SOIL RESOURCES OF CENTRAL OTAGO

D.W. BRASH and F.G. BEECROFT Agricultural Research Division, MAF, Alexandra Soil Bureau, DSIR, Dunedin

Abstract

The broad soil pattern of Central Otago is outlined. Four soil zones are identified and their climate, vegetation and landscape characteristics given. The paper reviews causes of variation in soil properties at the detailed, farm scale. The highly variable soil pattern on many farms is caused by the wide variations in climate and topography which often occur within short distances in Central Otago.

Farmers need to understand the soil pattern on their property to enable them to use soil resources efficiently, particularly with respect to **fertiliser** use and year-round integration of stock management between different soils of **varying** agricultural potential. The paper uses a local example to show how important soil chemical, morphological and physical properties can be measured and the resulting information used as the basis of achieving more efficient land use.

Keywords: Soil pattern, agricultural production potential, brown-grey earth soils, yellow-grey earth soils, yellow-brown earth soils.

INTRODUCTION

Wide variations in climate and topography dictate a highly variable soil pattern across Central Otago. Most farms cover a range of soils of varying agricultural potential. Intensive lowland farms generally have fairly uniform soils by comparison,

The purpose of this paper is to outline the broad soil-vegetation-landscape pattern of Central Otago and then to show how a more detailed study of the soil pattern at the farm scale can form the basis of more efficient land use.

Geography and Geology

The distinctive topography of Central Otago results from the warping and faulting of a schist peneplain to form a tilted, block-fault mountain range and basin system. The fault-angle depressions have been partly filled with lake bed sediments and outwash schist and greywacke gravel deposits which in turn have been eroded by rivers into residual hills and terraces. Numerous fans occur at the base of mountains and terraces. In many places the hills have been coated with a veneer of loess, and the terraces and fans with fine alluvium and loess. The broad soil pattern is related to climate and topography (Figure 1). The broad climate, soil and vegetation relationships are summarised in Table 1 (Leamy et al. 1974).

Soil fertility

Fertiliser requirements for the establishment of legumes in Central Otago are related to the soil pattern. Fertiliser requirements are low in the lower rainfall areas. Sulphur is the main requirement on brown-grey earth and yellow-grey earth soils. Some brown-grey earth soils have sufficient reserves of sulphate in the root zone to maintain stands of **dryland lucerne**. At higher altitudes or under higher rainfalls phosphate, sulphur and molybdenum are required in combination. Phosphate retention (PR) values are in the very low to low range (less than 30%) in most soils except the wet high country yellow-brown earth soils where medium values occur.

The soils of the brown-grey earth zone have high pH values, usually 6.0-7.0. Yellow-grey earths and yellow-brown earths have pH values in the 5.0-6.0 range except for some high country yellow-brown earths which have pH values below 5.0.

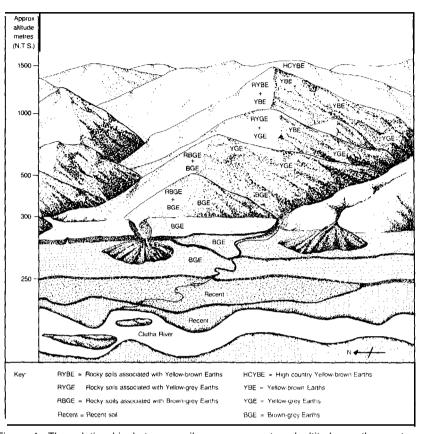


Figure 1: The relationship between soil groups, aspect and altitude on the western side of the **Dunstan** Range.

zone Soil	Climate		Vegetation		Landscape
	Moisture; Rainfall	Temperature; Mean annual temperature	Unimproved	Improved	
1 Brown-grey earths	Dry; 450 mm	Hot; 8-9.5°C	Scabweed, depleted fescue tussock, thyme, sweet brier	Pip and stone fruit, irrigated pasture, lucerne	Terraces, fans, lower slopes of inland basins
2 Yellow-grey earths	Drought-prone 450-650 mm	Warm; 6-8.8°C	Low altitude. short tussock (Festuca novae. zealandiae, Poa laevis).	Irrigated pasture, arable cropping browntop	Downland. fans, lower slopes and wetter parts of inland basins
3 Yellow-brown earths	Moist; 650-900 mm	Cool; 4.5-6°C	Snow tussock, (Chionochloa rígida, C. macra)	Pasture, oversown pasture, browntop	Uplands, mid- altitudes of mountains
4 High country yellow-brown earths		Cool-cold; 2-5.5 °C	Snow tussock high altitude short tussock, alpine herbs	Oversown pasture	High altitudes of mountains open tops

Soils of Central Otago hill country

Following the establishment of the broad soil pattern for the region (New Zealand Soil Bureau 1968) many detailed soil surveys of the valley floors were undertaken. The only relatively detailed hill country surveys are near Roxburgh (Leamy & Wilde 1971) and the Upper Manorburn Dam (Leslie 1974). These surveys only examine soil morphology and distribution.

The topography-related pattern of soil properties (particularly soil chemical properties) of hill and steepland soils in the yellow-grey and yellow-brown earth soil groups has been studied in North Otago (McIntosh et al. 1981). These soil groups also dominate Central Otago hill country. The study of McIntosh et al. (1981) gives a guide to the detailed soil variation that could be expected in Central Otago. Climate was the major cause of differences in soil properties between the "moist" (750-1030 mm annual rainfall) and "dry" sites (600-700 mm) but within each study area soil development was affected by five soil-forming factors; altitude, aspect, erosion processes, vegetation and slope position.

McIntosh et *al.* (1981) found shady slopes had lower *pH* and higher PR values than sunny slopes at both sites. As altitude increased *pH* levels declined and PR values increased at the "moist" site. In contrast, strong trends of topsoil properties with altitude were not found at the "dry" site. Erosion processes were masking the altitude trends by causing the loss of surface layers and exposure of less weathered and less leached parent material. On sunny slopes exposure to north-west winds, more frequent wetting and drying cycles and higher topsoil temperatures were considered to be causing erosion processes to proceed rapidly.

McIntosh et *al.* (1981) also related soil variation to vegetation differences. Soils under snow tussock *(Chionochloa rigida)* were deeper, more leached and had lower levels of available nutrients compared to soils under short tussock communities.

The influence of slope position (near-ridge, mid-slope or toe-slope) on soil development was small.

These factors affecting soil development can influence permanent soil properties such as pH or PR and temporary (adjustable) properties such as Olsen phosphate or sulphate-sulphur status. McIntosh et a/. (1981) found different soil properties could be influenced by different environmental factors. PR was influenced by aspect and altitude while the other factors, vegetation, erosion processes and slope position, strongly influenced Olsen phosphate.

McIntosh et al. (1985) related the pattern of legume sulphur and phosphate fertiliser response to the climate and altitude but found no difference in fertiliser performance between aspects.

Soil physical properties of Central Otago hill country have not been studied in detail. As the climate is dry or drought-prone on many of the valley floors and lower slopes of the ranges available water capacity (AWC) of a soil has a marked influence on its production potential. Brown-grey earths are, on average, below field capacity (FC) for each month of the year and below permanent wilting point (PWP) for six months or more, i.e. sub-xerous. Most of the yellow-grey earths are, on average, below FC for more than five months and below PWP for one to five months, i.e. Sub-hygrous.

Soil depth, texture and organic matter content strongly influence AWC. Determinations of AWC have been made on many valley floor sites. AWC held in the top 300 mm of soil ranges from 27 mm to 110 mm (Rickard & Cossens 1968). Few measurements of AWC have been made in hill country but similar ranges to that occurring in the valleys would be expected. Very low values would occur on low altitude, sunny slopes where soils are shallow with coarse textures and low organic matter content.

Pasture Production

Pasture production patterns vary greatly in Central Otago because of the wide climatic range. The interaction of temperature and moisture determine the annual production with warm moist (irrigated brown-grey earth) sites having higher production than cold (high altitude) or dry (dryland brown-grey earth) sites. This interaction also affects the seasonal distribution of pasture production.

Irrigation influences the reliability, seasonal pattern and annual production of valley floor pastures (Radcliffe & Cossens 1974). Although there are few measurements of pasture production in hill country, measurements from irrigated flats, sunny hills and shady hills at **Tara** Hills, near Omarama show the influence of altitude and aspect (Douglas & **Allan** 1984).

Scott (1979) showed the theoretical pattern of pasture growth in lowland, hill and high country sites under dry and moist conditions at the same soil fertility (Figure 2).

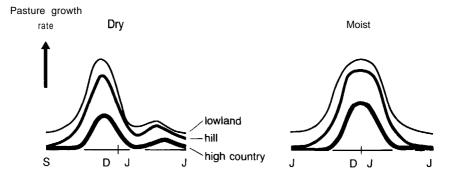


Figure 2: Seasonal distribution of pasture growth (Scott 1979).

The Soils/Vegetation Mosaic: A Local Example

Soils and vegetation exist as a mosaic of units in the landscape. Each unit has characteristic climate and soil chemical and physical properties that control its pasture **proiduction** potential, fertiliser requirements, response to irrigation and other production related factors. Currently published soil surveys of Central Otago hill country are not at sufficient detail to describe or predict soil variation at the farm scale.

A detailed study of soils on a farm property is used to illustrate the following:

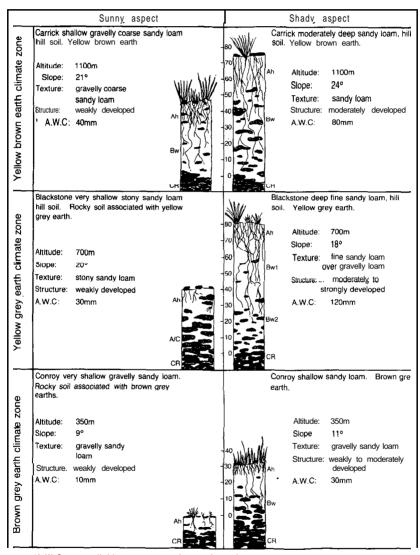
- (i) Variation in soil properties with altitude and aspect,
- (ii) The influence of the soil variation on farm management, e.g. land use and fertiliser policy,
- (iii) The value of detailed soil studies in achieving more efficient land use.

Northburn Station near Cromwell offered a study area from the valley floor up a ridge on the west side of the **Dunstan** Range to the subalpine mountain tops. The annual rainfall on Northburn at the Clutha River is about 400 mm rising to 1200 mm at 1500 m (Otago Catchment Board 1976).

Previous mapping (New Zealand Soil Bureau 1968) identified the Lowburn, Conroy and Alexandra soil sets at lower altitudes. These Soils are brown-grey earths. At higher altitudes the Dunstan set occurs on steepland and the Carrick set on rolling and hilly mountain tops. These soils are high country yellow-brown earths and their related steepland soils.

Field sampling on Northburn Station indicated brown-grey earths occur up to 500 m on shady slopes. Yellow-grey earths occur on shady slopes from 500 m to 900 m and yellow-brown earths occur above 900 m. On sunny slopes soils are very shallow and rocky showing few diagnostic features.

The soils were sampled at altitudes ranging from 300 to 1500 m at **midslope** positions on sunny and shady aspects and on two undulating bench sites. Soil morphological and physical properties (Figure 3) and permanent soil chemical properties (Figure 4) were examined.



'A.W.C. = available water capacity, estimated.

Figure 3: Aspect and altitude related soil variation, Northburn Station.

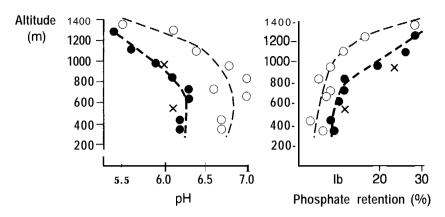


Figure 4: Trends in soil **pH** and phosphate retention with altitude and aspect, Northburn (0 sites on sunny aspects; ■ sites on shady aspects; x bench sites; with hand fitted curves for both aspects).

Field examination showed marked contrasts in soil depth, texture, structure and AWC between aspects and between zones (Figure 3). Soil pH declines with increased leaching which occurs under the higher effective rainfalls at higher altitudes and on shady slopes. Phosphate retentions, however, increase with altitude and from sunny to shady aspects. The two bench sites have equal or slightly lower pH and higher phosphate retention than shady aspects at the same altitude indicating these sites are more leached and more stable i.e. not eroding at the same rate as the steeper, aspect — related soils.

The brown-grey earth soils are too dry for clovers but suit lucerne. Most of the lucerne growth would occur in spring before soils dry out in November or December. Clover-based pastures would be prone to summer drought in the yellow-grey earth zone, particularly on the shallow soils of the sunny aspect. Pasture growth patterns would rarely be affected by lack of moisture in the yellow-brown earth zones but the low temperatures at the higher altitude limits annual potential pasture production in this zone.

This example shows that with help from people familiar with soils and landscape interpretation, farmers can learn to recognise the soil-vegetation-landscape pattern occurring on their own farm. Furthermore, the example shows that this pattern can be predicted.

Improving Farm Efficiency

Farmers already recognise soil differences in their stock management, pasture development and fertiliser policies. For example, Perriam (1985) has clearly illustrated the effective integration of different soil zones in the stock management on Bendigo Station, a large sheep station near Tarras.

The diverse soils-vegetation-landscape mosaic in the hills and **valleys** of Central Otago can be further exploited to make efficient land use decisions. Each'farm has its unique mosaic. This mosaic is not random, but has a pattern. Farmers need to recognise the pattern at the farm-scale so various mosaic units can be integrated into more efficient farm management, i.e. for high returns per unit fertiliser and high conversion of pasture to pastoral products.

The pasture production characteristics (production potential, seasonal pattern of production, fertiliser requirements) and the area of each unit need to be known. A

resource plan or map is required. With this plan each unit can be put to its best use as part of the total farm area.

To increase production it is necessary to determine what is limiting present production (Allan et al. 1985). It could be a summer feed deficit or lack of early spring grazing. By knowing the likely response to fertiliser, the cost of applying it and the pasture production pattern of various soil units land best-suited to filling a feed deficit can be developed.

If fertiliser expenditure is limited, those areas which provide pasture at critical feeding periods should be maintained. Various units can be combined to meet the annual stock feed requirements most efficiently with blocks that aggravate feed surpluses being eliminated from topdressing. Fencing changes may be required.

Within a large block previously receiving blanket topdressing, areas of land with high production potential can be identified and selectively topdressed. Too often development has been undertaken where it is cheapest and easiest rather than where it is needed. Selective application of fertiliser to the most responsive soils could be contemplated for Northburn. In the mid-altitude range fertiliser could be restricted to shady slopes, flat bench areas and only deep soils on sunny aspects.

At Northburn the main factor limiting increased carrying capacity is lack of winter feed. To overcome this limitation more development of the 1000-1300 m range could be contemplated to enable stock to be kept at this altitude later in the autumn than at present. This will allow conservation of saved pasture at 750-1000 m for the period from June to late August, which then allows best use of the warm but low producing dryland pastures at low altitudes (300-750 m) during the critical shearing and lambing period of late August to October. This option is cheaper than conserving or growing winter feeds at lower altitudes on either dryland or irrigated cultivatable land below 300 m.

The Northburn example shows that reducing fertiliser costs by the typical methods of concentration on lower altitudes or using lower blanket rates, non-selectively, would not necessarily be the most cost-effective options.

CONCLUSION

Wide variations in climate and topography in Central Otago have given rise to a highly variable soil pattern between farms and within a farm. Understanding this soil mosaic at the farm scale is the basis for making informed farm management decisions. Once factors limiting production are identified they can be treated. Improvements in stock management, fertiliser effectiveness and choice of land use are likely once the soil pattern is understood through mapping and soil chemical testing.

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