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FORESTS AND ANIMALS OF THE HOPE CATCHMENT

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ABSTRACT

Forests in the Hope River catchment in North Canterbury were classified into five associations, using a combination of Sorensen's 'k' index of similarity and a group average clustering procedure. The composition, structure and habitat of each association is described, and the ability to regenerate is related to stand parameters and regeneration frequency.

Analysis of faecal pellet counts was used to determine the status of red deer, opossum and hare, and their relative density for each association and for geographically defined sampling blocks.

The high altitude mountain beech forests are in good condition with adequate regeneration. Forests dominated by red beech are in good condition in the upper valley, less so in the lower valley.

INTRODUCTION

This paper reports the results of a survey of the forests and associated animals within the Hope River catchment in North Canterbury during November-December 1975, carried out in order to describe the composition, structure and habitat of the forests, and to establish permanent reference points to monitor future trends in forest health and the influence of noxious animals upon it.

The Area

The Hope River, a tributary of the Waiau River, drains the area from the Main Divide at Hope Pass. Most of the forest in the catchment is part of the Lake Sumner

State Forest Park, but the majority of the river flats and some of the unforested faces and mountain tops are Crown-owned land under pastoral lease.

The mountains (1300-1700 m) are of sandstones and argillites of the Torlesse group. Valley formations are glacial, but no glaciers or permanent snowfields are now present. Soils are yellow brown earths of the Lewis series, with a moderately acid loamy topsoil and a yellow friable subsoil.

North-west winds predominate, usually bringing precipitation. This decreases to the east (estimated 4000 mm at Main Divide; 1000 mm at Hope-Boyle confluence), there giving relatively dry conditions for plant growth. Throughout the year at high altitudes, and during the winter elsewhere, much of the precipitation falls as snow.

Settlement of the area involved introduction of domestic animals, particularly sheep, and the burning of the forests in the lower part of the valley. This was relatively ineffectual on the moister true left bank, but did remove the forest cover from much of the true right bank below Kiwi River. Cattle are now grazed on the river flats and open faces whence they penetrate the forest for considerable distances.

Red deer (*Cervus elaphus* L.) numbers reached their peak in the 1930s, when Government control operations commenced. However, commercial venison recovery, initiated in 1968, had a great effect, particularly on populations in the alpine grasslands and subalpine scrub.

Chamois (*Rupicapra rupicapra* L.) reached peak population in the 1950s and the decline in numbers has been accelerated by commecial venison recovery. European hare (*Lepus europeus* Pallas) are commonest on the open river flats, but are also present throughout the area to the altitudinal limits of the vegetation. Brush tailed opossum (*Trichosurus vulpecula* Kerr) are present in forest and scrub and relatively common at the lower altitudes. Feral pig (*Sus scrofa* L.) are widespread and common in the open areas of the lower valley. They penetrate the forest remnants throughout the area. Rabbit (*Oryctolagus cuniculus* L.) remain in low numbers in the lower part of the valley. The predators, stoats (*Mustela erminea* L.) and feral cats (*Felis catus* L.) are both fairly plentiful in the valley, but are mainly confined to the matagouri (*Discaria toumatou*)* areas near the riverflats.

Sampling Procedure

A total of 75 permanently marked plots and 137 reconnaissance plots were located at 200 m intervals along 26 randomly chosen altitudinal transects running from valley floor to treeline. At each reconnaissance plot, a sociological description was made listing all vascular plants within the following tiers: main canopy, 5-12 m, 2-5 m, 0.3-2 m, less than 0.3 m. The physiognomic dominant species and the density of the canopy were recorded, together with the altitude, aspect, slope, physiography, top height, soil depth and soil drainage. The amount of the forest floor covered by moss, litter, vascular plants, rock and bare soil, was also estimated.

Faecal pellet counting techniques were used to estimate deer, opossum and hare populations within the forest. Because of different hunting pressures and other disturbances it was assumed that animal populations would show a marked uneven geographical distribution. Hence, in order to minimise the likely bias on any estimate of population density, the area was divided into four sampling blocks (Fig. 1).

* Authorities for plant names as in Wardle and Guest (1977), or in Table S1.

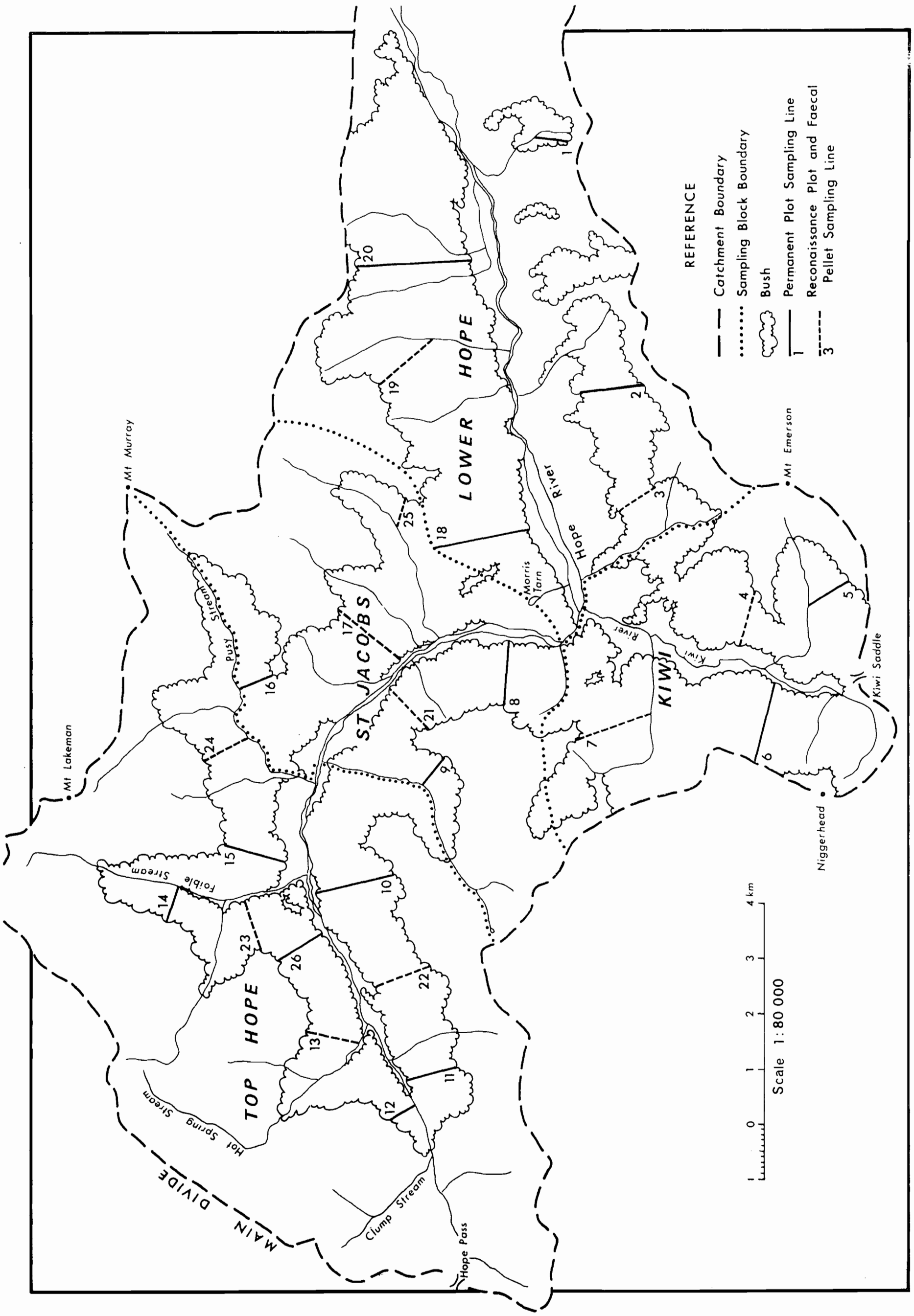


FIG. 1—Map of Hope Catchment showing sampling blocks and sampling lines

Block 1	Top Hope	2168 ha	Block 3	Kiwi River	1867 ha
Block 2	St Jacobs	1730 ha	Block 4	Lower Hut	2582 ha

It was considered that a minimum of 100 samples were necessary in each block. In all 620 pellet frequency plots were established and 117 point distance observations were made throughout the area. This gave a more intensive sample (1 plot/13 ha) than that recommended by Bell (1973). Pellet frequency data were collected using the general technique described by Bell (1973); 0.0004 ha circular plots were clustered in a cruciform pattern (nine plots, 10 m apart) around a central point at the forest reconnaissance plot. At these plots and at distances half way between them on the transects, point distance recording (Batcheler, 1973) of deer pellet groups was undertaken, thus establishing a 20% sub-sample of deer pellet group densities. Deer pellet decay rates were assessed using the method described by Bell (1973), and decay lines with marked pellet groups were sited in each of the four blocks.

On 15 of the transects, permanent plots were established on the sites of the reconnaissance plots. An area 20 m × 20 m was demarcated by tapes and the corners permanently marked with aluminium pegs. Within this area, all stems greater than 1 cm at 1.35 m above ground level were permanently tagged and the diameter measured 1 cm above the point of attachment. Stems taller than 1.35 m but having a diameter of less than 1 cm at this height were counted only. Within the plot, 24 systematically located circular sub-plots, each with a radius of 0.49 m were established and permanently marked by a numbered aluminium peg. Within each of these, the amount of regeneration of each species was recorded in six size classes between ground level and 1.35 m.

Analysis

The 137 sociological descriptions were classified into five associations using the numerical procedure involving Sorensen's "*k*" index of similarity, and a group average cluster analysis, similar to that described by Wardle *et al.* (1971).

The mean composition and habitat of each of the associations was then calculated. Stem diameter data were used to calculate basal area, mean stem diameter, stand density, sum of stem girth, and diameter distributions for each of the associations. Counts from the subplots were used to determine density values for regeneration of the tree and woody understorey species.

Pellet frequency data (p/N) were converted to pellet density using the density transformation: $-\log_e (1 - f)$. Conversion to pellet group density used a weighted mean multiplier (K) based on 2182 pellet density observations and equivalent point-distance samples from the Hope, Waiau and Rangitata catchments. Factor K (derivation detailed in Table S2*) approximates to 1077.5; equivalent values of 775 were used by Burrows *et al.* (1976) and 908 by Bell (1976). Absolute deer number estimates were derived by the method recommended by Bell (1973), using a defecation rate per deer per day of 12.5 groups (Batcheler, 1975). Pellet group decay rate for the forest was calculated as 0.008249 groups per day.

THE FORESTS

The forests of the Hope catchment cover 8361 ha, approximately 44% of the area. The canopy is composed almost entirely of red (*Nothofagus fusca*), silver (*N. menziesii*) and mountain beech (*N. solandri* var. *cliffortioides*). Together these species account for

96% of the basal area of the forests, with broadleaf (*Griselinia littoralis*) contributing more than half of the remaining basal area. In general terms, the distribution of the beeches reflects the effects of rainfall and altitude; mountain beech is dominant at high altitudes and in the east of the catchment (Fig. 2), red beech is found on the lower slopes and terraces, particularly on moister aspects, whilst silver beech is relatively uncommon on the lower part of the valley, but is present at all altitudes within the forest in the upper valley. Thus, generally, the situation is similar to that described by Burrows *et al.* (1976) for the Hurunui catchment. However, in studying the forest composition more closely, striking differences are noted:—

Beech Species:	Red		Silver		Mountain	
	Hurunui	Hope	Hurunui	Hope	Hurunui	Hope
Basal area (m^2/ha)	22.6	17.2	21.2	6.7	17.5	28.8
Stems/ha	296	225	1129	415	716	986
Mean diameter (cm)	20.5	19.9	10.2	9.0	13.3	14.8

In the Hurunui, silver beech is everywhere common, and in most places dominant, whilst in the Hope it only has a third of that density and rarely plays a dominant role. In the Hope, mountain beech is a more prominent member of the canopy than in the Hurunui. Both density and size are slightly greater and it is the usual treeline species, silver beech only being associated with it at the head of the valley. In a few places the beech canopy gives way to other sub-climax forms. The most common of these is found on slip and gully sites and is dominated by *Hoheria glabrata* with a ground cover of *Polystichum vestitum.* This is most likely a seral stage, as beech is regenerating where the dense fern cover will allow it. The other low forest form is composed almost entirely of large broadleaf, often with little understorey. These may be remnants of mountain beech — broadleaf forest, where the canopy has been destroyed by some catastrophe, without a seed year effecting its replacement.

From the vegetation patterns, it is assumed that the climate in the Hope is somewhat drier than in the Hurunui, and that such conditions have enabled the aggressive competitive nature of mountain beech to oust silver beech on sites where its growth was sub-optimal. However, in common with the Hurunui, a West Coast influence is noticeable in the forests at the head of the valley. The relative abundance of *Dracophyllum traversii, Olearia lacunosa* and *Pseudopanax lineare* in the upper forest are indicators of that influence which may be attributed to the effect of the low Hope Pass (946 m) on climatic variables and the ease of plant migration.

The analysis defined the forest into five associations. These associations and the habitat which they occupy are described below. The major plant species and their frequency of occurrence in the associations are given in Table S3*.

The Associations

Red Beech-Mountain Beech Forest (R-M)

The canopy of this forest type is composed of large red and mountain beech, their height and girth exceeding any others in the catchments. The mean top height of 30 m is considerably greater than that of the mixed beech association which occupies similar sites

* Tables with S numbers form a supporting supplement, obtainable from the editor on request.

(Fig. 3). Associated species are somewhat sporadic, broadleaf being the major constituent of the shrub tier. **Coprosma pseudocuneata** is also frequently found, whilst the forest floor, although chiefly covered in litter, has a variety of plants, of which **Grammitis billiardii**, and the orchid **Corybas triloba** are the most common. The association is found on the lower slopes and terraces (Fig. 4), particularly on the true left bank of the catchment below the Hope-Kiwi confluence.

Complex Mixed Beech Forest (R-S-M)

The association contains red, silver and mountain beech intimately mixed in the canopy and a very high number of associated species (Fig. 5). The red and mountain beech tend to be co-dominant in the canopy, with a large number of smaller silver beech stems forming a sub-canopy. It is most often found on terraces and lower slopes, but is more widespread at the head of the valley, where it extends quite high up the slopes (Table 1). Broadleaf dominates the shrub tier, but **Coprosma foetidissima**, **C. parviflora** and **C. pseudocuneata** are also common. **Corybas triloba**, **Grammitis billiardii**, **Polystichum vestitum** and **Hymenophyllum** spp. are the most frequently found species on the forest floor.

TABLE 1—The altitudinal distribution of the associations (number of plots)

Altitude (m)	R-M	R-S-M	M-BL	M-S	M
1300					6
1200			2	2	14
1100		1	3	5	10
1000		5	7	6	1
900	3	16	6	1	
800	4	15	1	1	
700	7	16	1		
600	2	2			

Mountain Beech-Broadleaf Forest (M-BL)

On some mid-slope sites, broadleaf forms a well-defined tall shrub layer beneath a mountain beech canopy. These sites tend to be very steep (Fig. 4), at mid-altitudes on the drier slopes. **Coprosma linariifolia** is often associated with the broadleaf, whilst lower tiers are dominated by **C. pseudocuneata**, **C. parviflora** and **Polystichum vestitum**. This forest type is particularly common on the true right bank of the lower valley, where in places it gives way to pure stands of broadleaf. Compared with other associations, a large amount of rock and bare soil is exposed. Expressing cover as percent:

Association:	R-M	R-S-M	M-BL	M-S	M
Vegetation	12	14	13	13	16
Moss	14	36	18	32	30
Litter	65	38	43	41	37
Soil	5	3	12	4	7
Rock	4	9	14	10	10

Mountain Beech-Silver Beech Forest (M-S)

Mountain beech is three times as common as silver beech in the canopy of this forest type. It usually occurs on steep upper slopes in the head of the catchment. Its mean top height is not significantly different from the mountain beech associations. A shrub layer containing broadleaf, **Olearia lacunosa** and **Pseudopanax simplex** is usual whilst the understorey is quite diverse with **Coprosma pseudocuneata**, **Grammitis billiardii**, **Polystichum vestitum**, **Ranunculus hirtus** and **Gaultheria antipoda** being common.

Mean and 95% confidence limits for each association:

Figure 2 - Altitudinal Range

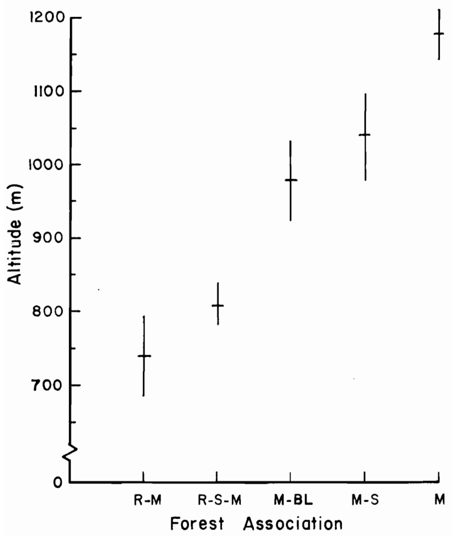


Figure 3 - Stand Top Height

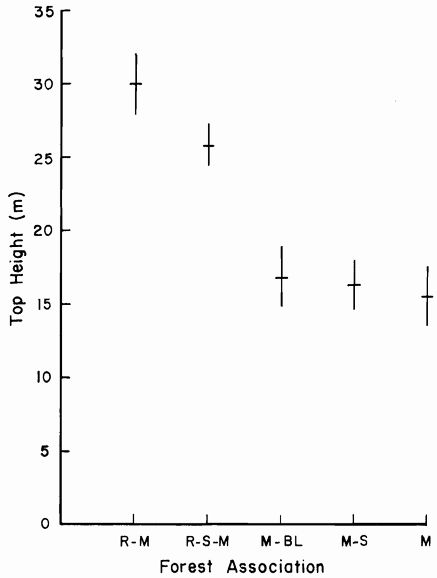


Figure 4 - Slope Values

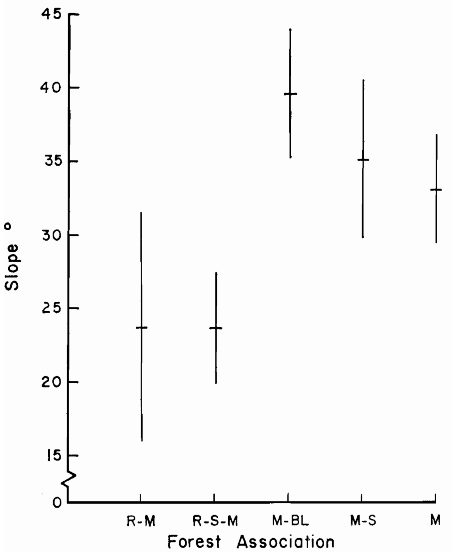
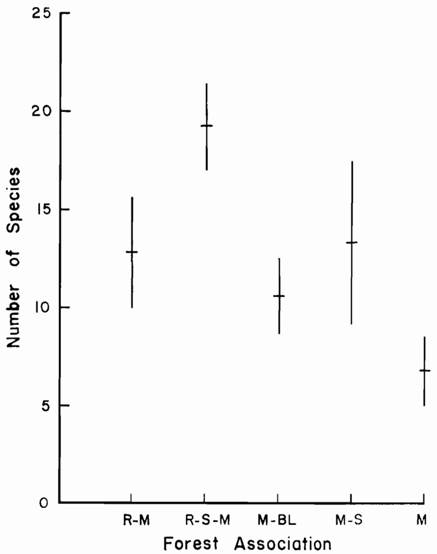


Figure 5 - Species Complexity



Mountain Beech Forest (M)

This forest type has fewest associated species (the most common **Coprosma pseudocuneata** and **Polystichum vestitum**, sometimes with **Blechnum penna-marina**, **Coprosma parviflora**, **Hymenophyllum** spp., **Pseudopanax simplex**, and **Uncinia** spp.) but is more diverse than simple mountain beech associations elsewhere east of the main divide (Wardle and Guest, 1977). In the Hope, it occurs on steep slopes of all aspects (Table 2) and forms the tree line in most places.

TABLE 2—Aspect distribution of the associations (number of plots)

Aspect (° E of N)	R-M	R-S-M	M-BL	M-S	M
360°	2	5	4	3	3
315	1	5	3	3	3
270	2	3	0	2	3
225	2	3	0	1	2
180	8	14	2	2	8
135	0	12	4	1	4
90	2	8	4	2	3
0	0	5	3	1	5

Animals

Red Deer

Mean pellet densities (Figs. 6 and 7) show no significant difference between the associations ($\psi^2 = 3.835$) but differences between the blocks are significant at the 90% confidence level ($\psi^2 = 7.668$). This is probably on account of the relatively large difference recorded between the St Jacobs and Lower Hope.

The estimated number of deer within the forest area (9 261 ha when adjusted for slope) is approximately 850 animals, with the Lower Hope (Block 4) and the Kiwi Stream (Block 3) having about twice the density (1 deer per 9 ha) than the Top Hope and St Jacob blocks (1 deer per 19 ha). This distribution pattern may be associated with the undoubtedly heavier commercial hunting pressure in the upper catchment and the substantial tract of unbroken forest in the Lower Hope with its proportionately restricted bush edge. Mean deer density within the forests of the Hope would appear to be about twice that reported by Burrows *et al.* (1976) for the Hurunui forest areas but actual numbers are approximately the same.

Opossum

No estimate of absolute animal numbers is available, but mean pellet densities (Figs. 8 and 9) show very significant differences between the forest associations ($\psi^2 = 14.169$). Very high populations exist in the red/mountain beech and complex mixed beech associations and these are largely confined to the lower slopes and terraces of the valley; overall there is a strong correlation with altitude. Differences in pellet density by sampling block is also very significant ($\psi^2 = 17.467$). Of interest is the fairly low numbers of opossum in the Lower Hope, which because of locality and ease of access has probably had the most intense pressure from commercial skin recovery operations in the past.

Mean and 95% confidence limits for each sampling block OR association:

Figure 6 - Deer Pellet Densities

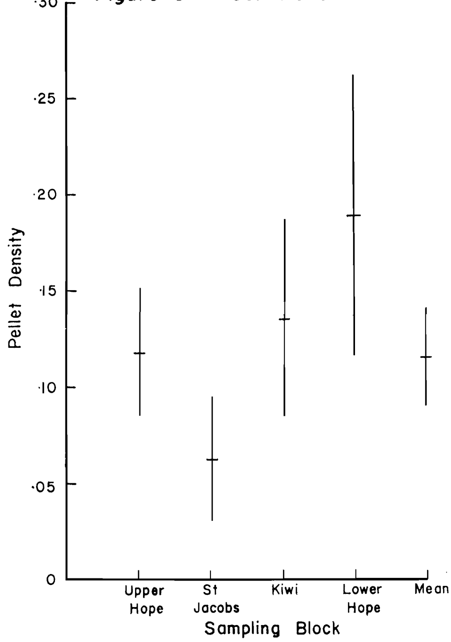


Figure 7 - Deer Pellet Densities

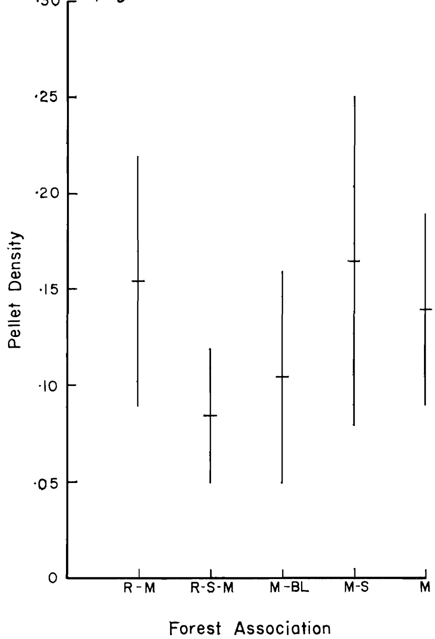


Figure 8 - Possum Pellet Densities

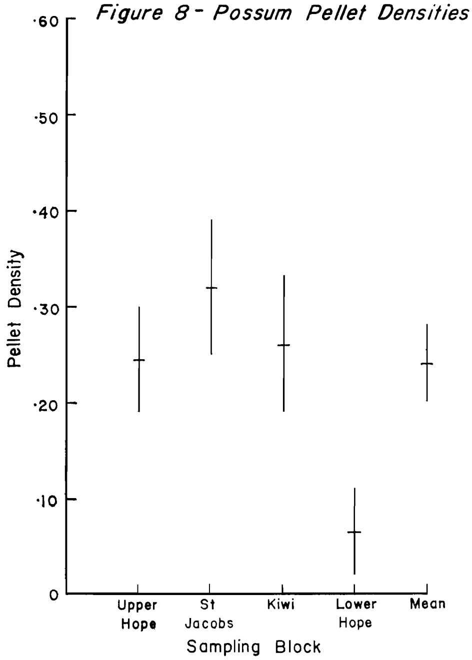
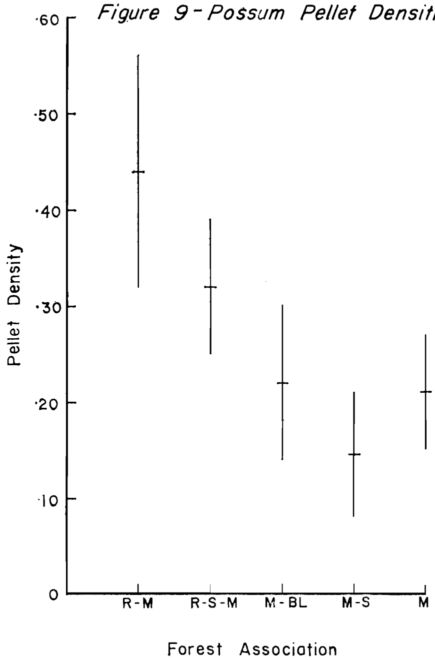


Figure 9 - Possum Pellet Densities



Hare

Out of the 620 pellet frequency plots examined, hare pellets were only recorded four times. Similar minimal usage of the forest is reported by Burrows *et al.* (1976) in the Hurunui. However, field parties reported heavy use of the matagouri-covered river flats by hares, and similarly, frequent pellet sign was evident in the grassland areas above tree line.

PRESENT CONDITION OF THE VEGETATION

In order to assess the condition of the forest, it is necessary to study its structure. The canopy is almost exclusively composed of red, silver and mountain beech, thus the continued wellbeing of the forest is totally dependent on the mortality and replacement patterns of these major species. It is necessary to relate the present canopy structure with the regeneration which has the potential for its replacement.

Although, in complex forest types, browsing may cause an increase in the amount of the exposed rock and soil at the expense of vegetative cover (cf. Manson, 1972), simple *Nothofagus* forests may be very healthy with no vegetative understorey, but a healthy canopy (Wardle, 1976).

Estimates given earlier indicate that vegetative cover varied from 26-50% whilst 9-14% of rock and soil were exposed. There is much less vegetative cover than in the Hurunui mixed forests, where vegetation cover was approximately 57% and exposed rock and soil a mere 1%. Lower rainfall may account for some of the difference, but the effect may be partially animal induced.

In assessing the health of the forest from its structure, it is necessary to compare forests from different areas. This gives a better understanding of the different stages in their replacement patterns and a clearer appraisal of the situation in any specific area.

Burrows *et al.* (1976) compared the beech forests in the Hurunui with those of the Wairau (Manson and Guest, 1975) and the Waitaki (Wardle and Guest, 1977). They found the Hurunui exhibited characteristics intermediate with the senescent Waitaki forests, and the juvenile Wairau forests. Not surprisingly, those of the Hope are most similar to the forests of the Hurunui.

	Waitaki	Wairau	Hurunui	Hope
Basal area (m^2/ha)	54.1	45.2	61.3	54.7
Tree stems/ha	1277	3661	2297	1798
Mean diam. (cm)	17.3	13.2	14.7	14.6
Seedlings/ha	4077	6137	4084	3742

Direct comparisons between the areas are complicated by the differing forest composition. The canopy of the Hope forests is not as mature as that in the Waitaki, where fewer stems of larger size constitute a similar basal area. In the Hurunui, more stems of a similar size are present per unit area than in the Hope. This may be a site quality factor, or reflect differing forest composition. Silver beech, a moderate shade bearer, is able to fill a niche within the red and mountain beech forests.

Because different patterns of mortality and replacement operate between forest types, it becomes necessary to study the stand factors for each of the associations (Table 3).

TABLE 3—Stand factors for each association

	R-M	R-S-M	M-BL	M-S	M
Tree stems/ha	557	1685	1377	2496	2769
Total stems/ha	691	2170	1983	3109	2855
Basal area/ha	41.0	56.3	54.3	54.7	56.1
Stems girth/ha	406.0	717.3	923.6	985.1	961.5
Mean diameter	21.0	11.9	15.5	12.7	12.7
Tree seedlings/ha	790	3165	1256	9235	6120
Total seedlings/ha	2604	5867	4369	18071	10368

There are big differences between the associations. Those dominated by mountain beech generally have a high density of moderately sized trees and apart from the mountain beech-broadleaf association, a high density of regeneration. The red beech-mountain beech association has few large trees, a lower than normal basal area, and low regeneration density. The mixed beech association has a moderate density of stems and regeneration; but a high basal area, despite a low mean diameter. This is accounted for by the different sizes of the components. The silver beech stems, although numerically dominant, are very small in comparison to those of red and mountain beech (Table 4).

Red Beech-Mountain Beech Forests (R-M)

This association is notable for the low density of larger-than-average stems, giving a lower-than-average basal area. The low density of stems is a feature of all stages of growth and seedling regeneration is by far the lowest of any of the associations. From the tall canopy of this association and the low altitude sites, one could not expect poor site quality to be responsible for the relative dearth of stems. Despite the association occurring in the relatively drier areas of the catchment the higher mountain beech element would be expected to provide a greater density of stems.

The possibility of an animal effect seems high. There was no large concentration of deer within this association, but opossums were relatively frequent. However, the presence of cattle, not estimated here, may be having the deleterious effect. This forest type, low down the valley, on terraces and moderate slopes, and usually adjacent to the grazed river flats, is the most susceptible to trespass by cattle. Their trampling and browsing may be the major cause of the poor condition of these forests.

Complex Mixed Beech Forests (R-S-M)

This complex forest type appears to have a reasonable amount of regeneration in relation to the canopy condition, but future health is secured more by the species diversity. The canopy trees are not unduly mature and a subcanopy of smaller silver beech would ensure continuation of the canopy should expansion of existing crowns be unable to fill any gaps. The number of permanent broadleaf seedlings now present suggests that previous pressure on them has been much reduced.

Forests Dominated by Mountain Beech (M-BL, M-S, M)

The relationships governing the mortality and replacement of mountain beech forests have been developed much further than for mixed beech forests. Initially Wardle (1970)

TABLE 4—Stand factors for the main components, beech species and broadleaf, in each association

	Red	Silver	Mountain	Broadleaf
R-M				
Stems/ha	342		214	
Basal area/ha	31.7		8.2	
Stem girth/ha	268.4		121.0	
Mean diameter	25.0		18.0	
Seedlings/ha	474		316	
Ephemeral regen. %	24		36	
R-S-M				
Stems/ha	392	771	357	163
Basal area/ha	28.9	12.4	13.9	1.1
Stem girth/ha	235.1	217.1	187.5	41.9
Mean diameter	19.1	9.0	16.7	8.2
Seedlings/ha	1702	1015	448	134
Ephemeral regen. %	36	24	35	40
M-BL				
Stems/ha			1351	286
Basal area/ha			47.0	5.7
Stem girth/ha			741.6	119.3
Mean diameter			17.5	13.3
Seedlings/ha			1256	0
Ephemeral regen. %			59	11
M-S				
Stems/ha		531	1724	132
Basal area/ha		13.1	40.8	0.6
Stem girth/ha		208.7	739.2	30.1
Mean diameter		12.5	13.6	7.3
Seedlings/ha		3315	5920	947
Ephemeral regen. %		18	77	30
M				
Stems/ha			2385	
Basal area/ha			56.1	
Stem girth/ha			959.0	
Mean diameter			12.8	
Seedlings/ha			6120	
Ephemeral regen. %			76	

concluded that a stand having a basal area of approximately 57 m^2/ha will be quite healthy even if no regeneration is present. Further, Wardle and Guest (1977) plotting frequency of regeneration against the sum of stem girth for various areas, concluded that the sigmoid curve so obtained showed the approximate level below which regeneration was not adequate in relation to the canopy condition. Using these criteria, the mountain beech forests of the Hope are remarkable for the quantity of regeneration in relation to the canopy. With basal areas of about 55 m^2/ha and total stem girths averaging nearly 960 m/ha, little regeneration should be expected. However, seedling densities averaging up to 9000 seedlings/ha are present.

The mountain beech-broadleaf association is in the least satisfactory condition, with a lower density of larger stems, and much less regeneration. It is perhaps the most susceptible to damage, occupying very steep sites in the driest areas of the catchment, and located adjacent to grazing land. The total lack of permanent seedlings suggested that the future of the broadleaf component is uncertain. There are, however, ephemeral seedlings present which should be able to compensate for the deficit of young stems, if allowed. Despite their effect on the broadleaf, the animals are not significantly affecting the ability of the forest to perpetuate itself.

The two treeline associations, mountain beech-silver beech, and mountain beech, appear to be in very good condition, with a superabundance of regeneration and ample smaller size stems for canopy replacement. Broadleaf, a common shrub in the former association, shows a classic inverse "J" curve of size distribution. These forests seem to have received the greatest benefits from helicopter operations against deer above treeline.

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