# Invertebrate values of kanuka (*Kunzea ericoides*) stands, Gisborne Region

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# CONTENTS

# Abstract

Kanuka stands in the Gisborne Region occupy areas with potentially conflicting land use capability, and are often regarded as having lower biological values than primary forest. This investigation compares invertebrate biodiversity between kanuka stands of two age classes, primary forest, and pasture, on the basis of Malaise-trapped Coleoptera and Lepidoptera, two of the major orders of insects (5000 and 2000 described species) in New Zealand.

For beetles and moths there is increasing complexity of community structure and numbers of species and trophic categories from pasture to old kanuka and primary forest. For both there is a change in faunal composition from pasture to all non-pasture sites, as expected, and biodiversity values increase to old kanuka and forest sites. In old kanuka, both orders were consistently as highly biodiverse as in forest. Stands with a diverse, largely closed understorey have the highest biological diversity; grazed stands of younger kanuka have the least.

More resident insect species of forest and old kanuka can move across pasture areas than was previously thought. For Lepidoptera, incidence of species not resident in a site could be high, indicating that non-extensive unsuitable habitats are no barrier to dispersion between breeding sites.

The distribution of conspicuous, large, ground-dwelling predatory beetles is dependent on factors other than presence/absence of kanuka forest; such beetles were collected only above 250 m a.s.l.

It is recommended that old kanuka stands with a diverse understorey/subcanopy should be classed with primary forest in land-use evaluations. Effects of grazing under kanuka on invertebrate representation need further evaluation; both young and older stands should be examined.

# 1. Introduction

Considerable areas of the North Island's East Coast district, from Gisborne (Fig. 1) through to Ruatoria about 150 km to the northeast, are occupied by kanuka (*Kunzea ericoides*, Myrtaceae). Much of the conservation estate occupies land over which there are conflicting views on potential use. No information was hitherto available on the invertebrate fauna of kanuka forest, in particular for insects, which with fungi form the greater part of the New Zealand land biota (fauna and flora).

The recent government-supported reafforestation/erosion control schemes in the Poverty Bay area of East Coast Conservancy, Department of Conservation, involve decisions on the conservation values of kanuka stands of varying age, distance trom recruitment sources, and on various landscape aspects. Decisions currently resting largely on floristically based criteria may be more broadly based if the information available includes data on invertebrates, which in terms of species, major families, and orders represented are ten times more biodiverse than the vascular plants.

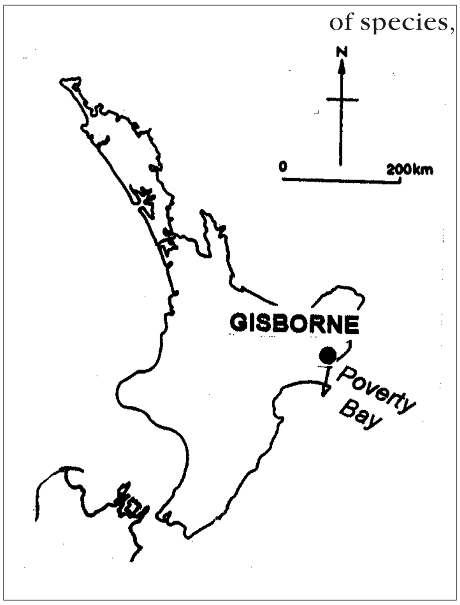


FIGURE 1. LOCATION OF THE GISBORNE REGION, NORTH ISLAND, NEW ZEALAND.

This investigation is a first attempt to compare invertebrate biodiversity in kanuka stands of two age classes with that in primary forest and pasture for Department of Conservation Science & Research Division (and largely at the instigation of East Coast Conservancy). The work was done by Manaaki Whenua - Landcare Research, Auckland, with sampling design, analysis and interpretation of Coleoptera data provided by J Hutcheson, Forest Research Associates, Rotorua.

Because invertebrates - particularly insects - are so diverse and numerous (over 20 000 insect species in New Zealand: Emberson 1994), and because feasibility studies had shown that the original contract proposal objectives were not all attainable, objectives were scaled down to deal with Coleoptera (beetles) and Lepidoptera (moths and butterflies) only. These two orders are respectively the most diverse and the third most diverse in New Zealand, with approx. 5000 and 2000 described species. Since a relevant methodology had already been tested (Hutcheson 1990), this was adopted, and John Hutcheson's expertise was subcontracted for sampling design and analysis of insect communities. Through adopting this approach, beetle community structure in kanuka stands can now be directly compared with that in other forest systems.

# 2. Objectives

Of the original four objectives proposed (1994), two were refined and expanded to emerge as follows:

- To sample in two age classes of kanuka, and in pasture and primary forest (to provide values from extremes of successional vegetation), species representation and community structure of Coleoptera and Lepidoptera.
- To record in these sites the occurrence of large predatory ground beetles (carabids).

The other two were discarded; for one, the target animals were not present, and for the other, fungus flies and crane-flies were too numerous as species and individuals to be dealt with, given the time and funding.

# 3. Methods

## 3.1 GENERAL

Habitats represented those found in the general area, and included: pasture within 20 m of kanuka shrubland (year 1); pasture isolated from indigenous regrowth and close to a farm dam (year 2); grazed kanuka shrubland approx. 30 years old; diverse shrubland dominated by kanuka approx. 60 years old; and a remnant patch of podocarp/tawa forest. Habitats were documented using standardised ‘recce’ plots (Allen & McClennan 1983, Allen 1992) (see Section 9.1). The project involved weekly sampling over December l993, repeated over December 1994, with data ready for analysis in April 1995 and interpretation by June 1995. The sampling period used has been defined as producing the most characteristic samples from habitats (Hutcheson 1990; Hutcheson 1996; Hutcheson & Kimberley, unpublished data). Traps were standardised in dimensions (Townes 1972) and orientation, first year’s data showing that smaller, commercially available traps did not provide samples which were clearly distinguishable between habitat types (Hutcheson 1994). The word ‘species’ in this report stands for recognisable taxonomic unit (RTU). Species-level identification was achieved for approx. 80% of the trap catch.

Data used here came from one trap per site in the first year and two traps per site in the second year. Sites were the same in the second year, apart from the pasture site. As the original pasture site appeared to be influenced by nearby diverse shrubland (Hutcheson 1994), in the second year a more isolated site some 600 m from indigenous regrowth was used. This site was adjacent to two farm dams, which also influenced the characteristics of the beetle catch.

Sample sites had to be within easy access of each other, to keep operational costs within budget. Two sampling techniques were adopted, as follows.

(a) Malaise trapping: two traps per site, either in parallel or in line; pots were changed every 7 days for 4 weeks in December (period of greatest beetle sample discrimination: Hutcheson 1990). Malaise traps are a fine mesh screen; both day-active and night-active organisms are guided into a high sleeve, pointing north, and drop into a pot of 75% ethyl alcohol. These are passive traps which are independent of the habitat sampled.

(b) Pitfall trapping: wide-mouthed plastic pots sunk in the ground, and partly filled with 50% ethylene glycol in water, to collect ground-crawling organisms. Again, the traps are passive, with no known attraction attributes.

Neither trapping method contravenes DoC guidelines, and traps were installed under the supervision of DoC staff.

## 3.2 COLEOPTERA

Coleoptera (beetles) from Malaise trapping were sorted to species/individuals by André Larochelle, Auckland. Names of taxa used in Table 1 are as in the New

Zealand Arthropod Collection (NZAC), Landcare Research Ltd, Auckland. Results for all species were treated as described in Hutcheson (1990, 1996). Weekly catches were subjected to the polythetic, divisive, classification procedure, TWINSPAN (Hill 1979).

The most useful (and simplest) diversity index - a summing of the abundance classes (SAC) found to optimise sample discrimination (Hutcheson 1990) - was applied. This measure is dominated by species richness, but abundance is associated with individual species, and allows diversity of sample divisions based on biological attributes (e.g. functional groups) to be compared. Further information is available on request from J. Hutcheson, Forest Research Associates, PO Box 1031, Rotorua.

### 3.3 LEPIDOPTERA

Specimens of Lepidoptera (moths and butterflies) were collected along with the beetles, sorted to RTUs and recorded; funding allowed only the 1993 series to be used. The species were scored as to whether they could be deemed resident (R) at the site or vagrant (V). Scoring was generally easy, as the site vegetation records (Appendices, Sections 9.1 and 9.2) provided ample evidence as to whether the host plant or niche was present. For example, the lack of Fabaceae (clover, lotus) at the older kanuka site meant that *Coleophora* spp. (clover casebearer moths) and *Zizina labradus* (light blue butterfly) were vagrant at that site. Only resident species are considered in the simple analysis given below (Section 4.2). Thus, they cannot be directly compared with the Coleoptera figures. The data are presented in the Appendices, Section 9.3. Names of taxa used in Section 9.3 are as in Dugdale (1988).

### 3.4 PREDATORY GROUND BEETLES

For pitfall trapping, method (b) above, species of predatory ground beetles only were recorded.

# 4. Results

### 4.1 COLEOPTERA

Summarised results by trap and site are presented from Malaise trap sampling of Coleoptera conducted within the habitat types. Conclusions are drawn from data compiled over the two sampling seasons. Results show the variability between years, and traps. Divisive classification (TWINSPAN) of the weekly catches of beetles demonstrated clear discrimination between the various habitat types.

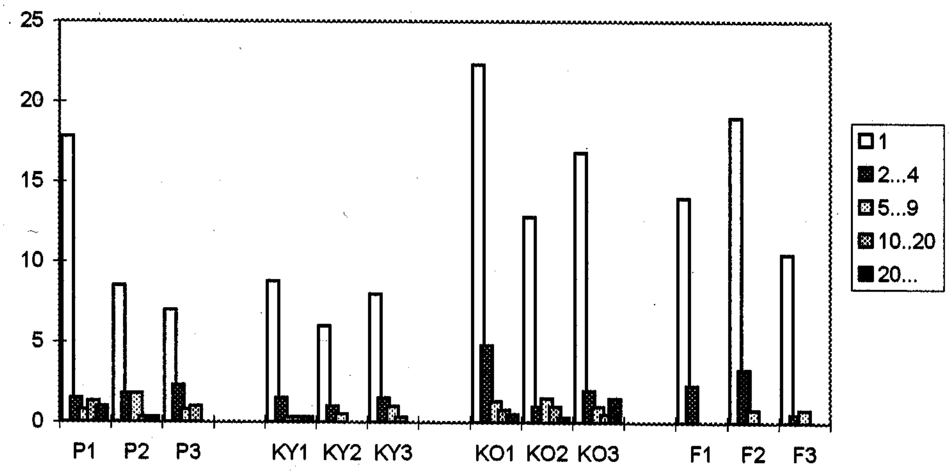


FIGURE 2. NUMBER OF SPECIES OF COLEOPTERA PER ABUNDANCE CLASS (SEE LEGEND) IN EACH TRAP. P, PASTURE; KY, GRAZED YOUNG KANUKA; KO, DIVERSE SHRUBLAND DOMINATED BY OLDER KANUKA; F, REMNANT PATCH OF PODOCARP/TAWA FOREST; TRAP 1, YEAR 1; TRAPS 2 AND 3, YEAR 2.

First-year samples showed a range of diversity indices to reflect similar trends of increasing biodiversity from grazed young kanuka, through mature forest and pasture, to older kanuka dominating diverse shrubland. A range of diversity measures revealed a similar pattern across the habitat types. Abundance class distribution of average weekly catch by trap is shown in Fig. 2.

Sample diversity as measured by summed abundance classes of all species was highest in the old kanuka shrubland, followed by forest, pasture, and young kanuka (Fig. 3).

The relatively high diversity of the pasture site catches was influenced by the landscape diversity of the two sites - indigenous regrowth within 20 m of the year 1 site, and adjacent farm dams near the year 2 site. Presence of Scirtidae (whose larvae are aquatic filter-feeding detritivores) at the dam site appeared to have less influence than the diverse shrubland, returning a lower catch of both individuals and species in the year 2 pasture traps (Fig. 4). However, this may be an artefact of the unresolved taxonomic status of this family.

The proportions of the trophic categories in the samples showed detritivores to be species-rich and abundant at the forest site and species-rich but of lower abundance at the kanuka sites and the year 1 pasture site. Herbivores were abundant at both kanuka sites, and a high abundance of aquatic Scirtidae in the year 2 pasture site (P2, P3) reflected the influence of the dams (Fig. 5).

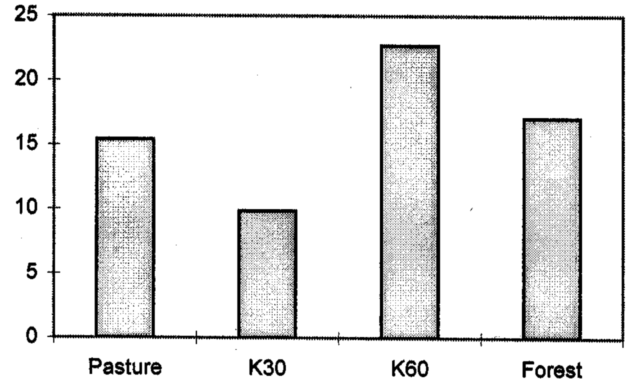


FIGURE 3. BIODIVERSITY OF COLEOPTERA IN THE FOUR HABITAT TYPES (K30, K60 = KANUKA SITE WITH APPROX. AGE), BASED ON AN AVERAGE CATCH FROM THE THREE TRAPS IN EACH, AND DERIVED FROM SUMMING THE ABUNDANCE CLASSES IN FIG. 2.

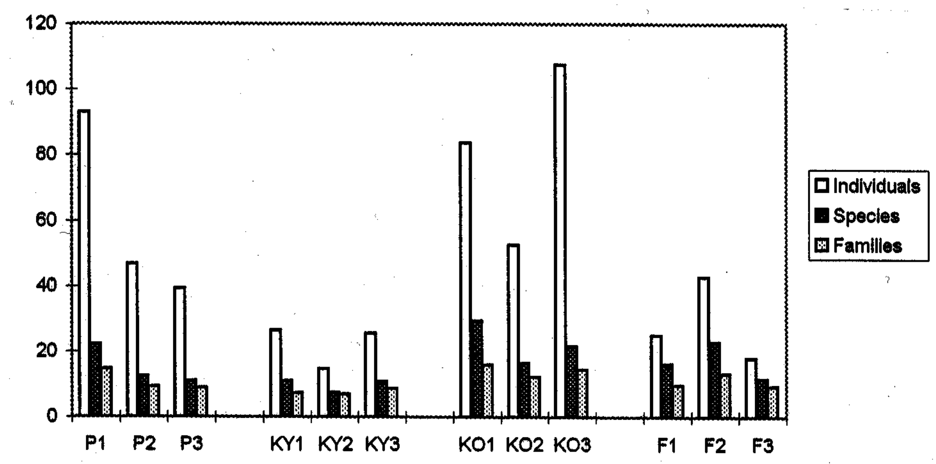


FIGURE 4. AVERAGE CATCH NUMBERS OF COLEOPTERA INDIVIDUALS, SPECIES, AND FAMILIES FROM TRAPS DENOTED AS IN FIG 2.

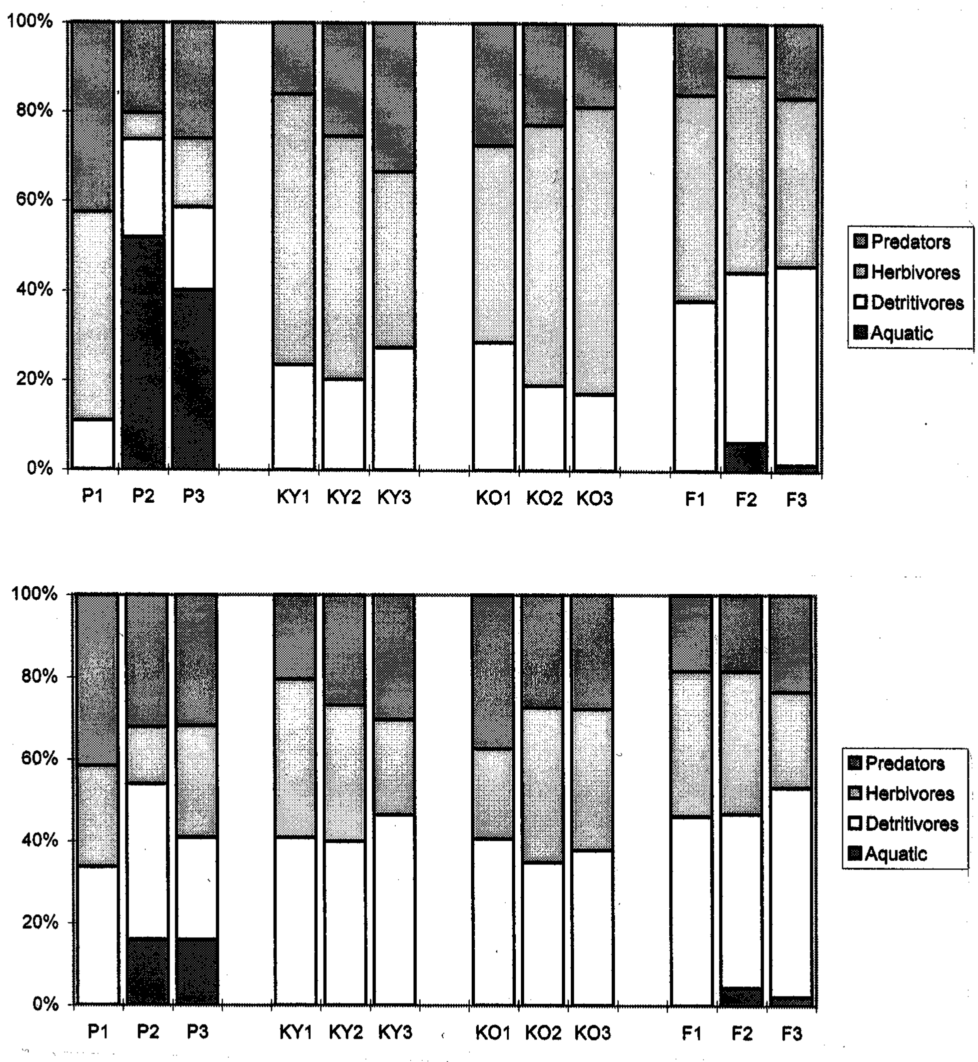


FIGURE 5. PERCENTAGE FUNCTIONAL COMPOSITION OF THE COLEOPTERA COMMUNITIES IN TERMS OF NUMBER OF INDIVIDUALS (ABOVE) AND NUMBER OF SPECIES (BELOW). CONVENTIONS AS IN FIG 2.

Comparison of the two elements of Fig. 5 suggests that the high relative abundance of the aquatic component in samples P2 and P3 at the site beside the farm dams came from a limited number of species. While this may be so, it also highlights taxonomic difficulties associated with the Scirtidae.

The New Zealand Arthopod Collection's Scirtidae are overseas being revised, and determination to species on present understanding requires dissection of genitalia. This was not a pragmatic option, given the constraints on time and other resources inherent in this research brief.

Difficulties with taxonomy are present with dominant groups in the other habitats also. Both the *Eucolaspis* spp. nr *pallidipennis*, dominant in the shrubland types, and the *E.* spp. nr *brunnea,* dominant in the forest types, are difficult complexes with taxonomy relatively unresolved.

Species caught in sufficient abundance to average five or more specimens per catch (sampling frequency = 4 catches per trap year) are listed in Table 1. These indicate a difference in the species dominating the two pasture sites, a more consistent dominant component in thc young kanuka and the mature forest, and a larger dominant component with accompanying variation in the older kanuka shrubland.

## 4.2 LEPIDOPTERA

For the moth and butterfly fauna (178 species: see Appendices, Section 9.3), representation rose from pasture (37) to young kanuka (62) to old kanuka (112) to primary forest (131).

### Number of resident species by site

A gradual increase in faunal richness from pasture to forest is evident (Table 2). Note, too, that both old kanuka and forest each support well over 100 species.

### Trophic categories

The two major classes 'herbivores' and 'detritivores' were divided into subclasses (Table 3). The herbivores were split into herb (H), subcanopy (SC), and canopy (C) feeders, and the detritivores into litter (L), dead wood (W), large fungi (B), and fur or feather (K) feeders. Predators (P) stand alone.

While there is a clear trend, from pasture to forest, of rising detritivore representation with increasing complexity of the site vegetation, the similarity between old kanuka and forest is better expressed when each trophic category is subdivided, as in Table 4.

## 4.3 PREDATORY GROUND BEETLES

All records of large species came from localities over 200 m a.s.l. The *Mecodema* species 2.7–3.5 cm long, present on ridges at 260 m with scattered beech patches 1.5 km north of the research area, was absent from all other sites. One skeleton of a (possibly different) giant species was found at the forest site (480 m). Only a relatively small ground beetle (1.5 cm long) was collected at the old kanuka site.

## 4.4 SUMMARY OF FINDINGS

The increase in amount and variety of litter present in old kanuka and forest compared with pasture and young kanuka is indicated by the increasing

TABLE 1. SPECIES AVERAGING FIVE OR MORE SPECIMENS PER TRAP CATCH OVER THE 4-WEEK SAMPLING PERIOD. 'WEEK (49-52)' DENOTES IST TO 4TH WEEK IN DECEMBER; OTHER CONVENTIONS AS IN APPENDICES, SECTION 9.3.

| | Species (family) | Abundance class | Trophic category | Week (49-52) |
|---|---|---|---|---|
| PI | *Dasytes subcyaneus* (Melyridae) | 5 | p | 50 |
| | *Pyronota festiva+laeta* (Scarabaeide) | 5 | L | 50 |
| | *Eucolaspis* spp. nr *pallidipennis* (Chrysomelidae) | 5 | L | 51 |
| | *Pristoderes scaber* (Colydiidae) | 4 | p | 50 |
| P2 | *Cyphon* sp. C (Scirtidae) | 4 | A | 49 |
| | *Cyphon* sp. A (Scirtidae) | 4 | A | 49 |
| | *Anisomeristes thoracicus* (Corylophidae) | 3 | p | 49 |
| | *Eucioides suturalis* (Anthribidae) | 3 | D | 49 |
| | *Coccinella undecimpunctata* (Coccinellidae) | 3 | p | 50 |
| P3 | *Cyphon* sp. A (Scirtidae) | 4 | A | 50 |
| | *Cyphon* sp. C (Scirtidae) | 4 | A | 49 |
| | *Baculipalpus strigipennis* (Oedemeridae) | 4 | D | 50 |
| | *Coccinella undecimpunctata* (Coccinellidae) | 3 | p | 50 |
| KYI | *Eucolaspis* spp. nr *pallidipennis* (Chrysomelidae) | 5 | L | 51 |
| | *Stenomordellaria neglecta* (Mordellidae) | 3 | p | 50 |
| KY2 | *Eucolaspis* spp. nr *pallidipennis* (Chrysomelidae) | 3 | L | 50 |
| KY3 | *Eucolaspis* spp. nr *pallidipennis* (Chrysomelidae) | 4 | L | 49 |
| | *Stenomordellaria neglecta* (Mordellidae) | 3 | p | 49 |
| KOI | *Eucolaspis* spp. nr *pallidipennis* (Chrysomelidae) | 5 | L | 50 |
| | *Soronia* sp. 01 (Nitidulidae) | 4 | L | 50 |
| | Aleocharinae Unit A (Staphylinidae) | 4 | p | 50 |
| | *Enicmus foveatus* (Lathridiidae) | 4 | D | 48 |
| | *Mesocolon alacre* (Leiodidae) | 3 | D | 48 |
| K02 | *Eucolaspis* spp. nr *pallidipennis* (Chysomelidae) | 5 | L | 51 |
| | *Melanophthalma/Corticaria* spp. (Lathridiidae) | 4 | D | 48 |
| | *Stenomordellaria neglecta* (Mordellidae) | 4 | p | 51 |
| | *Soronia* sp. 01 (Nitidulidae) | 3 | L | 50 |
| | *Soronia hystrix* (Nitidulidae) | 3 | L | 49 |
| K03 | *Eucolaspis* spp. nr *pallidipennis* (Chrysomelidae) | 5 | L | 50 |
| | *Stenomordellaria neglecta* (Mordellidae) | 5 | p | 50 |
| | *Melanophthalma zelandica* (Lathridiidae) | 4 | D | 48 |
| | *Melanophthalma/Corticaria* spp. (Lathridiidae) | 3 | D | 48 |
| | *Soronia hystrix* (Nitidulidae) | 3 | L | 49 |
| | *Eburida sublineata* (Cerambycidae) | 3 | D | 51 |
| F2 | *Peniticus suffusus* (Chrysomelidae) | 3 | L | 48 |
| | *Eucolaspis* spp. nr *brunnea* (Chrysomelidae) | 3 | L | 48 |
| F3 | *Oemona simplicollis* (Cerambycidae) | 3 | D | 50 |
| | *Eucolaspis* spp. nr *brunnea* (Chrysomelidae) | 3 | L | 49 |

complexity of both the litter-feeding and wood-feeding detritivores. The apparent depression of herbivore figures in forest may be influenced by the height of the canopy (>30 m) in relation to that of the Malaise trap (1 m), as some canopy herbivores may not have descended to within range of the Malaise trap. However, comparable sampling within the canopy of podocarp/broadleaf forest has shown much reduced total insect activity in

TABLE 2. NUMBER OF LEPIDOPTERA SPECIES COLLECTED BY SITE, WITH ESTIMATED TOTAL FOR RESIDENTS (R) AND VAGRANTS (V), DECEMBER 1993.

| Site | Species (*n*) | V (est.) | R (est.) | Total for Dec* (V+R) |
|---|---|---|---|---|
| P (pasture) | 43 | 20 | 37 | 57 |
| KY (young kanuka) | 71 | 20 | 62 | 82 |
| KO (old kanuka) | 77 | 9 | 112 | 121 |
| F (primary forest) | 112 | 14 | 131 | 145 |

*Only species collected are apportioned here; species not collected in the area but known to feed on a host present in the area (e.g. *Pyrgotis arcuata* on kahikatea) were not included.

TABLE 3. PERCENTAGE DISTRIBUTION OF HERBIVORY AND DETRITIVORY IN RESIDENT LEPIDOPTERA, BY SITES. H, HERBIVORES; D, DETRITIVORES.

| Site: | Pasture | | Young kanuka | | Old kanuka | | Forest | |
|---|---|---|---|---|---|---|---|---|
| Trophic category: | H | D | H | D | H | D | H | D |
| % species | 84 | 16 | 65 | 35 | 63 | 37 | 54 | 46 |
| % individuals | 99 | 1 | 84 | 16 | 69 | 31 | 46 | 54 |

TABLE 4. LEPIDOPTERA IN PASTURE, KANUKA STANDS, AND FOREST, BY LARVAL TROPHIC CATEGORY. HERBIVORES:H (HERBS), SC (SUBCANOPY), C (CANOPY). DETRITIVORES: L (LITTER), W (DEAD WOOD), B (LARGE FUNGI), K(ANIMAL FIBRE), P (PREDATORS).

| | | Herbivores | | | Detritivores | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Site: | | H | SC | C | L | W | B | K | P | Total |
| Pasture | spp. | 31 | 0 | 0 | 4 | 1 | 0 | 1 | 0 | 37 |
| | % | 84 | - | - | 11 | 2.5 | - | 2.5 | - | |
| Young kanuka | spp. | 23 | 4 | 13 | 15 | 5 | 0 | 0 | 2 | 62 |
| | % | 37 | 6 | 21 | 24 | 8 | - | - | 3 | |
| 01d kanuka | spp. | 27 | 21 | 22 | 22 | 15 | 2 | 0 | 3 | 112 |
| | % | 24 | 19 | 20 | 20 | 13 | 1 .7 | - | 2.6 | |
| Forest | spp. | 19 | 26 | 23 | 31 | 28 | 2 | 0 | 2 | 131 |
| | % | 14.5 | 20 | 17.5 | 23 | 21 | 1.5 | - | 1.5 | |

the forest canopy. Beetle samples showed a similar trophic structure at 15 m to 1 m, with no increase in the proportion of herbivores (Hutcheson 1996, unpublished data).

## Species representation

For the beetle fauna (170 species in 1993, 155 in 1994) young kanuka gave the lowest figures, and forest figures were less than those for old kanuka. The 'drop off' in primary forest dominated by tawa has also been noted for tawa-podocarp forest on the Volcanic Plateau in the central North Island. Using summed abundance classes (SAC) for beetle biodiversity, old kanuka gave the highest SAC figure, followed by forest. Again, young kanuka gave the lowest.

## Representation by trophic categories

For beetles (Fig. 5), representation of detritivores (on litter and wood), herbivores, and predators in the kanuka stands differs from that at the forest site in that herbivores and detritivores were represented often by many individuals but few species (herbivores) or by many species but fewer individuals (detritivores). At the forest site, the difference between numbers of species and individuals was less, indicating that fewer species were conspicuously dominant. That is, the forest detritivore beetle fauna is more balanced.

For Lepidoptera, on the basis of numbers of species scored as resident at a site, there was a steady progression from high herbivore/low detritivore incidence in pasture to close to a 50:50 balance between the two functional groups in forest, with old kanuka intermediate between young kanuka and forest (Table 3).

## Stand architecture and trophic niche

For both Coleoptera and Lepidoptera the more complex the stand, the more complex the functional composition of the insect community. As canopy height increased and tiers developed, so these became used and their use partitioned. With increase in canopy height, and tier development, sources of litter increased in bulk and variety. Little difference is evident in the representation of subcanopy and canopy herbivores, or in wood-feeding detritivores, between old kanuka and primary forest.

## Vagrancy

This category was estimated for Lepidoptera only. Species that are passing through a site, but which cannot breed there (either no host or no host niche) were surprisingly abundant, particularly at the first pasture site (Table 2), where stands of old kanuka were less than 50 m distant from the Malaise traps. This indicates that a mosaic or patchwork of kanuka stands may not be as fragmented (in terms if immigration of fauna) as might be thought. Nearly half the Lepidoptera in the pasture Malaise traps were vagrants in the area, including species not previously known to be dispersable. The other surprise was the relatively large number of pasture species in the forest Malaise traps - mostly grass-moths and sod webworms, abundant in pasture some 200 m upslope from the forest. Presence of vagrant species at the young kanuka site was expected, as bog and grassland species dispersed through the narrow kanuka enclave to other open sites. Lack of a lower tier would also encourage moths to fly through to the sunlit area beyond the kanuka.

### Grazing pressure

As well as stand architecture, grazing (removal of a developing understorey) may have been a factor in the low numbers of beetle and moth species at the chosen young kanuka site. There was no 'intermediate' tier, and the faunal figures may be a reflection of this.

### Canopy-dwelling Lepidoptera available to birds

Two-thirds of the Lepidoptera collected at the old kanuka site were species with larvae on kanuka (C), *Hoheria* (C), *Coprosma* (SC), *Olearia* (SC), *Pittosporum* (SC) and *Cyathodes* (SC), as either generalists or specialists. In particular the most abundant species were present as caterpillars dislodged from the kanuka canopy (probably by wind or rain), indicating that the canopy was supporting large numbers of caterpillars of 5–20 mm body length. The most common species were *Declana floccosa*, *Poecilasthena subpurpureata*,* *Pseudocoremia lupinata*,* *Ps. pulchraria*, and *Ps. suavis*. Species marked with an asterisk are restricted to kanuka, and were particularly abundant.

The abundance of potential bird prey in the canopy and the diverse fauna of detritivores on the forest floor indicate that an older kanuka stand can provide a substantial food resource for insectivorous birds.

### Predatory ground beetles

While results are meagre, the presence in the area of a possible complex of giant carabids (ground beetles) is of conservation interest, as they belong to endemic flightless groups prone to local speciation. Their ability to withstand reafforestation is unknown.

# 5. Conclusions

Data from this standardised approach to comparing insect communities show the highest diversity to occur in the 'shrubland' dominated by older kanuka. Diversity appears to be significantly lower in the grazed younger kanuka; from the species captured, this may be attributable more to the removal of understorey by grazing than to the relative immaturity of the kanuka. Apparent diversity of the pasture samples was raised by 'landscape diversity' (a) through species associated with adjacent diverse shrubland in year 1, and (b) through species associated with adjacent aquatic habitat in year 2. Our difficulties in siting the pasture traps in pure pastoral habitat reflect the degree of landscape diversity in the area selected for sampling.

1. The lower diversity and abundance found in forest in comparison with the old kanuka shrubland is in accord with results from sampling of podocarp/ tawa forest on the Volcanic Plateau, and is perhaps influenced by the slower

turnover of vegetation in this habitat type. Preservation of the majority of endemic biological diversity does not appear to be served by retention of young kanuka which is continually grazed, but may be achieved by release from grazing of areas within the landscape, such that a diverse understorey is able to develop and evolve in both space and time.

2. The extent to which ungrazed indigenous patches and corridors of vegetation are required within the landscape to retain endemic biological diversity has not been established, but species do use and move across a pastoral system where this is integrated with ungrazed regrowth.
3. Where ungrazed areas occur on difficult-to-manage steep hillsides and gullies, and farm resources are concentrated into more easily managed and more productive territory, the values and goals of ecological, economic, and social sustainability may not be in conflict.
4. The observed high incidence of movement across unsuitable (pasture) sites of forest moths indicates that landscapes that are a mosaic of forest and pasture can retain high diversity in at least two major insect orders.
5. In terms of entomological values based on species representation, abundance, and feeding habits, old kanuka with a diverse, ungrazed understorey is close to primary forest for Lepidoptera, and slightly above primary forest for Coleoptera.
6. The distribution of conspicuous, large, ground-dwelling predatory beetles is dependent on factors other than simple presence/absence of forest cover; all such records come from ridges or slopes of higher hills (over 250 m a.s.l). A different sampling regime, at a different season, would be more informative.

# 6. Recommendations

- Old kanuka stands with a diverse understorey/subcanopy should be classed alongside primary forest in land-use evaluations (see Conclusion 1, above).
- Effects on invertebrate representation of grazing under kanuka stands should be evaluated; both young and old stands should be included (see Conclusion 2, above).
- Effects of reafforestation on the survival of endemic giant ground beetles (carabids) need evaluating (see Conclusion 6, above).

# 7. Acknowledgements

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