SOME PEDOLOGICAL TRENDS FROM RECENT WEST COAST SOIL SURVEYS AND THEIR RELEVANCE TO FOREST USE

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(Received for publication 4 April 1977)

ABSTRACT

Recent soil surveys connected with plans to utilise West Coast beech forests have covered areas from the Mokihinui River to Hokitika at more detailed scales than were previously available. Seven main soil groups have been recognised; their properties are briefly described. Four major pedological trends have been identified in the region. These are:

1. Increasing incidence of gley soils on low glacial outwash terraces with increasing rainfall.
2. An increase in gleying in hill and steepland soils with higher rainfall, coupled with microtopography and parent material contrasts.
3. Increasing tendency for soil and geological instability with increasing angle and length of slope on certain rock types, possibly coupled with higher rainfall and changes in land use.
4. Contrast in types and down-profile movement of organic matter associated with different forest types, mainly beech/podocarp and podocarp/hardwood forest.

Trend 1 has already been largely recognised in planning for potential use for forestry. Trend 2 is reflected by differential growth in some areas already planted in exotic forest. Trend 3 is of major significance in making wise land use decisions. Trend 4 is of relevance in methods of land preparation and in management of protection forests.

INTRODUCTION

Soil surveys have been carried out during each summer field season on the West Coast between 1972 and 1975. All major areas in which conversion to exotic forests was proposed, between the Mokihinui River north of Westport and the Hokitika and Kokatahi Rivers, have been surveyed at scales of 1 : 63 360 or latterly at 1 : 50 000. Approximately 4000 km^2 have been mapped in the course of these surveys.

Five blocks of country have been covered. These are: 1, Inangahua Depression; 2, Grey Valley; 3, Greymouth-Hokitika Region; 4, Charleston-Punakaiki Region; 5, Mokihinui-Orikaka Region. Locations and boundaries are shown in Fig. 1.

So far the results of the Inangahua Depression survey (Mew *et al.* 1975) have been published and interim reports on the Grey Valley and Greymouth-Hokitika are available (Adams and Mew, 1976a; b). This paper summarises the broad findings in

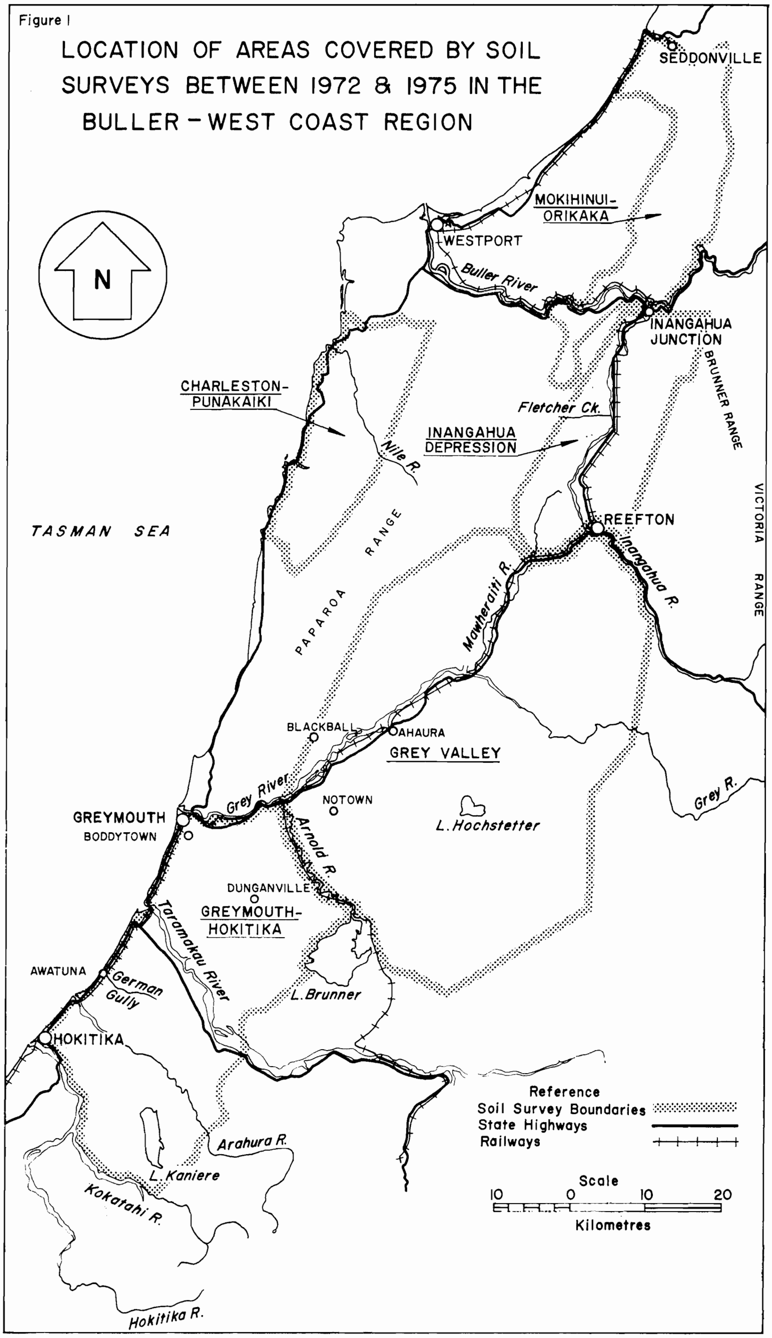
Figure I
LOCATION OF AREAS COVERED BY SOIL SURVEYS BETWEEN 1972 & 1975 IN THE BULLER - WEST COAST REGION
N
SEDDONVILLE
MOKIHINUI-ORIKAKA
WESTPORT
Buller River
INANGAHUA JUNCTION
BRUNNER RANGE
CHARLESTON-PUNAKAIKI
Fletcher Ck.
INANGAHUA DEPRESSION
Nile R.
VICTORIA RANGE
TASMAN SEA
REEFTON
PAPAROA RANGE
Inangahua R.
Mawheraiti R.
BLACKBALL
AHAURA
GREY VALLEY
Grey River
NOTOWN
Grey R.
GREYMOUTH
BODDYTOWN
L. Hochstetter
Arnold R.
DUNGANVILLE
GREYMOUTH-HOKITIKA
Taramakau River
AWATUNA
German Gully
L. Brunner
HOKITIKA
Reference
Soil Survey Boundaries
State Highways
Railways
Arahura R.
L. Kaniere
Kokatahi R.
Scale
10 0 10 20
Kilometres
Hokitika R.

these and the other regions mentioned. It also considers the implications of some of the pedological trends in terms of forest use.

All five blocks were mapped in the course of a reconnaissance survey of the South Island at 1 : 253 440 (New Zealand Soil Bureau, 1968).

SURVEY METHODS AND TYPE OF DATA OBTAINED

Selected ground traverses based on air photo interpretation were made throughout all blocks. Soils were examined in soil profile pits, with soil augers, and at roadside cuttings.

Soil mapping units enclose either areas of essentially uniform soils, intricate mixtures of several soils shown as complexes, or associations.

The team survey technique in which a number of people were involved, was used. In order to facilitate the handling of large quantities of data, a standardised description card was designed with tick boxes which enabled most of the soil descriptive terms to be sorted by computer. A number of natural features such as landform, land use and both past and present vegetation were recorded as well as features directly related to the soil profile. These observations, together with the altitude and rainfall ranges of the mapping units, derived from topographic and isohyet maps respectively, lead to a total environmental picture from which trends can be gauged and on which wise land use decisions can be based.

SOIL GROUPS

The soil pattern over such a wide area is varied and complex when considered at the 1 : 50 000 scale. The 7 main groups that have been recognised are Recent soils, Yellow-brown sands, Yellow-brown earths, Gley soils, Gley podzols, Podzols, and Organic soils.

Recent soils

Recent soils show only slight profile development. In the region as a whole they occur mostly on river flats still subject to flooding. Different series are separated on the basis of parent material changes and drainage differences. A wide range of textures (silt loams to stony sandy loams) and rainfall conditions (2000-5000 mm) are found but because the soils are young, these factors are relatively unimportant.

The nutrient status is not high except for phosphorus in some instances; they are, however, less leached than the other soils of the region.

Yellow-brown sands

These are of comparatively local distribution on the coast between Greymouth and Hokitika; they are also mapped in a small area just south of the mouth of the Mokihinui River north of Westport. They show yellow-brown loamy sand subsoils on weakly weathered dune sands, and are developed under rainfalls between 2500 and 3800 mm. Nutrients are probably comparable with the recent soils but only very limited data are available (Gibbs **et al.**, 1950).

Yellow-brown earths

Yellow-brown earths are widespread throughout the region. This group was most extensively subdivided from the sets used as mapping units at the 1 : 253 440 scale (N.Z. Soil Bureau, 1968). The yellow-brown earths occur on terraces, rolling land, and hill country with associated soils on the steep land in all the mapped areas. Parent material, drainage, and vegetation have been the main criteria for the establishment of new series, many of which are significant in terms of present and potential land use.

The main characteristics of the group are the presence of brown nut-structured topsoils on friable, moderately thick, well-drained yellowish brown subsoils. Relatively undecomposed organic horizons frequently occur over the topsoils; silt loam textures predominate in the mineral layers. The soils are generally strongly leached except in some organic layers and are of very low natural nutrient status. These soils are intermediate in age between the youthful recent soils and the much older podzols and gley podzols.

Gley soils

Gley soils, with permanently high water tables, are found mainly on terraces but extend onto fans, rolling land, hill country and steep land in the south-eastern Grey Valley and inland parts of the Greymouth-Hokitika region where high rainfalls combined with heavy textures, lack of structure and relatively impervious underlying materials prevent through-drainage. In many instances iron accumulation at interfaces or in the underlying material suggests either gleying or podzolisation. The two processes are often closely linked in the region and methods of determining which is predominant are still being investigated.

A wide range of profile morphologies is currently recognised within the soils with high water tables. Basically they are characterised by light grey or grey massive or block-structured G horizons, sometimes mottled, and usually of silt loam texture. Nutrient status is low to very low for all these soils.

Gley podzols

As with the gley soils, many profile forms are currently grouped under this heading, from organic-stained soils with marked iron pans (Addison series) to thick light grey to grey massive, impervious silt loam layers over iron-cemented gravels (Okarito series). These soils are extremely leached and have the lowest nutrient status of any West Coast soils. All occur on terrace remnants generally at intermediate or high levels. In some situations, usually close to terrace edges under still existing forest covers, profiles with similar textures but more olive subsoil colours contain humus or iron pans within the gleyed layers.

Podzols

Podzols, with little or no influence of excessive water in the upper horizons, are of relatively minor extent. These soils, characterised by bleached A_2 horizons over iron pans on brownish yellow subsoils, occur in some places close to intermediate and high level terrace margins and on ridges on the terraces themselves; they are, however, more common on rolling moraine, complexed with freely drained yellow-brown earths. In a few areas they are located on older dunes, fans and hill country. Nutrient status is very low; inorganic phosphorus, iron and aluminium levels are high in the pans.

Organic soils

Only two soil series are recognised in this group; Rotokohu series and Kini series. Both consist of more than 60 cm of organic material on alluvium or glacial outwash gravels, sands or silts. Neither is very widely distributed. The former carries a vegetation cover of flax and/or kahikatea and is thought to be a mesotrophic peat in contrast to the Kini series, with principally sphagnum moss and rushes, which give rise to more acid peat. There is usually also a topographic separation between the two; Rotokohu series occupying low level back swamps behind dunes, and hollows on floodplains and low glacial outwash terraces. The Kini series tends to infill depressions on high glacial outwash terraces.

CHIEF PEDOLOGICAL TRENDS

The 5 soil surveys have been carried out in an area approximately 160 km by 45 km of complex geology, topography, and vegetation types. In addition, climate differs between the coastal belt and the inland valleys and there is a tendency for rainfall to increase to the south as well as towards the main mountain ranges. The time required for soil formation is a further variable. With the size of the area now covered some trends related to these factors have become evident; they are usually a result of interactions of several soil-forming factors some of which are not yet fully understood. The 4 trends discussed below increase in intensity towards the southern parts of the region.

Trend 1: Increasing incidence of gley soils on low glacial outwash terraces with increasing rainfall

This trend is illustrated particularly well in the Grey Valley on glacial outwash terraces of the Loopline formation of similar height and parent materials, and of Otiran age. Just north of Ahaura (Fig. 1), under a rainfall of about 1900 mm (N.Z. Meteorological Service, pers. comm.) the predominant terrace soil is a yellow-brown earth of the Ahaura series, a freely drained silt loam or fine sandy loam overlying gravels at 40 to 60 cm. Twenty kilometres to the south-west the terraces of the Arnold River are largely covered by imperfectly to poorly drained gley soils of the Maimai series. These are of similar depth to the Ahaura series but have greyish brown to bluish grey mottled G horizons, generally waterlogged. The rainfall in this area is about 2800 mm. Between the two extremes there is a gradual change in the proportions of each soil type on terraces of similar height. A third, transitional soil also occurs.

To the north of the Grey River (true right bank) the transition occurs in the vicinity of Moonlight Creek probably due to higher rainfall from the proximity of the Paparoa Range; Blackball, 7 km to the south-west, records an average annual rainfall of 3435 mm. The pattern is also borne out on the Loopline terraces of the Taramakau and Arahura Rivers of the Greymouth-Hokitika region where the rainfall is everywhere greater than 2500 mm and the predominant soils belong to the Maimai series.

In the two regions further up the coast to the north, the Charleston-Punakaiki region and the Mokihinui-Orikaka region, similar soils also predominate although they tend to be more podzolised, frequently containing iron pans in the subsoil. They are distinguished for these reasons as the Addison series. Rainfall is once again greater than 2500 mm except for a narrow strip along the coast south of Westport where it is between 2000 and 2500 mm.

TABLE 1—Site characteristics for terrace soils in Grey Valley with rainfall as main variable

Location	Soil Group	Soil Series	Rainfall	Drainage	Vegetation: Past	Vegetation: Present
North of Ahaura	Yellow-brown earth	Ahaura	1900 mm	Freely drained	Red & silver beech forest with scattered rimu and kahikatea	Mainly pasture
20 km south-west of Ahaura near Arnold River	Gley	Maimai	2800 mm	Imperfectly to poorly drained	Rimu, mountain beech, some silver beech	Pakihi vegetation, some pasture

In the Inangahua Depression Maimai soils also occur (Mew, *et al.,* 1975), in some places under rainfalls lower than 2000 mm. However, in these situations, topography becomes the dominant factor as the soils are located in back swamps away from terrace margins and at the foot of hills and terrace scarps where water concentrates.

This trend is reflected in a marked change in vegetation types. The freely drained terraces formerly carried red and silver beech forest with scattered rimu and kahikatea; some remnants of this forest still exist but the land is mainly used for pastoral farming, the soils being some of the best suited for this use in the region. By contrast the poorly drained terraces carried rimu with mountain and some silver beech; when cleared these became covered in an association of manuka, umbrella fern, and wire rush (pakihi vegetation) for which development methods are only now showing initial signs of success.

Trend 2: An increase in gleying in hill and steepland soils with higher rainfall, coupled with microtopography and parent material contrasts

Hill and steepland soils under a 2000 mm rainfall in the Inangahua Depression are predominantly yellow-brown earths or steepland soils associated with yellow-brown earths on moderately permeable parent materials such as Old Man Gravels or less permeable muddy sandstones. Slight gleying may be present in accumulation situations at the foot of slopes. This pattern continues south-westwards down the central part of the Grey Valley but in the steep lowland country due south of Ahaura under about 2500 mm rainfall, weakly gleyed steepland soils related to lowland yellow-brown earths (Cockabulla steepland soils from Old Man Gravels) start to appear at all levels on the slope. There is some correlation with concave positions and the soils are complexed with freely drained equivalents. In the Mount Riley area of Omoto State Forest north-east of Dunganville near Greymouth where the rainfall is higher, Cockabulla steepland soils predominate in all positions, spurs, ridge crests and gullies, on the upper slopes over the part of the area underlain principally by Old Man Gravels.

Two other instances of this trend may be cited. The first concerns hill and steepland soils on Tertiary siltstones of the Blue Bottom formation under rainfalls between 2500 mm and 3800 mm in the Greymouth-Hokitika region. The soils are shown in Table 2.

TABLE 2—Relationship between topography, drainage, soil group and soil series in the Greymouth-Hokitika region

	Well drained; yellow-brown earths and steepland soils associated with them	Imperfectly drained; gleyed or strongly gleyed yellow-brown earths and steepland soils associated with them
Hill country	STILLWATER HILL SOILS	RUNANGA HILL SOILS
Steep land	KOKIRI STEEPLAND SOILS	SHAMROCK STEEPLAND SOILS

In the weakly to moderately dissected hill country south of Greymouth around Boddytown, Stillwater hill soils and Runanga hill soils occur in complexes, but where the slopes steepen in the more dissected blocks of Waimea State Forest east of Awatuna and drainage might be expected to improve, the two steepland equivalents, Kokiri steepland soils and Shamrock steepland soils, both occur. However, Shamrock soils tend to be associated with gullies, so there is some expression of the topographic factor, in contrast to the Runanga/Stillwater complexes where either soil may occur in any slope position. There is no evidence of a rainfall increase between the two areas, and in this case the gleying is thought to result from a combination of impermeable underlying siltstone and heavy subsoil textures (silty clay loam or clay loam) together with topographic and microtopographic variation in the steepland soils, as not all Shamrock steepland soils occur in gullies.

The second instance is that of steepland soils derived from Tertiary fine sandstones in the Charleston-Punakaiki region under rainfalls between 2500 and 3800 mm. Comparatively short, steep, strongly dissected slopes occur in many places, and carry a complex of well-drained steepland soils associated with yellow-brown earths (Matiri steepland soils) and imperfectly-drained steepland soils associated with strongly gleyed yellow-brown earths (Henniker steepland soils). These soils are well represented in the vicinity of the Nile River road south of Charleston. The two soils occur together in an irregular pattern, the reasons for which are not at present fully understood, although microtopography plays some part. Henniker soils, however, occur on spur crests, spur sides, gullies and from the top to the bottom of slopes. Textures are generally silt loams as for Matiri soils, and parent materials are identical. Other examples of complexes of gleyed and non-gleyed steepland soils occur in this region where texture and topographic variation are recognised as playing prominent roles in influencing soil properties.

Trend 3: Increasing tendency for soil and geological instability with increasing angle and length of slope on certain rock types, possibly coupled with higher rainfall and changes in land use

The Grey Valley may be taken as an example of an area where there is evidence of this trend in the strongly dissected lowland country away from the main ranges. At the head of the valley between the Mawheraiti River and Reefton lies a block of hill country with Blackball hill soils, yellow-brown earths underlain by the Old Man Gravels formation, known locally as the Maimai block. The rainfall is close to 2000 mm. Most slopes are in the 25° to 30° range with a few up to 40° (short steep slopes into gullies) or as low as 5° (ridge crests); lengths have not been measured but it is possible to get an approximate relative idea for different hill blocks by considering the height separation between a base level such as the Mawheraiti or Grey Rivers and the general level of the ridge crests over a standard distance. The separation east of the Mawheraiti River is about 185 m. Little erosion is present under undisturbed beech/podocarp forest in this area other than on exceptionally steep slopes or where the hills have been undercut by rivers. By contrast, slight to moderate soil slip and moderate gully erosion is present in the Mount Fox-Mount Riley region of Omoto State Forest north-east of Dunganville. Here the soils are Cockabulla steepland soils (steepland soils associated with weakly gleyed yellow-brown earths), also from Old Man Gravels. Rainfall is between 2500 mm and 3800 mm. Predominant slopes range from 32° to 40°; the height separation in the Mount Riley-Dunville area is about 245 m which implies moderately long steep slopes. Clearance of forest within the last five years has allowed rainfall to reach the ground surface directly rather than through tree interception and has apparently markedly increased already existing erosion (O'Loughlin and Gage, 1975), although this requires further study. Increased steepness and lengths of slopes relative to those of the Maimai block, coupled with heavier rainfall, appear to play a significant part in the greater amount of actual erosion present.

A further example where a change in land use has affected the amount of erosion present on slopes steeper than in another less disturbed area with similar parent material is the Notown block, lower Grey Valley, which can be contrasted with the northern end of the Inangahua Depression. Both areas are underlain by Tertiary muddy sandstones, with siltstone and mudstone bands.

The hill country immediately to the south-east of Inangahua Junction has most slopes about 25° and 28°; altitudinal variation over a measured distance between creek and hill top is about 150 m showing that slopes are not particularly long. The vegetation is hard beech forest. Some natural soil slip erosion is present resulting from the 1968 Inangahua earthquake. To the west of Notown slopes range from 25° to 40° and average 32° (O'Loughlin and Gage, 1975); the height difference over the same distance as above is 210 m, indicating rather longer slopes. Logging started in the area in 1955 and continued until 1971; some parts were left up to 10 years between clearing and planting in exotic species and it is these that show the greatest incidence of soil slip erosion which has resulted in the loss of 1.3% of the total ground surface (O'Loughlin and Gage, 1975). The former forest cover was of podocarp/hardwood forest. Rainfall at Inangahua Junction is about 2500 mm per year and is similar at Greymouth, the nearest station to Notown with long-term records. It is thought that storm conditions coupled with the long period between clearing and planting on erosion-susceptible soils and parent materials were mainly responsible for the extensive slipping at Notown. Again, increased steepness and lengths of slopes coupled with heavier rainfall relative to the Maimai block, appear to play a significant part in the greater amount of actual erosion present.

Trend 4: Contrast in types and down-profile movement of organic matter associated with different forest types, mainly beech/podocarp and podocarp/hardwood forest

The boundary between forest where beech is a prominent species and where it is absent occurs in the lower Grey Valley between the Ahaura and Arnold Rivers. Previous soil surveyors (N.Z. Soil Bureau, 1968) have recognised the change in forest type by distinguishing Blackball hill soils from Arahura hill soils at the 1 : 253 440 scale. Subsequent surveys as reported on in the present paper have also shown that there are reasons for maintaining the separation and have produced general evidence in support of it. There are three main contrasts:

(1) *Thickness of organic matter accumulations*

There is a strong tendency for greater organic matter accumulation under podocarp/ hardwood forest. Measurements made in the course of the Grey Valley survey included the L, F and H layers in a single organic horizon designated 0. For 8 sites on Mahoneys steepland soils (steepland soils related to yellow-brown earths) under beech/podocarp forest and from Old Man Gravels, the average thickness of accumulated organic matter is 10 cm. The equivalent soil under podocarp/hardwood forest is Blackwater steepland soil, 12 profiles of which had an average accumulation of 28 cm of organic matter over the mineral horizons.

(2) *Kind of organic matter*

Different kinds of organic matter build up under the various forest types. Although there are at present no quantitative studies on the contrasting properties of the kinds of organic matter in the West Coast region, general observations suggest that under beech/podocarp and podocarp/hardwood forest the litters have similar physical properties, but that the fermentation layers (F) and humus layers (H) differ. Under podocarp/hardwood forest they tend to be wetter and have a more greasy feel and a less granular appearance than the F and H layers under beech/podocarp forest. Under beech the F and H layers tend to sometimes dry out, especially on north-facing, well drained sites, but this is not the case under podocarp/hardwood forest.

(3) *Mobility of organic matter*

Evidence from the recent surveys shows that there are more and thicker humus cutans, principally in the B horizons of yellow-brown earth and gleyed yellow-brown earth hill soils and associated steepland soils, under podocarp/hardwood forest than under beech/podocarp. Also, there is a tendency for humus to build up at the B/C interface under podocarp/hardwood, especially if the underlying material is relatively impermeable, such as the massive Tertiary siltstone underlying Shamrock steepland soils. Humus accumulations do occur at B/C interfaces in soils under beech forest but are less common and not so well developed.

RELEVANCE OF TRENDS TO FOREST USE

The planned land uses in the West Coast Beech Project area include conversion to exotic forests, beech or podocarp management, farming or reservation as ecological reserves, amenity reserves and protection forest. Recent Soil Bureau surveys have concentrated on the areas considered by the New Zealand Forest Service as having potential for exotic conversion, or beech or podocarp management within these areas; no up-to-date work has yet been carried out to the east of the Brunner and Victoria Ranges where beech management only is proposed, or in the long finger valleys which penetrate the Paparoa and other ranges.

The relevance of the trends described in the previous section to the uses proposed is here considered in terms of their influence on the suitability or otherwise for conversion or management.

Trend 1: Increasing incidence of gley soils on low glacial outwash terraces with increasing rainfall

This trend is largely recognised in both forest typing (N.Z. Forest Service, unpubl. data) and in planning. Most of the well-drained terraces are outside State Forests and are used for pastoral farming, except in the Fletcher Creek/Stony Creek area of the Inangahua Depression. Here part of the terrace system is proposed for exotic conversion (for which it appears suitable apart from a moderate limitation due to stoniness) and part for ecological reserve to protect some of the last remaining stands of large red and silver beech with occasional rimu and kahikatea. However, in the Bell Hill locality east of the Arnold River in the Lower Grey Valley, two areas proposed for farming reflect the trend by having a cover of poorly drained Maimai soils. One of these (the easternmost) has now become a Lands and Survey development block (G.P.S. Allan, pers. comm.) and the other is expected to follow suit at a later date. The Department of Lands and Survey already have large holdings in this area and are experimenting with methods of developing land under pakihi vegetation. The soils have severe limitations to farming and forestry because of high natural water tables, comparatively shallow, stony profiles and low natural fertility.

Trend 2: Increase in gleying in hill and steepland soils with higher rainfall

This trend is of greater significance than the previous one as it applies to many of the hill and steepland blocks proposed for conversion to exotic forestry on sites with rainfalls more than about 2500 mm.

Where exotic plantings have already been carried out, for example around German Gully in Waimea State Forest, tree growth reflects the complex pattern of well drained Kokiri steepland soils and imperfectly drained Shamrock steepland soils, with trees having less height and diameter on the wetter sites. The differences do not appear to be related to other factors such as nutrient levels or poor stock at planting (G.P.S. Allan, pers. comm.). If this differential growth persists then overall productivity might be expected to be less than that for trees on well drained sites. Soils with impeded drainage proposed for exotic conversion occur in the Mokihinui-Orikaka region, the Charleston-Punakaiki region, the Grey Valley, and the country between Greymouth and Hokitika; they are shown on the 1 : 50 000 maps of these areas and must be taken into account in any refined planning for forest use.

Trend 3: Increasing instability with increasing angle and length of slope on certain rock types

The third trend is also important in considering the use to be made of forested land under the beech scheme. The 1 : 50 000 soil surveys have highlighted areas where soil and geological instability are likely to be problems if the total forest cover is removed. The measurements and causes of such instability have been described by O'Loughlin and Gage (1975) in their detailed studies on selected areas. They concluded that in the Notown study area clear felling was unacceptable due to the large amount of subsequent landsliding. Some form of forest management for sustained yield may be acceptable in such areas which are still forest-covered but experiments will have to be carried out to determine the best type of land use. Techniques for measuring and evaluating actual erosion under present forest cover and for analysing the complex factors which influence landsliding are being assessed by collaboration between Soil Bureau and Forest Research Institute.

Trend 4: Contrast in types and down-profile movement of organic matter associated with different forest types, mainly beech/podocarp and podocarp/hardwood forest

This trend, the contrast in kinds of organic matter associated with beech/podocarp and podocarp/hardwood forest, does not appear to affect the potential exotic conversion areas to any great extent except that in podocarp/hardwood areas where organic matter thicknesses tend to be greater, planting of pines in mineral soil may be somewhat impeded. This would apply especially if burning ceased to be a common practice in land preparation.

However, the trend does appear to be important in:

(1) **The field of beech management.** Beech seems to regenerate best on a mineral soil surface. Techniques such as scarifying may have to be used in beech management areas to ensure adequate regeneration. Some disturbance may also help podocarp regeneration.

(2) **Reservation for ecological studies.** As the natural boundary between the two forest types lies in the southern part of the Project Area where much disturbance has already

taken place, it is important that some of the remaining areas where the change can still be seen should be reserved for study.

(3) **The protection forests.** Destruction of the ground cover and disturbance of the organic layer (which normally protects the soil surface) by noxious animals is widely accepted as one of the major factors in upland and high country erosion. However, no work appears to have been done in comparing the effects of variation in thickness and kind of organic matter under the different forest types. The data obtained from the current surveys on soils of the mountain ranges are insufficient to show significant trends in this field.

CONCLUSIONS

Seven soil groups of decreasing natural nutrient status from Recent soils to Gley Podzols have been recognised over an area of approximately 4000 km^2, surveyed at scales of 1 : 63 360 and 1 : 50 000. Four major pedological trends, three of them probably coupled with increasing rainfall, have been identified. Two trends relate to a greater incidence of gleyed soils proceeding in a southerly direction, one of them links increasing length and angle of slope with soil instability, and the fourth contrasts types of organic matter under different vegetation covers. These trends are of varying importance when potential uses for forestry are considered. Recognition of areas where stability would be threatened by a major change in land use is of major importance. Terraces with potential drainage problems have been largely excluded at the planning stage, but retarded growth of exotics is already evident in some hill country and steepland situations where gleyed soils occur. The distribution of organic matter layers of different thicknesses and kinds may become significant if burning ceases to be used in preparing land for planting exotic trees. It also partly affects the severity of erosion on steep mountain slopes.

REFERENCES

ADAMS, J. A. and MEW, G. 1976a: Interim report on the limitations for exotic forestry of the soils of the Grey Valley, South Island, New Zealand. **N.Z. Soil Bureau Record 47.**

——— 1976b: Interim report on the limitations for exotic forestry of the soils of the Greymouth-Hokitika Region, South Island, New Zealand. **N.Z. Soil Bureau Record 49.**

GIBBS, H. S., MERCER, A. D. and COLLIE, T. W. 1950: Soils and agriculture of Westland, New Zealand. **N.Z. Soil Bureau Bulletin 2.** 24pp.

MEW, G., WEBB, T. H., ROSS, C. W. and ADAMS, J. A. 1975: Soils of the Inangahua Depression, South Island, New Zealand. **N.Z. Soil Survey Report 17.**

NEW ZEALAND SOIL BUREAU. 1968: General survey of the soils of the South Island, New Zealand. **N.Z. Soil Bureau Bulletin 27.** 404pp.

O'LOUGHLIN, C. and GAGE, M. 1975: A report on the status of slope erosion on selected steep areas, West Coast Beech Project area. **N.Z. For. Serv., For. Res. Inst.,** unpubl.