CHAPTER THIRTEEN

Brown Earth, Green Land

WHEREAS the Canterbury-North Otago lowlands have a relatively simple physiography (vast stony outwash and alluvial terraces with loess-covered downlands at their margins), the lowlands of coastal Otago-Southland lie instead in a much more complicated geological and climatic setting.

Although the soil parent materials of these southernmost lowlands are geologically youthful, the rocks and landforms have much older origins related to crustal plate movements since Permian times. Fig. 13.1 shows how the intensely folded and uplifted rocks of the Southland Syncline (greywackes, basaltic tufts, diorite, gabbro, and a range of ultrabasic rocks such as serpentine and peridotite) are wedged between the hard Fiordland rocks and the huge block of Otago schists. Today they curve as a vast arc from where the Alpine Fault cuts across the end of the Olivine Range and the lower Cascade valley in South Westland, through the Livingstone Mountains and the Te Anau basin, the Takitimu/Eyre Mountains, the Hokonui Hills (Plate 13.1), the Longwood Range and the uplands of southeast Otago, to the Southland coastline and the northern tip of Stewart Island. During the Tertiary Period the lower-lying parts of the syncline were filled with younger sediments (limestones, mudstones and sandstones), associated lignites, while, to the north, volcanic activity formed the Otago Peninsula. Much later, in the cold late Quaternary Period, the lowlands were partly covered with glacial outwash gravels and mantled with loess. Yet the basement rocks of the Southland Syncline still dictated the flow of the major Waiau, Aparima, Oreti, Mataura and lower Clutha river systems which flow along, or through, gaps in these major geological structures (Fig. 13.1).

The mountains and uplands within the syncline have a significant climatic effect on the region. The land on the northern side of the Murihiku Escarpment (Plate 13.1), which marks the northern boundary of the Hokonui Hills and the south-east Otago uplands, is significantly drier and slightly warmer and more sheltered from the dominant south-westerly winds that so influence the climate of the uplands and the Southland Plains.

Consequently, the soils can be considered in terms of three distinct climatic subregions:
- the drier lowlands north of the Murihiku Escarpment (annual rainfall, 700 – 900 mm);
- the moister Te Anau basin, Southland Plains and uplands south of the Murihiku Escarpment (annual rainfall 900 – 1600 mm);
- wet Stewart Island (annual rainfall 1600 – 4000 mm).

Lowlands North of the Murihiku Escarpment

The coastal parts of Otago between the Murihiku Escarpment and Shag Point mainly consist of low, rolling hills, generally covered with schist loess. Dense grey soils (described in Chapter 6) are common in this drier landscape, the most widespread being Warepa soils (Plate 13.2). After European settlement of coastal Otago, large areas of Warepa soils were intensively cultivated for wheat and oats. The repeated heavy cropping without the application of fertilisers led to the exhaustion of their natural nutrient supply, and the consequent abandonment of many farms. Today large areas of Warepa and associated dense grey soils north and south of Dunedin...
Warepa soils cover nearly 50,000 ha of the downlands and low gently rolling hills of coastal and south Otago. They are typical weakly to moderately leached dense grey soils which have developed in schist loess where the climate is seasonally dry and the annual rainfall 700–900 mm. This profile is a particularly good example of the effect of weather constantly wetting and drying a roadside cutting, thereby sculpting a very distinctive morphology. The gammate-veined fragipan has been fretted away by water because it lacks the weathering products (clays and organic matter) which provide the strongly developed nut and block structure of the overlying Bg (25–35 cm) and BCg (35–60 cm) horizons, which now protrude from the cutting face.

Highcliff soils are widespread around Dunedin and on Otago Peninsula, particularly on the easy-rolling lower midslopes and footslopes of the hills where loess has been mixed with soil parent material weathered from the underlying basalt. This profile has 25 cm of dark brown topsoil over a thick, firm, heavy-textured Bw horizon (25–110 cm), containing prominent basalt boulders. The upper part of the Bw is of medium nut structure but the lower part (75–110 cm) has a pronounced coarse blocky structure with clay skins prominent on the faces of the aggregates. Below 110 cm, the C horizon is deeply weathered with the iron oxides, goethite and haematite, contributing much of the pronounced red-brown colour.

The Highcliff soils commonly occur in association with Warepa soil (Plate 13.2), dense grey soils with completely different morphology. In contrast, the Highcliff soils show most of the features of volcanic loamy clays, reflecting the dominant influence of volcanic minerals in their mixed parent materials.

Looking south-west across the upper Waitati valley to Mt Leith (right) and Mt Cargill (left) beyond. The broad rolling summits of these volcanic hills carry Cargill soils although rock outcrops can be seen on the steep slopes near the summits. The soils on the valley slopes are quite variable — Cargill, Highcliff (Plate 13.4), Mihiwake and Warepa soils (Plate 13.2) — depending on the depth of loess and colluvium over volcanic rock.
Fig. 13.1

Major rock types of Southland Syncline, loess deposits and probable direction of loess movement. As the glaciers retreated with the waning of the Ice Age, the lowlands were partly covered with outwash gravels and mantled with loess. North-westerly winds would have carried loess from the Otago uplands down to the South Otago downlands and from the Te Anau basin through to the upper margins of the Southland Plains. Lower sea levels would have exposed the continental shelf in Foveaux Strait, allowing westerly and southerly winds to carry loess onto the Southland Plains.
The lower Taieri River floodplain, looking southwards from near Momona airport towards the coastal hills beyond Otokia. The true right bank is stopbanked in an attempt to protect the market gardens in the foreground from flooding. Yet, because of the lack of a comprehensive Taieri River control scheme, the record June 1980 flood inundated 5000 ha of the Taieri Plains. Floodwaters ponded around Lake Waihola 8 km downstream, and banked up the Waipori River behind these stopbanks causing $15 million (1980) worth of damage and leaving many areas under water for nearly two months.

Looking south across the south Otago downlands near Clinton. The Muruhiku Escarpment along the northern margin of the south-east Otago uplands is in the distance. Te Houka soils occur in the foreground where the annual rainfall is 700 mm, but these grade into Warepa soils (Plate 13.2) close to the hills where the rainfall rises to 800 mm. With the exception of only 36 ha of land under indigenous forest near Balclutha, all the loessial dense grey soils in this landscape have been developed for intensive mixed farming, especially sheep and cropping for wheat, oats and barley.
and Otago Peninsula are maintained in intensively managed pastures but significant areas are also being established in exotic forest plantations, especially in Silver Peaks, Berwick and Otago Coast State Forests.

The hills of Dunedin and Otago Peninsula (Plate 13.3) also carry a loess mantle where slopes are gentle. However, like Banks Peninsula (Chapter 12), the underlying volcanic rocks contribute to the soil parent material where the loess has been eroded away. Consequently the soil pattern is complex — a mixture of dense grey soils (such as Warepa soils) where the loess is thick; volcanic loamy clays (such as Cargill soils) where the basic volcanic rocks are soil-forming; and a wide range of soils from mixed loess/volcanic parent materials. A widespread example of the latter are the Highcliff soils (Plate 13.4), well-structured soils capable of supporting good hill pastures.

South of Dunedin lie the only significant areas of alluvial soils in Otago. The great Clutha which drains the vast mountainous hinterland, and the smaller Taieri which follows a tortuous route down from the eastern basins and uplands, finally meander slowly through low-level floodplains before reaching the sea (Plate 13.5). The floodplains and river flats of the lower Taieri amount to 16 000 ha, with well-drained recent alluvial soils (see Chapter 7) lying at the top of the plains around Mosgiel and Outram, and more gleyed soils between Mosgiel and Lake Waikouaiti. Some of the recent alluvial soils, such as the Wingatui soils, are the most versatile and fertile in the province; although they total less than 0.5 percent of the area of Otago they are strategically important because of their location adjacent to a major city and airport.

The Wingatui soils and associated Clutha soils in the Mosgiel-Outram district, are important for the production of vegetables and black currants, largely for the population of Dunedin. In recent years production has remained rather static because of the absence of any process-vegetable industry. Because of the slower growth rates of vegetables in this cooler climate, there have always been hopes of establishing an export industry specialising in the canning of baby carrots and potatoes.

The agricultural importance of the Wingatui soils led to a prolonged public controversy over the direction of any expansion of Mosgiel borough. In fact, this threat of urban expansion onto a limited area of excellent soils highlighted the potential loss of important soils nation-wide. The result was legislation in the Town and Country Planning Act for the protection of soils of high value for food production (see Chapter 14).

The lower Clutha Plains cover 10 000 ha coastwards from Balclutha where the entrenched river spills out onto a 10 km-wide floodplain; it then splits into two branches around Inchelclutha, where it has built up 2–4 metre-high levees above the level of the delta. These levees indicate the enormous load of sediment that the river is still depositing on its floodplain and the risk of serious flooding of these productive soils. Twenty years after European settlement of the district commenced, the gold mining of the narrow strips of alluvial soils in Central Otago, and the burning and overgrazing of the tussock grasslands of the interior uplands, combined in contributing sediment to the disastrous Clutha flood of 1878 (still the largest ever recorded for the Clutha). By this time most of the Inchelclutha delta was being cultivated; debris carried down from the highlands devastated these farms, and the river changed its outlet, thereby finally eliminating Port Molyneux, the original transport and commercial centre of the district. Since the Otago Catchment Board was formed in 1949 it has built 120 km of stopbanks and 230 km of drainage channels on the Clutha delta; but as development of the upland tussocklands and bogs continues, this still remains one of the most difficult areas of New Zealand to protect from flooding.

Dairy farming is the most important use of the lower-lying soils, particularly the gleyed Koau soils which are highly productive when drained. The soils on the levees (Clutha and Matau soils) are fertile and well drained. Their versatility ensures they are equally suitable for dairying or market gardening. The Clutha soils were among the first to be cultivated in the South Island and they are still among the most productive in the country; potato yields average 25 tonnes/ha and fodder crops (swedes, beets) for cattle exceed 100 tonnes/ha. The production of these fodder crops is important as winter feed for the large population of beef cattle now carried on the adjacent south-east Otago uplands since their tussock vegetation has been transformed to pasture in recent years.
Loess, often to a depth of 6 m, covers the downlands of south Otago. This exposure at Stewarts Claim (a disused gold mining site) near Waikaka, shows at least three major periods of loess accumulation during the last (Otrian) glaciation of the late Quaternary Period: the lowest (A) began accumulating 70 000 - 80 000 years ago; the middle (B) 30 000 years ago; and the top (C) 16 000 - 18 000 years ago. Layer (C) is the parent material of the present-day Waikoikoi soil at the site.

West of the lower Clutha lie the downlands of south Otago, over 150 000 ha of rolling pastoral farmland extending from the confluence of the Waikaia and Mataura Rivers down to Balclutha (Plate 13.6). Loess, up to 6 m thick in many places (Plate 13.7), has smoothed out and rounded off the topography and is the most important soil-forming parent material throughout the district. Most of this loess is of mixed composition, probably from various sources — schist derived from the floodplains of rivers draining the Garvie, Umbrella and Blue Mountains of the Otago uplands and the Waimea Plains to the north-west, and greywacke from the uplands to the south (Fig. 13.1).

The soils developed in the loess are dense grey soils in the drier areas (700 - 900 mm annual rainfall), grading through to lowland brown earths (see Chapter 8) as the annual rainfall climbs to 1000 mm. A sequence of four soils — Warepa (Plate 13.2), Waikoikoi (Plate 13.8), Arthurton and Waikaka — can be recognised along this soil-moisture gradient across the downlands. When these four soils are considered alongside the drier loess soils of North Otago, the effect of changing climate on the morphology of the loess soils throughout the southern half of the South Island can be illustrated.

Fig. 13.2 shows in sketch form these changes in six of the main loess soils in the southern regions. The Ngapara and Timaru soils (Plate 12.9) of the North Otago-South Canterbury downlands occur in a seasonally dry climate with an annual rainfall of only 550 - 700 mm. They have a very pronounced fragipan (Cx horizon) at about 30 - 60 cm depth and the climate is so dry that very little gleying occurs in the B horizon above the fragipan. Rainfall on the Warepa and Waikoikoi soils increases to 700 - 900 mm, allowing water to percolate into the subsoil and perch above the fragipan. The tell-tale patterns of gamma-shaped veins penetrating deeply into the disintegrating fragipan are most pronounced in these intermediate members of the soil/climate continuum (see Plates 13.2 and 13.8). Rainfall on the Arthurton and Waikaka soils is higher still (900 - 1150 mm) and a fragipan is not present. These moister soils are well drained and show little or no evidence of gleying. In terms of the major soil groups mapped in Fig. 1.6b, the Ngapara, Timaru, Warepa and Waikoikoi soils are dense grey soils, the Waikaka is a lowland brown earth, and the Arthurton is intermediate.

The south Otago downlands are a highly productive and intensively farmed area. Although there is a certain amount of cropping for cereals and supplementary winter feed, they are essentially an area of intensive pastoral production of prime lamb for export markets, stud sheep, and store sheep and cattle.
Plains and Uplands of Southland

The soils of the Te Anau basin, Southland Plains and uplands south of the Murihiku Escarpment have developed in a moister environment; they are mainly brown earths (or related stony soils) compared with the dense grey soils which predominate on the downlands to the north.

The Te Anau basin lies in the extreme north-west corner of the region tucked between the Fiordland massif (Chapter 9) and the Livingstone and Takitimu Mountains. Thirty years ago the landscape between Mossburn and Te Anau on the main highway approach to Fiordland National Park was still very natural, a vista of red tussock, with scattered areas of bog pine shrubland, wetland vegetation and beech forest in the tributaries of the Mararoa River draining the Livingstone Mountains. Most of this vegetation on the rolling moraines, fans and terraces has now been converted to pastures (Plate 13.9). However, an area of red tussock near Gorge Hill has now been reserved to retain something of this indigenous landscape and, it is hoped, to provide a better habitat for the endangered Takahe which is now largely restricted to the inhospitable Murchison Mountains of Fiordland.
Looking south-west across the terraces along the upper Waiau River towards Lake Manapouri and the mountains of Fiordland, from a glacial moraine near Te Anau. The Te Anau soils (Plate 13.10) on the foreground moraine are undergoing development from red tussock and scattered shrubland to pastures. Monowai soils predominate on the outwash terraces in the middle distance. Although the annual precipitation in the basin is only 1000 - 1200 mm, the cool temperatures and cloudy conditions mean that little of this moisture is evaporated and the soils are strongly leached.

Because the soils of the Te Anau basin have such a high capacity for retaining phosphate, development costs were high on account of the need for very high levels of superphosphate fertiliser (up to 1.5 tonnes/ha) in the initial year of pasture establishment. Maintenance levels are also high (400 kg/ha) and it remains to be seen if the 11 – 12 stock units carried per hectare will be sufficient to maintain the viability of this enormous state-sponsored agricultural development of a group of rather difficult soils.

The striking Te Anau soils on the glacial moraines have developed in gravelly till derived from the granite, diorite and greywacke of the surrounding mountains (Plate 13.10). Since the glacial outwash surfaces within the basin (and down the Waiau valley and the Upper Oreti-Waimea Plains near Lumsden) acted as loess sources for the downlands and plains to the east (Fig. 13.1), these landscapes are consequently left with many stony terrace soils (see Chapter 12); examples are the Lynwood and Monowai soils within the Waiau catchment and the Oreti soils in the Oreti-Mataura catchments. The Monowai soils are similar to the Te Anau soils in that they are friable, strongly leached, and have a high capacity to retain phosphate but they are stonier, and lack the pronounced colour transition for their subsoils are dark reddish-brown rather than grey.

The agricultural development of the Te Anau basin soils has not been easy. On behalf of the Crown, the Department of Lands and Survey repurchased most of the pastoral runs in the basin, beginning with Lynwood Station in 1953. With the acquisition of the 50 000-ha Burwood Station in 1966, the department's land development holdings totalled nearly 140 000 ha. Research indicated the superiority of oversowing these stony soils as a pasture-establishment technique, rather than adopting conventional cultivation methods. Furthermore, the physical properties of the soils ensured good drainage, and precipitation was generally adequate. But the main disadvantages were the cloudy, windy climate (with cold winters) and the plant-nutrient deficiencies associated with the strongly leached soils.

South of the Te Anau basin and the Waimea Plains lie the main river systems of Southland – the Waiau, Aparima, Oreti and Mataura. These rivers have a narrow fringe of recent alluvial soils (Mataura, Tuatapere and Makarewa soils) associated with their floodplains, stony terrace soils (which were sources of loess), and loess-covered downlands and rolling terraces where the loess accumulated. The influence of the volcanic rocks of the Southland Syncline is most apparent in the west, where
many soil parent materials have been derived from the Livingstone, Takitimu and Longwood mountains and ranges. Such an example is the Drummond soils on the large Drummond Fan between the Aparima and Oreti Rivers. They are friable well-drained soils with many of the physical properties of the volcanic loamy clays (see Chapter 3). Where these soils are deep and their structure strongly developed (fine nut and granular), they exhibit good tilth and are very suited to mixed farming. They are ideal for cash crops of potatoes, sugar beet, oats and wheat.

South of the Hokonui Hills, the Southland Plains slope down to Foveaux Strait. From Gore in the north to Wyndham in the east and Otautau in the west, these loess-covered terraces and gently rolling downlands make up one of the most important agricultural areas in New Zealand (Plate 13.11). Most of the 4000 farms on the plains and the low rolling hills are now sheep producing, but earlier this century dairying was as important. Traditionally the Romney has reigned supreme, with these farms producing about 15 percent of New Zealand’s total wool and meat output through the intensive stocking of 16–22 stock units/ha.

The annual rainfall on the Southland Plains is 1000–1200 mm and is well distributed throughout the year; the weather is often cloudy (Invercargill’s sunshine totals only about 1600 hours/year) and the temperature is cooler. All these climatic factors combine to maintain the soils of the plains in a much moister condition than soils on the Canterbury, Wairarapa or Heretaunga Plains. Indeed, it is this greater soil moisture during the stressful summer/early autumn growing season that gives the soils of the Southland Plains such an advantage in pasture production — despite their low winter temperatures when growth virtually ceases (see Fig. 14.2).

Because of this higher moisture status, the loess of the plains has weathered to produce lowland brown earths with pockets of organic soils (Invercargill and Otanomomo soils) and gley soils (Dacre soils) in the low-lying parts (Fig. 1.6b). The loxland brown earths cover about 200 000 ha, and are versatile soils suitable for intensive pastoral or arable farming; some are used for horticulture.

The Waikiwi soils (Plate 13.12) are the most extensive brown earths on the undulating terrace land; they supported red tussock and podocarp/hardwood forest at the time of European settlement, but were quickly converted to pasture. They are moderately well drained soils, and although strongly leached they show no sign of clay or iron/aluminium movement down the profile. Their natural fertility is moderate to low but after the application of lime, superphosphate and potash they are easily capable of producing 15 000 kg of pasture dry matter/ha.

East of the Mataura River lie the wetter greywacke uplands of south-east Otago — the pasture and tussock-covered parallel valleys and ridges of the Kaiwera district and Kahiku Range, and the dense podocarp/hardwood forest of the Beresford and MacLennan Ranges closer to the coast in the remote Catlins locality. Kaiwera hill soils, extensive in this district and in the Hokonui Hills, are typical brown earths. Local loess soils have proven very suitable for pasture development through aerial oversowing and topdressing; the loess is mostly derived from the former floodplain of the Mataura River, but its mineralogy indicates that up to 30 percent could have come from the local rocks of the Southland Syncline.

Close to the scenic coastline between Nugget Point and the mouth of the Mataura River, the annual rainfall rises to 1400 mm on the forested ranges and undulating uplands between 200 and 350 m in altitude. The combination of increased leaching and forest vegetation has caused these same greywacke parent materials to become podzolised. These Hinahina and Tautuku soils (Plate 13.13) are very strongly leached, of very low natural fertility and usually poorly drained. They are largely unsuitable for agricultural development because of their high cost of development and management. Much of the forest has been logged for rimu and the area of cutover forest is now steadily declining as less merchantable timber is chipped for export. A sensible land-use strategy based on a conservation ethic would be for central and regional government to encourage more actively the protection of the remaining indigenous forest landscape in private ownership, or acquire it for incorporation into the Catlins State Forest Park or the proposed Catlins Coastal Park. In this manner some of the landscape of this charmingly different and remote corner of Otago would remain in its natural state, a reminder of the great changes wrought by fire and the plough throughout the rest of the region.
The Waikiwi soils are the most important of the lowland brown earths of the Southland Plains. They have developed in deep loess over weathered gravels; they, and the closely associated Edendale soils, cover 65,000 ha and are among the most versatile of Southland's soils. Worm mixing of the A and B horizons is a feature of this profile between 20 and 30 cm depth; some worm channels can even be found at 45-50 cm. The subsoil is a uniform yellowish brown in colour with the Bw (30-45 cm), BC (45-60 cm) and C (60+ cm) horizons passing from silt loam to silty clay loam in texture.

The Tautuku soils are podzols which have developed under podocarp/hardwood forest on the undulating coastal hills of south-east Otago. Forest litter covers a dark reddish brown Ah horizon (0-10 cm) which can have an organic-matter content as high as 35 percent by weight. The E horizon is not pale like the gley podzols of Northland or the West Coast, but chemical analysis shows that the horizon has lost iron and aluminium. The Bwh horizon (20-45 cm) is brown to yellowish brown, humus stained, and exhibits high phosphate retention because of its high content of amorphous iron and aluminium. Thin iron pans (Bms) occur at various depths in the profile.
Stewart Island

Stewart Island is 172,000 ha in area and geologically can be thought of as an extension of the plutonic igneous rocks of Fiordland and the Southland Syncline (Fig. 13.1); the southern highlands consist of granite, the northern highlands of diorite, and the two blocks are separated by the fault depression of the Freshwater valley and Paterson Inlet. These hard rocks are generally only weakly weathered in chemical terms, but physical weathering (and the absence of significant glacial influence on the landscape during the late Quaternary) has resulted in a topography with many spectacular landforms (Plate 13.14). Climate and vegetation, in particular, have moulded the unique Stewart Island landscape – the only remaining part of New Zealand where an intact and colourful podocarp/hardwood forest on shallow peaty soils over bedrock extends from the subalpine zone down to a heavily indented coastline; the only place where large rimu and rata trees overhang the sea waters of the many sheltered coves. All forest was eliminated from the island when conditions became too cold in the late Quaternary; rimu, miro, kamahi, and rata subsequently re-established through birds and winds spreading their seeds but several common trees, such as beech, celery pine, cedar and kowhai, have been unable yet to recolonise the island.

Stewart Island is cloudy, windy and wet. Annual rainfall is 1600 mm at the coastline, rising to 4000 mm on the subalpine summits of the Tin Range and Mt Anglem. The subalpine tops are covered with organic soils (Kaherekoau soils) the closest examples we have to the blanket peats of the northern hemisphere (see Chapter 3). Yet the bushline on the Tin Range in the southern highlands is as low as 400 m altitude, reflecting the severity of the climate.

Although the soil pattern of the island is not known in detail, two features are evident:
- □ topography is not a major factor, for even soils on quite steep slopes have organic-rich topsoils; peat formation seems to be a dominant process;
- □ with increase in altitude and wetness the soils pass sequentially from brown earths (showing some evidence of podzolisation), to podzols, to organic soils.

These soils are of pedological interest because Stewart Island (at latitude 47°S) is the southernmost part of temperate New Zealand. But they warrant little discussion on economic grounds, for there is no agriculture or production forestry of any significance on the island, nor is there ever likely to be, because of the overwhelming importance of the island for nature conservation.

Plate 13.11 (opposite)

At the northern end of the Southland Plains, gently rolling loess-covered downlands slope down from the Hokonui Hills, seen in the background of this view looking north-west from Waimumu south-west of Gore. Significant areas of these downlands along the Mataura River cover lignite deposits. Research is underway to ensure that these productive soils are rehabilitated to their former (or even higher) productivity if largescale mining is to occur (see Plate 14.6).

Plate 13.14

View south-eastwards across the granite domes in the upper Robertson catchment from near Mt Allen, the highest point (750 m) on the Tin Range in southern Stewart Island. The distinctive shape of the landscape is not due to glaciation but to exfoliation of the granite, whereby the rock flakes off in the prevailing climatic conditions leaving rounded domes devoid of soils and vegetation. The talus slopes ringing the domes carry organic-rich soils and dense subalpine scrub which is extremely difficult for humans to penetrate but important as one of the last habitats of the flightless nocturnal parrot, the kakapo.