The following four papers were delivered as part of a symposium on "Fiordland Ecology" at the 1961 Conference.

GEOLOGICAL FACTORS IN FIORDLAND ECOLOGY

B. L. WOOD

N.Z. Geological Survey, Dunedin

INTRODUCTION

Geology influences forest ecology in two ways in Fiordland, depending on the steepness of slopes. In the area of steep glaciated mountains, variations of the soil-forming properties of the rocks cause variations in the depth of soil, to which the forest ecology is closely related. In the areas of low relief — coastal benches, glacial shelves, foothills and valley floors — the type of plant cover depends on ground-water levels, which are determined by the permeability and weathering properties of rock formations.

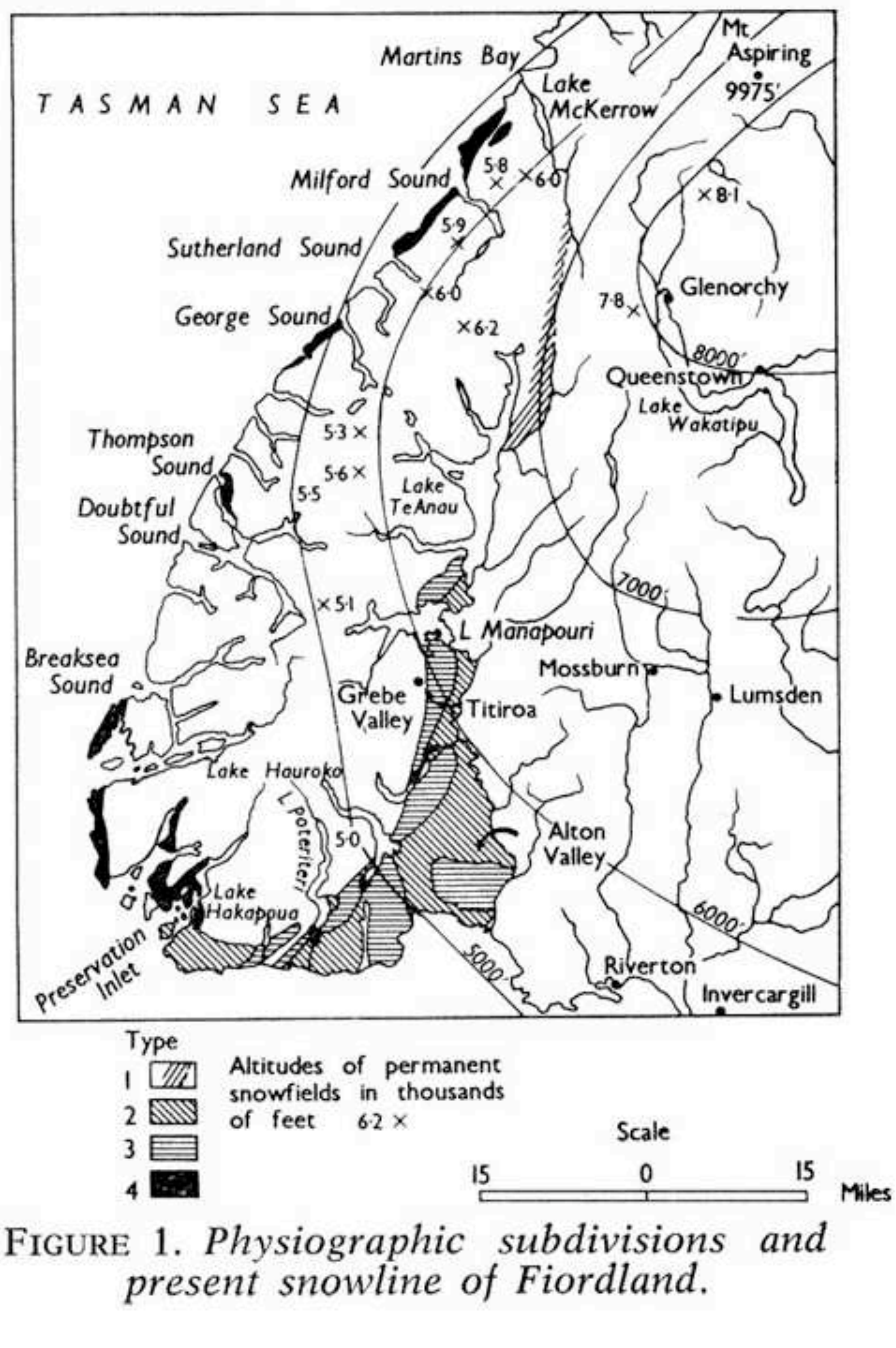

FIGURE 1. *Physiographic subdivisions and present snowline of Fiordland.*

Only the broader effects of these factors can be considered in this account; precise information must await more detailed work.

PHYSIOGRAPHIC SUBDIVISIONS

For the present purpose several types of terrain may be distinguished in Fiordland (Fig. 1). The first, and largest in area, comprises the steep glaciated ranges of schist, gneiss, and plutonic rocks such as granite (Wood 1960). These rocks are for the most part strongly resistant to glacial erosion, chemical weathering, and solution, but some types are less resistant to mechanical erosion arising from water-scour, frost action, debris avalanches, or the plucking action of tree-roots.

A second type comprises a large area of broad coastal terraces on the south coast, which rise in tiers to 1500 ft. above sea-level. Each terrace is underlain by bouldery alluvium 20 ft. to 80 ft. thick, which rests on nearly flat surfaces cut across more or less impermeable Tertiary mudstone and sandstone, or, near Preservation Inlet, on massive granite.

Between the first and second types is a zone of foothills consisting of easily eroded Tertiary sandstones and mudstones. The zone is widest near lakes Hakapoua, Poteriteri and Hauroko, and narrows to a small area of coastal hills in Preservation Inlet.

A fourth type comprises the scattered areas of glaciated coastal hills, pavements, and benches occurring close to the western coast, and on the gentler slopes adjoining the fiords of the south-west. Such areas may in places be underlain by thick glacial deposits, but more commonly the ice-worn rock is only thinly covered or may be bare of any rock debris. Both the glacial deposits and solid rock are less permeable and free-draining than are the gravels of the coastal terraces.

ECOLOGICAL CONTROLS

On the steep slopes of the first type of terrain, the soil cover is usually thin and commonly consists of several inches of forest litter or peat, with a very shallow sandy layer at the base. "The extreme shallowness of the mineral horizon in the soil is not solely due to the steepness of the country. It is a feature of almost all soils formed *in situ* from metamorphic rocks in the Fiordland region, and is particularly characteristic of ice-shorn, over-ridden spurs, and of *roches moutonnées*. . . ." (Wright & Miller 1952: 10). Chemical decay appears to be slow in the cool, moist climate of Fiordland, and Wright & Miller (1952: 11) suggest this may be related in some way to the insulation provided by the early accumulation of forest litter and the marked acidification of percolating waters.

Under such circumstances any factor which causes a greater supply of inorganic soil components can stimulate forest growth. One important characteristic of almost all the hard rocks of Fiordland is that they show effects of mechanical strain and incipient granulation, varying from slight, almost "normal" cleavages within and bounding mineral grains, to numerous strong cleavages and cracks each penetrating several crystals, with slightly crushed boundaries. These features can usually be seen only under the microscope; nevertheless they appear to make it easier for the rock to be broken down by mechanical erosion. They appear also to have determined the variations in the resistance of the rocks to glacial erosion, although the type and attitude of the major joint-system has also had some influence. For example, an area of somewhat fractured granitic rocks adjoining Thompson Sound has resisted ice erosion more than the adjoining gneiss, probably because of a prominent platey jointing that lies parallel to the hill-slopes.

The variation in the rocks of the degree of these incipient weaknesses is controlled by a number of factors, among them lithology (particularly in the gneisses), relative age and relation to the folding movements that the rocks have undergone (especially in the granites), and location on the various parts of fold structures. The interplay of these factors with those of slope, aspect, drainage, etc., results in a complex small-scale distribution-pattern of the greater or lesser mineral contents of the soils.

The most striking example of this property of the Fiordland rocks is on Mt. Titiroa (5643 ft.) near Lake Manapouri. Most of the mountain consists of a pink coarsely crystalline granite which was emplaced late in the sequence of igneous intrusions, and which is closely penetrated by cleavages and fractures. The rock is quite brittle, and pieces may even be broken off by hand. This friable granite is being weathered so rapidly that the talus of fresh feldspathic sand and rubble resembles snow from a distance and is so plentiful in places as to prevent the growth of plant cover.

In the area of coastal terraces, ecological control is exerted by high ground-water levels. These lead to stunted root-systems (peg-roots, etc.) on forest trees, swamp-forest associations, and large bogs. The conditions are similar to those on West Coast pakihi lands, and are due to the formation of impervious iron-pan layers in the subsoils, on which percolating water tends to become perched closer to the surface. It seems likely that the ground-water levels are still rising by growth of the iron-pans. To a much lesser extent some parts of the alluviated valley-floors show these conditions (e.g. Grebe Valley), although most are fairly free draining.

The third type of area, the Tertiary foothills, is probably the most fertile in Fiordland; the rocks are, however, most susceptible to erosion. A similar area in the Alton Valley has been described by Holloway (1954).

The fourth type — of glaciated coastal benches and foothills — shows effects both of thin skeletal soil, and of high ground-water levels, as well as the effects of the strong, prevailing westerly winds. In addition, a small area of coastal hills between Sutherland and Milford Sounds consists of ultrabasic rocks which form a stony orange-brown highly infertile soil on which grows a characteristically stunted forest.

PRESENT SNOWLINE IN FIORDLAND

Altitudes of the lower limits of present permanent snowfields in Fiordland are shown on Fig. 1; these are based on estimates made in the field, often from distant views from neighbouring peaks, and are probably accurate only to within 200 ft. Moreover, many of the snowfields are obviously diminishing in size and their lower limits are rising. However, contours based on the figures indicate a convex shape for the present snow-line, similar to that demonstrated by Willett (1940) for the Pleistocene snow-line. The relation of the present snow-line to the present upper timber-line is not known, but they are probably approximately parallel.

REFERENCES

HOLLOWAY, J. T., 1954. Forest and climates in the South Island of New Zealand. *Trans. Roy. Soc. N.Z.* 82: 329–410.

WRIGHT, A. C. S. and MILLER, R. B., 1952. Soils of South-west Fiordland. *Soil Bureau Bull.* (*n.s.*) 7.

WILLETT, R. W., 1940. Pleistocene glaciation epochs: their number, sequence and correlation. *Proc. 6th Pacific Sci. Congr.* 2: 823–827.

WOOD, B. L., 1960. Sheet 27 Fiord. (1st Ed.) *Geological Map of New Zealand* 1:250,000. Dept. of Sci. and Ind. Res., Wellington, N.Z.

THE ALTITUDINAL GRADIENT IN FOREST COMPOSITION, STRUCTURE AND REGENERATION IN THE HOLLYFORD VALLEY, FIORDLAND

A. F. MARK and F. R. SANDERSON

Botany Department, University of Otago

INTRODUCTION

The forest on the eastern side of the Hollyford Valley in the vicinity of the Deadman's Hut-Harris Saddle track was analysed to describe the changes in composition, structure and regeneration of the forest associated with a change in altitude from the valley floor at 300 ft. a.s.l. to the treeline at 3250 ft. Such an approach resembles the "gradient analysis" of Whittaker (1956), although the method used was somewhat different.

Results of a similar study made recently on undisturbed forest at Blanket Bay, Secretary Island, about 70 miles to the southwest (Mark 1963), provide a useful comparison.

The work described here was done by a party of botany students and staff during a University of Otago Science Students' Association expedition in May, 1960.

Financial assistance from the J. Speden Bequest Fund, administered through the Dunedin Garden Club, is gratefully acknowledged, as also is the field assistance of M. Holdsworth and Misses A. Adams, E. Begg, P. Berry, C. Cotton, E. Fair, R. Gore, J. Greenall, R. Hobson, G. Macdonald, J. Miles, M. Murrell and G. Parsons.

GEOLOGY

According to Grindley (1958), three types of geological material occur in the area studied. The site on the Hollyford Valley floor consists of outwash and moraine of the last glaciation. The upper Hollyford Valley consists of diorite and diorite gneiss of the Fiordland Complex, while the main