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4. Characterisation of Materials

4.1 SAMPLING AND ANALYTICAL METHODS

Main horizons of a representative Ahaura series profile under standing partially cutover beech-podocarp forest were sampled for chemical and panicle size analyses. These samples represent the undisturbed or natural in-situ soil as a control for comparison with the reconstituted soil and other materials.

Soil and other materials were sampled in duplicate from each of the trial plots. These comprised:

- topsoil and organic layers combined,
- subsoil,
- mixed soil materials,
- fines (<2 mm) in both the surface and underlying overburden gravels.

In addition, duplicate samples of mudstone/sandstone overburden were collected from a subsidiary demonstration trial at the mine site. This trial is situated at another location on the mining site and is not directly comparable with the principal research trial described in this report. However, the results are included in this report for convenience and as a reference for comparison of materials.

The methods used for chemical analyses are described by Blakemore et al. (1987). Particle size analysis of the fine earth fraction (<2 mm) was determined by the method of Claydon (1989).

Chemical analyses and ratings for chemical properties have not been directly linked to the potential growth of indigenous woody vegetation. Only Bray-P levels and amounts of 0.5M-HCl-soluble Mg (Mgr) have been related to foliar levels in trees (Pinus radiata). However, the relative ratings are internally consistent and form a basis from which change can be monitored and growth can perhaps eventually be related.

4.2 RESULTS AND DISCUSSION

4.2.1 *Soil Chemistry*

Results for the soil chemical analyses are presented in Tables 1 and 2. Note: Trace elements were not analysed in this study.

4.2.la In-situ Ahaura soil

Chemical analyses for the four horizons sampled from an in-situ Ahaura series soil show the soil to be acidic and of relatively low natural fertility. Most of the plant nutrients that were analysed were concentrated in the surface organic layers. This suggests that the organic matter is likely to be a very important source of plant nutrients for this soil.

TABLE 1. SOIL AND OVERBURDEN CHEMISTRY (ANALYSTS: K.M. GIDDENS, L.J. GILLIGAN, C.D. MORGAN, H.W. RURU, M.D. TAYLOR, D.J. VICKERS.)

SAMPLE	LAB.NO.	HORIZON	DEPTH (cm)	pH (H_2O)	pH (H_2O_2)	KC1-A1 (me/100) g	CARBON (%)	NITROGEN (%)	CEC (pH7) (me/100 g)	EXCHANGEABLE (ME/100 g)				BS%	OLSEN-P (ug/g)	BRAY-P (ug/g)	SO_4-S (ug/g)	MGR (me/100 g)
										Ca	Mg	K	Na					
Ahaura soil (in situ)	CS223a	0	12-0	4.1		1.9	27.7	0.71	43.2	6.59	1.84	1.13	0.23	23	12	12	12	3.2
	CS223b	Ah	0-22	4.5		4.7	6.5	0.23	18.4	0.15	0.17	0.08	0.03	2	0	3	2	5.8
	CS223c	Bs	22-50	5.2		0.8	2.4	0.06	11.6	0.02	0.01	0.02	0.02	1	0	4	46	38
	CS223d	BC	50-70	5.3		0.4	0.63	0.02	4.6	0.00	0.00	0.01	0.01	0	1	46	23	33
Replaced soil (Topsoil organic layers)	CS376a	O+Ah	0-30	4.3	4.6	3.2	9.6	0.37	30.8	3.01	1.76	0.63	0.11	18	3	6	8	4
	CS376b	O+Ah	0-30	4.3	4.9	4.3	14.6	0.36	26.4	2.41	1.36	0.46	0.15	17	4	5	8	6
(Subsoil)	CS375a	Bs+BC	30-60	5.2	5.2	1.5	2.4	0.07	10.1	0.08	0.06	0.06	0.00	2	1	8	69	36
	CS375b	Bs+BC	30-60	5.1	5.0	2.8	4.0	0.12	12.5	0.11	0.10	0.08	0.00	2	0	3	37	22
Respread soil (mixed materials)	CS219a		0-50	5.2		1.7	3.7	0.13	11.8	0.41	0.11	0.13	0.04	6	1	4	34	14
	CS219b		0-50	5.0		1.6	1.5	0.05	9.2	0.06	0.05	0.04	0.03	2	1	23	59	32
	CS219c		0-50	5.0		2.0	2.9	0.09	10.8	0.15	0.12	0.06	0.04	3	1	16	50	29
	CS219d		0-50	4.9		2.2	3.2	0.10	10.3	0.11	0.10	0.09	0.04	3	1	15	25	24
Fines in surface respread overburden gravels	CS374a		0-60	5.6	2.8	0.6	0.20	0.01	3.1	0.09	0.04	0.06	0.01	6	11	165	11	27
	CS374b		0-60	5.7	3.8	0.6	0.19	0.01	3.2	0.07	0.04	0.07	0.00	6	11	167	10	25
Fines in underlying respread overburden gravels	CS220a		60-80	5.5		0.3			2.8	0.02	0.01	0.04	0.04	4	9	154	15	23
	CS220b		60-80	6.1		0.3			4.1	0.08	0.03	0.06	0.04	5	5	139	12	27

TABLE 2. CHEMISTRY OF MUDSTONE/SANDSTONE OVERBURDEN ON DOC DEMONSTRATION TRIAL. (ANALYSTS: K.M. GIDDENS, L.J. GILLIGAN, P.L. SEARLE.)

SAMPLE	LAB NO.	pH (H_2O)	pH (H_2O_2)	KC1-A1 (me/ 100 g)	CARBON (%)	NITRO-GEN (%)	CEC (pH7) (me/ 100 g)	EXCHANGEABLE (me/100 g)				BS%	OLSEN P (ug/g)	BRAY P (ug/g)	SO4-S (ug/g)	MGR (me/ 100 g)
								Ca	Mg	K	Na					
Overburden	CS540a	6.6	6.0	0.0	2.4	0.06	25.4	14.9	10.8	0.51	0.54	(100)	3	32	200	15
Overburden with coal	CS540b	6.1	5.4	0.0	6.3	0.09	13.3	5.31	3.72	0.15	0.37	72	1	13	65	74

The pH ranges from extremely acid in the organic and topsoil horizons to moderately acid in the subsoils. Exchangeable-Al is medium-high in the upper horizons, decreasing significantly in the subsoil. These results suggest that plants tolerant of acidic soil conditions are most suited for revegetation if lime is not applied.

Predictably, organic-matter contents decrease with depth down the soil profile. Cation exchange capacities follow a similar trend, ranging from very high in the organic layers to very low in the lower subsoil. Exchangeable cations are at medium levels in the organic horizons but decrease significantly in the mineral soil horizons, with negligible levels in the lower subsoil. The cation exchange data indicate that the soil is strongly leached.

Phosphorus contents are generally low to very low, suggesting that P deficiency may affect plant gowth. However, a high content of Bray-P was measured in the lower subsoil, probably indicating the presence of primary apatite minerals from the alluvial gravels parent material. This hypothesis is supported by the high Bray-P contents for the fines from the overburden gravels. Sulphate-S increases down the profile from low or very low to medium levels in the subsoil. Reserve Mg is low in the upper two horizons and very high in the subsoil.

4.2.lb Rehabilitated soil materials

The chemistry of the soil placed by the original horizons on the trial tends to reflect the differentiation between the organic and topsoil layers and the subsoil. Values for all chemical attributes for the surface materials tend to be intermediate between those for the organic horizons and the mineral topsoil (Ah). Similarly, the respread subsoil tends to exhibit chemical characteristics between the upper (Bs) and lower (BC) subsoil. The respread subsoil has slightly higher organic matter levels and exchangeable bases compared to the in-situ subsoil. This probably results from some minor inclusions of topsoil and organic matter during the earthmoving operations.

The respread mixed soil samples have somewhat variable chemistry, indicating the inhomogeneous nature of this material. In general, the chemical attributes for the mixed soil are similar to those for the upper subsoil (Bs) of the in-situ soil. KCl-Al levels are somewhat higher, approximating the value for the in-situ organic layer.

4.2.lc Fines in the gravels

The chemistry of the fine (<2 mm) materials in the gravels is significantly different from that of the soil materials. The fines are moderately to slightly acidic, have low exchangeable-Al levels, and very low organic-matter contents. Nitrogen deficiency is likely to be a significant constraint for plant growth with respect to non-leguminous species.

This material has very low cation exchange capacity and exchangeable cations. In contrast, phosphorus contents are significantly higher, especially Bray-P, indicating that this may be an important potential source of P for tree nutrition. SO_4-S is low and reserve Mg is high.

4.2.1d Overburden mudstone/sandstone

The overburden mudstone/sandstone has a significantly different chemical composition compared to the soil materials and the fines in the overburden gravels. Overall, the overburden mudstone/sandstone has a higher nutrient status than most of the soil materials, with the exception of nitrogen, which is lacking.

This overburden material is only slightly acidic to near neutral, has no detectable exchangeable-Al and has low to medium carbon contents, depending on the amount of coal inclusions. The cation exchange capacity is medium to high as a consequence of the higher clay content compared to the soil materials (see particle size results). Exchangeable cations and the percentage base saturation are significantly higher than the soil materials. Phosphorus contents are low to medium whereas $S0_4$-S is high to very high. Reserve Mg is at medium levels.

These data suggest that the overburden mudstone/sandstone has a chemical composition which significantly differentiates it from the gravels and soils as a potential plant growth medium for land restoration. However, its physical characteristics may be a major limiting factor (see the following section).

4.2.2 Particle Size Distribution

Particle size distribution data are given in Tables 3 and 4 and grading curves are presented in Figure 11.

The soil materials in the sample of Ahaura soil horizons and in the respread soil materials on the trial plots are relatively coarse textured — predominantly sandy loams (texture classes described by Milne *et al.* 1991). Two samples have loamy sand textures — the lower subsoil of the in-situ Ahaura profile and one of the respread topsoil/organic material samples. Clay contents range from 5% to 16%, silt 15-34% and sand 54-79% (Table 3). Fine sand (0.2–0.06 mm) tends to be the dominant sand fraction.

The 'fines' (<2 mm fraction) in the overburden gravels have contrasting particle size distributions to the soil materials. They have sand textures and are dominated by the coarse sand fraction (2-0.6 mm). Silt contents are minimal (10-12%) and there is a very low content of clay (0-4%).

The soil materials tend to be well graded (Fig. 11) whereas the gravel fines are more uniformly graded materials. However, a complete particle size analysis of the bulk materials in the gravels, including stones and boulders, would demonstrate a predominance of very coarse particles (boulders). Because the stones and boulders are regarded as inert in terms of water and nutrient supply to plants, they have not been assessed in this study. Effort has been concentrated on characterising the fines which are of importance for root growth and development.

TABLE 3. PARTICLE SIZE DISTRIBUTION - FINE EARTH FRACTION (<2 MM). (ANALYST: J. CLAYDON)

SAMPLE	LAB.NO.	HORIZON	DEPTH (cm)	COARSE SAND 2-0.6 mm (%)	MEDIUM SAND 0.6--0.2 mm (%)	FINE SAND 0.2-0.06 mm (%)	SILT 0.06-0.002 mm (%)	CLAY <0.002 MM (%)
Ahaura soil (in situ)	CS223b	Ah	0-22	12	17	25	33	12
	CS223c	Bs	22-50	22	17	22	24	14
	CS223d	BC	50-70	31	28	20	15	5
Replaced soil (Topsoil)	CS376a	Ah	0-30	16	21	24	32	7
	CS376b	Ah	0-30	14	18	25	34	9
Replaced soil (Subsoil)	CS375a	Bs+BC	30-60	25	22	23	19	11
	CS375b	Bs+BC	30-60	15	19	27	25	15
Respread soil (mixed materials)	CS219a		0-50	11	18	28	27	16
	CS219b		0-50	8	20	33	28	10
	CS219c		0-50	25	20	23	21	11
	CS219d		0-50	16	24	26	24	10
Fines in surface respread overburden gravels	CS374a		0-60	51	24	11	11	3
	CS374b		0-60	51	23	11	12	4
Fines in underlying respread overburden	CS220a		60-80	48	26	11	10	4
	CS220b		60-80	56	21	12	11	0

TABLE 4. PARTICLE SIZE DISTRIBUTION - FINE EARTH FRACTION (<2 MIN) OF MUDSTONE/SANDSTONE OVERBURDEN ON DOC DEMONSTRATION TRIAL.

OVERBURDEN	LAB. NO. SAMPLE	COARSE SAND 2.0–0.6 mm (%)	MEDIUM SAND 0.6–0.2 mm (%)	FINE SAND 0.20–0.06 mm (%)	SILT 0.06–0.002 mm (%)	CLAY <0.002 mm (%)
1	CS540a	0	2	6	48	44
2	CS540b	4	11	19	37	29

A general assessment of the physical properties of the soil materials shows that the good drainage and friable consistence of the in-situ Ahaura soil is in accord with the sandy loam textures. However, the coarse textures, uniform particle size gradings and inherently weak soil structures potentially make the soil particularly prone to compaction and physical degradation from earthmoving operations. Compaction and structural breakdown is likely to adversely affect the drainage characteristics and possibly also soil aeration. Some surface ponding has been observed on the trial.

The coarse soil textures tend to be in accord with the chemical characteristics such as the strongly leached status and relatively poor nutrient levels in the mineral soil horizons,.

The overburden gravels are inherently excessively drained and drought-prone. Field evidence shows that compaction by machinery can cause some localised impeded drainage and surface ponding under heavy rainfalls, which contrasts with the natural physical properties. Low chemical buffering capacity and relative chemical inertness are consistent with the coarse sandy texture of the gravels matrix of fines.

The overburden mudstone/sandstone has significantly higher contents of clay (29-44%) and silt (37-48%) compared to the soil materials (Table 4). These materials have silty clay or clay loam textures (Milne *et al.* 1991). The finer textures are consistent with the higher nutrient status of these overburden materials. However, field observations indicate that the mudstone, in particular, is weakly structured and, once exposed in stockpiles or on the surface, breaks down readily under heavy rainfall. This leads to surface sealing and ponding of water in hollows. Hence, physical conditions for future plant growth favour plants adapted to such wet conditions unless amelioration techniques or conditioning materials are used.

4.3 CONCLUSIONS FROM CHARACTERISATION OF MATERIALS

- The in-situ Ahaura soil materials are acidic and of relatively low natural plant nutrient status. Most of the plant-available nutrients are concentrated in the organic matter which is, however, extremely acidic.

- The chemical characteristics of,the placed soil by original horizons tend to be intermediate between the in-situ derivative materials. That is, the upper respread layer has soil chemmcal levels intermediate between the upper (Bs) and lower (BC) subsoils.
- The matrix fines (<2 mm) in the overburden gravels are relatively inert, but this material is a potential source of phosphorus for magnesium for plant nutrition.
- The mudstone/sandstone overburden on the demonstration trial plots has a higher fertility status compared to the soil materials, especially the cations and sulphate-S, except for nitrogen which is very limiting.
- Sandy loam textures predominate in the soil materials. The overburden gravels have a coarse sand matrix. The mudstone overburden has silty clay or clay loam textures.
- The soil materials are freely draining in-situ but may exhibit degraded physical conditions as a consequence of structural breakdown and compaction caused by earthmoving operations for site rehabilitation. The overburden gravels are drought-prone, and also plant growth may be impeded as a consequence of compaction. The respread overburden mudstone has poor physical characteristics for plant gowth. Plants tolerant of impeded drainage are recommended for this material.

FIG. 11 PARTICLE SIZE GRADING CURVES - REFER TO TABLES 3 AND 4 FOR SAMPLE DESCRIPTION.

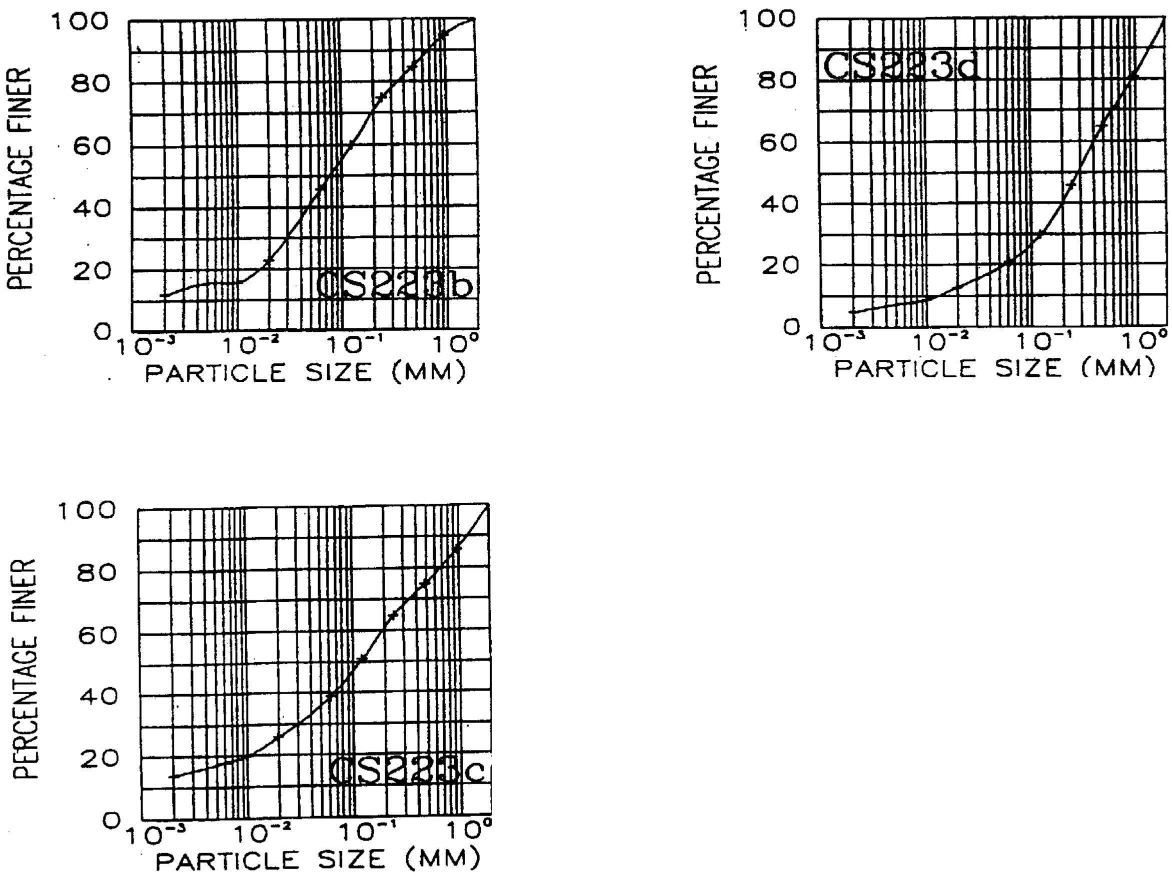


Fig. 11 (continued)

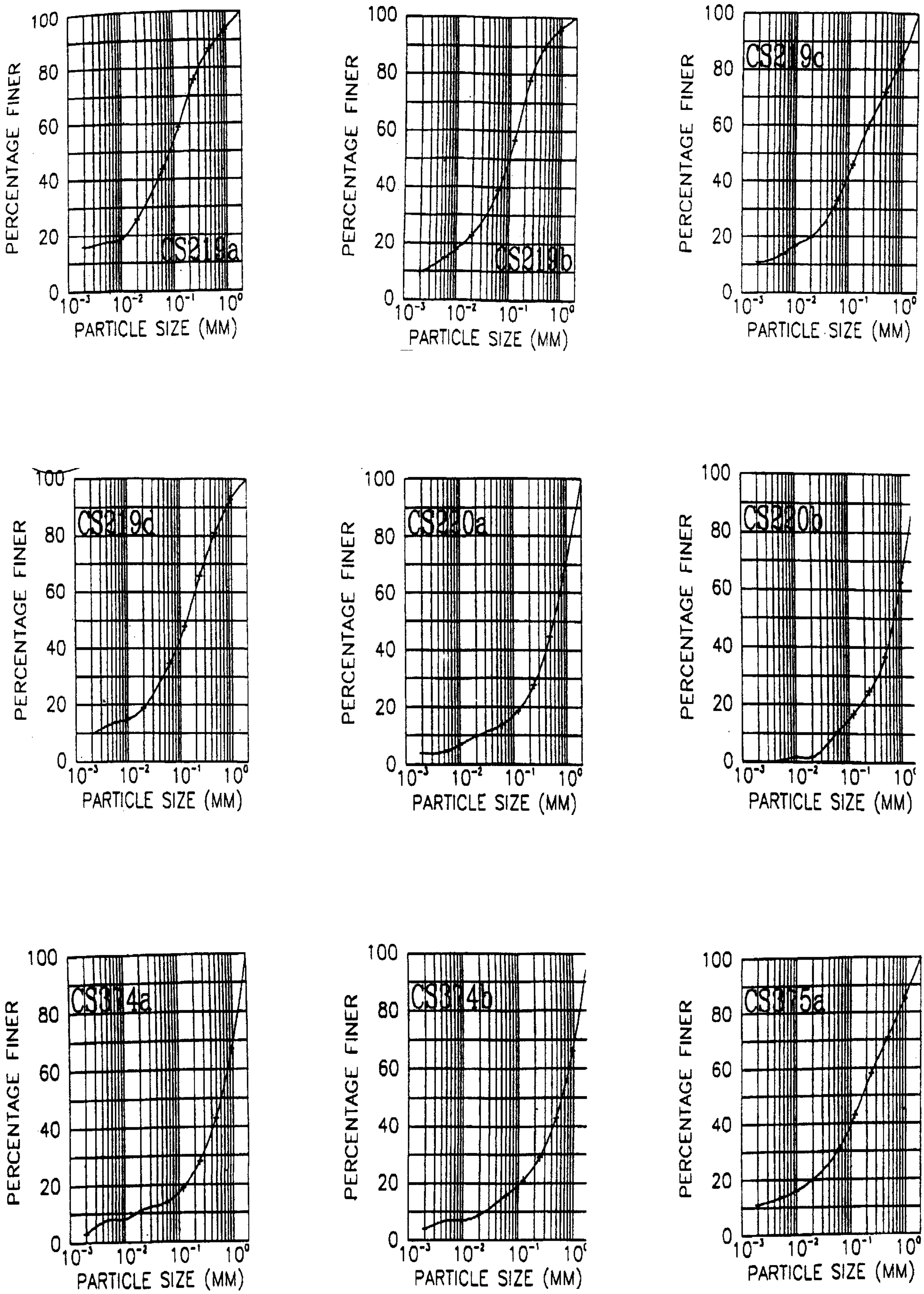
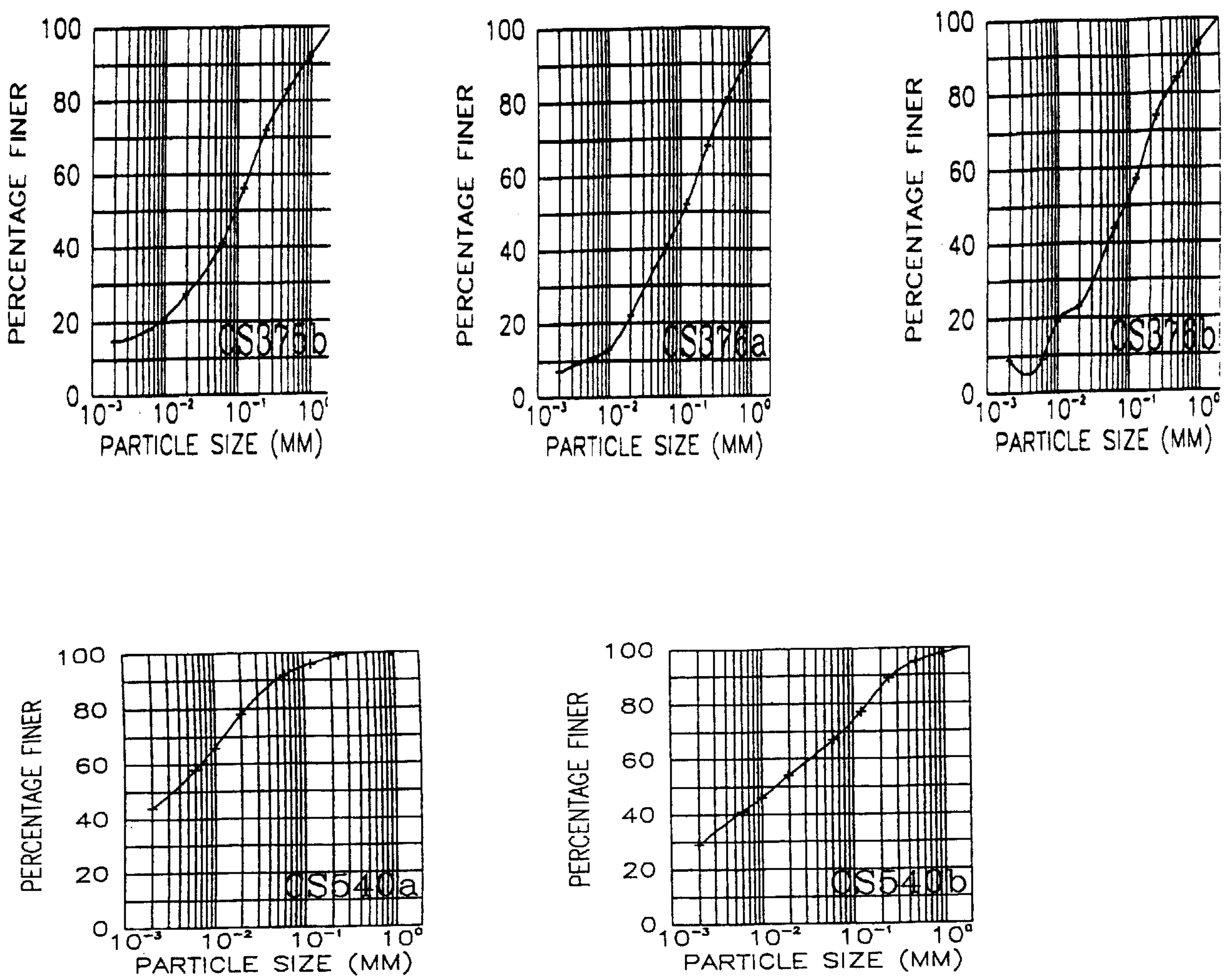


Fig. 11 (continued)



5. General Discussion and Conclusions

The soil analyses used for characterising the materials of the rehabilitation trials and the in-situ soil provide a general measure of their chemical and physical properties. Interpreting the results for the specific physical and nutritional requirements of a range of indigenous woody plant species has a high degree of uncertainty. There is little or no documented information on the specific soil fertility needs for the indigenous forest species being tested in these trials. Although this research programme will help our understanding of the interactions of rehabilitated plant growth media and native plant responses for some mining sites, there are fundamental questions on the soil chemical and physical requirements of indigenous plants which remain to be investigated.

2. Particle size distributions are amongst the most basic forms of soil physical data. There are broad associations between particle size distribution and other physical properties which have more direct impact on plants — for example, moisture retention, hydraulic conductivity, aeration, soil strength or penetration resistance, etc. However, particle size distributions provide only a very generalised soil physical measurement for interpreting plant response.

   In order to gain a better understanding of the effects of physical conditions of soil, or other media, on the revegetation process, periodic measurements are being made of the soil moisture status (in the saturated to slightly unsaturated range using tensiometry) and oxygen diffusion rates (ODR — a measure of aeration conditions in the rooting zone). Correlations between the particle size properties of the different materials used in the trial, ODR and moisture conditions, and plant response will be evaluated when sufficient results are available.

3. Visual observations of surface ponding on the respread overburden gravels are somewhat surprising, given the extremely coarse texture of these materials. Earthmoving and compaction by heavy machinery seems to cause sufficient densification and close particle packing to inhibit water movement through the gravels that normally drain freely. An extension to the research programme would be necessary to further study how and why there is an apparent surface drainage impediment in the compacted respread gravels.

4. Changes in the soil hydrology from the natural forest ecosystem are highly likely for the rehabilitated soils. Under the forest canopy, rainfall is concentrated by stem flow and by dripping from the leaves and branches. In contrast, rainfall is distributed more-or-less evenly across the rehabilitation trial site because it lacks a vegetation canopy at this stage of revegetation. In addition, preferential water flow pattems down through the natural in-situ soil along root channels, worm holes, etc. are disrupted and not generally present in the rehabilitated soils. Both factors, along with the changes in the organic cycling regime, are likely to strongly influence soil leaching conditions. The consequences of these changes on soil properties and consequential plant responses are unknown. Sampling the trial soil materials after 5 and 10 years would indicate the longer-term trends in changes to the soil materials consequent to stripping, respreading and revegetation.

   Consolidation of the soil materials with time is being monitored. Other changes in soil organic-matter contents and soil chemistry are not being regularly monitored in the short term. However, further analytical soil testing at 5 and 10 years after rehabilitation is planned and is recommended in order to make predictions about the future soil conditions and long-term vegetation changes.

5. There is a significant contrast between the soil materials on the rehabilitation trial site and the overburden mudstone/sandstone used for the demonstration trial. The overburden mudstone used was from a buried geologic stratum from immediately above the coal seams. It contained some contamination of coal but no soil materials.

The differences between the physical and chemical characteristics of the overburden mudstone and the soil materials are likely to have long-term ecological implications for site restoration. It is postulated that two substantially different vegetation types will grow on the two different materials in the absence of any substantial management.

6. Research Opportunities

1. Relate plant establishment and growth of indigenous beech-podocarp forest species to soil chemical and physical properties. Associated with this potential research is a need to establish accurate fertiliser responses for a wide range of indigenous forest plants. Work is also required to establish the relationships between the chemical contents of foliage of native trees and shrubs and soil chemical properties.
2. Monitoring and adjusting the continuing management of the rehabilitated and revegetated mined areas will be necessary to ensure environmentally acceptable outcomes. Weed and animal control are of critical importance. Maintenance or booster fertiliser applications may be required to stimulate the development and growth of preferred trees and shrubs.
3. Soil materials on the trial plots should be resampled at 5 and 10 years for comparative analyses aimed at detecting changes in soil properties with time. This information, together with the results and trends from the revegetation studies, will indicate likely consequences of the rehabilitation techniques for the long-term forest ecology.
4. Investigation of the reasons for the apparent surface drainage impediment in the compacted respread gravels.

7. Acknowledgements

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8. Appendices

8.1 DETAILED PROFILE DESCRIPTIONS

Soil Name: Ahaura Stony Sandy Loam

Description of Profile No. : GC91/1 **Author:** CWR, DMcQ;
Date: 6-Feb-1991

Map reference:	L30 1071 0730	**Map Series: NZMS 260**	
Classification:	Yellow-brown earth, Acidic Allophanic Brown Soil		
Survey:	Land Restoration Trial, Giles Ck	**Region:**	Nth Westland
Location:	Giles Creek Coal Nine Area		
Topdressing:	Nil		
Annual Rain:.	3200 mm	**Elevation:**	180 m
Landform:	Surface of terrace in terrace system		
Flooding:	Less than one year in 10		
Microrelier:	Forest dimpled		
Drainage:	Well		
Land Use:	Former forestry		
Vegetation:	Silver and mountain beech forest		
Parent Materials:	Weakly weathered, granite alluvium		
Notes:	Vegetation type is indigenous cutover forest being cleared for coal mining. Sampled profile for chemical and particle size characterisation.		

Horizon	**Depth (cm)**	**Horizon description**
H	0-12	Very dusky red (2.5YR 2.5/2) humus; loose soil strength; uncemented; moderately developed fine crumb structure; abundant coarse roots; moist; very thin litter and fermentation layers at surface; indistinct wavy boundary.
Ah	12-33	Dark brown (7.5YR 3/2) stony sandy loam; weak soil strength; uncemented; friable; moderately developed medium block structure breaking to moderately developed fine nut; few coarse roots; many moderately weathered rounded granite stones; distinct irregular boundary.
Bs	33-63	Strong brown (7.5YR 5/8) very stony silt loam; few dark brown (7.5YR 3/3) distinct organic coatings on ped faces; weak soil strength; uncemented; firm; weakly developed fine block; few coarse roots; many strongly weathered rounded granite stones; indistinct wavy boundary.
BC	63-85+	Light yellowish brown (2.5Y 6/4) gravelly loamy coarse sand; very weak soil strength; uncemented; very friable; single grained; no roots; weakly to moderately weathered granite gavels; few coarse inclusion of Bs materials.

Soil Name: Ahaura Fine Sandy Loam

Description of Profile No. : GC90/12 **Author:** CWR, GM
Date: 6-Jun-1989
Map reference: L30 1070 0730 **Map Series: NZMS 260**
Classification: Yellow-brown earth, Acidic Allophanic Brown Soil
Survey: Land Restoration Trial, Giles Creek **Region:** North Westland
Location: Giles Creek Coal Mine Area
Topdressing: Nil
Annual Rain: 3200 mm **Elevation:** 180 m
Landform: Surface of terrace in terrace system
Flooding: Less than one year in 1 0.
Microrelief: Forest dimpled
Drainage: Well drained
Land Use: Former forestry
Vegetation: Silver and mountain beech forest
Parent Materials: Weakly weathered, granite alluvium
Notes: Vegetation type is indigenous cutover forest.

Horizon	Depth (cm)	Horizon description
H	0-8	Dark reddish brown (5YR 2/2) humus; loose soil strength; uncemented; weakly developed fine crumb structure; abundant medium live roots; moist; distinct wavy boundary.
Ah	8-17	Brown to dark brown (7.5,YR 4/2) fine sandy loam; moderately weak soil strength; uncemented; weakly developed fine nut structure; common medium live roots; moist; few worms; indistinct wavy boundary.
Bs1	17-50	Strong brown (7.5YR 5/8) stony silt loam; moderately weak soil strength; uncemented; weakly developed medium blocky structure breaking to weakly developed fine blocky structure; few distinct brown to dark brown (7.5YR 4/4) organic coatings; many moderately weathered subrounded granite stones; few fine live roots; moist; diffuse smooth boundary.
Bs2	50-85	Strong brown (7.5YR 5/6) stony silt loam; moderately weak soil strength; uncemented; weakly developed fine blocky structure; few distinct brown to dark brown (7.5YR 4/4) organic coatings; abundant moderately weathered subangular alluvial granite stones; few fine live roots; moist; indistinct wavy boundary.
BCs	85-105+	Yellowish brown (10YR 5/6) bouldery loamy coarse sand; loose soil strength; weakly cemented; single grain; common prominent dark reddish brown (5YR 3/3) iron/humus coatings; abundant weakly weathered subrounded alluvial granite boulders; moist.

Soil Name: Hokitika Loamy Fine Sand

Description of Profile No.: GC90/24 **Author:** CWR, GM
Date: 8-Jun-1989
Map reference: L30 1080 0370 **Map Series:** NZMS 260
Classification: Recent soil. On Yellow brown earth, Recent soil on Placid Acid Brown Soil
Survey: Land restoration trial, Giles Creek **Region:** North Westland
Location: Giles Creek Coal Mine Area
Annual Rain: 3200 mm **Elevation:** 175 m
Landform: Surface of terrace in terrace system
Landform genesis: Fluvial
Microrelief: Forest dimpled **Flooding:** Every 5 years
Drainage: Well drained
Land Use: Former forestry
Vegetation: Red and silver beech forest
Parent Materials: Weakly weathered, granite alluvium
Notes: 2 cm beech leaves and twigs on surface. Vegetation type is indigenous cutover forest.

Horizon	Depth (cm)	Horizon description
Ah	0-6	Dark greyish brown (10YR 4/2) loamy fine sand; very weak soil strength; uncemented; weakly developed fine nut structure; no coatings; many medium live roots; moist; sharp wavy boundary.
Cu	6-11	Light brownish grey (2.5Y 6/2) sand; loose soil strength; uncemented; single grain; few medium live roots; moist; sharp wavy boundary.
bAh	11-25	Dark greyish brown (10YR 4/2) fine sandy loam; moderately weak soil strength; uncemented; weakly developed medium nut structure breaking to weakly developed fine nut structure; few coarse live roots; moist; indistinct wavy boundary.
bBw	25-48	Yellowish brown (10YR 5/4) silt loam; moderately weak soil strength; uncemented; moderately developed medium blocky structure breaking to weakly developed fine blocky structure; few weakly weathered subrounded alluvial granite stones; few fine live roots; moist; distinct wavy boundary.
2bBs	48-123	Dusky red (2.5YR 3/2) stony coarse sand; very strong soil strength; strongly cemented; massive breaking to single grain; continuous ironpan; abundant weakly weathered subrounded alluvial granite stones; moist; few boulders (30-50 cm); multiple Fe-pans; distinct wavy boundary.
2bBC	123-166	Dark yellowish brown (IOYR 4/4) stony coarse sand; loose soil strength; uncemented, single grain; abundant weakly weathered subrounded alluvial granite stones; moist; few boulders (30-50 cm); indistinct wavy boundary.

2bCH 166-266 Dark reddish brown (5YR 2/2) stony coarse sand; very firm soil strength; weakly cemented; massive breaking to single grain; many prominent dark reddish brown (5YR 2/2) organic coatings; abundant weakly; moist; few boulders (30-50 cm); humus staining continues below 266 cm.

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