THE ARTHROPODS OF THE FLOORS OF SIX FOREST TYPES ON THE WEST COAST, SOUTH ISLAND: A PRELIMINARY REPORT

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SUMMARY: The arthropods of the floors of six forest types (three podocarp/beech forests, a beech forest without podocarps, a young plantation of *Pinus radiata* and a podocarp/hardwood forest) were examined. The podocarp/beech forests are richest in species and numbers of animals. The beech forest has fewer species and individuals than podocarp/beech but also has less varied litter. Most species found in beech are also present in podocarp/beech. Young *P. radiata* has an impoversihed fauna with few species and low numbers of animals. Some animals are able to survive in protected situations and deep organic deposits when beech is cut over and burnt prior to planting with pines. The podocarp/hardwood forest examined has fewer species and lower numbers of animals than the other indigenous forest types probably because of unfavourable soil and climatic conditions.

INTRODUCTION AND METHODS

When proposals for large scale utilisation of beech forest resources on the West Coast of South Island were put forward by the New Zealand Forest Service in 1971 (New Zealand Parliamentary Paper 1971) very little was known about the beech forest ecosystem. The desirability of improving our knowledge of these forests, so that areas which were scientifically unique could be better conserved, was obvious. To this end the invertebrate fauna of the floor of each of five forest types in the Reefton area (Fig. 1) was sampled from time to time between January 1972 and April 1973. These included three types of podocarp/beech forests, a beech forest with no podocarps and a young *Pinus*

TABLE 1. *Landform, Soils, Forest Types and Main Plant Species of the Six Forest Sites Studied.*

Landform and soils	Forest types	Main Species
Low terraces AHAURA SOILS* *140m - 230m a.s.l.*	podocarp/beech PB1 **	*Nothofagus menziesii, N. fusca, Podocarpus ferrugineus, P. spicatus*
	beech B2 **	*N. menziesii*
	pine *Pinus*	*Pinus radiata, Leycesteria formosa*
High terrace OKARITO SOILS * 300m a.s.l.	podocarp/hardwood XPH21 **	*Metrosideros umbellata, Dacrydium colensoi, D. biforme, Leptospermum scoparium*
Slopes at low altitudes BLACKBALL HILL SOILS * 270m a.s.l.	podocarp/beech PB5 **	*N. fusca, N. menziesii, N. truncata, P. ferrugineus*
Slopes at high altitudes MATIRI STEEPLAND SOILS* 440m a.s.l.	podocarp/beech PB15 **	*N. fusca, D. cupressinum, D. intermedium*

*Soil types as in N.Z. Soil Bureau, 1968.
**Classification according to Masters *et al.*, 1957.

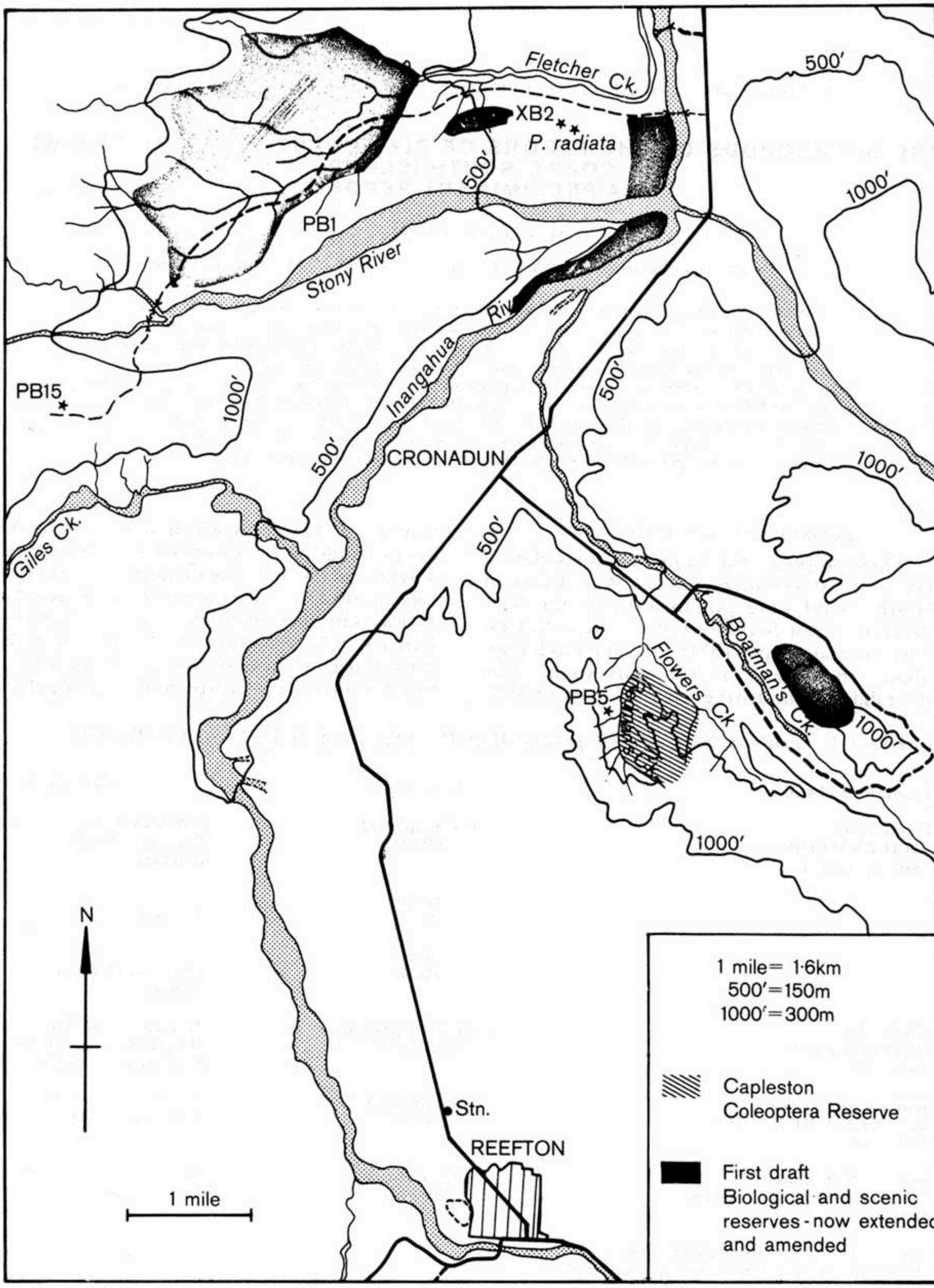

FIGURE 1. *Location map for five forest types in the Reefton area.*

radiata plantation planted in 1968. The fauna of a podocarp/hardwood forest floor in Mawhera State Forest, near Ahaura, was also examined. The podocarp/beech and beech forests are relatively unmodified, but the podocarp/hardwood forest was cut over some years ago.

Details of landform, soils and main plant species for the areas sampled are given in Table 1, together with forest type as classified by New Zealand Forest Survey (Masters *et al.* 1957).

Samples were collected at approximately two monthly intervals from each forest type except PB5, which was not sampled from March to July 1972. An intensive sampling programme was started in PB5 in September 1972.

Organic matter on the forest floor is usually composed of three horizons which together form the organic profile: the L or litter horizon, composed of freshly fallen leaves and organic debris; the F or fermentation horizon, composed of leaves and debris fragmented, though recognisable, and usually matted together; and the H or humification horizon composed of finely-divided organic matter. The organic profile overlies the mineral soil and may be incorporated to a varying extent into the upper most or A horizon of the mineral profile. The animals of these four horizons were examined by collecting samples of each horizon separately over an area of 25 x 25 cm. The thicknesses of the horizons varied so the sample volume was not constant.

The animals were extracted from the samples in the laboratory by means of Tullgren funnels. Although this method of extraction is unsuitable for collecting slow-moving animals such as earthworms, nematodes, Mollusca (slugs and snails), and the immature stages of some insect groups, it is the most convenient way of removing most groups of arthropods from large samples.

Some of the groups considered to be most important in the primary breakdown of the organic matter on the forest floor have been examined. These include Lepidoptera larvae (caterpillars), Coleoptera (beetles), and Diplopoda (millipedes).

RESULTS AND DISCUSSION

Under all forest types studied the highest densities of animals were found in the L and F horizons. Acari (mites), Araneida (spiders), Phalangida (harvestmen), Pauropoda, Isopoda (woodlice), Collembola (springtails), Protura, Diptera larvae and Lepidoptera larvae were common. During the summer the L horizon became very dry, but the F horizon remained damp relative to the other horizons. This, plus the composition of the F horizon (partially broken-down organic matter which is an ideal food and substrate for many animals and microorganisms), are probably reasons for the concentration of animals in this horizon.

Other groups appear to prefer both the F and H horizons. These include many species of beetles, and ants, which may be present in large numbers in the H horizon. Not many animals are found in samples of the A horizon, particularly when the overlying organic horizons are over 15 cm deep or where there is little organic matter in the A horizon.

TABLE 2. *Arthropod Groups and Numbers of Individuals Found in L, F, H and A horizons of the PB1 Forest Floor, January 1972.*

Group	Horizon	L	F	H	A
	Thickness of layer (cm)	2.5	3.5	7.5	15+
Acari		1546	2289	166	24
Araneida		5	7		
Phalangida		2	6		1
Pseudoscorpionida		16	59	11	1
Diplopoda		23	9	2	
Chilopoda		1	1	3	
Pauropoda		19	17	6	
Symphyla		2	15	18	1
Copepoda			16	1	
Ostracoda		5			
Isopoda		8	8		
Amphipoda			1		
Collembola		290	470	65	5
Diplura					1
Protura		5	29	1	
Hemiptera		32	3	1	6
Coleoptera adults		4	31	81	18
Coleoptera larvae		13	15	27	1
Diptera adults			1		
Diptera larvae		37	45	3	1
Lepidoptera larvae		28	10		
Hymenoptera		2	24	14	
	Total	2038	3056	389	59

The arthropod groups from the January 1972 samples from the PB1 forest floor are listed in Table 2, along with numbers of individuals and the horizons in which they were found. This set of samples is fairly typical of those taken from podocarp/beech forests at this time of the year.

Average numbers of individuals per collection for the sorted groups are given in Table 3. Although these figures give some idea of the relative abundance of animals within each forest type they do not indicate the variety of species within each group, which is also relevant when attempting comparisons between different forest types. Numbers of individuals may also give misleading results. The high average number of Lepidoptera per collection in PB15, for example, can be accounted for by the presence in one set of samples (March 1972) of 372 first instar larvae of an oecophorid moth. A batch of eggs must have been present in the samples which hatched just before collection or even during extraction.

The number of species of Lepidoptera, Curculionidae (weevils), and taxa of other Coleoptera are given in Table 4. Coleoptera are represented by many more species than any other insect group. Thirty species of Curculionidae alone have been recognised from the samples. Within other families of Coleoptera, for example, Staphylinidae and Elateridae, many larval forms cannot be assigned to a species. These have been grouped under one 'taxon' although more than one species is represented. Similarly, because many species of several families, such as Staphylinidae, Pselaphidae and Scydmaenidae, are underscribed, they are included under a single family taxon.

TABLE 3. *Average Numbers of Animals per Collection From Six Forest Types.*

Group	PB1	PB5	PB15	B2	*Pinus*	XPH21
Pauropoda	8.6	3.8	9.8	0.8	0.1	0.5
Symphyla	33.0	9.2	19.1	13.6	26.1	0.1
Diplopoda	12.1	3.4	5.4	5.4	1.6	1.8
Chilopoda	9.9	16.2	8.4	8.9	1.3	7.4
Araneida	5.2	7.9	6.1	3.4	0.6	1.9
Hymenoptera — Formicidae	23.2	30.8	12.0	6.6	0.1	6.9
Coleoptera — Curculionidae	8.9	14.4	15.1	6.5	—	4.0
Other Coleoptera	130.0	53.9	87.0	85.4	26.3	9.4
Lepidoptera	16.3	13.2	56.1	5.5	0.3	0.4

Tables 3 and 4 show that there is a much richer fauna both in numbers and in species in podocarp/beech forests, particularly PB1 and PB5, and beech forest than in the podocarp/hardwood and young pine forests sampled. Podocarp/beech forests have a varied vegetation and thus the organic matter on the forest floor is composed of the remains of many plant species. This probably has a bearing on the variety of animals present in the organic material. Although beech forest is composed of a variety of plant species other than beech there is still less variety than in podocarp/beech forests, and there are correspondingly fewer insect species in beech forests than in podocarp/beech forest growing under similar conditions (PB1). Within the podocarp/beech forests there are fewer species present in PB15 although the fauna is still rich and varied. The podocarp/hardwood forest examined has been cut over and is on a high terrace (300 m) on Okarito soil. The organic layers, particularly the H horizon, were always wet and often waterlogged in winter. Litter in the sample area was composed of mainly *Metrosideros* leaves, and a combination of wetness, near anaerobic conditions and possibly unpalatability of litter could account for the low animal numbers and species recovered from this forest type.

TABLE 4. *Number of Taxa of Lepidoptera and Coleoptera in Six Forest Types.*

	PB1	PB5	PB15	B2	*Pinus*	XPH21
Lepidoptera	16	20	13	14	2	3
Curculionidae	14	17	12	8	0	9
Other Coleoptera	48	52	31	39	16	21

Animals of the organic horizons of forest floors are important agents in litter breakdown. Fragmentation of litter speeds up the release of nutrients. Animals are largely responsible for the initial degradation of litter and by fragmenting it expose a large area to the action of smaller animals and microorganisms. The rate of litter breakdown and the speed of turnover of organic matter on forest floors is related partly to the size and variety of the animal population. Thus PB1 forest which has high numbers of animals and a wide variety of species has little accumulation of organic material on the forest floor. The depth of organic matter may be as little as three centimetres, with slightly deeper accumulation in hollows. In the podocarp/hardwood forest, where few animals were present in the organic horizons, deep accumulations of organic matter have developed.

An interesting situation is found on the floor of the young pine forest. Little remains of the organic horizons formed under beech forest when an area is burnt prior to planting with pines. Four years after burning the young pine forest has only a thin L horizon, composed in this case of bracken fronds, *Leycesteria* leaves, charred remains of beech twigs and branches and a small amount of pine needles. Very little other organic matter is present, and the F and H horizons are indistinguishable. What material is present beneath the L horizon can be identified as having its origins under beech forest, with the addition of charred fragments of the former forest. These organic horizons are at the most 2.5 cm deep, and have virtually no animals in them, those few that are there being mainly different from the ones under beech. Some groups which are normally common in the L and F horizons of beech forests, such as weevils, are entirely absent from the pine samples and most other groups are poorly represented (Table 3).

Under the shelter of sections of fallen trunks, and in hollows which may have been wet at the time of burning, accumulations of organic matter of beech forest origin up to nine centimetres deep are found. Some species are found in these accumulations which are also present, mainly in the H horizon, in beech forests. This suggests that some animals are able to survive in such protected situations when an area is burnt. Most of the animals are destroyed, however, and numbers of species and individuals found in the pine plantation after four years are very low. There is evidence that species diversity increases with age in pine forests up to 25 years old, but after this there is a levelling out, and only a small proportion of species found in pine are amongst those found in beech (J.S. Dugdale pers. comm.).

The most common beetles in the samples are Staphylinidae of the genus *Holotrochus*. They are present in high densities at most times of the year and are most numerous in the H horizon. As examination of the gut contents of some adults and larvae has shown that both ingest fragments of vegetable matter, it is reasonable to suppose that they feed on the finely divided organic debris of the H horizon. Support for this is found in the samples taken from young pine forest. Of the total *Holotrochus* adults and larvae found in these 81.4 percent were in one set taken from an accumulation of organic matter surviving from the original beech forest. With sufficient organic matter remaining in the H horizon for them to feed on in the four years since burning the population has probably increased, and the presence of larvae indicates that breeding is still taking place.

Densities of *Holotrochus* adults and larvae are given in Table 5 together with their numbers as percentages of the total Coleoptera in each forest type. This shows the existence of an inverse relationship between the abundance of *Holotrochus* and thickness of the organic horizons in different forests. In the shallow layers of organic matter on the floors of terrace podocarp/beech and beech forests *Holotrochus* spp. occur at relatively high densities. Podocarp/beech forests on sloping ground have deeper organic horizons and lower densities of *Holotrochus* and the podocarp/hardwood forest examined had both the deepest organic horizons and the lowest densities of *Holotrochus*. The densities of *Holotrochus* alone show their contribution to breakdown of organic matter must be considerable, and the relationship with thickness of the organic horizons suggests their density may be an indication of the rate of breakdown of organic matter in a forest.

TABLE 5. *Percentage of Total Coleoptera and Maximum Densities of* Holotrochus *spp., Adults and Larvae, in the Organic Horizons of Six Forest Types.*

	PB1	PB5	PB15	B2	*Pinus*	XPH21
% total Coleoptera	67.4	27.7	52.9	47.8	76.1	15.0
Maximum density per m²	470	180	215	350	185	65

CONCLUSIONS

Podocarp/beech forests, particularly PB1 and PB5, are richest in species and numbers of animals. Beech forest has fewer species and fewer individuals than podocarp/beech probably because of the less varied litter. Very few species found in beech litter are found in litter under young pine where there are few species and low numbers of animals. Some animals found in the deeper accumulations of organic matter which are remnants of the beech forest profile are thought to have survived burning. These may be found in high numbers suggesting that they are able to maintain their population size in these old deposits. Podocarp/hardwood forests have some species in common with podocarp/beech but also have species peculiar to them. In the area of this forest type sampled low numbers of both species and individuals were found probably due to adverse soil and climatic conditions.

Size of animal population in the organic horizons of indigenous forest floors may influence breakdown and rate of turnover of organic matter. Those forests with diverse and large populations have less build-up of organic matter than forests with small populations.

Burning of cut-over areas of indigenous forest prior to planting with exotics almost totally destroys the animals in the organic layers of the original forest floor and destroys the upper layers of the organic profile. If burning could be replaced by a less catastrophic management technique many animals would survive, particularly those able to utilise a wide range of foodstuffs providing a pool for selection and the virtual sterilisation (from the animal point of view) of the forest floor would be avoided. Under the present system there are very few animals present on the floor of pine forests four years after burning.

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