just scattered co-dominants in forest.

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POST-GLACIAL VEGETATION CHANGE IN COASTAL SOUTHLAND

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Radiocarbon dating and pollen analysis of raised bogs in coastal Southland show that the present forest pattern is of relatively recent origin (McIntyre and McKellar, 1970; M. H. McKellar, unpublished; McGlone, unpublished).

The first forest to colonise the region at the beginning of the post-glacial was dominated by *Podocarpus spicatus* and *Dacrycarpus dacrydioides*. From 10 000 to 5-6 000 years ago this forest showed little change, except for a tendency for *Dacrycarpus* to decrease. At about 5-6 000 years ago there was an upsurge of *Dacrydium cupressinum*. At the same time, or shortly after, *Nothofagus menziesii* began to increase. After its initial rapid increase, *D. cupressinum* stabilised but *N. menziesii* has continued to increase slowly right up to the present. *Dacrydium bidwillii / biforme* group, although present before the rise of *D. cupressinum,* increased in abundance on the bog surfaces. The prominent layer of *D. bidwillii / biforme* group wood found in many Southland bogs probably dates from this period. The final major forest change recorded in these bogs, the spread of *Nothofagus fusca* group (this group includes all New Zealand *Nothofagus* species, except *N. menziesii),* occurred between 2 500 and 2 000 years ago.

The few dates available tend to support the hypothesis that migration from a distant source was a minor factor in the change of forest type. *D. cupressinum* has easily dispersed seed and it is conceivable, though unlikely, that it spread to Southland from a distant source: the same cannot be said of *N. menziesii*. Johnson (1978) and Wardle and McKellar (1978) have shown that *N. menziesii* survived throughout the last glaciation in Fiordland. The restricted dispersal ability of *N. menziesii,* and its present disjunct distribution in eastern Southland and Otago, suggests that it also survived in several locations in the east during the last glaciation. The increase in *N. menziesii* forest can be seen, therefore, as a spread from isolated nuclei rather than, as envisaged by Harris (1963), a migration from west to east.

The most likely reason for the upsurge of both *D. cupressinum* and *N. menziesii* was a change from the relatively dry and warm conditions prevailing in the early post-glacial in coastal Southland, to a wetter and cooler climate. Wetter conditions favour *D. cupressinum,* whereas wet and cool climates encourage *N. menziesii* and D. *bidwillii / biforme*. Stronger westerly air flow over the South Island bringing more frequent south-westerly cold fronts may have provided such conditions.

The late expansion of *N. fusca* group is more difficult to explain, but its apparent synchroniety in widely separated areas suggests that the ultimate cause was also climatic. In Central Otago the spread of *N. fusca* group was associated with destruction of forest by fire (McGlone, unpublished). Possibly, the last few millenia have seen increasingly variable weather patterns leading to more extreme events, such as drought and storms, which have opened up forest to invasion by *N. fusca* group.

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DENDROCHRONOLOGY AND DENDROECOLOGY- AN INTRODUCTION

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Trees record past events at two levels; their annual rings respond to the various climatic, competitive and phenological events of the year, while the population age frequency distribution reflects changing patterns of survival and recruitment. Traumatic events affecting growth, such as severe storms or fires, may leave their mark both on the annual ring of the year in question, and on the age structure of the succeeding population.

The dendrochronologist is interested in the pattern of wide and narrow rings from year to year, and these patterns can be matched between selected trees, and "average" sequences measured. The average pattern of ring width variation on a site is referred to as the site chronology, and it can be used for a variety of purposes. For example, specimens of unknown age can be accurately dated by matching to the average pattern. This aspect of dendrochronology has been extensively used for dating archaeological sites. Also, the annual ring width chronology can be correlated with rainfall or temperature records and thus used to reconstruct the history of climate over lengths of time far exceeding those covered by instrumental records. The methods and uses of dendrochronology have been reviewed by several authors (e.g. Ferguson, 1970; Fritts, 1976; Ogden, 1978a).

Dendroecology may be defined as the study of annual growth rings in an ecological context. Interest usually centres on the ages of trees and on changes in growth rates and recruitment. Traumatic events affecting a large proportion of the population are often of particular interest and may be very precisely dated if the event markedly alters the growth rate of the survivors; or leaves some other "signature".

Studies on the ecology of New Zealand forests have frequently commented on age-class distributions (e.g. Holloway, 1954). Such comments have often relied on an assumption that age and size (diameter at breast height) are at least roughly correlated (e.g. Ogden, 1971) although where this relationship has been carefully studied it has been found to be of rather limited predictive value (Clayton-Greene, 1977; Ogden, 1978c). It is important to make a clear distinction between the methods, aims and acceptable levels of accuracy involved in the ageing of individuals for the study of stand dynamics on the one hand, and the cross-dating of individual ring-width sequences for the purposes of dating or climatic reconstruction on the other.

Speculation about the dynamics of tree populations can only be satisfied by categorising, counting and ageing individuals. In principle, where the trees in question have annual rings, the latter is relatively easy, although in practice a number of difficulties arise:

1. It is easy to take an increment core from a tree, but much more difficult to ensure that that core goes through the (chronological) centre.
2. Allowance must be made for the time taken for the tree to grow to the height at which the core was taken.
3. Individual annual rings, or groups of rings, may be absent on some radii.

Although certain allowances can be made to minimise all of these errors, the net result is that while we may arrive at an estimate of the minimum age, in most cases the true age eludes us. To establish an age frequency distribution for an area of forest we must also solve sampling problems which may differ from site to site or between species. However, a brief consideration of the size-frequency distribution in an unthinned pine plantation, which frequently approximates a log-normal hierarchy, should convince the ecologist of the need for age data. In such a case, size and mortality bear no relationship to age. From my experience with conifers in Tasmania and New Zealand, I suggest that many such natural populations resemble a "competitive thinning monoculture", with a very restricted age range, more closely than they resemble steady state multiple aged systems (Meyer, 1952), despite the intriguing computer modelling possibilities offered by the latter!

While in general the forest ecologist must accept a fairly large variance associated with his age estimates, the dendrochronologist is concerned with the absolute dating of each ring to the year of its formation. The technique relies upon, and is justified by, its absolute accuracy. Age estimates derived from a properly constructed tree ring chronology have no variance; it is for this reason that tree ring chronologies are proving so valuable in locating sources of error in radiocarbon dating (e.g. Damon *et al.,* 1974; Pearson *et al.,* 1977). This emphasises the fact that a tree ring chronology based on dated wood samples can also be analysed in other ways –for example, for isotopic composition (see e.g., Pearman *et al.,* 1976). Palaeoclimatic reconstruction using isotope ratios is a rapidly developing field, and it is likely that cross sections of old trees will prove to be important sources of material for such work. For this reason there is an urgent need to conserve ancient wood samples.

Chronology construction involves a series of selections which are subjective when first made, but which can be objectively vindicated as the work progresses. In climatic reconstruction, the first requirement is to choose a species and a site which is "sensitive" to climatic variations. The concept of "sensitivity" is discussed by Fritts (1976); in ecological terms it generally implies the choice of a site in which the species is close to its limits of tolerance for one or more environmental factors. For example, I have used *Athrotaxis cupressoides* growing at timberline in Tasmania (Ogden, 1978b). Within such a site the older individuals will be cored, and the cores subsequently mounted for examination. Repetition of sites is an important aspect of chronology construction; it is the recognition of similar patterns of ring width variation over the same time span on different sites which gives confidence in the cross-dating and in the climatic nature of the signal recorded by the trees.

Once a set of cross-dated cores has been obtained from a site the ring widths must be measured and averaged. Usually the raw data are converted into indices, either by dividing each individual ring width by the equivalent year value for a curve fitted to the whole of the data, or in some other way. The purpose of this indexing is to remove any long-term growth trends which are unique to individual trees and not climatic in origin (for details see Fritts, 1976). The final steps in chronology construction involve comparisons between sites, and may lead to the averaging together of a number of site chronologies to produce a regional or master chronology. Because different tree species respond to climatic influences differently, they may produce rather different chronologies even when sampled on tile same sites. Consequently, in the reconstruction of climate from tree rings it is important to work on several species, which together will provide a much more complete picture than would anyone species alone. The major intellectual (and statistical) difficulty lies in understanding the main aspects of the species' response to climate, and it is here that physiological and ecological knowledge of the species is invaluable. It is likely that the full potential of dendroclimatology will not be realised in New Zealand until detailed "Biological Flora" accounts, or something similar, are available for a wide range of conifer and hardwood species.

One of the major challenges in dendrochronology is the interpretation of medium and long-term trends in tree ring sequences. In general, direct instrumental records of climate are not long enough to be of much use in this problem, but where such trends agree between trees from widely separated sites a climatic cause is implied. Population age structure, and perhaps also spatial distribution patterns, may also respond to long-term climatic shifts, so that studies in dendroecology carried out simultaneously with chronology construction (based on more extreme sites) may well be complementary. On the other hand, the ecologist must guard against climatic explanations for structures which may have arisen solely through stand dynamic processes.

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MAPPING SEDIMENT SOURCES IN THE HARPER-AVOCA STATE FOREST

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INTRODUCTION

Large amounts of sediment in rivers draining from the mountains may cause channel instability and bank erosion, silting of reservoirs and canals, deterioration in water quality, and increased flooding because channel capacities are reduced. One of the objectives of management of the New Zealand mountainlands is therefore to conserve the soil and vegetation cover to limit downstream effects, as well as to maintain on-site productivity. Soil conservation and erosion control are costly, and require adequate planning; this in turn requires a thorough inventory of areas requiring attention. Where downstream effects are concerned, the critical consideration is the number and severity of sources of sediment supply to the river. A procedure for providing an inventory of sediment sources has been developed by several New Zealand organisations, and the Forest Research Institute has refined and tested the procedure in the Harper and Avoca River catchments in Canterbury (Mosley, 1979).

PROCEDURE

All valley bottoms and many ridge crests in the catchments were traversed and each feature supplying sediment to the river system was noted on large-scale aerial photographs, being classified according to the type of feature and severity of sediment production. This information was then transferred to a 1: 30 000-scale map. The categories of features identified were:

- riparian slip
- eroding river bank
- gully
- debris-avalanche scar
- rockfall source
- scree (sub-classified into sheet, cone, chute, and basin scree).

The severity categories were: slight; moderate; severe; very severe; extreme. Sources were placed on this scale according to their estimated ability to supply sediment to the river system over a period of several decades. The categories were designed in such a way that a member of one class supplies, over the long term, four to five times as much sediment as the next lower class. The classification therefore provides information on the relative importance of each sediment source, and should not be used to estimate actual quantities of sediment produced by each. Estimates of severity rely on qualitative interpretation of such factors as the presence of geological fault lines; amount, type and age of vegetation; and freshness of rock surfaces. Hence the procedure is in many respects similar to procedures used for mapping other phenomena which are difficult to quantify such as soil and lithology.

EVALUATION

Although qualitative, the procedure demands an objective approach and requires that attention be paid to the many pieces of evidence that indicate geomorphic activity. It is rapid, 700 sediment sources having been identified, classified and plotted in the 270 km^2 Harper-Avoca catchment in 15 days. Trials showed that results in the Harper-Avoca were reasonably reproducible, both by a single surveyor and by different surveyors, but they are difficult to compare with similar surveys in other areas because of differences in the suites of land-forms and erosion features, in rates of erosion, and in the background and training of survey personnel. The procedure is more suited to the assigning of priorities for erosion control within a single area than for differentiation between areas.

Some Results

Although 47 % of the total catchment was mapped as bare rock and scree and 8 % as severely eroded grass-scrubland, only 18 % actually feeds sediment to the rivers. Several subcatchments, such as the upper Avoca under Mt Greenlaw, feed no sediment to the main river because glacial or ancient landslide deposits block the valley bottoms. Similarly, material moving downslope from many areas of scree and from bare rock outcrops piles up at the foot of the slope on glacial or river terraces.

The location and severity of sediment sources are generally independent of such factors as slope angle, elevation, and aspect but there is a relationship between the frequency with which sediment sources occur in each subcatchment and the mean slope of the subcatchment. The strong influence of geomorphology is amplified by computing values of "channel gradient index", an index of the erosive and transporting power of a stream which is the product of channel slope and upstream drainage area. There is a close correspondence between the peaks of sediment source frequency elevation bands and of channel gradient index (Fig. 1).

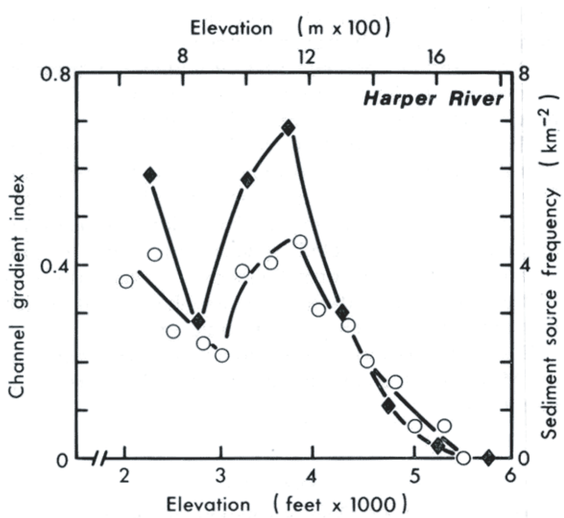

FIGURE 1. *The relationship between frequency of sediment sources, (diamonds) channel gradient index (circles) and elevation in the Harper River Catchment.*

It is almost axiomatic that erosion rates are at a minimum under a forest cover. However, the forest cover in the Harper-Avoca catchment is most continuous in the very altitude zone at which channel gradient index and sediment source frequency are greatest, at 1000-1300 m above sea level. Hence, frequency of sediment sources is greatest in the forest and lower in both the induced! low altitude grassland and the alpine grassland.

Sediment sources in the forest are mainly of natural origin, and many are classified as severe to extreme because of vigorous stream action, steep valley side slopes, and the presence of geological fault lines. Such sources probably provide the bulk of the sediment being introduced into the main river system, and present serious difficulties to the soil conservator. The less severe features that can be effectually treated supply a relatively small proportion of the total sediment so that their treatment would be ineffective in reducing sediment loads. Moreover, vast quantities of gravel stored in valley bottoms, fans, and terraces represent a source of supply of sediment for many decades.

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NUTRIENT DISTRIBUTION IN A SALT MARSH

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Two salt marsh herbs are being investigated at Pollen Island in the upper Waitemata Harbour. *Salicomia australis* is known to be typical of salt marsh with high salt levels while the other species, *Samolus repens,* occurs in a wider range of habitats, from salt marshes to shingle banks to coastal cliffs.

The relationship between plant mineral content and soil mineral content is being investigated at six positions across the salt marsh. *Salicomia* is found in all six sites while *Samolus* is present in all except the lowest. Ten nutrients (Na, K, P, N, C, Cl, Fe, Zn, Ca and Mg) are being examined.

Initial results for sodium and potassium show that both have a gradient of soil concentration across the marsh, the highest values being in the lower marsh. Analysis of *Salicomia* showed that sodium content decreased up the marsh but that there was no gradient for potassium. The sodium content for *Samolus* showed no trend while potassium varied slightly showing a lower content in plants from the lower marsh. Both species showed a large degree of control over the uptake of sodium and potassium.

REGENERATION STUDIES ON TIRITIRI MATANGI ISLAND

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Research investigating the potential for regeneration has been undertaken on Tiritiri Matangi Island (nereafter referred to by the local name of Tiri) in the Hauraki Gulf Maritime Park. The study is concentrated in a small ridge-top area of dense grassland dominated by cocksfoot *(Dactylis glomerata)* and yorkshire fog *(Holcus lanatus)* but with danthonia *(Notodanthonia racemosa)* and *Bothriochloa macra* becoming prominent on the drier kanuka side. The grassland is bordered on one side by manuka *(Leptospermum scoparium)* scrub and on the other by kanuka *(L. ericoides)* bush front. The island is predominantly grass covered with four gullies containing bush and a number of valleys supporting bracken *(Pteridium aquilinum)* and manuka scrub.

Tiri is free from the devastating effects of the opossum *(Trichosurus vulpecula)* but during the past 110 years (since the erection of the lighthouse) the island has been grazed by sheep and cattle (Esler, 1978). It has also, at various times, been infested with goats, rabbits and pigs (all of which have been exterminated). Grazing of the Maritime Park reserve ceased in 1972 and the major herbivores remaining today are the kiore *(Rattus exulans)* and the pukeko *(Porphyrio porphyrio)*. Thus, in the relatively undisturbed conditions which exist at present, there is an opportunity to investigate (and if necessary direct) the rate and course of regeneration back to a cover of bush with which the island was originally almost certainly clothed.

Seed traps at ground level and 1.5 m above ground have been set up at several distances from the bush fronts. Once a month the seeds were identified and counted. Two types of information about the seeds can be obtained from this trapping: –

(a) the seasonal abundance of each species, and

(b) an indication of the extent of dispersal of each species.

Soil samples were taken from the areas occupied by the seed traps for extraction of seeds. It was found that although viable seeds of woody species, such as manuka, kanuka and pohutukawa *(Metrosideros excelsa)*, were dispersed into the area in relatively large numbers very few were present in the soil. On the other hand, a larger proportion of viable rush and grass seeds were present in the soil than were caught in the seed traps. This implies that in the event of a disturbance to the vegetation, grasses and rushes could establish since their seeds are present in the soil in the greatest numbers.

From a survey of seedlings of bush species within the grassland a number of kanuka seedlings were found on the kanuka side of the ridge, plus mapou *(Myrsine australis)* and *Coprosma rhamnoides* seedlings on the manuka side. Esler (1967) working on Kapiti Island observed that invasion of grassland by manuka and kanuka ceased when sheep and goats were removed because the dense turf which developed completely inhibited establishment of these two species. On Tiri no seedlings have appeared in the grassland study area in the past two years. The age of all seedlings found is unknown but it seems likely that they date from when grazing ceased, since the grassland vegetation which has subsequently developed is very deep and dense.

From these results, and observations elsewhere on the island, it appears that regeneration will not take place by direct invasion of the grassland by manuka but will, however, proceed via invasion of the grassland by bracken and subsequent infiltration by mahoe *(Melicytus ramiflorus)*, mapou and other large-seeded species-a very slow process.

The present vegetation of Tiri presents a considerable fire hazard throughout most of the year. Therefore a suggested management plan to hasten the rate of regeneration involves planting seedlings and cuttings of selected species (of island origin) on some ridges to form "islands" of vegetation as centres for regeneration (comparable to that which is at present occurring from some gullies).

The information presented comprises part of an M.Sc. degree in Botany at the University of Auckland.

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A STUDY OF THE NUTRITIVE VALUE OF JUVENILE AND ADULT LEAVES OF *PSEUDOPANAX CRASSIFOLIUS*

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The hypothesis under investigation is that the possession of a juvenile growth habit in many New Zealand tree species is due to natural selection resulting from browsing by moas. It is suggested that selection for low nutritive value in these juvenile forms might result, since plants of low nutritive value would provide a poor food for browsing animals. It might be expected that such plants would be of low feeding preference.

Pseudopanax crassifolius (lancewood) shows considerable leaf and habit dimorphism between juvenile and mature stages. The older juvenile form shows morphological adaptations suggestive of selective pressure from browsing animals, e.g., sharply serrated leaf margins; tough, leathery leaves and a broken outline providing a degree of camouflage. These adaptations are lost in the mature form.

Analyses show that the leaves of the mature form as compared to those of the older juvenile form, on a dry weight basis, possess approximately five times the protein content, 1.25 the soluble carbohydrate, 1.25 the ash and 0.75 times the insoluble carbohydrate. This preliminary study was based on replicated samples of 25 juvenile plants and 10 adults from the same site.

Thus, particularly with respect to protein, the mature form possesses a higher nutritive value to browsing animals. It is one of the features of *P. crassifolius* that the mature form does not develop until it is taller than approximately 4 m, a height above that of the tallest moas.

In conclusion, the low nutritive value found in the older juvenile form supports the hypothesis that selection for low nutritive value is a further adaptation resulting from browsing.

THE ADAPTIVE ADVANTAGES OF DELAYED IMPLANTATION IN THE STOAT

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In the stoat *(Mustela erminea),* delayed implantation (a pause in the development of the embryo lasting 9-10 months) is associated with extreme sexual precocity of the juvenile females (they can make fertile matings as nestlings of 6 weeks old). In contrast, the weasel *(M. nivalis),* a species which is apparently closely related to stoats and similar in habits, shows neither of these characters. Two general questions arise: what is the advantage of delayed implantation to stoats, and why do stoats differ from weasels? The paper explored some possible answers suggested by current theoretical ideas on the evolution of life-history strategies.

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COMPARISONS OF BIRD POPULATIONS IN EXOTIC PLANTATIONS AND NATIVE FOREST

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In November 1977, a two-year study was started in the Nelson area (South Island) to compare the composition and seasonal trends of bird populations in exotic plantations and native beech *(Nothofagus)*/ podocarp forest. The main technique was to conduct standard five-minute bird counts (Dawson and Bull, 1975) twice per month at marked stations along transects in nine study areas. Three of these were in the Rai-Whangamoa State Forest with transects (containing 20 stations each) running between *Pinus radiata* plantations *(c.* 10, 16 and 30 years old) and adjacent beech/podocarp forest. The other six study areas (containing 10 stations each) were in the Golden Downs State Forest. Four were within exotic stands *(c.* 7, 15 and 30 year-old *P. radiata* and 47 year-old *Pseudotsuga menziesii)* away from native forest. The remaining two were within patches of beech/podocarp forest *(c.* 150 and 23 ha in area), surrounded by exotic plantations.

The results have yet to be fully analysed, but an overview is possible. The bird species recorded may be divided into four main groups. Firstly, there were five native species (kereru *(Hemiphaga novaeseelandiae),* rifleman *(Acanthisitta chloris),* yellow-breasted tit *(Petroica macrocephala),* bellbird *(Anthornis melanura)* and tui *(Prosthemadera novaeseelandia)),* which were consistently more abundant in native forest. Kereru and rifleman were virtually restricted to native forest study areas. Secondly, there were two other native species (brown creeper *(Finschia novaeseelandiae)* and robin *(Petroica australis)),* which were abundant in the old *P. radiata* and *Ps. menziesii* at Golden Downs, but rare or absent in all other study areas. Thirdly, there were five ubiquitous species (grey warbler *(Gerygone igata),* fantail *(Rhipidura fuliginosa),* song thrush *(Turdus philornelos),* blackbird *(T. merula)* and silvereye *(Zosterops lateralis»* which were similarly abundant in both exotic and native forest. Fourthly, there was a group of introduced specie3, mainly finches *(Fringillinae)* but also including Californian quail *(Lophortyx californica),* skylark *(Alauda arvenis)* and hedge sparrow *(Prunella modularis),* which were more abundant in exotic forest. Finches (especially chaffinches *(Fringilia coelebs))* were also common in native forest, particularly during the winter of 1979 after heavy beech seeding.

Several other species were recorded occasionally or seasonally in both exotic and native forest. They included the Australasian harrier *(Circus approximans),* weka *(Gallirallus australis),* shining cuckoo *(Chalcites lucidus)* and kingfisher *(Halcyon sancta).* Parrots and parakeets (Psittaciformes) were recorded very rarely in the areas studied.

Perhaps the most intriguing results of this study are those for bellbird and tui. Both species were abundant in native forest, but there was considerable variation between areas. For example, the 23 ha remnant at Golden Downs had a very high overall abundance of 6-7 bellbirds/count, whereas one of the Rai-Whangamoa native forest areas had only c. 1.5 f count. One factor which may influence such contrasts in the abundance of honeyeaters in beech forests is variation between areas in the availability of honeydew, produced by the scale insect *Ultracoelostoma assimile* which infests beech trees. Further research on honeydew as a food source for beech forest fauna is currently in progress at Nelson.

Both bellbirds and tuis occurred regularly in the exotic forest study areas, with bellbirds averaging c. 0.5 f count in several stands. This contrasts with the irregular occurrence of both species in the exotic stands surveyed by Gibb (1961) in the extensive Kaingaroa plantations of the North Island. The relative proximity of most Nelson stands to areas of native forest may be important here. Results from Golden Downs show seasonal patterns of abundance for both bellbird and tui, indicating a concentration of birds into native forest patches during the winter. "Oases" of native forest are clearly important for the maintenance of some native bird species in exotic plantations.

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PREDATION BY MAMMALS ON EGGS AND NESTLINGS OF NATIVE AND INTRODUCED BIRDS IN KOWHAI BUSH, KAIKOURA

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Before human settlement native New Zealand birds evolved in the absence of carnivores, and it has been argued that as a result they are particularly vulnerable to introduced mammalian predators such as mustelids, rodents and cats. According to this argument native birds would be expected to suffer heavier predation than species introduced from regions where birds and predators coexist. In this paper I compare the rates of predation on eggs and nestlings of eight species of native birds with those on five species of introduced European birds.

The study was conducted at Kowhai Bush in November and December 1975-1977. Kowhai Bush (240 ha) is a strip of lowland forest (60-150 m a.s.l.) along the Kowhai River 8 km northwest of Kaikoura (South Island, New Zealand). The vegetation (see Dobson, 1979) is a mosaic of successional stages arising after intermittent flooding. Kowhai Bush supports relatively dense populations of native birds, particularly the bellbird *(Anthornis melanura),* brown creeper *(Finschia novaeseelandiae),* grey warbler *(Gerygone igata)* and fantail *(Rhipidura fuliginosa).* Common introduced birds include the blackbird *(Turdus merula),* song thrush *(T. philomelos),* chaffinch *(Fringilla coelebs)* and redpoll *(Acanthis flammea).* Seven species of mammalian predators, all introduced, inhabit Kowhai Bush but only four are sufficiently agile climbers to be able regularly to reach birds' nests. These are the stoat *(Mustela erminea),* weasel *(M. nivalis),* ship rat *(Rattus rattus)* and house mouse *(Mus musculus).*

Nests were found by systematically searching the Bush, and were subsequently visited periodically to check on their progress. The height, position, and species of tree were recorded for each nest. Sign left at plundered nests was carefully noted and used to deduce the identity of the predator responsible, following the descriptions and details of diagnostic sign provided by Moors (1978) and Flack and Lloyd (1978). Predators were attributed to mustelids (stoats and weasels) or rodents (rats and mice), or were classified as unknown if the sign was inconclusive.

TABLE 1. *Identity of predators which robbed nests of native and introduced birds in Kowhai Bush in November and December 1975-77.*

	Predators					
Bird	Mustelids		Rodents		Unknown	
Group	n	%	n	%	n	%
Native	30	75.0	5	12.5	5	12.5
Introduced	24	77.4	6	19.4	1	3.2
Total	54	76.1	11	15.5	6	8.4

One hundred and sixty-one nests were found. The fates (i.e. fledged, abandoned, or preyed on) were known for 109 nests, 61 being from native and 48 from introduced birds. The largest samples in the former group were for fantails (31), brown creepers (9), and grey warblers (7), and in the latter for song thrushes (22), chaffinches (10), and blackbirds (9). Twenty-eight nests (26%) fledged, 71 (65%) were preyed on (Table 1) and 10 (9%) were deserted. Fledging success was 31 % for native birds and 19 % for introduced birds, but the difference was not significant (differences regarded as statistically significant if $p \sim 0.05$). Both groups suffered similar rates of predation. There was no significant relationship between the number of visits to a nest and the likelihood of its predation. Native birds suffered almost equal predation on eggs (20 nests) and chicks (21), whereas introduced species lost twice as many nests with eggs (20) as with chicks (10). The difference was due to bias from the high survival of fantail nests at the egg stage (86 % nests hatched) compared with the other species. On the basis of sign left at plundered nests, mustelids were the most frequent predators for both groups of birds, robbing at least four times as many nests as did rodents (Table 1). Observations and data from trapping and tracking tunnels indicated that stoats were probably the most important mustelid predator, and ship rats the main rodent one.

Twenty species of tree or shrub were used for nest sites, with kanuka *(Leptospermum ericoides)* being utilised most often by both native (38 % of nests) and introduced birds (45%). Kanuka is one of the dominant trees in Kowhai Bush. There were no significant differences between the average heights of nests which fledged or were robbed for the two groups of birds. Neither were there significant differences between the mean heights of nests preyed on by mustelids (native birds 3.0 m, introduced birds 2.3 m) or rodents (both 2.5 m). The range in heights of nests robbed by mustelids (0.7-8.0 m) exceeded that for rodents (0.4-4.8 m), but in general height was no protection from predation.

The fates of nests were also examined in relation to whether they were sited in the canopy or on the main trunks of trees. Introduced birds built relatively more nests on main trunks than native birds did (45% v. 18%; $p < 0.01$), but nests of both groups were equally likely to be robbed wherever they were situated (predation rates for both sites and groups 60-65%). More nests were robbed by mustelids in the canopy than on main trunks, whereas the reverse was true for rodents. However, the sample sizes were small for robbed nests on trunks, and no differences among nest sites and bird groups were significant.

In summary, there was no evidence from this study that eggs and nestlings of native birds in Kowhai Bush were any more vulnerable to introduced mammalian predators than were the eggs and chicks of introduced birds. Both groups suffered equally heavy predation, the long-term effects of which need careful evaluation. The data presented here refer mainly to small passerines with high productivity, and their vulnerability may not be as great as that of other native birds whose reproductive output is lower, or who are flightless, or whose nests are more easily accessible to predators.

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