

Regional patterns of biodiversity in New Zealand: one degree grid analysis of plant and animal distributions

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Regional patterns of biodiversity in New Zealand are illustrated by showing numbers of species in 1° latitude × 1° longitude grid squares. Biodiversity maps are given for twelve speciose groups of lichens, plants and animals which have been recently taxonomically revised. Centres of biodiversity are evident in Nelson and Otago. Other groups would probably highlight Canterbury/north Otago. The different roles of location and environment in the origin and preservation of these patterns of biodiversity are discussed.

Keywords: biodiversity; biogeography; New Zealand; insects; flowering plants

INTRODUCTION

It is generally accepted that levels of biodiversity vary considerably from region to region. This is of great interest both theoretically, for biogeographic science, and practically, as it will possibly influence allocation of conservation resources. Unfortunately, how to measure biodiversity is less widely agreed on. The simple, pragmatic method used in this paper has not been applied in New Zealand before. The results obtained in the present survey are novel, and give greater resolution of areas of endemism and diversity than has been available before.

Levels of biodiversity in New Zealand are assessed here using numbers of species and subspecies in squares of 1° latitude by 1° longitude. This follows similar approaches to studying biodiversity with a grid system which have been made by botanists working in South Africa (Dahlgren 1963; Nordenstam 1969; Oliver et al. 1983; Goldblatt 1990; Hartmann 1991) and Australia (George 1979; Hopper 1979; Craven 1987). Global studies of areal biodiversity using similar techniques have recently been initiated in the United Kingdom (Williams et al. 1994; Gaston et al. 1995). Dahlgren (1963) gave a useful discussion of the grid method and its evident limitations, concluding that it “has certain advantages over others, and the general features of the concentration of species are demonstrable.” Units much smaller than one degree or half-degree squares (e.g. ecological plots) are subject to greater sampling error, while larger area units such as floral and faunal regions are not agreed on by all biologists and may obscure smaller-scale geographic trends in biodiversity. Haila (1996) and Haila & Margules (1996) point out that at any one survey site it is possible to record only a sample of biological diversity, and the issue then is to decide which components of the biota should be sampled.

Previous studies in New Zealand have concentrated on floristic or faunistic lists for ecological sites or regions, whereas this study utilises the rather different data found in the distribution maps of taxonomic revisions. The advantage of this approach is the high quality of the data; the disadvantage is that suitable data are not available for many groups.

The papers in Hawksworth (1995) discuss different modes of assessing biodiversity and

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emphasize that not all species are of equal significance for biodiversity. Two similar species represent less biodiversity than do two very different ones. This observation emphasizes phylogeny and has been stressed by cladists, but could be made from almost any phylogenetic or non-phylogenetic viewpoint. It is quite valid, but, as Harper & Hawksworth (1995) indicate, "it is difficult to see how sufficient phylogenetic data could be generated in the near future for this method to be used to compare the diversity of whole countries." To avoid the problem Faith (1992) suggested that features of organisms rather than taxa, such as species, could be used in biodiversity studies. Discussing this possibility I noted (Heads 1993) that features or characters are the raw data of taxonomy and biodiversity, and emphasizing these is a sound approach. Nevertheless, the practical problems of dealing with such large amounts of data would be daunting in preliminary studies of biodiversity which presumably should deal with groups that are as large as possible. A taxonomy is useful above all as a summary or at least a sample of a vast amount of variation in populations where characters often recombine in a kaleidoscopic way. The general principle that taxa and taxonomies can be used in comparative biogeographic analysis if the samples used are large enough seems valid.

METHODS

A survey was made of New Zealand groups that have been recently revised, are putatively monophyletic, are relatively speciose and have been mapped in detail. (The comparatively small scale of grid used here means that only dot maps furnish suitable data; highly generalised outline maps are too ambiguous.) Biodiversity data was extracted from these revisions. In fact there are very few groups in New Zealand which have been treated in this sort of detail, and so the groups used here have virtually chosen themselves. Not all available groups have been surveyed (e.g. *Asplenium*, Brownsey 1977; earthworms, Lee 1959; lizards, Pickard & Towns 1988), but probably a large proportion have. The publication of the superb *Fauna of New Zealand* series means that there are more treatments available for animal groups than plant groups. Altogether fifteen groups were analysed. These include one genus of lichens, 6 taxa of flowering plants and 7 groups of insects, including the caddis flies (Trichoptera) as a whole, one group of flies (Diptera), one group of beetles (Coleoptera), one group of wasps (Hymenoptera), two groups of moths (Lepidoptera) and two groups of stoneflies (Plecoptera).

RESULTS

Of the fifteen groups studied, Anthribidae (Holloway 1982), Nepticulidae (Donner & Wilkinson 1989) and Sciadopinae plus Medeterinae (Bickel 1991) all showed centres of diversity around the main cities, indicating that these groups are still relatively poorly collected. The maps for these groups are not illustrated. The remaining twelve taxa studied all showed one or both of two main centres in the South Island, in Nelson and northwest Otago respectively.

Three groups showed centres of massing in the northwest South Island. The flowering plant family Thymelaeaceae (Fig. 1) shows a Nelson centre of biodiversity, with diversity dropping off gradually to the south and more rapidly to the north.

The flowering plant family Onagraceae (Fig. 2) shows a similar pattern to that of Thymelaeaceae, having a centre in Nelson.

Trichoptera, the caddis flies (Fig. 3), also show a northwest South Island centre, but with diversity highest on the Paparoa Range.

A second main pattern is shown by three groups with centres of biodiversity in Otago.

Ourisia (Scrophulariaceae) is a genus of mountain herbs (Fig. 4) centred on northwest Otago (Mt Aspiring – Humboldt Mtns).

In *Olearia* (Compositae), an unnamed group of species allied to *O. virgata* and bearing small, opposite leaves has a centre in northwest Otago (Fig. 5).

Anisotome (Umbelliferae) also has a northwest Otago centre (Fig. 6).

A third main pattern is shown by the following six groups which have centres in both Nelson and Otago, with a drop-off in diversity in the central South Island.

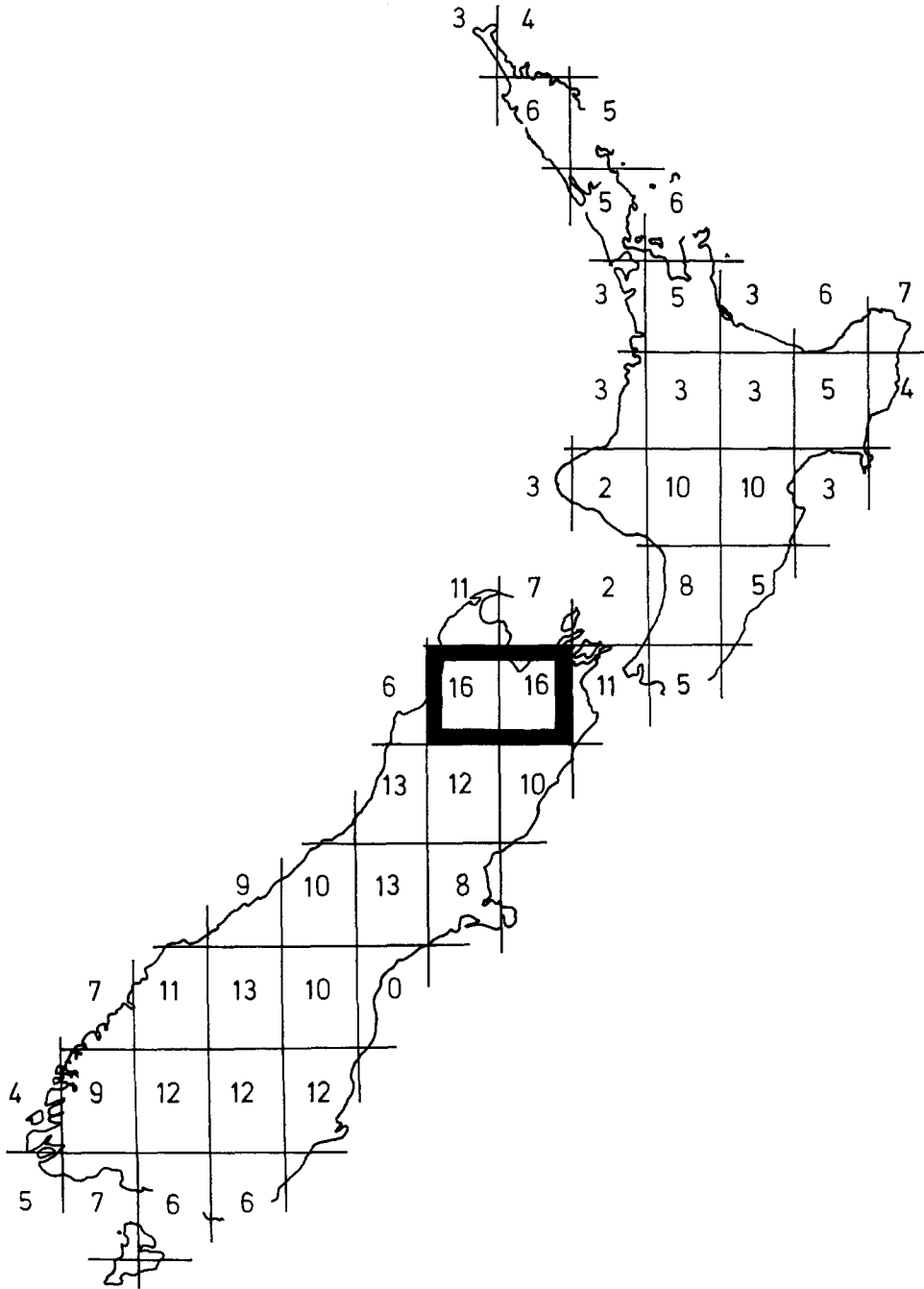


Fig. 1 Species and subspecies numbers in Thymelaeaceae (Angiospermae) (derived from Heads 1990, 1994b).

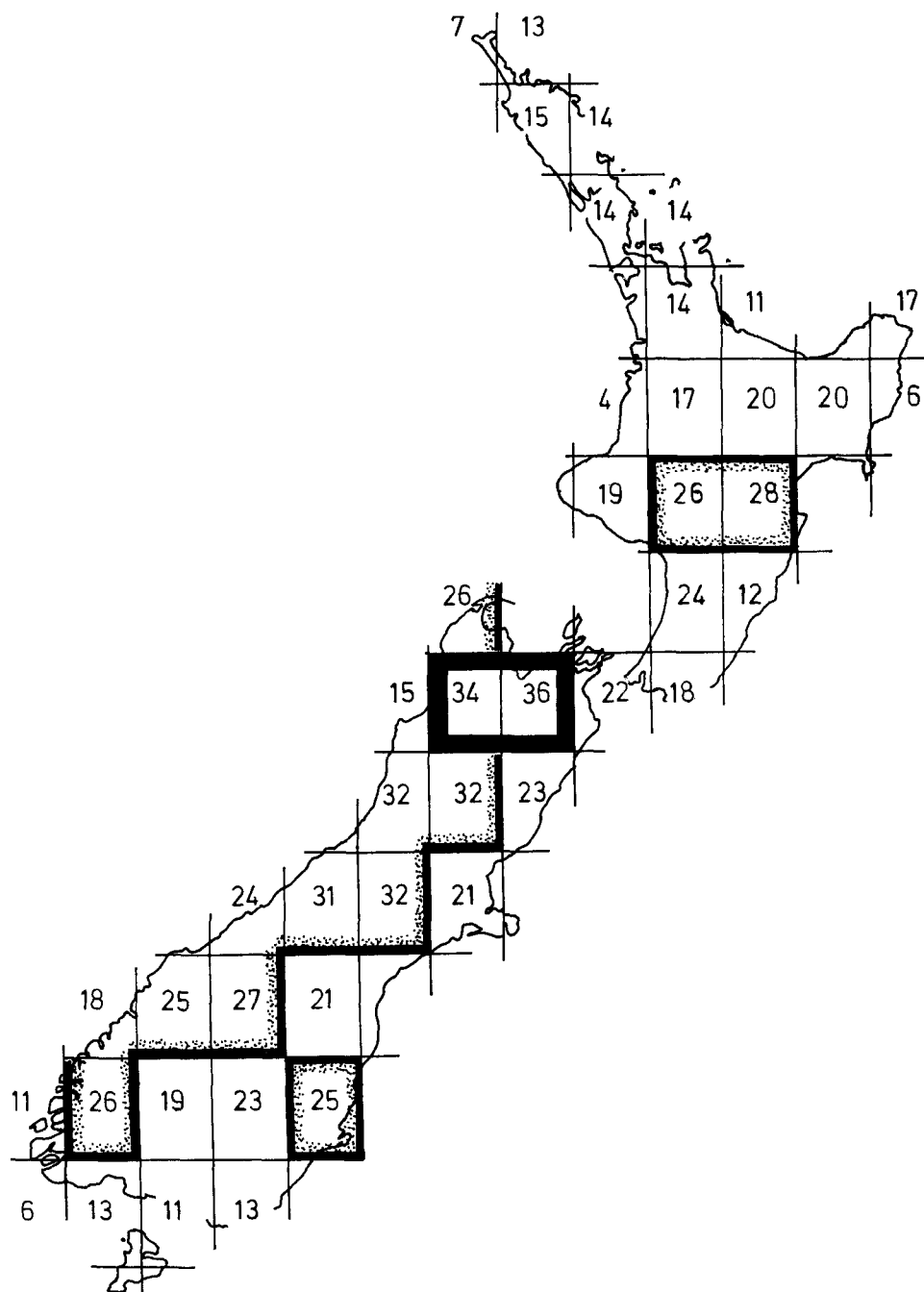


Fig. 2 Species and subspecies numbers in Onagraceae (Angiospermae) (derived from Raven & Raven 1976; Godley & Berry 1995).

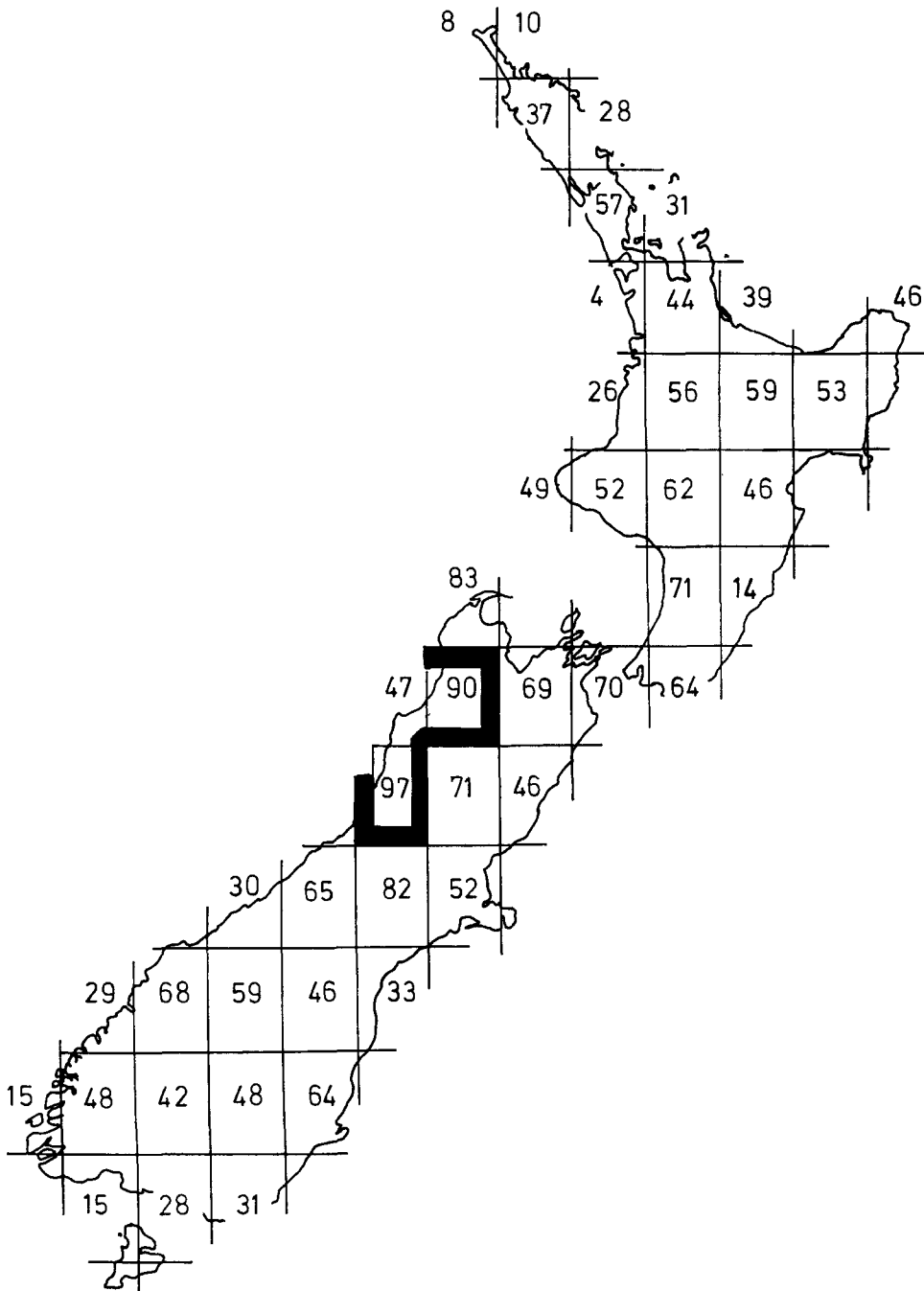


Fig. 3 Species and subspecies numbers in Trichoptera (Insecta) (derived from J. Ward, unpubl. data).

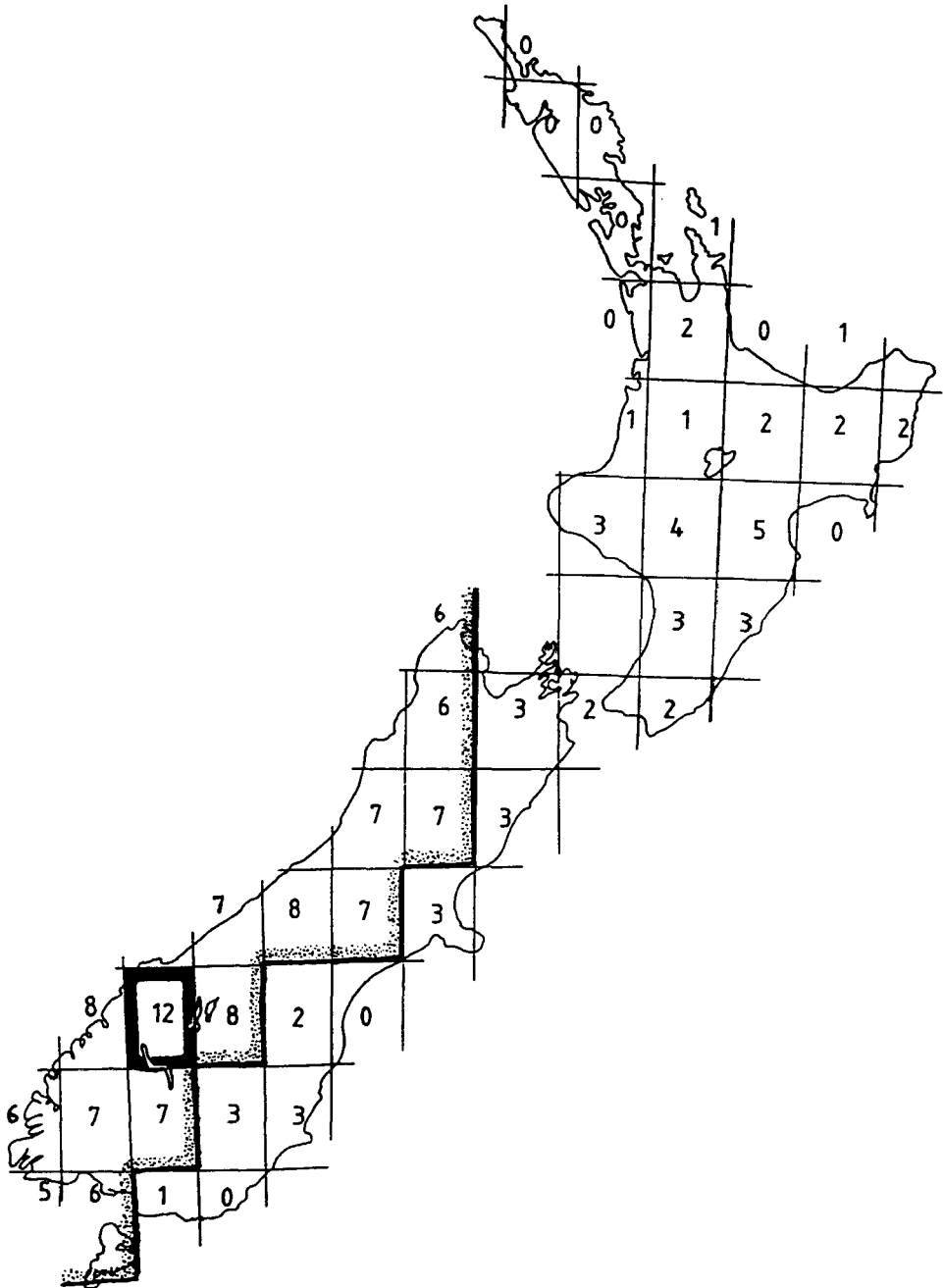


Fig. 4 Species and subspecies numbers in *Ourisia* (Scrophulariaceae) (from Heads 1994a).

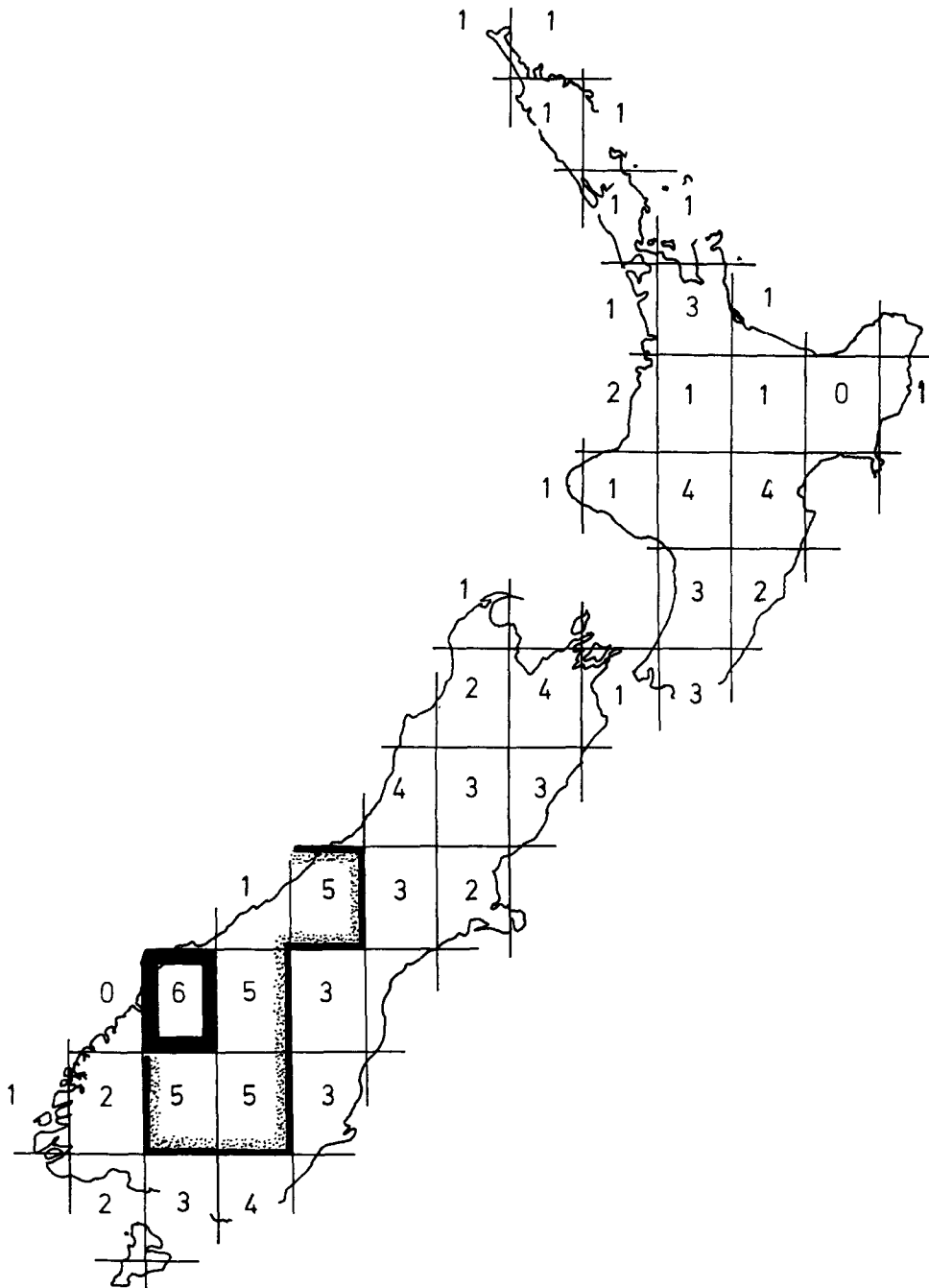


Fig. 5 Species and subspecies numbers in a group of *Olearia* species allied to *O. virgata* (Compositae) (from M. Heads, unpubl. data).

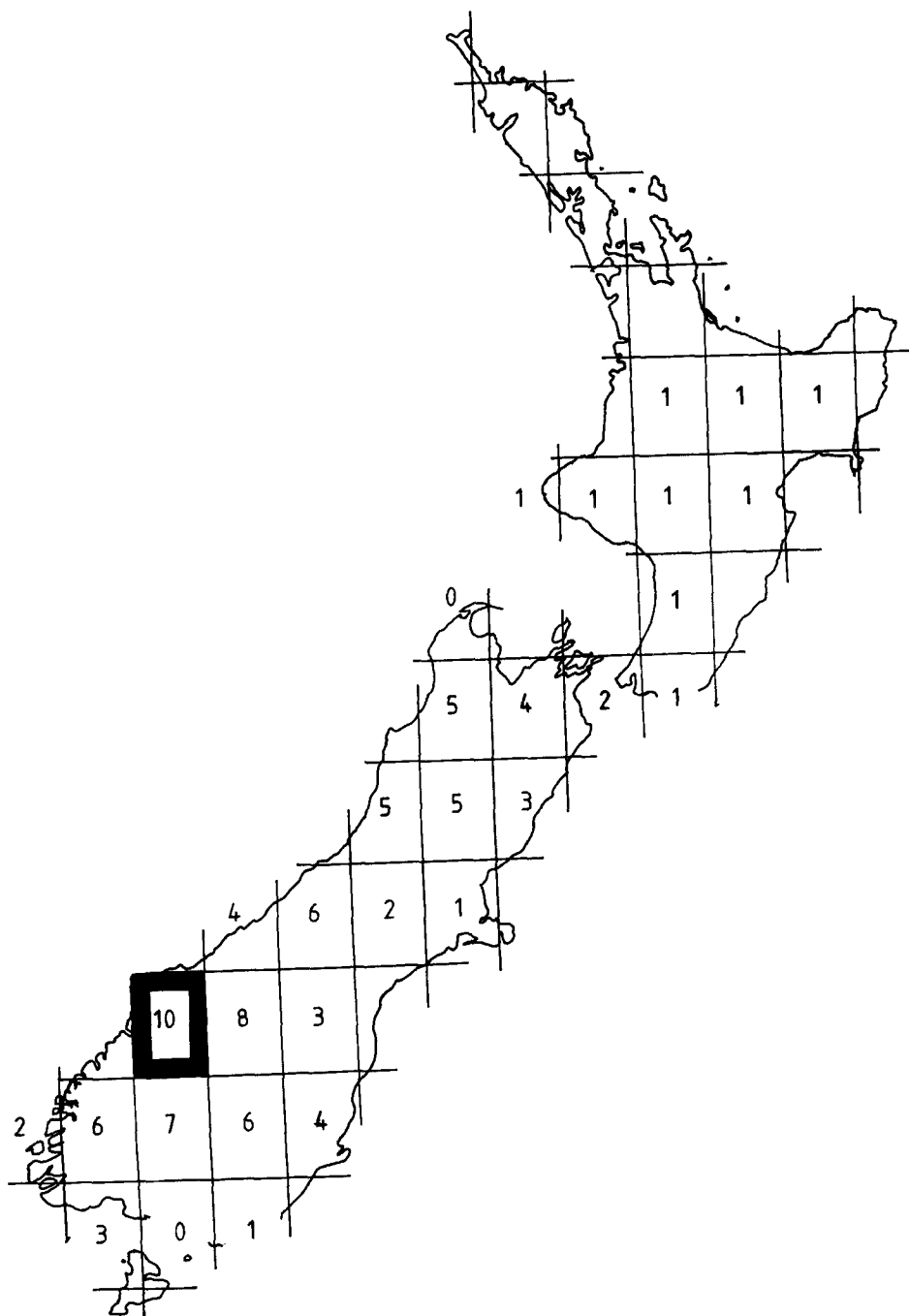


Fig. 6 Species and subspecies numbers in *Anisotome* (Umbelliferae) (derived from Dawson 1961).

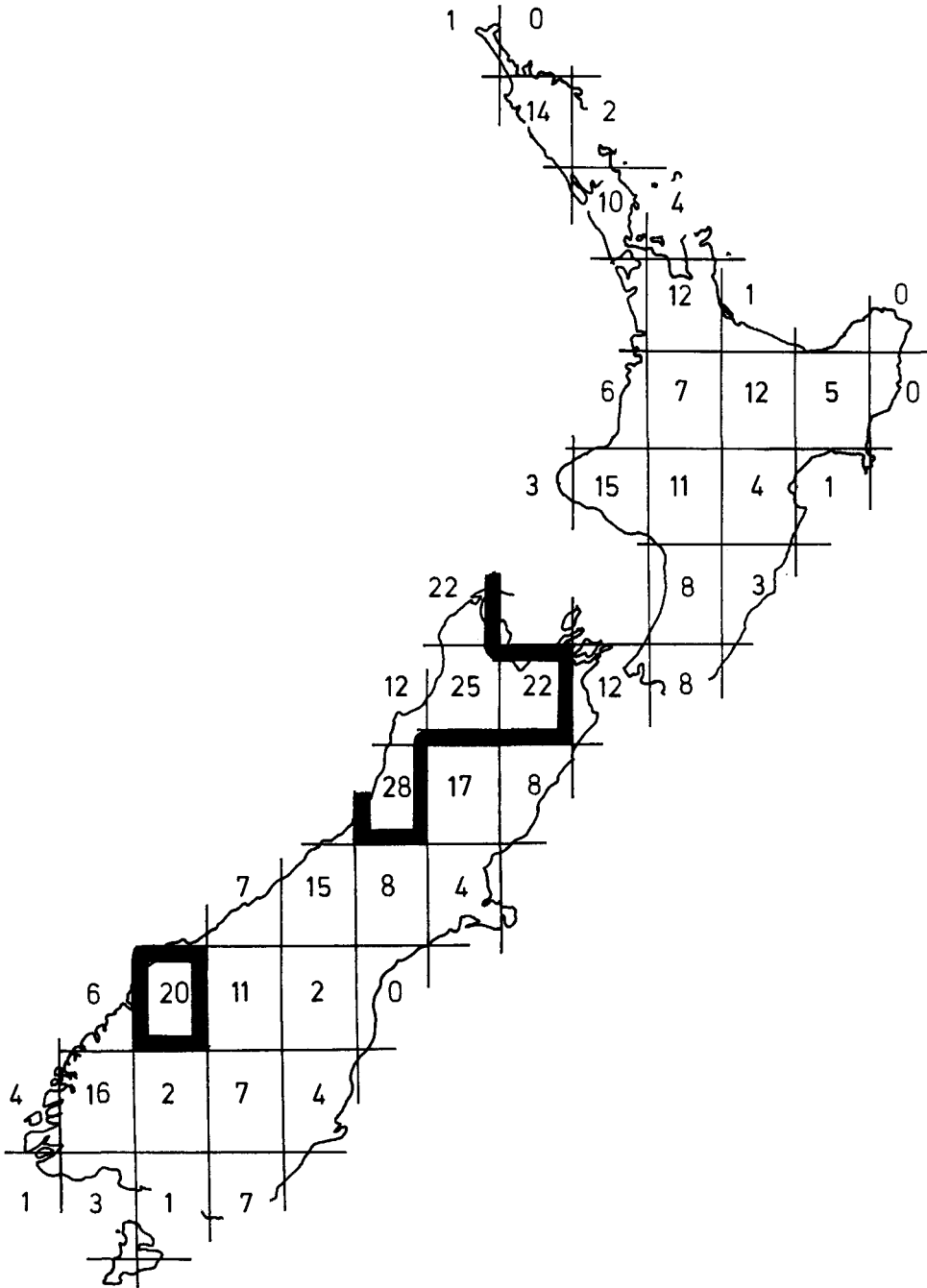


Fig. 7 Species and subspecies numbers in Ambositrinae (Hymenoptera) (derived from Naumann 1988).

The subfamily Ambositrinae (Hymenoptera) (Fig. 7) has centres in the Paparoa Range and northwest Otago.

The moth family Hepialidae (Fig. 8) has centres in northwest Nelson and central Otago.

Biodiversity maps of constituent genera of the plant family Scrophulariaceae, including the diverse genus *Hebe*, have been published elsewhere (Heads 1993, 1994a,c,d,e). The family as a whole has centres in Nelson and northwest Otago (Fig. 9).

The family Notonemouridae (Plecoptera) (Fig. 10) has centres in northwest Nelson/Paparoa Range and northwest Otago.

The Antarctoperlinae (Plecoptera) (Fig. 11) have centres in Nelson, Paparoa Range/Spenser Mtns. and Otago.

The lichen genus *Pseudocyphellaria* has centres in northwest Nelson and northwest Otago (Fig. 12).

DISCUSSION

The different factors giving rise to spatial pattern in biodiversity are of considerable interest. The biogeography of a group is often interpreted as a function of its ecology. Nevertheless, the group of *Olearia* cited above comprises lowland trees and shrubs, but has the same northwest Otago centre as *Ourisia*, a group of mountain herbs. Here groups with very different ecology have similar biogeography (cf. Dahlgren 1963). This indicates that aspects of a group's biogeography, such as its distribution and the location of its main centre of diversity, are not determined simply by present ecology.

Through the processes of phylogeny and dispersal a region inherits a group of species, and which particular species are inherited depends primarily on location – the biogeographic factor. Within the region the given species are 'sorted' ecologically into whatever suitable habitats are present. (In fact, sorting may have already occurred at an ancestral stage.) Alternatively, species become extinct. Biodiversity is maintained if suitable environments are present, but present environments and ecological relations are not necessarily the key to understanding either the past or future of living communities.

The size of an area does govern its biodiversity to a degree; for example, there is greater diversity on the large islands of Melanesia than on the smaller islands of Polynesia. Nevertheless, in *Pseudocyphellaria* (Fig. 12) the northern part of northwest Nelson has more diversity than the much larger central Fiordland region. Here the area effect is swamped by location. Phylogeny and speciation in the group has been effected by a major bio-geological evolutionary centre in northwest Nelson and this has led to a high level of biodiversity even in smaller areas in the region.

On the other hand, *Pseudocyphellaria* has not been stimulated into much speciation in Fiordland for some reason, probably because during the last major phase of modernisation (the Mesozoic Rangitata Orogeny) ancestral populations were not there, or were not diverse there.

It could be argued that the diversity in northwest Nelson is due simply to the diverse rock types currently exposed at the surface, such as large areas of limestone, volcanics, granites and others. However, central Otago, which is a centre of biodiversity, does not have the same lithological diversity, and Fiordland has a range of rock types but appears relatively low in biodiversity, at least in the taxa analysed here. If the Nelson limestone were somehow to be made inaccessible to plants, for example by being tectonically eroded away or covered with lava flows, plants could well switch to a similarly basic habitat, such as soils on basalt. This process may have happened in the Kawhia area of the central western North Island (P. de Lange, pers. comm. 1996.) Geologists have pointed out that terranes hundreds of kilometres wide have disappeared from within New Zealand (Landis & Blake 1987), and the biota of these terranes may well have been redeposited onto extant strata (Heads 1989).

At sites such as the junction of Buller and Takaka terranes in northwest Nelson zones of biological differentiation appear to correlate with geological fold belts and terrane suture zones (Heads 1989). Terrane suturing has led to major phases of physiographic change such

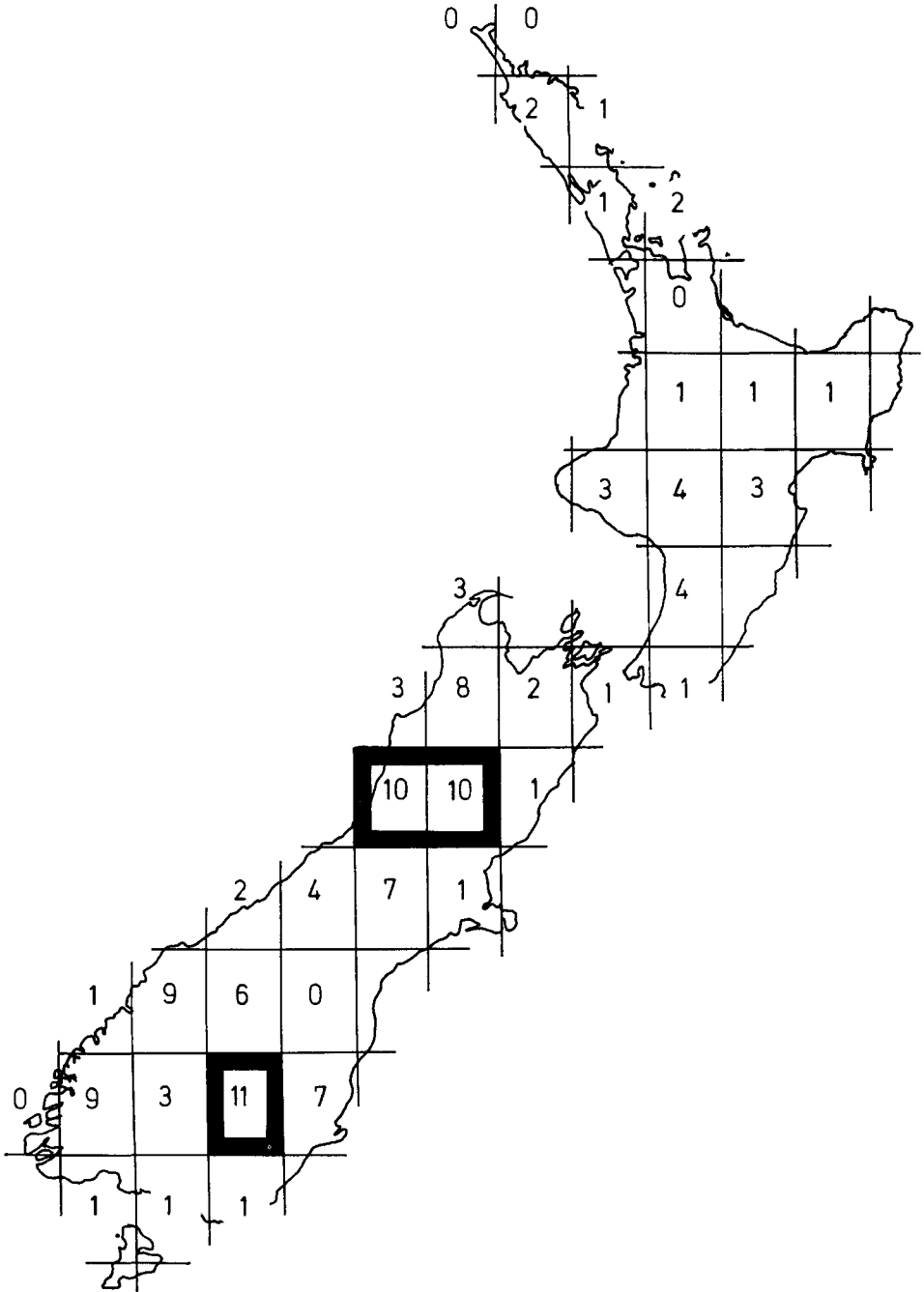


Fig. 11 Species and subspecies numbers in Antarcticoperlinae (Plecoptera) (derived from McLellan 1993).

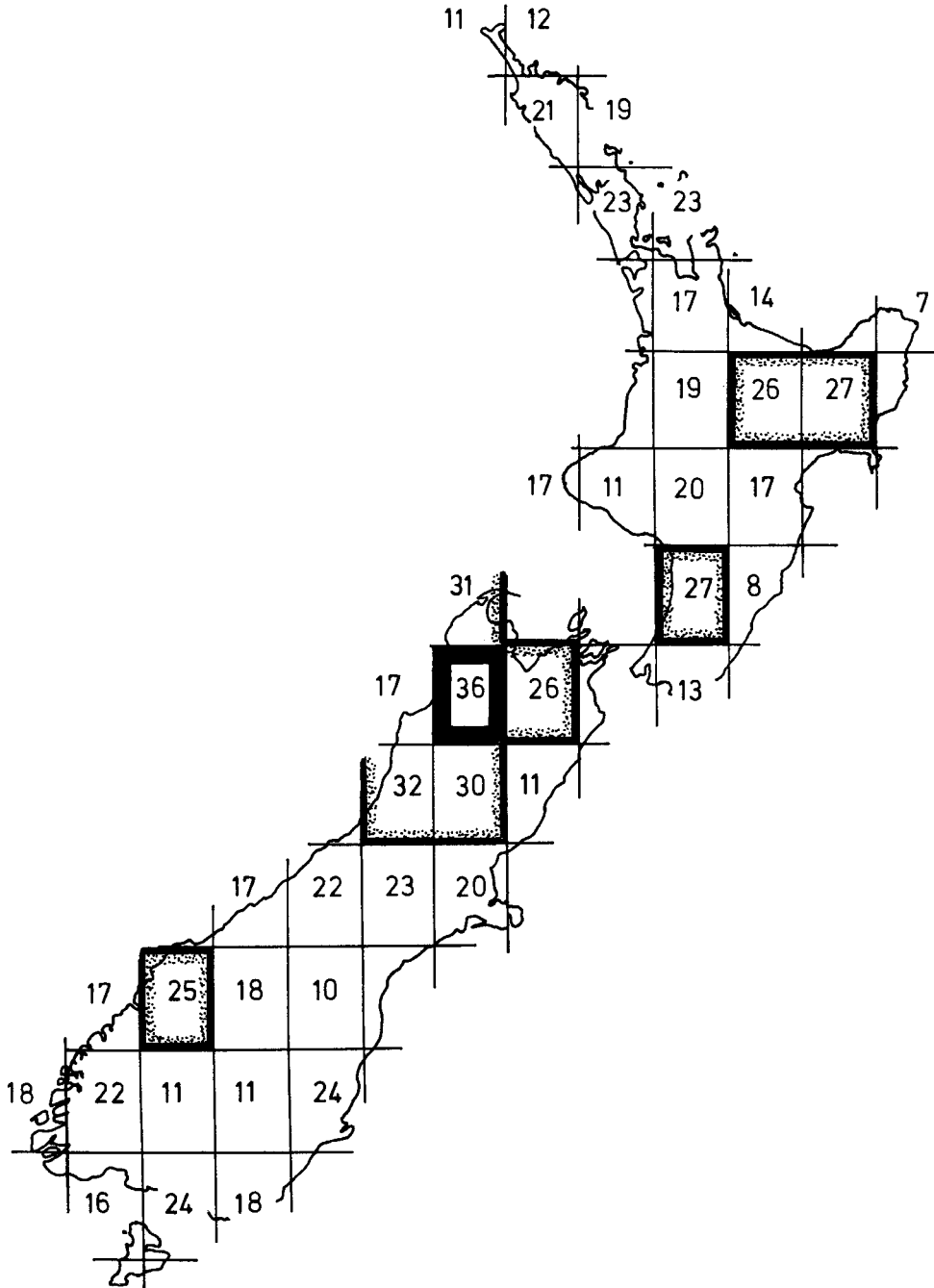


Fig. 12 Species and subspecies numbers in *Pseudocyphellaria* (lichens) (derived from Galloway 1988).

as the Rangitata orogeny. Events of such great age are often felt to be irrelevant to modern biotas, but the centres of biodiversity may already have been present as centres of biodiversity before the present species existed as such.

A centre of biodiversity which has not been identified in this study, possibly because it occurs less frequently, involves groups with distribution massing on the Torlesse geological terrane in the east of the South Island. Examples from the dicotyledons include the Compositae tribe Inuleae (Breitwieser & Ward 1993), *Notothlaspi/Ischnocarpus* (Cruciferae), *Exocarpus* (Santalaceae), *Carmichaelia* (Leguminosae) (mapped by Heenan 1996), and *Parahebe* sect. *Paniculatae* (Scrophulariaceae) (Heads 1994e). It is interesting that all these groups have closest relatives around the Indian Ocean (Africa, India, Malesia, etc.) rather than the better known South Pacific connections with South America. A particularly striking example is the genus *Kirkianella* in the Compositae tribe Lactuceae (= Cichorieae) and endemic to New Zealand (Allan 1961). This has been associated with genera represented most strongly in Africa and Asia, and least in South America: *Sonchus* (tropical Africa, Asia), *Launaea* (Africa, Mediterranean, Asia), *Crepis* (South Africa, Asia, North America) and *Hieracium* (temperate regions excluding Australasia) (Croizat 1952; Allan 1961). In contrast, taxa which are diverse in the west of New Zealand, such as *Nothofagus* (Heads 1989), have strong connections with South America. The respective global connections of the different New Zealand centres of biodiversity remain to be worked out. If there are correlations this would have implications for dating the New Zealand centres.

CONCLUSIONS

This study supports work by Wardle (1963) and Burrows (1965) which indicated disjunct centres of biodiversity in Nelson (plus the Paparoa Range) and Otago. There is some evidence (Figs 2, 12) for a third, less important centre in the central North Island. It is possible that there is really only one major New Zealand centre of biodiversity, which has been disrupted by the formation of Cook Strait and movement on the Alpine fault, separating the Nelson and Otago centres.

Regional studies of New Zealand biodiversity would benefit most from further mapping of species and subspecies in diverse and well collected groups. An obvious plant group requiring treatment is the genus *Coprosma* (Rubiaceae). Among animals, the land and freshwater birds have been mapped (Bull et al. 1985) but breeding localities of seabirds (not mapped) are also of special interest.

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