CHAPTER NINE

Mountain Barrier to the Wet West Wind

Mountains dominate the landscape of the South Island. They extend in an unbroken chain for 750 km from the Inland Kaikoura Range in Marlborough to the Cameron Mountains in the remote wilderness of south-west Fiordland. In addition, two other mountain arcs – the Tasman Mountains of north-west Nelson and the block mountains of Central Otago – radiate out from the main north-east/south-west axis of the Southern Alps. Lowlands are of limited extent in the South Island, for 70 percent of the land lies above 300 m altitude; two-thirds of these uplands are also steep lands, the remaining third being valley floors, intermontane basins and the undulating crests of the Otago block mountains. This chapter deals with the wet western part of the South Island mountains – the high mountains of the Southern Alps and the lower ranges of north-west Nelson and Fiordland. The drier basins and frontal ranges lying immediately to the east are described in Chapter 10.

Mountain-building and the Alpine Fault

The great Alpine Fault rends the landscapes of the western South Island for 500 km from Milford Sound to Lake Rotoiti where the headwaters of the Buller River emerge from the St Arnaud Range. Satellite photographs show this line very clearly, marking where the Pacific and Indian-Australian Plates are grinding past each other (Plate 9.1). Lateral movement along this fault line has separated the hard, crystalline rocks (granite and gneiss) of the Tasman Mountains-Buller district from those of Fiordland, just as the ultramafic rocks of the Nelson mineral belt (Chapter 8) have been separated from those of the Red Mountain area of South Westland.

As well as this lateral movement, vertical movement has thrust up the block to the east of the Alpine Fault, forming the Southern Alps. During the Ice Ages of the Quaternary Period huge ice caps built up throughout the length of the wet, western mountains. These ice plateaux fed valley glaciers that descended to the Tasman Sea, something like the glaciers of the Alaskan and Patagonian coastlines today. In the far south, the glaciers carved deep into the hard gneiss and granodiorite rock. As the ice melted and the sea level rose, these sheer-walled ‘U-shaped’ valleys were flooded and transformed into the distinctive fiords of Fiordland.

As the Southern Alps were pushed up, the countervailing forces of erosion ensured that they were continually being worn down. Large amounts of erosion debris were transported out of the high mountains by glaciers and meltwaters (Plate 9.2), to be deposited as an apron (or ‘piedmont’) at their base. To the west, this debris built up the narrow piedmont of the West Coast lowlands (Chapter 11) and, to the east, the large intermontane basins of inland Canterbury and Central Otago (Chapter 10), and the huge fan surface of the Canterbury Plains (Chapter 12).

Climatic Gradients and Mountain Soils

A wide variety of soils has developed within this mountain environment. Some soils are skeletal, just a few grains of sand among the rocks of a talus slope but sufficient for hardy alpine plants to establish a toehold. On more stable slopes
Plate 9.2

Looking north-east across the terminal lake at the snout of the moraine-covered Godley Glacier, Mt Cook National Park. The lake is impounded by more moraine, left after the retreat of the Maud Glacier (bottom left). Alpine tussock and herbfield vegetation can be seen only on the limited area of stable soil sites high above the level of valley glacier influence. The extensive talus slopes are a natural feature of these greywacke mountains which lie in the eastern part of the wet, high mountain zone.

in wetter areas, a dense carpet of fellfield vegetation can be supported by peaty soils (Plate 9.3). A mosaic of vegetation communities can be found on steep mountain slopes, reflecting the different ages of the soils on the slope and the cyclic nature of soil development when erosion is active. Wide textural differences occur within the soil parent materials on different mountain landforms – fractured bedrock on eroded sites; sharp, angular stones on talus slopes; less angular stones and boulders (till) on moraines; rounded stones, gravel, and sand on the lower part of fans, on terrace surfaces and in the alluvium of outwash floodplains.

The soils of the mountainous regions of the South Island lie along a very pronounced climatic gradient that influences their chemical and physical properties – and the vegetation they support. As Fig. 9.1 shows, four climatic/topographic zones running from north-west to south-east can be identified:

- the very wet, western slopes of the high mountains (annual precipitation: 5000–11 000 mm);
- the wet, eastern slopes of the high mountains (5000–1500 mm);
- the seasonally dry or semi-arid intermontane basins (900–500 mm in Canterbury; 900–400 mm in Central Otago);
- the seasonally moist slopes of the frontal ranges to the east of the basins (900–1400 mm).
Fig. 9.1
Cross-section of South Island high mountains, intermontane basins and eastern frontal ranges, from Fox Glacier to Fairlie. (a) precipitation; (b) topography, soils and vegetation.
Plate 9.4

The headwaters of the Cropp River, a tributary of the Whitcombe River, central Westland. This area lies in the zone of maximum precipitation (11 000 mm/year), uplift (12 mm/year) and erosion (11 mm/year) within the central Southern Alps. The smooth U-shaped glacial cirque at the head of the valley (less than 2500 years old) contrasts sharply with the intense V-shaped dissection of the older surfaces on the foreground slopes.

The rate of erosion in these faulted schist mountains is among the highest measured in the world. The amount of suspended sediment transported out of the mountains by the Wanganui, Whataroa, Whitcombe, and Hokitika Rivers is very high — as much as 17 000 tonnes/km²/year in the latter. This is ten times higher than that carried by the Waimakariri River on the eastern side of the divide. Yet, paradoxically, most of the slopes pictured are much better vegetated than the scree-covered slopes of the less wet eastern slopes of the high mountains (Plate 9.2).

Inset: A closer view of steep, dissected slopes (40 degrees to 50 degrees on average), high drainage density, and widespread, small-scale surface erosion. Most soils in this landscape are recent and skeletal.

Plate 9.3

A feature of the wet, high mountains is the luxuriance of their alpine plant communities. This vigorous association of tussocks and herbs (such as the flowering species of *Celmisia* and *Aciphylla*) provides a dense cover to the thin, peaty soils which have developed on granite mountain slopes of the Victoria Range in North Westland.
Figure 9.1 also shows the contrast in precipitation (snow and rainfall) and vegetation between the western and eastern zones. On the very wet western slopes the dense podocarp/kahikatea/Quintinia or podocarp/beech forest gives way to subalpine scrub, snow tussocks and alpine fellfield with an increase in altitude. On the eastern side of the main divide where the rainfall drops away sharply, the subalpine forest is generally mountain or silver beech and tussock grasslands begin to dominate the drier montane landscape. These eastern basins and frontal ranges have suffered successive fires in both prehistoric and historic times and their soils have also been significantly modified by erosion.

This basic pattern of the four climate/soil/vegetation zones shown in Fig. 9.1 will be referred to throughout Chapters 9 and 10 because it recurs with only minor variations from Marlborough to Fiordland.

**Very Wet Western Mountains and Fiordland**

It is the wetness of the western slopes of the Southern Alps and Fiordland that gives them unity in terms of soil landscapes; in other terms they are quite heterogeneous: greywacke parent rocks in Canterbury, schist in Westland and western Otago, and a complex mixture of granite, granodiorite, gneiss and ultramafic rocks in Fiordland and western Nelson. The annual precipitation of 5000–11 000 mm on the western slopes is the highest in the country; most rainfall is quickly shed from the steep mountain slopes via vegetation communities, soils, and a closely spaced network of drainage channels which have evolved to handle this enormous throughput of water (Plate 9.4).

The dense cover of vegetation tends to mask the intensive erosion of both soil and bedrock. Erosion seems to be a cyclic event on these mountain slopes, for most soils are probably only 1000–2000 years old, and develop only shallow A/C horizons before they are stripped away (Plate 9.5). The tell-tale signs of past soil erosion can be read in the vegetation. On stable sites, kahikatea or beech trees usually form the forest canopy; on eroded sites, fuchsia, mahoe and pate are common at lower altitudes and mountain ribbonwood in the subalpine zone. The rapid revegetation of the erosion scars is aided by the higher rate of weathering which increases the availability of plant nutrients; however, in this very high-leaching situation nutrients can be quickly lost and the maturing vegetation becomes increasingly dependent for its healthy survival on nutrients retained in the soil organic cycle, or on the addition of fresh mineral material (colluvium). The whole environment is very mobile and most of the soils do not survive this relatively youthful phase. Those that do, progressively decline into the state of soil senescence which characterises the more stable landscapes on the less wet eastern side of the divide.

Fiordland, over 1 000 000 ha of mountains, lakes, and fiords, contains many examples of rapid soil turnover. Although the mountains are not as high as the Southern Alps, slopes are extremely steep, often precipitous (Plate 9.6). Yet forest vegetation still clings to slopes of 55–60 degrees where the soil mantle is extremely shallow – often only 25–30 cm of litter and peat over weakly weathered granite or gneiss. Where mineral soils occur, they are strongly leached and some show evidence of gleying (Plate 9.7).

This remarkably steep landscape also has a superficial look of stability since landslide scars heal quickly because of the relatively mild, very wet climate. Subtle differences in forest composition and colour indicate the paths of past debris avalanches, which seem to occur when the forest and peaty soil mass on a steep slope become saturated with water. The entire covering then slides off, leaving the underlying rock once again exposed (Plate 9.6). Earthquakes may also trigger these huge debris avalanches.

The source of nutrients for the Fiordland forests is something of an enigma, and salt spray from the frequent westerly storms may provide important inputs of potassium, magnesium, nitrogen, sulphur and phosphorus.

The soils of Fiordland, like those of the rest of the wet, high mountains, have no agricultural or forestry potential. Almost all of the area is an unmodified wilderness protected as Fiordland National Park, by far the largest of New Zealand’s national parks. The spectacular landscapes of Milford Sound (Plate 9.6) are a source of inspiration and enjoyment for visitors, and New Zealand is as well known internationally as a tourist attraction for its views of Mitre Peak as it is for the geysers and volcanoes of the volcanic plateau of the North Island (Chapter 2).
View south-east up Milford Sound, past Mitre Peak to the Darran and Wick Mountains of northern Fiordland. Because these mountains consist of hard, crystalline gneiss and granodiorite rocks, the imprint of the glaciers that long ago carved these U-shaped valleys and fiords has not been substantially modified by erosion. The soils are shallow and coarse textured; although they are capable of shedding the huge quantities of rainfall and snow that they receive, they periodically slide in whole sections off the very steep mountainsides.

Resolution steepland soils are a widespread, variable group of soils on the granodiorite and gneiss mountain slopes of Fiordland. They occur under snow tussock and fellfield and at lower altitudes, under silver beech forest, they grade into Titiraurangi steepland soils. They are rankers, too young to show any more than an Ah horizon over bedrock. Some, such as this profile, show obvious gley features.
Wet Eastern Mountain Slopes

The eastern slopes of the main divide are still wet, but nowhere near as wet as the western slopes; annual precipitation has dropped to 1500 mm-or-so where the mountains give way to the intermontane basins (Fig. 9.1). The contrasts with the western slopes are striking. The luxuriant podocarp/hardwood forest, subalpine shrublands, and snow-tussock grasslands of the west are replaced by a mosaic of depleted beech forest and tussock grassland, and large areas of unvegetated talus slopes and erosion scars. In the higher mountain valleys huge unvegetated talus slopes stream down into valley floors marking the retreat paths of former glaciers (Plate 9.2). Many of these talus slopes are, ironically, relatively stable landforms and the older ones have developed pale red weathering rinds over the thousands of years that their rocks have been exposed.

After the retreat of the glaciers around 10000 years ago, the warmer climate allowed the widespread establishment of beech forests and snow-tussock grasslands on the lower eastern mountain slopes between 1000–1700 m altitude. The rate of soil erosion over much of this landscape was relatively low until 500–700 years ago when large areas of forest were destroyed by fires (probably started by Polynesian moa-hunters). Some of the destroyed forest was replaced by snow tussock (or short tussock in the drier regions); in other areas revegetation was slow, and subsequent burning and grazing by European settlers accelerated soil erosion. In addition, natural hazards – earthquakes, storms causing catastrophic windthrow of forests (Plate 9.8), and floods – all contributed to soil loss by triggering localised erosion. This is the eroded landscape of the widespread Tekoa and Kaikoura steepland soils (Plate 9.9).

In those parts of the landscape where the vegetation was not destroyed, soil development advanced to the point where soil fertility declined significantly. The degree of soil development often depends upon subtle changes in topography which can exert considerable influence on the flow of water through the soils on the slope. Fig. 9.2 is a cross-section of such a landscape in this wet eastern mountain zone. Although the difference in height between the basin rim and the floor is
a mere 10 m, five very distinct soils can be identified. The four mature mineral soils have subsoils which:

- show a degree of podzolisation;
- are acidic and have a poor ability to retain nutrients against leaching;
- are extremely deficient in important nutrients, such as phosphorus, sulphur, potassium and magnesium;
- have a moderately high ability to retain phosphate.

Nevertheless all five soils show major differences in their hydrology: the upper slope soils are free draining; the lower slope soils are gleyed; and the soil in the floor of the basin is a very poorly drained peat. The soil profile of the backslope (Lewis steepland soil) is shown in Plate 9.10.

Whereas the clay fraction of the typically weakly weathered soils of the less stable sites predictably consists of micaceous minerals, the clays in the soils on stable sites tend to differ with depth and horizon development. Smectite dominates the E horizons of the podzolised soils, vermiculite and kaolin are widespread throughout the profile, and allophane (and sometimes gibbsite) is a significant feature of the subsoils (especially Bw and Bs horizons). This pattern of clay mineralogy supports the chemical evidence (e.g. very low nutrient content) for some of these mountain soils being strongly developed, despite their mobile environment.

All of these soil factors make revegetation of any exposed subsoils very difficult if the topsoil has been eroded away. Surveys of hundreds of thousands of hectares of depleted mountain landscape have shown that the bare ground is generally associated with such truncated soils of very low nutrient status. The low soil fertility is probably the key limitation to the rehabilitation of this landscape, and the success of techniques like aerial oversowing and topdressing is attributable to the restoration of vital nutrients to the soil/plant cycle.

The contrasting soil erosion/vegetation vigour on the two sides of the wet, high mountains thus provides an interesting paradox. The very high rainfall of the western slopes gives rise to very high levels of erosion; the suspended sediment transported away in rivers draining the western slopes can be up to ten times
higher than on the eastern side of the divide (Plate 9.4). Yet the scars quickly re-vegetate and the fine-weather visitor can easily overlook the awesome power of these mountain deluges. The widespread erosion scars of the eastern slopes are equally misleading. Often they do not indicate present-day high rates of soil erosion but, rather, relict erosion scars which have failed to heal because of the high surface temperatures, droughtiness, and lower fertility of the exposed subsoils—subsoils largely leached of nutrients precisely because they have been on stable sites subject to slow rates of erosion. In a more dynamic environment these infertile soils would have been stripped away (exposing fresh rock for weathering) or rejuvenated by being covered with fresh, less weathered colluvium from upslope.

So, contrary to conventional wisdom, the high proportion of erosion scars in the Marlborough and Canterbury mountains should not be equated with high current rates of soil erosion. They may be an eyesore to the casual visitor, but they have their own stark beauty and do not necessarily indicate that the land is being mismanaged.

**Conservation Importance of Mountainlands**

The wet, high mountains are the one region which has largely resisted the endeavours of settlers, both Polynesian and European, to utilise the soils for plant or animal production. Despite the impact of introduced wild herbivores such as deer, chamois, thar and possums, the vegetation still gives the impression of being virgin. The indigenous element in the landscape is still overwhelming.

The importance of conserving these lands has been recognised for most of this century. To the forester they are ‘protection forests’; to the trapper and mountaineer they are the ‘great outdoors’; to the tourist they are the ‘scenic gems’ of New Zealand. In the past their most intensive management requirement has been control of wild introduced animals to conserve their critically important mantle of soil and vegetation and the water that they yield to the inhabited lowlands. Although this early conservationist view of their importance as watersheds should not be denigrated for its utilitarian approach, today’s perspective is more one of cherishing and protecting these mountain lands because they are our least-modified natural landscapes, and thus the best remnants of our indigenous heritage. Most of the area is now strictly protected from exploitation as a chain of parks—Northwest Nelson Forest Park and Nelson Lakes, Arthur’s Pass, Westland, Mt Cook, Mt Aspiring and Fiordland National Parks.

The scientific importance of the alpine soils should not be overlooked for they support the most prolific range of our indigenous plants. There are 600 species above the bushline alone; that is, nearly 30 percent of New Zealand’s total flora of higher plants (Plate 9.3). These alpine plants have successfully exploited the wide range of soils occurring in different ecological niches—screes, cliffs, cirques, bogs and tarns, moraines, snowbanks, stream levees, and even bare rock surfaces. This degree of evolution is quite remarkable, considering that the mountains were probably not extensive until the onset of the early Quaternary Ice Ages, a mere two million years ago.