INTERIM REPORT ON THE LIMITATIONS FOR EXOTIC FORESTRY OF THE SOILS OF THE GREYMOUTH - HOKITIKA REGION, SOUTH ISLAND, NEW ZEALAND.

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Physical soil limitations by G. Mew

Chemical soil limitations by J.A. Adams

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INTRODUCTION

Parts of the Greymouth-Hokitika region are scheduled to play a major role in future forestry operations in Westland. This report summarises the potential physical and chemical limitations of all of the soils of this region for exotic forestry. The area covered during the soil survey is approximately 1040 km^2 and comprises the region from the Grey and Arnold Rivers in the north to the Hokitika and Kokatahi Rivers in the south. It is bounded by the Tasman Sea and the foothills of the Southern Alps. The report describes not only State Forests but also extensive areas of country not currently being considered for exotic forestry.

The present report and soil map provide basic medium-scale soil survey data and an assessment of the potential physical and chemical soil limitations likely to affect the growth of exotic forests and particularly radiata pine.

PREVIOUS WORK

No detailed work has been published on the soils of the Greymouth-Hokitika region.

The entire region was originally surveyed at a scale of 1:253 440 by Gibbs et al. (1950). The area was later described at the same scale in the reconnaissance survey of the South Island (N.Z. Soil Bureau 1968). The present survey has updated this information.

THE PRESENT SOIL MAP

The present soil map at a scale of 1:50 000 has been prepared from surveys of the Greymouth-Hokitika region by a number of soil survey teams during 1974 and 1975. Detailed soil data are not presented in this interim report but will be published in the complete survey.

The boundaries of the mapping units define areas of essentially uniform soils, intricate mixtures of several soils which are mapped as complexes (e.g. B1H + F1H), or predictable mixtures of several soils which are mapped as associations (e.g. F1 - Mm). Boundary lines were surveyed by relating their positions to marked features of the landscape where possible. Air photo interpretation was used to link boundaries in other areas.

It should be stressed that the soil map at the above scale and the assessment of potential limitations is not sufficiently detailed for management planning at larger scales; e.g. 1:10 000. This is particularly relevant in the extensive areas of hill country and steep land mapped as complexes and associations of two or more soil units. More intensive surveys of key areas should be made prior to the next stage of planning.

EXPLANATORY NOTES FOR THE ASSESSMENT OF SOIL LIMITATIONS FOR EXOTIC FOREST GROWTH

Physical and chemical soil limitations for exotic forest growth are presented in Tables 1 and 2 respectively. These explanatory notes are intended to outline the criteria by which the limitations have been assessed and the method of classification adopted, and provide information on the manner in which the data should be used. The tables are given to assist users of the interim soil map, pending publication of the complete survey.

Physical soil limitations

The data used as a basis for the assessment of physical soil limitations have been abstracted from soil unit sheets. These are the basis source documents used for recording and storing information about soil units after compilation from the field recordings. The sheets for the Greymouth-Hokitika region are at present held on file by Soil Bureau pending publication of the complete survey.

Profile morphological properties and site characteristics that would be expected to relate to site productivity are grouped under five headings in Table 1.

(i) *Textural limitations*

Limitations to tree growth caused by horizons often with little or no structure, some very compact and high in silt, or with blocky structure and relatively high clay contents, and some with no cohesion.

(ii) *Tangible impediments to rooting*

Limitations to tree growth caused by the presence of one or more of the following profile features:

(a) iron pans in the soil profile or in the underlying material, or both,

(b) shallow profiles,

(c) excessively stony or bouldery horizons,

(d) relatively impenetrable underlying rock or gravels.

(iii) *Lack of moisture*

Limitations to tree growth caused by possible drying out in summer.

(iv) *Excessive moisture*

Limitations to tree growth caused by the presence of high water tables or a soil drainage impediment; a limitation caused by susceptibility to flooding; or a limitation caused by a higher rainfall than average for most of the area.

(v) *Erosion hazard*

The degree of erosion hazard following removal of the present forest cover as shown by field assessment of current erosion related to underlying materials, soil drainage, texture and structure.

The degree of limitation with regard to each soil physical or chemical limiting factor is expressed by a rating system; 0 - negligible limitation, 1 - slight, 2 - slight to moderate, 3 - moderate, 4 - moderate to severe, 5 - severe. The limitations of lack of moisture, erosion hazard, and excessive moisture except for high water tables, have been rated directly from the unit sheets based on observations made during the survey, and published meteorological information where applicable.

Effective rooting depth

Textural limitations, tangible impediments to rooting, and the presence of high water tables have been rated using the concept of effective rooting depth as a basis. Effective rooting depth was considered to be the mean profile depth to an effective rooting barrier, that is to one of the above limitations. Ratings have been made using the following classes:

Effective rooting depth (cm)	Degree of limitation	
>75	negligible	0
60-75	slight	1
45-60	slight to moderate	2
30-45	moderate	3
20-30	moderate to severe	4
<20	severe	5

These classes are based on data contained in Jackson (1965), Jackson and Gifford (1974) and Raupach (1967).

Scores allocated according to the above criteria were modified where it was consider d necessary to allow for the degree to which a particular profile parameter was likely to limit the effective rooting volume. Thus a soil with a moderately thick, hard continuous iron pan at 35 cm would have a higher rating than one with a thin, soft discontinuous pan at the same depth, because of the greater degree of effectiveness of the pan in the first soil as a barrier to tree rooting.

Chemical soil limitations

The data used as a basis for the assessment of chemical soil limitations were the routine analyses of representative profiles collected during this survey and that of the Grey Valley (Adams and Mew 1976), together with additional analyses particularly intended to assess the potential chemical limitations of the soils for radiata pine growth. These analyses included Bray-2 P, HCl-soluble Mg, and HCl-soluble K. All horizons of all sampled profiles were analysed. Analytical results are held at Soil Bureau, DSIR.

The degree of limitation for chemical soil limitations was based on the same six-point scale used to rate physical soil limitations except in the case of nitrogen, where a four-point scale was used (see p. 9). The complete soil profile (including organic horizons) has been considered, except for profiles containing a physical impediment to rooting rated at 4 (moderate to severe) or 5 (severe), where horizons underlying the rooting impediment were not considered.

In studying Table 2, it should be noted that it relates mainly to potential deficiencies. The chemical limitations are based largely on soil analyses from virgin sites and hence do not take into account management practices such as burning which are known to greatly improve short-term nutrient availability. Because of this deficiency symptoms related to the suggested chemical limitations are unlikely to be observed in areas of young radiata pine established on sites which were burnt prior to planting. However, it is considered likely that the deficiencies predicted from the limitation ratings will appear during the later stages of the first rotation and in subsequent rotations.

Ratings for the individual chemical factors in Table 2 have been made using quantitative criteria where possible. Trace element assessments, however, are mainly subjective. Where analyses from more than one profile are available for a soil unit, the ratings shown in Table 2 represent mean values.

(i) *Nitrogen*

Rating classes used are based on the results of Waring (1962) and use Total N as the diagnostic criteria.

Total N (%)	Degree of limitation
>0.15 in top 10 cm	0
0.10-0.15 in top 10 cm	2
0.05-0.10 in top 10 cm	3
<0.05 in top 10 cm	5

(ii) *Phosphorus*

Rating classes used are based on the results of Ballard (1974) and use Bray-2 P levels as a diagnostic criteria.

Bray-2 P (ppm)	Degree of limitation
>12 throughout profile	0
9-12 in top 10 cm	1
3-9 in top 10 cm, >9 below	2
<3 in top 10 cm, >9 below) or 3-9 in top 10 cm,<9 below)	3
<3 in top 10 cm, 3-9 below	4
<3 throughout profile	5

(iii) *Cations*

Ratings have been based largely on HCl-soluble Mg and HCl-soluble K levels. The rating classes for magnesium are derived mainly from the results of Adams (1973) and for potassium from the results of Raupach and Clarke (1972).

Magnesium

HCl-soluble Mg (ppm)	Degree of limitation
>500 throughout profile	0
300-500 in top 20 cm, >500 below	1
300-500 throughout profile	2
<300 in top 20 cm, >500 below	3
<300 in top 20 cm, 300-500 below	4
<300 throughout profile	5

Potassium

HCl-soluble K (ppm)	Degree of limitation
>300 throughout profile	0
200-300 in top 20 cm, >300 below	1
200-300 throughout profile	2
<200 in top 20 cm, >300 below	3
<200 in top 20 cm, 200-300 below	4
<200 throughout profile	5

(iv) *Trace elements*

Rating classes are largely subjective and are based on a knowledge of typical trace element contents of soils from various parent materials.

For those soils which were not sampled for chemical analysis in either this survey or that of the Grey Valley (Adams and Mew 1976), assessments of chemical limitation ratings have been made from available analyses of pedologically similar soils. These soils are marked with an asterisk in Table 2.

Method of classification

The method of classification used in Tables 1 and 2 is that in Adams and Mew (1976). Some of the soils common to both that report and the present one have slightly different degrees of physical and chemical soil limitations for certain limiting factors. These result mainly from minor differences in profile morphology and chemical properties over the greater geographic range now covered.

In Table 1, Atarau and Ruru steepland soils have been transferred from Class D (soils with moderate physical soil limitations) to Class E (soils with moderate to severe physical soil limitations). This is because of the greater degree of observed erosion (including debris avalanches) in the Lake Kaniere area resulting from a slightly increased schistose sandstone content of the parent material.

Relationship between the limitation tables and the soil map

The soils within each limitation class shown in Tables 1 and 2 are arranged in the order of the physiographic legend of soils on the soil maps for ease of cross reference. As has been noted previously, many areas on the maps are shown as complexes or associations of two or more soil mapping units. At the scale used, it is not possible to give precise areas for each soil within a complex or association. As a general rule the soil mapping unit symbols are listed in order of decreasing areal extent,but in areas of complex topography the proportions may be modified when more detailed surveys are carried out. With regard to the assessment of limitations in areas mapped as complexes or associations, consideration of individual areas will be necessary. Where a soil having a moderate to severe or a severe limitation rating under the limiting factor headings (on the table) of a kind extremely difficult to overcome using current technology(e.g. a '5' rating for erosion hazard) occurs in the first two symbols of any mapping unit, then serious consideration should be given to excluding that unit from use. Where such a soil is listed in the remaining symbols it must be considered in terms of the limitation ratings of the other soils in the mapping unit.

The physical and chemical soil limitations presented in Tables 1 and 2 represent the natural properties of each soil unit which provide a limitation to exotic forest growth in the absence of ameliorating management practices. No attempt is made in this report to suggest possible methods of management by which particular limitations might be reduced or overcome.

It should be recognised that suitable management practices (e.g. fertiliser applications) may overcome many of the limitations of some soils but also that chemical soil limitations are likely to prove easier to remedy than physical soil limitations. The latter also vary considerably in terms of the possible management practices necessary to overcome them: thus although high water tables represent a severe limitation, they are not necessarily comparable with severe erosion hazards. It should also be noted that the classification used in this report does not distinguish between soils having different numbers of limitations of a particular severity. The number of limitations of any soil should be considered as well as their severity when overall assessments are being made.

The suitability of the different mapped soils for exotic forestry will in general follow the limitation classification with soils having severe physical or chemical soil limitations being the least suitable. However, there may be some soils for which differences occur as has been noted above. A comparison of the soils in terms of their suitability for exotic forestry is beyond the scope of this report.

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TABLE 1: Physical soil limitations for exotic forest growth in the Greymouth-Hokitika region.

Key: Limiting factors

f = flooding
wt = high water table or soil drainage restriction
p = iron pan in soil or underlying gravels
r = higher rainfall than average
sh = shallow profiles
st = stones or boulders
ur = relatively impenetrable underlying rock

Degree of limitations for each limiting factor

0 = negligible
1 = slight
2 = slight to moderate
3 = moderate
4 = moderate to severe
5 = severe

CLASS	SOIL MAPPING UNITS	PHYSIOGRAPHIC POSITION	LIMITING FACTORS				
			TEXTURAL LIMITATION	TANGIBLE IMPEDIMENTS TO ROOTING	LACK OF MOISTURE	EXCESSIVE MOISTURE	EROSION HAZARD
B Soils with slight physical soil limitations	Karoro soils	Recent dunes	0	0	1	0	1
	Mahinapua soils	Old dunes	0	0	1	0	1
C Soils with slight to moderate physical soil limitations	Rutherglen soils Rutherglen soils, rolling phases	Old marine benches	1	1 (p)	0	2 (wt)	0
	Ikamatua soils	Main post-glacial terraces	0	2 (sh) 1 (st)	0	0	0
	Deadman hill soils	Hill country	0	2 (st)	0	0	1

Table 1 (cont.)

CLASS	SOIL MAPPING UNITS	PHYSIOGRAPHIC POSITION	LIMITING FACTORS				
			TEXTURAL LIMITATION	TANGIBLE IMPEDIMENTS TO ROOTING	LACK OF MOISTURE	EXCESSIVE MOISTURE	EROSION HAZARD
	Arahura hill soils	Hill country	0	2 (sh) 2 (st)	0	0	1
	Runanga soils	Rolling land	2	1 (sh)	0	2 (wt)	1
D Soils with moderate physical soil limitations	Hokitika soils	River flats	0	3 (sh) 1 (st)	1	3 (f)	0
	Harihari soils	River flats	0	3 (sh) 1 (st)	0	3 (f) 3 (wt)	0
	Ahaura soils	Low glacial outwash terraces	0	2 (sh) 3 (st) 1 (p)	0	0	0
	Mitchells soils	Old fans	0	3 (sh) 3 (st)	0	0	0
	Hochstetter soils	Rolling land	0	1 (sh) 3 (st)	0	0	0
	Blue Bottle soils	Rolling land	0	3 (st) 1 (p)	0	2 (wt)	0

Table 1 (cont.)

CLASS	SOIL MAPPING UNITS	PHYSIOGRAPHIC POSITION	LIMITING FACTORS				
			TEXTURAL LIMITATION	TANGIBLE IMPEDIMENTS TO ROOTING	LACK OF MOISTURE	EXCESSIVE MOISTURE	EROSION HAZARD
Soils with moderate physical soil limitations (cont'd)	Arnold hill soils	Hill country	0	1 (sh) 1 (ur)	0	0	3
	Hochstetter hill soils	Hill country	0	1 (sh) 3 (st)	0	0	1
	Stillwater hill soils	Hill country	1	1 (sh)	0	0	3
	Runanga hill soil	Hill country	2	1 (sh)	0	2 (wt)	3
	Blue Bottle hill soils	Hill country	0	2 (sh) 3 (st)	0	2 (wt)	3
	Flagstaff hill soils	Hill country	0	2 (sh) 3 (st) 1 (p) 2 (ur)	0	3 (wt)	1
	Blackwater steepland soils	Steep land	0	1 (sh) 2 (st)	0	0	3

Table 1 (cont.)

CLASS	SOIL MAPPING UNITS	PHYSIOGRAPHIC POSITION	LIMITING FACTORS				
			TEXTURAL LIMITATION	TANGIBLE IMPEDIMENTS TO ROOTING	LACK OF MOISTURE	EXCESSIVE MOISTURE	EROSION HAZARD
Soils with moderate physical soil limitations (cont'd)	Ngahere steepland soils	Steep land	0	1 (sh) 3 (st)	0	0	2
	Cockabulla steepland soils	Steep land	0	1 (sh) 3 (st)	0	2 (wt)	3
	Wakamarama steepland soils	Steep land	0	2 (sh) 3 (st) 2 (ur)	0	0	3
E Soils with moderate to severe physical soil limitations	Kumara soils	Low glacial outwash terraces	3	2 (sh) 3 (p)	0	4 (wt)	0
	Turiwhate soils	Young fans	0	3 (sh) 4 (st)	0	2 (r)	0
	Kamaka soils	Young fans	2	0	0	1 (f) 4 (wt)	0
	Elliot soils	Old fans	0	4 (sh) 4 (p)	0	2 (r)	0

Table 1 (cont.)

CLASS	SOIL MAPPING UNITS	PHYSIOGRAPHIC POSITION	LIMITING FACTORS				
			TEXTURAL LIMITATION	TANGIBLE IMPEDIMENTS TO ROOTING	LACK OF MOISTURE	EXCESSIVE MOISTURE	EROSION HAZARD
Soils with moderate to severe physical soil limitations (cont'd)	Flagstaff soils	Rolling land	0	3 (sh) 3 (st) 2 (p) 3 (ur)	0	4 (wt)	0
	Kaiata hill soils	Hill country	2	0	0	2 (wt)	4
	Atarau steepland soils	Steep land	0	2 (sh) 3 (st) 2 (ur)	0	2 (r)	4
	Ruru steepland soils	Steep land	0	2 (sh) 3 (st) 2 (ur)	0	2 (wt) 2 (r)	4
F Soils with severe physical soil limitations	Karangarua soils	River flats	0	2 (sh) 1 (st)	0	1 (f) 5 (wt)	0
	Maimai soils	Low glacial outwash terraces	0	3 (sh) 3 (st) 1 (p)	0	5 (wt)	0

Table 1 (cont.)

CLASS	SOIL MAPPING UNITS	PHYSIOGRAPHIC POSITION	LIMITING FACTORS				
			TEXTURAL LIMITATION	TANGIBLE IMPEDIMENTS TO ROOTING	LACK OF MOISTURE	EXCESSIVE MOISTURE	EROSION HAZARD
Soils with severe physical soil limitations (contd)	Rotokohu soils	Low glacial outwash terraces	4	0	0	5 (wt)	0
	Okarito soils	Intermediate and high glacial outwash terraces	5	1 (sh) 1 (p)	0	4 (wt)	0
	Okarito soils rolling phases	Intermediate and high glacial outwash terraces	5	1 (sh) 1 (p)	0	3 (wt)	0
	Mawhera soils	Intermediate and high glacial outwash terraces	5	1 (sh) 1 (p)	0	5 (wt)	0
	Mawhera soils rolling phases	Intermediate and high glacial outwash terraces	5	1 (sh) 1 (p)	0	4 (wt)	0
	Kini soils	Intermediate and high glacial outwash terraces	4	0	0	5 (wt)	0
	Serpentine soils	Young fans and old beach ridges	0	3 (sh) 5 (st)	0	3 (wt)	0

Table 1 (cont.)

CLASS	SOIL MAPPING UNITS	PHYSIOGRAPHIC POSITION	LIMITING FACTORS				
			TEXTURAL LIMITATION	TANGIBLE IMPEDIMENTS TO ROOTING	LACK OF MOISTURE	EXCESSIVE MOISTURE	EROSION HAZARD
Soils with severe physical soil limitations (cont'd)	Moana soils	Rolling land	0	4 (sh) 3 (st) 5 (p)	0	1 (wt)	0
	Callaghans steepland soils	Steep land	0	1 (sh) 1 (ur)	0	0	5
	Kokiri steepland soils	Steep land	1	1 (sh) 1 (ur)	0	0	5
	Matiri steepland soils	Steep land	0	2 (sh) 2 (ur)	0	0	5
	Omoto steepland soils	Steep land	2	1 (sh) 1 (ur)	0	1 (wt)	5
	Shamrock steepland soils	Steep land	1	1 (sh) 1 (ur)	0	4 (wt)	5

Table 1 (cont.)

CLASS	SOIL MAPPING UNITS	PHYSIOGRAPHIC POSITION	LIMITING FACTORS				
			TEXTURAL LIMITATION	TANGIBLE IMPEDIMENTS TO ROOTING	LACK OF MOISTURE	EXCESSIVE MOISTURE	EROSION HAZARD
Soils with severe physical soil limitations (cont'd)	Nemona steepland soils	Steep land	0	1 (sh) 3 (st) 1 (p) 1 (ur)	0	4 (wt)	5
	Claddagh steepland soils	Steep land	0	3 (st)	0	2 (r)	5
	Otira steepland soils	Steep land	0	1 (sh) 3 (st) 1 (ur)	0	2 (r)	5

TABLE 2: Chemical soil limitations for exotic forest growth in the Greymouth-Hokitika region.

Degree of limitation for each limiting factor.

0 = negligible
1 = slight
2 = slight to moderate
3 = moderate
4 = moderate to severe
5 = severe

CLASS	SOIL MAPPING UNITS	PHYSIOGRAPHIC POSITION	LIMITING FACTORS			
			NITROGEN	PHOSPHORUS	CATIONS (Mg, K)	TRACE ELEMENTS
A Soils with negligible chemical soil limitations	Hokitika soils	River flats	0	0	0	0
	Harihari soils	River flats	0	0	0	0
	Ikamatua soils	Main post-glacial terrace	0	0	0	0
	Karoro soils	Recent dunes	0	0	0	0
B Soils with slight chemical soil limitations	*Mahinapua soils	Old dunes	0	1	0	0

Table 2 (cont.)

CLASS	SOIL MAPPING UNITS	PHYSIOGRAPHIC POSITION	LIMITING FACTORS			
			NITROGEN	PHOSPHORUS	CATIONS (Mg, K)	TRACE ELEMENTS
C Soils with slight to moderate chemical soil limitations.	Ahaura soils	Low glacial outwash terrace	0	2	0	0
	Mitchell s soils	Old fans	0	2	0	0
D Soils with moderate chemical soil limitations	*Karangarua soils	River flats	2	3	3	0
	Blue Bottle soils	Rolling land	0	3	1	0
	Flagstaff soils	Rolling land	0	3	3	0
	Arnold hill soils	Hill country	0	3	2	0
	Blue Bottle hill soils	Hill country	0	3	1	0

Table 2 (cont.)

CLASS	SOIL MAPPING UNITS	PHYSIOGRAPHIC POSITION	LIMITING FACTORS			
			NITROGEN	PHOSPHORUS	CATIONS (Mg, K)	TRACE ELEMENTS
Soils with moderate chemical soil limitations (cont'd)	Flagstaff hill soils	Hill country	0	3	3	0
	Ngahere steepland soils	Steep land	0	3 (5)	2 (1)	0
	Omoto steep land soils	Steep land	0	3	0	0
	Shamrock steepland soils	Steep land	0	3	0	0
	Nemona steep land soils	Steep land	0	3	1	0
	Claddagh steepland soils	Steep land	0	3	3	0
E Soils with moderate to severe chemical soil limitations	Rutherglen soils	Old marine benches	1	1	4	0

Table 2 (cont.)

CLASS	SOIL MAPPING UNITS	PHYSIOGRAPHIC POSITION	LIMITING FACTORS			
			NITROGEN	PHOSPHORUS	CATIONS (Mg, K)	TRACE ELEMENTS
Soils with moderate to severe chemical soil limitations (cont'd)	*Turiwhate soils	Young fans	0	4	3	0
	Kamaka soils	Young fans	0	4	3	0
	Moana soils	Rolling land	0	4	4	0
	Kaiata hill soils	Hill country	0	4	0	0
	Blackwater steepland soils	Steep land	0	4	2	1
	Wakamarama steepland soils	Steep land	0	4	3	0
F Soils with severe chemical soil limitations	*Maimai soils	Low glacial outwash terrace	0	3	5	2
	Kumara soils	Low glacial outwash terrace	2	4	5	1
	Rotokohu soils	Low glacial outwash terrace	2	5	5	3

Table 2 (cont.)

CLASS	SOIL MAPPING UNIT	PHYSIOGRAPHIC POSITION	LIMITING FACTORS			
			NITROGEN	PHOSPHORUS	CATIONS (Mg, K)	TRACE ELEMENTS
Soils with severe chemical soil limitations (cont'd)	Okarito soils	Intermediate and high glacial outwash terrace	2	5	5	2
	Okarito soils rolling phase	Intermediate and high glacial outwash terrace	2	5	5	2
	Mawhera soils	Intermediate and high glacial outwash terrace	2	5	5	2
	Mawhera soils rolling phase	Intermediate and high glacial outwash terrace	2	5	5	2
	Kini soils	Intermediate and high glacial outwash terrace	2	5	5	3
	*Serpentine soils	Young fans and old beach ridges	0	5	3	0
	Elliot soils	Old fans	0	5	3	0
	Hochstetter soils	Rolling land	0	5	1	0

Table 2 (cont.)

CLASS	SOIL MAPPING UNITS	PHYSIOGRAPHIC POSITION	LIMITING FACTORS			
			NITROGEN	PHOSPHORUS	CATIONS (Mg, K)	TRACE ELEMENTS
Soils with severe chemical soil limitations (cont'd)	Runanga soils	Rolling land	0	5	1	0
	Hochstetter hill soils	Hill country	3	5	1	0
	Deadman hill soils	Hill country	0	5	1	0
	*Stillwater hill soils	Hill country	0	5	1	0
	Runanga hill soils	Hill country	0	5	1	0
	Callaghans steepland soils	Steep land	0	5	1	0
	Cockabulla steepland soils	Steep land	2	5	3	1
	Kokiri steepland soils	Steep land	0	5	0	0

Table 2 (cont.)

CLASS	SOIL MAPPING UNITS	PHYSIOGRAPHIC POSITION	LIMITING FACTORS			
			NITROGEN	PHOSPHORUS	CATIONS (Mg. K)	TRACE ELEMENTS
Soils with severe chemical soil limitations (cont'd)	Matiri steepland soils	Steep land	0	5	1	0
	Atarau steepland soils	Steep land	0	5	1	0
	*Otira steepland soils	Steep land	0	5	3	0
	Ruru steep-land soils	Steep land	3	5	3	0

* soils not sampled for chemical analysis during this survey or that of the Grey Valley (Adams & Mew 1976).