Land Rehabilitation to Indigenous Forest Species

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CONTENTS

Part I Soil Studies

C.W. Ross and G. Mew

1. Introduction

Alluvial gold mining and open-cast coal mining are industries important to the Westland economy. Renewed interest in large-scale opencast hard-rock gold mining in the region may add another dimension to regional mining. There are over 100 gold and coal mining operations in Westland and about 400 mining licences - excluding hobby licences and quarries (Metcalfe 1992). Many of the mining activities are located on conservation lands administered by the Department of Conservation.

In the past, after mining of indigenous ecosystems such as beech-podocarp or podocarp-hardwood forests, there has been no planned and managed restoration. Abandoned mining sites have often reverted to gorse, manuka, and other scrub vegetation. Alternatively, mining has provided a means for conversion to exotic forestry or pastoral farmland.

Environmental constraints now placed on the mining industry as a consequence of the Resource Management Act 1991, and public pressures brought about by greater community environmental awareness, have focused attention on restoration of native forests. This is particularly relevant to the DoC estate, where the ethic of conservation advocacy should ensure mining conditions which restore indigenous vegetation after mining.

Techniques for artificially enhancing natural revegetation of mining sites to beech-podocarp or podocarp-hardwood forest on the West Coast have received little attention (Fitzgerald 1987; Ross 1988; Mew & Ross 1989; Gregg *et al.* 1990; Metcalfe 1992). There is a need to provide regulating authorities and miners with practical and appropriate methods of environmental engineering to restore native forest vegetation on mined areas.

A collaborative research project between Landcare Research (formerly DSIR Land Resources) and the N.Z. Forest Research Institute was initiated for the Department of Conservation, West Coast Conservancy, in 1990 to investigate techniques for re-establishing indigenous vegetation. An operational coal niine at Giles Creek, Maimai (near Reefton), was selected for the field investigations. The coal seams at this mine have an overburden of varying thicknesses of alluvial gravel, mainly granite, over layers of sandstone and mudstone. The gravels are similar to those mined for gold elsewhere in the region. Thus the restoration research has potential application to alluvial gold mining sites, as well as some coal mining situations.

The research programme aims to answer some fundamental questions about suitability of plant growth media and soil replacement for re-establishing indigenous vegetation, fertiliser responses, and which of the desired indigenous species are most suited to artificially revegetating restored land after mining.

This information will enable DoC managers and other regulating authorities, such as the West Coast Regional Council, to prescribe achievable mining licence conditions for restoring indigenous vegetation. Also, the field trials will demonstrate to miners what may be achieved and what are the consequences of different forms of restoration management.

2. Soil Resources of the Mining Site

2.1 METHOD OF SOIL SURVEY

Soils investigations at the Giles Creek mining licence area began in June 1990. Twenty-four soil profiles were described, the majority on two major traverses (Fig. 1) of about 500 m and 400 m long, approximately at right angles to the road to the mine site, and within the immediate area of proposed mine and spoil heap extension at that time. A small number of spot observations were made on other parts of the cutover terrace and also north of Giles Creek on the site of a chipwood logging trial.

Traverses were laid out on compass bearings of 120° magnetic and soil observations generally made at 50 m intervals for quantitative assessment. A soil auger was used to obtain material for description. Notes were also made on principal vegetation cover, landforms and drainage. Two full soil profile descriptions were made from cutting faces (Appendix). Soil descriptions were made according to the methods of Taylor & Pohlen (1970) with horizon nomenclature from Clayden & Hewitt (1989). Another long traverse, of 700 m with a starting point about 600 m east of the mine entrance gateway resulted in a further 17 profiles in February 1991. Profiles described in the direction of Giles Creek from the mine road were on a back-bearing of 300° magnetic. One full soil profile description was made from a cutting face and soil samples collected for analytical characterisation.

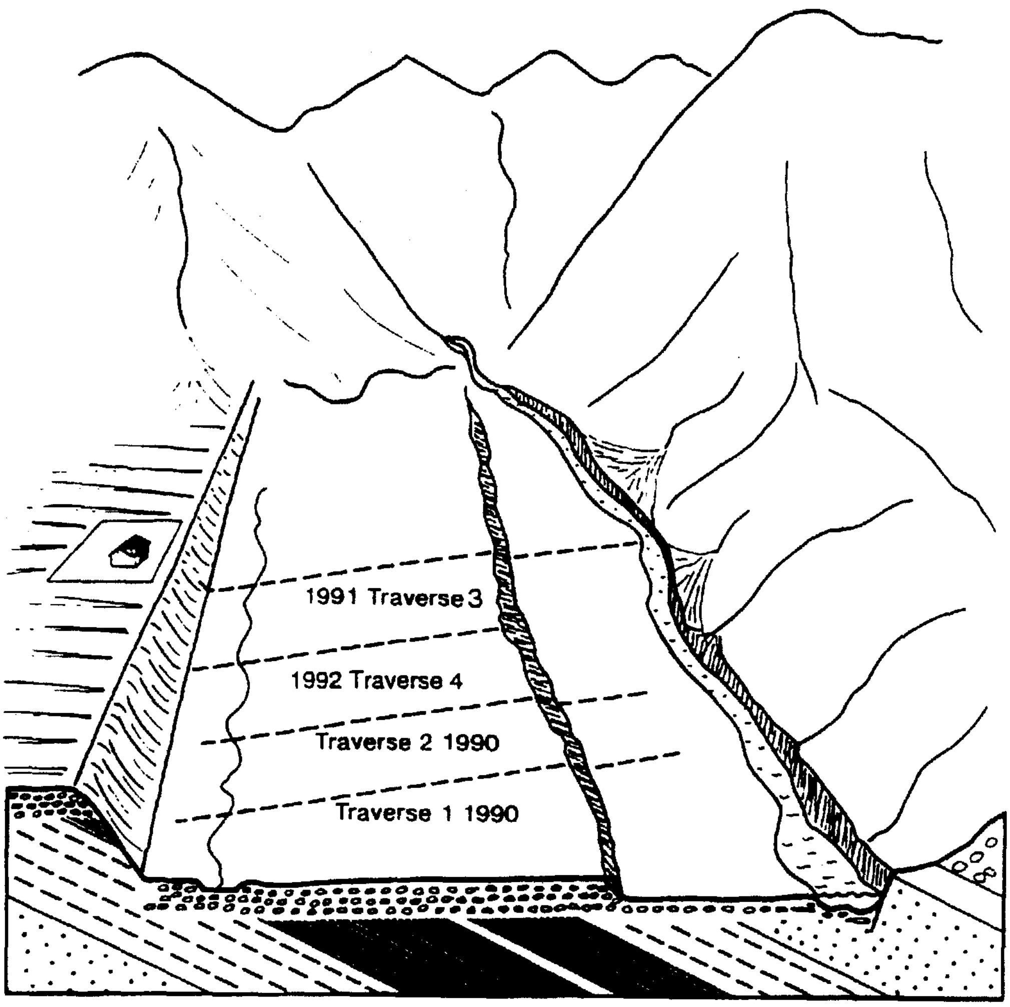
A fourth traverse of 10 auger profiles, 460 m long, with a starting point approximately 400 m north-east along the mine road from the 1991 transect, was surveyed in February 1992. Eight additional observations of soil series only (not described profiles) were made from fresh soil exposures at 50 m intervals along an improved 400 m track to the coal-settling ponds below the washing plant.

In total, there were 5 traverses over the area (Fig. 1), with 51 soil profile descriptions plus a further 8 soil series only observations. Morphological data from all field visits were sorted together then matched to produce variability statements for the soil series recognised. Particular attention was given to thickness of organic layers (litter and “duff”), topsoil, and total mineral soil depths to auger-impenetrable underlying gravels.

2.2 RESULTS OF SOIL SURVEY

Results are summed from all soil observations on the site. Of the 59 soil observations, 32 (54%) can be grouped within the *Ahaura series* yellow-brown earths (Allophanic Brown Soils; Hewitt, 1992), 4 (7%) profiles are *Ikamatua series* (incipient yellow-brown earths/Acid Brown Soils) and 9 (15%) are *Maimai series* (gley soils/Acid Gley Soils). Nine profiles (15%) were basically too stony to determine what series they belonged to from soil auger observations only. It is likely that they are within the Ahaura series however. Of the remaining 5 (9%) profiles, one is a Recent Soil *(Hokitika series),* two are Perch-Gley Podzols *(Kumara series),* and the 2 others are from the hilly slopes bordering the terrace; both are yellow-brown earths (Acid Brown Soils). General descriptions of these soil series are provided by Mew *et al.* (1975) and Mew (1980).

FIG. 1 DIAGRAMMATIC VIEW OF GILES CREEK TERRACES FROM EAST TO WEST SHOWING APPROXIMATE LOCATIONS OF SOIL TRAVERSES. NOT TO SCALE.

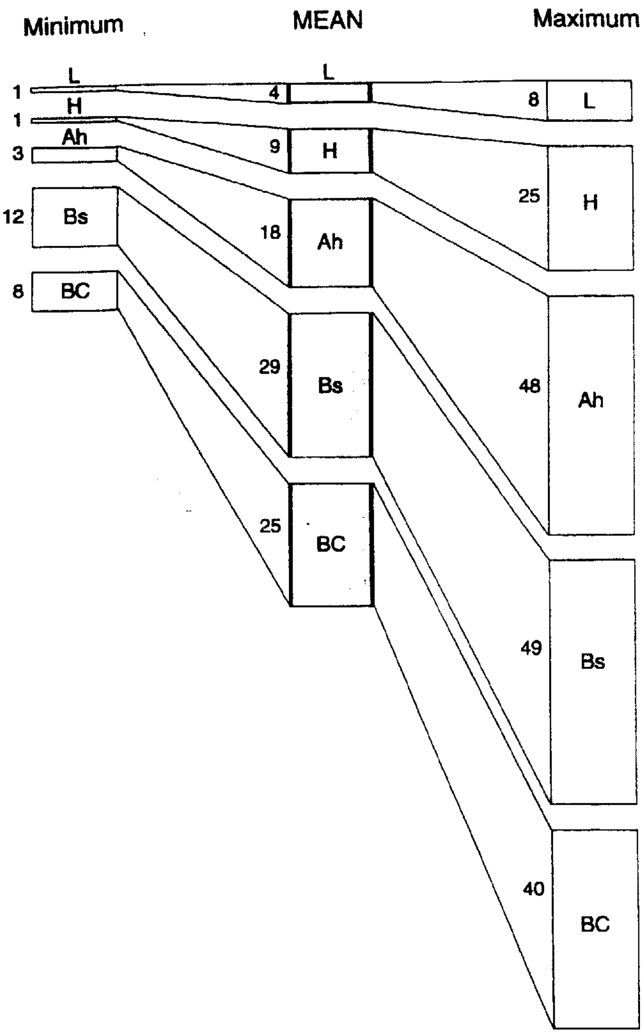


2.2.1 Ahaura Series

The survey indicates that the Ahaura series is the most commonly encountered soil on the main terrace surface, particularly where the latter is well drained. Characteristic profile features are as follows:

Organic horizons (L, F and H layers) average only 9 cm thick, with a range from 1 to 26 cm. Litter layers are very thin; most of the organic material is dark reddish-brown humus, with fine crumb structure and containing abundant roots. Note that adding thicknesses for L and H horizons on Fig. 2 does not produce the average given above. This is because not all profiles have all of the various organic layers.

FIG. 2 MEANS AND RANGES OF INDIVIDUAL HORIZON THICKNESSES (IN CM) WITHIN AHAURA SERIES PROFILES, GILES CREEK.
Note thatAB horizons have been excluded because they occur only rarely.



Mineral topsoils (Ah) average 18 cm in thickness (Fig. 2); the range is from 3 to 48 cm. The main colour is brown to dark brown; both silt loams and fine sandy loams occur in about equal proportions, and some are stony. These horizons are friable, and tend to have weak nut structure. Some profiles contain transitional, worm-mixed layers (AB horizons) between topsoils and subsoils.

Ahaura subsoils are brightly coloured because of iron enrichment. Enriched horizons are an average 29 cm in thickness, with a range from 12 to 49 cm. They are mainly strong brown or yellowish brown, and of silt loam texture; some are stony and most are friable, with weak fine block structure. Colours are paler with depth (tending to olive) and there is little or no structure, especially in the underlying stony or bouldery sands. Total mineral soil thickness ranges from 30 to 75 cm, with a mean of 46 cm. A typical Ahaura soil profile is illustrated in Fig. 3, and detailed profile descriptions are given in the Appendix.

A few profiles tend to have paler subsoil colours and strong brown mottling, indicating partly impeded drainage. Other profile characteristics are similar to those for the main Ahaura series.

2.2.2 *Ikamatua Series*

Data on the Ikamatua series are currently confined to the 4 profiles described in 1990 from the lowermost terrace remnant beside Giles Creek at the eastern end of the licence area. One profile was overlain by 60 cm of recent flood deposits, so was atypical of the series.

From the limited data, profiles have some similarities to the Ahaura series, except that the subsoil colours are paler (light olive brown), the soils are less silty (fine sandy loams), and have very weak or no structure. Gravels tend to become predominant below about 70 cm.

2.2.3 *Maimai Series*

Data on the Maimai profiles are also limited. However, Maimai profiles tend to occur on poorly drained sites, in this instance close to streams and the hillslopes up to the next terrace level. Organic horizons appear to be very thin (< 10 cm). Mineral topsoils range from 12 to 50 cm thick. Beneath the topsoils are subsoils which become excessively stony at 18 to 80 cm beneath the ground surface; subsoils are greyish brown in colour from translocated organic matter and are generally wet. Textures are commonly silt loams or fine sandy loams in both topsoils and subsoils, but tend to be coarser with depth (humic coarse sand for example). Some upper horizons are stony.

2.2.4 *Soils of Minor Occurrence*

Four profiles differ from the series described above. Two of them are important to this study: a Recent Soil on the immediate floodplain close to Giles Creek, and a Perch-gley Podzol. Recent soils show only minimal topsoil development (in this instance 40 cm thick) over unweathered sands and/or gravels. The poorly drained Perch-gley Podzol had 12 cm of silt loam topsoil overlying a gleyed and leached silt loam horizon of 41 cm thickness. Gravels were encountered at 53 cm depth.

2.3 CONCLUSIONS FROM SOIL SURVEY

- Ahaura series (yellow-brown earths/Allophanic Brown Soils) are the dominant soils over the mining licence area, comprising 60–70% of the 59 soil observations made from five traverses across the site.
- The average components of an Ahaura profile are about 10 cm of surface organic horizons and 20 cm of mineral topsoil. Subsoils have a mean thickness of close to 30 cm over stony or bouldery alluvium. Total average profile depth to the underlying gravels is 45 cm. Silt loam and fine sandy loam textures predominate.
- Soils of the Maimai series (15%), Ikamatua series (7%), Kumara series (3%) and Hokitika series (2%) are of minor occurrence over the surveyed area, but their presence has important ecological implications.

FIGURE 3. PROFILE OF AHAURA SILT LOAM. THE KNIFE IS 23 CM LONG.

3. Earthworks and Trial Design

3.1 PLANT GROWTH MEDIA TREATMENTS

The main trial was designed to test the effects of various potential growth media and treatments on the establishment, survival, and growth rates of a range of indigenous species of possible use for restoration after mining.

The trial contains three plant growth media treatments:

1. Original soil profile placed over gravels, i.e. mixed organic layers and mineral topsoil on subsoil on gravels.
2. Mixed soil placed over gravels, i.e. all organic and mineral soil materials mixed together on gravels.
3. Gravels to the surface, i.e. no soil material.

The effects of compaction by earthmoving machinery on the gravels are being tested as secondary treatments. Half of the soil placement and gravels only plots contain compacted gravels. The other half of the plots had the underlying or surface gravels ripped to about 80 cm depth at 1.5 m spacings.

FIG. 1 LAY-OUT OF THE PLOTS IN THE GILES CREEK BEECH FOREST REHABILITATION TRIAL, SHOWING THE LOCATION OF TENSIOMETERS. TRIAL LAYOUT FEBRUARY 1992.
(BASED ON FIG. 4 OF ROSS & MEW 1993).

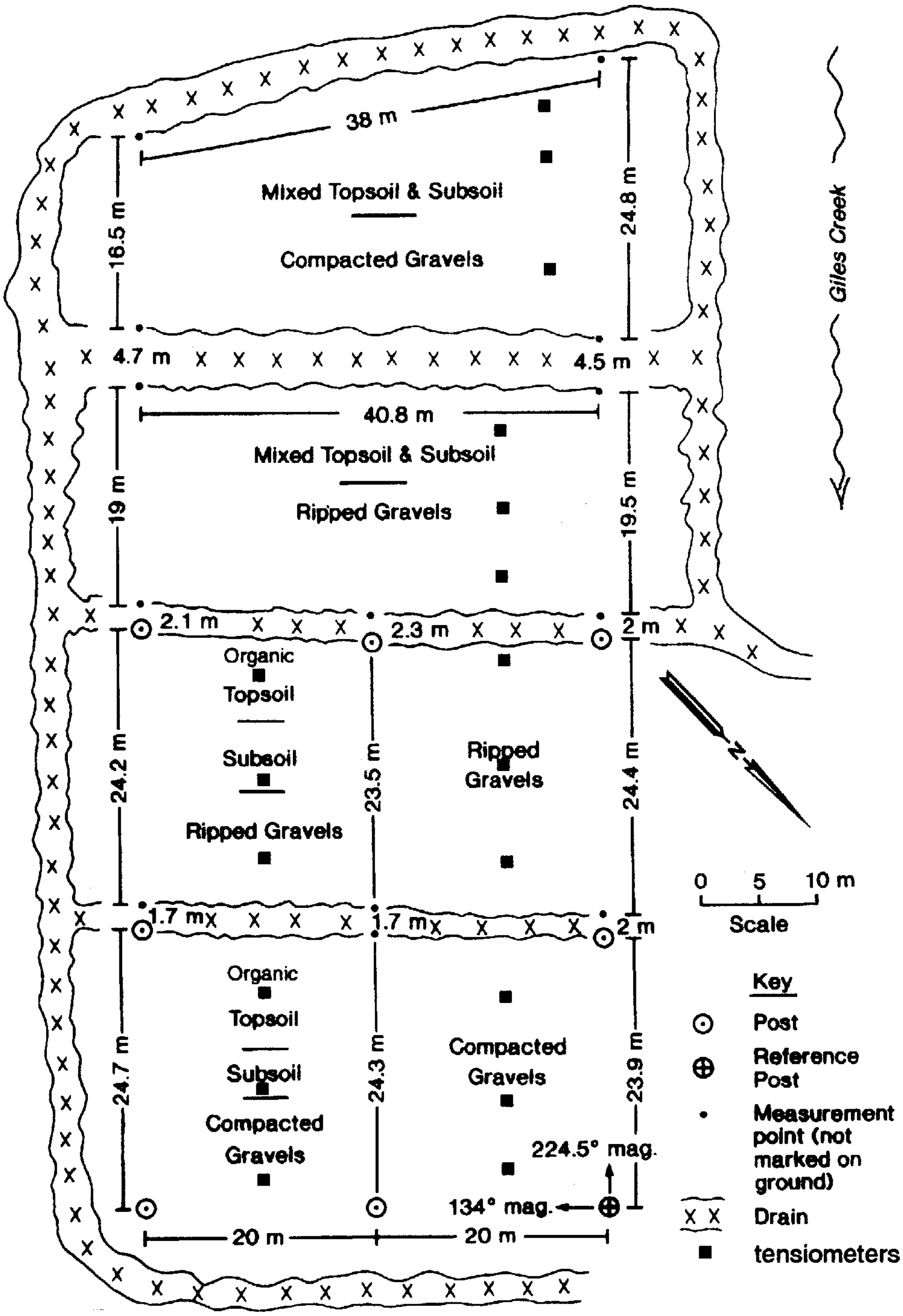


FIGURE 5. CONSTRUCTION OF THE GRAVEL PLATFORM FOR THE "GRAVELS TO THE SURFACE" TREATMENT.

FIGURE 6. RIPPING TO AMELIORATE COMPACTION IN THE GRAVELS.

3.2 TRIAL LAYOUT AND EARTHWORKS

The field layout of the rehabilitation trial is illustrated in Fig. 4. The original soil and gravels plots are approximately 24 m x 20 m. The mixed soil plots are approximately 40 m x 20 m. Open surface drains were dug around the trial area and between plots in order to intercept runoff water from the surrounding area and prevent excessive water movement between plots. All plots are flat to minimise aspect and microsite variability.

The earthworks were done in two phases as a consequence of mining operations.

The general gravel placement and recontouring of the trial site took place before 1991. The earthmoving and soil placement for the mixed soil plots was carried out in February 1991. The remaining plots were constructed in one day in February 1992.

Overburden gravels were dug using hydraulic excavators and transported/ respread using motorised scrapers and dump trucks (Fig. 5). Bulldozers were used for the final recontouring and for ripping (Fig. 6).

The soil materials were dug with an hydraulic excavator after the beech forest trees and tree stumps had been removed. Using this type of machinery it was possible to segregate the organic and topsoil materials from the subsoil (Fig. 7). Soil materials were transported in dump trucks or scrapers. Subsoil was spread directly from the scrapers (Fig. 8). Topsoil and organic material was spread with an hydraulic excavator without tracking across the deposited material at any time. All final contouring was done with an hydraulic excavator.

FIGURE 7. STRIPPING SURFACE ORGANIC LAYERS AND TOPSOIL FROM A CLEARED FOREST AREA.

FIGURE 8. SPREADING SUBSOIL OVER COMPACTED SOILS.

FIGURE 9. PLACING TOPSOIL AND ORGANIC MATERIALS OVER SUBSOIL BEFORE SPREADING WITH HYDRAULIC EXCAVATOR.

FIGURE 10. CONSTRUCTING THE ORIGINAL SOIL PROFILE PLOTS. THE "GRAVELS TO THE SURFACE" PLOTS ARE IMMEDIATELY BEHIND THE EXCAVATOR. THE MIXED SOIL REPLACEMENT PLOTS ARE IN THE BACKGROUND. THE ISOLATING OPEN DRAIN IS ALSO VISIBLE ALONG THE LEFT SIDE OF THE PHOTO.

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