BIOCLIMATIC ZONES AND BANKS PENINSULA

HUGH D. WILSON*

Banks Peninsula is an island-like, oval-shaped block of dissected and sea-embayed hill country of volcanic origin, jutting into the Pacific from the eastern edge of the Canterbury Plains. At first glance its swelling hills seem to make up a uniform, open, grassy landscape, the result of forest clearance during the last 1000 years. Closer inspection, and attempts to map the present vegetation cover, quickly reveal a complex pattern. Extensive grazed pasture forms a mosaic with fragments of old-growth forest, vigorous second-growth forest and treeland, native scrub, exotic plantation, shrubland, fernland, short tussockland, tall tussockland, rock outcrops, coastal cliffs, tidal inlets, saltmarsh, exotic scrub of gorse and broom, and one sizeable, slightly brackish, freshwater lake. There are small areas of wetland, of dunes, and beaches of sand, stones and boulders.

Ecologists seek to understand such patterns, and to discover what inter-relating physical and biological factors determine what vegetation grows where.

In simple terms, five groups of variables are relevant:

1. the plants available for forming vegetation. We could call this the available gene pool, with both native and introduced elements;

2. climate, determined overwhelmingly by latitude and altitude but with significant lateral gradients as well, especially those to do with distance from the sea, available moisture, and topographic effects (including rain shadows and aspect);

3. soil characteristics, largely determined by the complex interaction of parent material, climate, topography and vegetation, but influenced also by historical accident;

4. disturbances, including those determined by topography, geological processes, extreme climatic events, biological fluctuations, fire, and human activities.

5. the dynamics of the whole vegetation spectrum, e.g. its successional, regenerative and competitive characteristics.

Address: Hinewai Reserve
Long Bay Road
R.D. 3 AKAROA

[Hugh is currently working on a book `The Botany of Banks Peninsula']

Part of understanding the vegetation of any particular area is to relate it to the wider world. One aspect of this for me was the need to sort out a sensible classification of altitudinal zonation for Banks Peninsula, one that gave due weight to vegetation change with increasing altitude on the peninsula itself but one that could also be directly related to altitudinal zones suggested for other parts of New Zealand and the world.

For example, what we in New Zealand have long called "lowland forest" or "temperate rain forest" seems to have a lot of similarity with forest at much higher altitudes in the tropics. Similarly, short vegetation growing above the upper altitudinal limit of trees is called "alpine vegetation" all over the world although it occurs at very different altitudes and varies greatly in detail from place to place. It seems reasonable to assume that similarities in vegetation reflect similarities in environmental conditions, especially climate, and we know a lot about how climate changes with altitude or latitude. On an isolated high mountain such as Taranaki it is especially easy to observe a broad altitudinal banding of vegetation, at least that a wide band of forest gives way to a band of much shorter vegetation as altitude is gained.

Many authors have given names to these bands or zones to clarify the association of a particular major sort of vegetation with a major sort of climate and to enable useful comparisons to be made from place to place. In New Zealand we are familiar with the lowland/montane/subalpine/alpine/nival zones based on the writings of Zotov (1938), Wardle (1964) and Burrows (1967). In simple terms, the lowland zone is marked by tall, complex, species-rich forest; the montane and subalpine zones are characterised by shorter, simpler, less species-diverse forest; the alpine zone is occupied by short vegetation of grasses, other herbaceous species and subshrubs; and the nival zone is marked by perennial snow and ice. Each zone is delineated by a more or less abrupt change at its lower and upper boundaries, none more striking than the timberline and the snowline.

Altitudinal zonation is a reflection of falling mean temperatures with increasing altitude. Mean temperature also falls with increasing distance from the equator, either northwards or southwards towards the poles. It has always intrigued me that simply by walking upwards on a mountain you can travel in a few hours (if you haven't traded your natural fitness for a motorcar) from the forest zone into the zone of perennial snow and ice. You can also experience the same transition by journeying at sea level, but it would be a very long journey of thousands of kilometres.

So far the picture is reasonably simple. But in the real world there are lots of intriguing complexities. One interesting one is that zone limits rise with increasing distance from the sea, a phenomenon often known as increasing "continentality" (or decreasing "oceanicity"). This is observable even in insular New Zealand; timberline in the interior of the South Island is up to 200m higher than timberline near the coast. At equivalent latitudes, in the interior of continental North America, timberlines are some <u>2000</u> metres higher than in New Zealand, a huge difference. Continental climates are characterised by much greater extremes between warmer and cooler seasons than in oceanic climates; winters are much colder, and summers much warmer. Although not

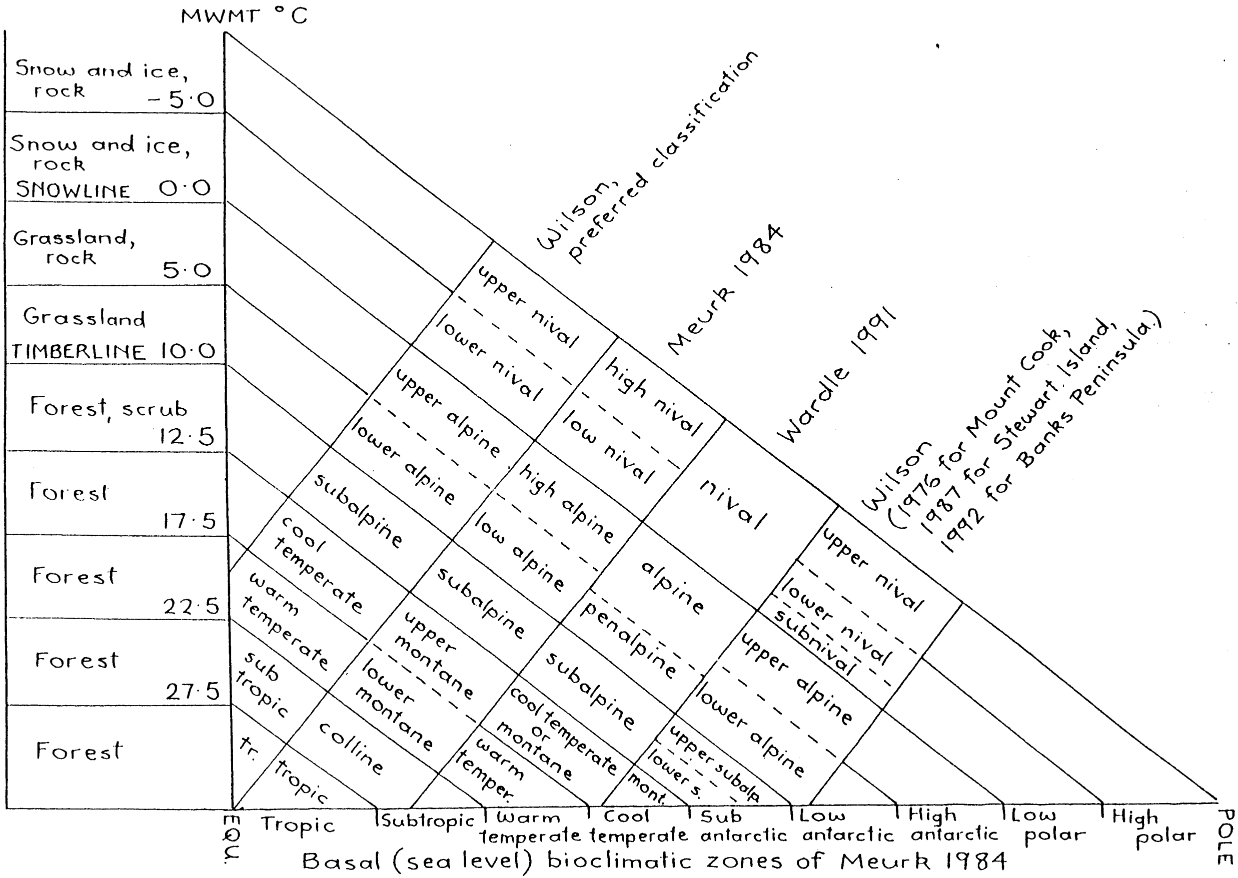

Fig. 1. Altitudinal and latitudinal zones in the southern hemisphere showing their relationship to each other and to probable mean warmest month temperature (MWMT), and the naming of zones by some authors.

immediately obvious, it is the summer temperatures - when plants are growing - that are the important ones in determining timberline. Indeed, timberlines throughout the world seem to be more or less at the altitude where the mean temperature of the warmest month hovers around the 10°C mark. The picture is complicated by the much longer growing seasons in oceanic climates than in continental ones.

Of course timberline could also vary from country to country because native timberline tree species vary in their tolerance to cold. This is surprisingly less relevant than you might think (try planting continental northern hemisphere timberline conifers in New Zealand at anywhere near the altitude they reach at equivalent latitudes in their native territory - say on top of Mount Tasman - and see if they grow!). Nevertheless, Peter Wardle (1991) pointed out that they can be grown some distance above the natural timberline in New Zealand. He suggested that the climatic equivalent of a northern hemisphere timberline lies a couple of hundred metres above the actual New Zealand timberline, and proposed that the band between the two lines be called the "penalpine" zone, characterised by tall *Chionochloa* grasses, plus herbs and shrubs less than 1m tall. "Because native trees are absent", he wrote, "most ecologists have regarded this as the lower part of the alpine belt, but spontaneous spread and experimental establishment of exotic trees, especially north-temperate conifers, indicates that this is invalid. Mid-summer temperatures are lower than in uppermost north-temperate forest belts, but growing seasons are longer".

Another complexity is the climatic continuum between humid and arid. The potential vegetation of any locality is limited by levels of available moisture, and the critical levels are themselves influenced by mean annual temperatures and their effect on evapotranspiration. Also, the altitude of the snowline is much higher on drier mountains than on wet ones at equivalent latitudes and at similar measures of continentality - compare the snowline of the Kaikoura Mountains with that of Westland.

Colin Meurk (1984) aimed to incorporate all these complexities and achieve the sort of consistency necessary if our bioclimatic classification is to be really useful for global comparisons of ecological data. He took the temperature regime as the primary factor in determining zones, but encompassed the variables of continentality and aridity. His treatment is also notable for taking the New Zealand situation as its starting point and for not being misled by northern bias. He stressed that zones had to be based on "potential plant-life form on non-limiting soils", not simply on existing vegetation that reflects (as well as available energy and moisture), "climate history, chance establishment, genetic potential of local species, terrain instability, intrazonal soils, and biotic disturbance".

Peter Wardle's suggestion of the "penalpine belt" is in line with the goal of achieving the sort of consistency that Colin Meurk stressed. It is unfortunate to some extent, in that it replaces the clear-cut natural timberline as the lower boundary of the alpine zone in New Zealand, with a poorly defined boundary said to be where extensive grassland gives way to short, patchy vegetation and large expanses of bare rocky ground. Actually, where limiting factors such as oversteepened ground, erosion and prolonged snow-lie are minimal, continuous

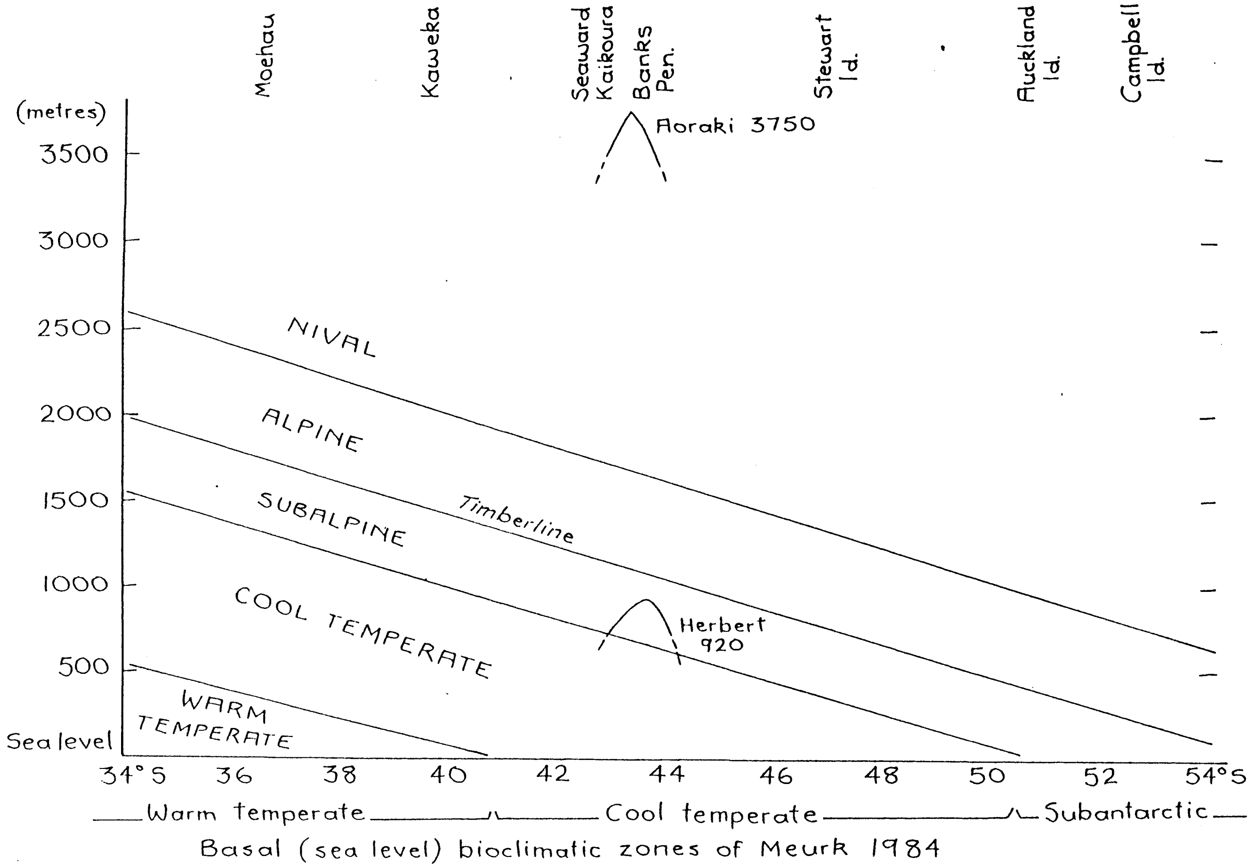

Fig. 2. Altitudinal and latitudinal zones in the New Zealand region from 34° S to 54° S, showing Banks Peninsula in context with the rest of New Zealand. Variation due to continentality is not indicated here.

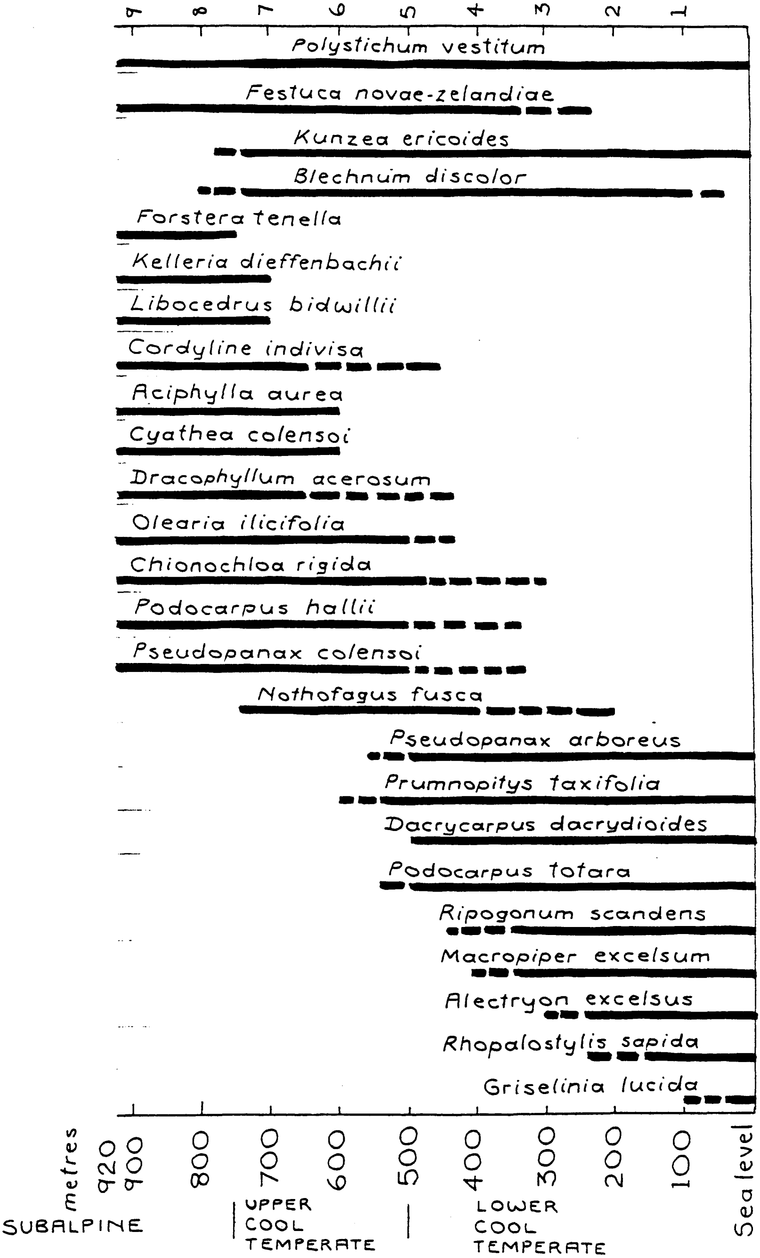

Fig. 3. Altitudinal range of some species on Banks Peninsula. Broken lines represent scattered occurrences beyond the main populations.

Chionochloa grassland ascends to meet the snowline. Wardle's penalpine belt more or less corresponds with the lower alpine zone proposed by Burrows in 1967 so his change is not a fundamental one. Nevertheless, I prefer to stay with Burrows' naming, and place more weight on the observed natural patterns than on the small anomalies suggested by the growth of introduced northern conifers, at least until we can more rigorously compare continental and oceanic timberline phenomena. The system of zone names I prefer is shown in Fig. 1, in the left hand column. Note that I also drop the names `montane' and `lowland' for altitudinal zonation in favour of `cool temperate' and `warm temperate', as it makes plainer their relationship with Meurk's basal or sea level bioclimatic zones.

Banks Peninsula is not high enough to project above a potential or actual timberline, so for the purposes of a zonal classification for this region I can quietly ignore the problems above timberline. Figs 2 and 4 suggest a zonation for the Peninsula based on the considerations outlined in this article and on an altitudinal plotting of numerous species regarded as significant climatic indicators, some of which are shown in Fig. 3. This scheme differs considerably from the tentative diagram in Wilson (1992) and supersedes it, being based on sounder interpretation of data and clarifying the place of Banks Peninsula in a New Zealand and global context.

Banks Peninsula appears to fall into the cool temperate, oceanic, subhumid bioclimatic cell of Meurk and projects altitudinally into the subalpine zone. A marked altitudinal boundary also lies around 500m, reflected in an abrupt change in the species composition of old-growth forest remnants, and less clearly in second-growth forest and grassland. At about this altitude lowland totara gives way to thin-bark totara, and lowland fivefinger to mountain fivefinger. Mahoe is abundant below this altitude, sparse above it. Matai, kahikatea, pigeonwood, kawakawa and silver tree fern drop out. Although found throughout in forest and scrub, pepperwood becomes very abundant above 500m, and so does shield fern and crown fern on forest floors. Within its limited range in Akaroa Ecological District, beech becomes dominant in the forest canopy above this limit. Broadleaved cabbage tree, mountain holly and *Cyathea colensoi* are also characteristic of this upper level forest; so was *Libocedrus* until it was depleted to the point of rarity. So I have tentatively distinguished upper and lower segments of the cool temperate zone on Banks Peninsula.

With decreasing altitude below 500m, warmth-demanding or cold-avoiding species become increasingly diverse and prominent. Some (such as kawakawa, pigeonwood, supplejack and silver tree fern) are more or less widespread through the lower cool temperate forests. Some are more or less restricted to the warmest microclimates near the sea where they add a warm temperate element to the forest. I have tentatively identified these areas as belonging to a 'maritime' segment of the cool temperate zone. Characteristic of maritime cool temperate forest on Banks Peninsula are : nikau palm, mamaku tree fern, and shining broadleaf, plus a longer list of plants that are especially abundant here but extend further inland and upwards to about 200 or 300m : akeake, titoki, ngaio, shining spleenwort, native passion vine, *Lastreopsis glabella* and *L. velutina*. Most of these reach their natural southern limit on Banks Peninsula.

Whether distinguishing 'upper', 'lower' and 'maritime' divisions of the cool temperate zone is useful beyond Banks Peninsula remains to be seen.

The subalpine flora of Banks Peninsula comprises particular species in such characteristic genera as *Chionochloa, Dracophyllum, Aciphylla, Acaena, Anisotome, Gingidia, Gaultheria, Hebe, Parahebe, Brachyglottis, Celmisia, Ourisia, Forstera, Geum, Kelleria, Rytidosperma, Wahlenbergia, Euphrasia, Leucopogon* and *Pentachondra,* totalling a substantial number of species, but much fewer than in the high mountains far to the west.

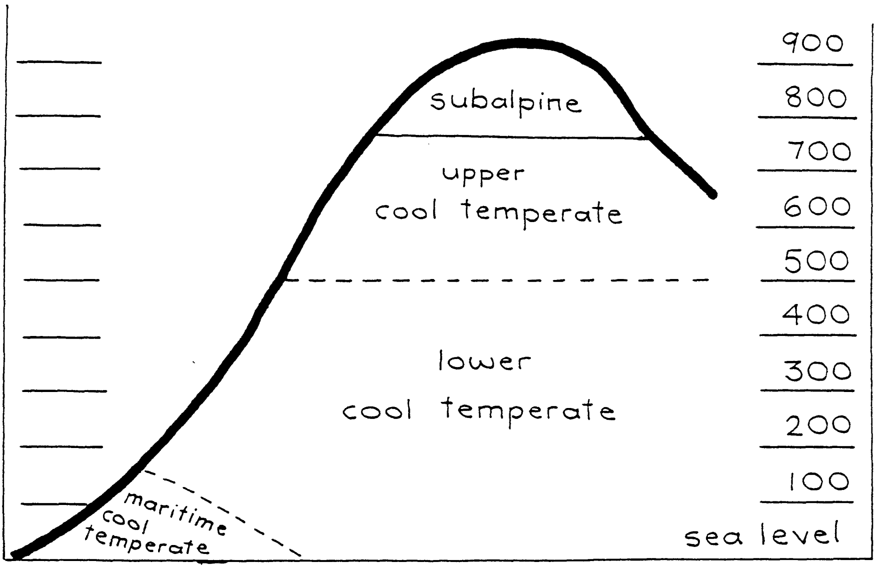

Fig. 4. Bioclimatic zones of Banks Peninsula.

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