SOIL IN RELATION TO FOREST TYPE IN BEECH FORESTS IN THE INANGAHUA DEPRESSION, WEST COAST, SOUTH ISLAND

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SUMMARY: The relationship between soil pattern and forest cover in the Inangahua Depression, West Coast, is examined and discussed. The relative effects of five soil forming factors, topography, parent material, climate, time and organisms are considered. The first four factors may be placed in a sequence of decreasing importance from climate through time and topography to parent material.

The soil pattern, predominantly yellow-brown earths, and the present distribution of vegetation are given, and the interactions between soil and vegetation discussed. A separate section attempts to describe the history of soil development and forest colonisation in the light of published evidence and the results of recent soil and forest surveys.

Conclusions are threefold. First, the beech and podocarp forest type that predominates in the Depression has enhanced the development of the major soil groups of the area. Second, there is a direct relationship between the pattern of forest types and soils over only about half the area considered. Third, a straightforward developmental sequence can be established to explain the present distribution of soils and vegetation without necessarily invoking recent climatic change.

INTRODUCTION

There has been considerable discussion in New Zealand on the role soils play in determining the composition and distribution of beech forests and on the effects these forests have had on soils.

General mention of soils in the beech forest ecosystem is made in the early work of Cockayne (1926) but apart from the observation that all beech forests tend to occur on poorer soils, little emphasis is put on this factor. Holloway (1954) also considers the soil to be of only limited significance in his major work on the Southland forests, climatic change being the main contributor to the distribution of different forest types. From a pedological standpoint Molloy and Cox (1965) considered that the role of beech forest cover, combined with topography, has been highly significant in contributing to the present soil pattern in a sequence in the east of the South Island. In a further paper Cowie (1965) also contends that, on a North Island site under black beech *(Nothofagus solandri* var. *solandri)*, it is the vegetation which leads to strong leaching in an area where climate, topography and parent material appear to be no different from adjacent sites which were formerly under podocarp/broadleaf forest.

Little work has been carried out in New Zealand on the nutrient status of beech ecosystems. However studies on a hard beech *(N. truncata)* site in the Hutt Valley (Miller & Hurst, 1957; Miller 1963a, b, c, 1968; Miller & Dutch, 1971) give some indications of the nutrient levels necessary for satisfactory growth of hard and red beech (*N. fusca*). Other work currently being carried out on this site involves studies of litter breakdown, micropedology, hydrology and leachates. Studies on the chemistry of soils under beech and other vegetation types have been made in the South Island by Campbell (1974) and Tan (1971).

As pointed out by Holloway (1954), much research remains to be done on the whole ecology of beech forests. The main object of this paper is to investigate the relationship between the forest cover and the soil pattern in the Inangahua Depression, a tectonically controlled valley approximately 30 km long, between Inangahua Junction and Reefton, bounded by the Paparoa and Victoria Ranges (Fig. 1). Data was gathered during the course of a soil survey (Mew, Webb, Ross and Adams, 1975) which was concentrated on the hill and terrace country, with less emphasis on the river flats and marginal steeplands. Previous work on the soils of the district

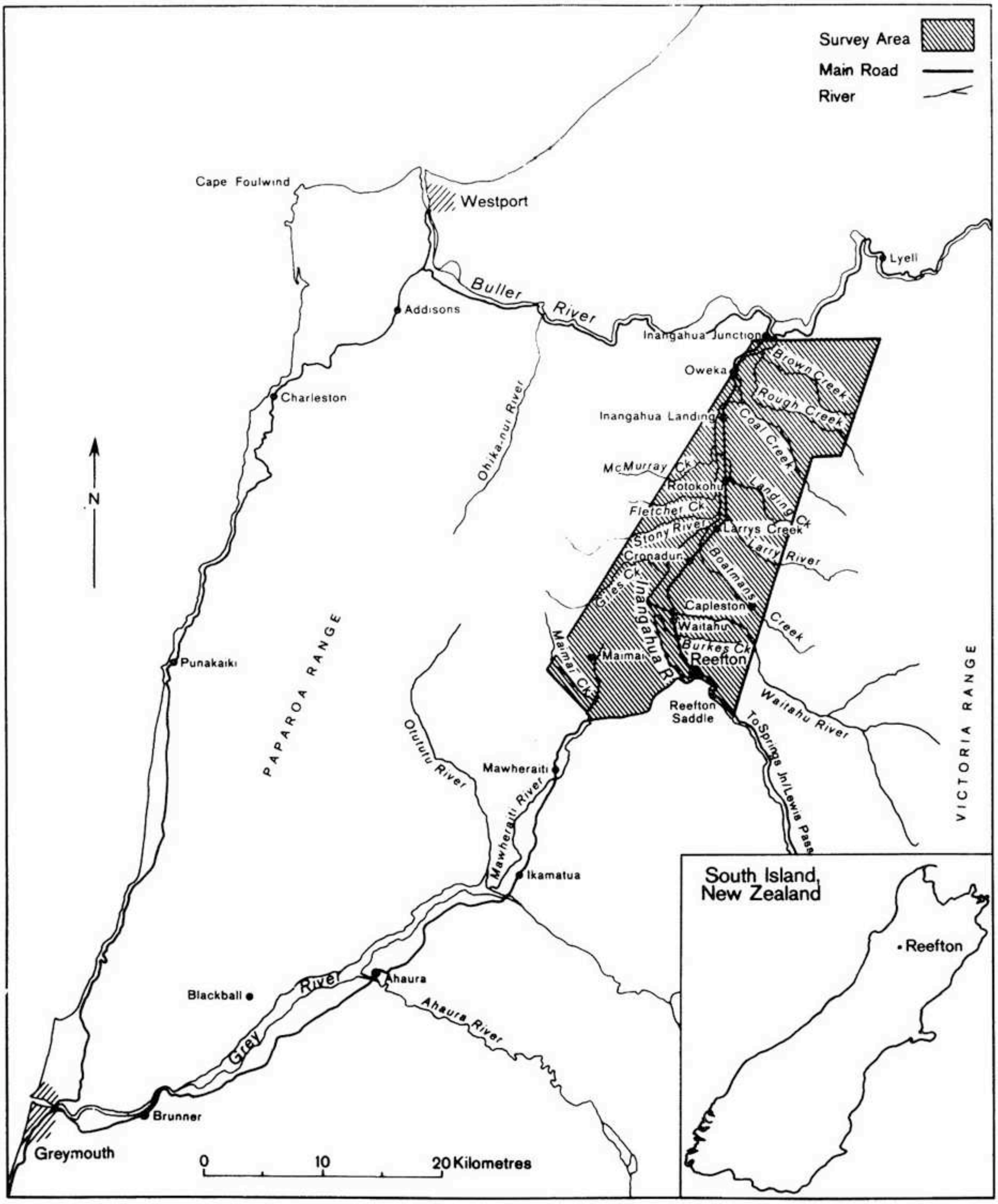

FIGURE 1. *Location of Survey Area.*

includes reconnaissance mapping at a scale of 1:253 440 (N.Z. Soil Bureau, 1968a) and the coverage of a small area at a scale of 1:63 360 by Kear (1965).

The forests under discussion are beech forests *sensu lato*. Red, hard, silver beech *(N. menziesii)*, and mountain beech *(N. solandri* var. *cliffortioides)* usually form the principal components, but are commonly mixed with other tree species in this area. More detailed descriptions of forest types are given later.

SOIL FORMING FACTORS

Soil formation is related to a number of environmental factors. These have been defined by Jenny (1941) as topography, parent material, climate, time and organisms. The latter includes vegetation, the soil fauna and the activities of man. The five factors will be considered as an aid to understanding the relative distributions of soils and forest types.

Topography

The proportions of different landforms in the mapped area of the Inangahua Depression are approximately as follows: terraces, including the river flats, 45.5%; hill country, 36.5%; and steeplands, 18%. Narrow floodplains border the Inangahua River and its tributaries. These are flanked by low terraces now out of the reach of flooding. Residual low, intermediate and high glacial outwash terraces occur in scattered blocks separated by dissected hill country. Steeplands border the Depression on both sides.

In the comparatively small areas of poorly drained flat terraces the topographic factor contributed to the present soil pattern by helping to prevent the free flow of water away from these situations, but other factors such as climate and time are more important in the development of the sequence of soils on the terraces as a whole. Where other factors can be seen to be constant, for example over short distances with uniform climate on moderately steep hill slopes cut into Upper Wanganui series conglomerates (Old Man Gravels) with a cover principally of hard beech, the main effect of topography is to cause lateral movement within solum material which prevents podzolisation and gleying. On the steeplands, especially where underlain by weathered granitic material, buried profiles are evidence of considerable periodic downslope movement.

Parent Material

The range of parent materials found in the area includes recent river alluvium, outwash gravels, sands and silts with some loess, Upper Wanganui series conglomerates and Tertiary sedimentary rocks, Pre-Cambrian indurated sandstones, and granite. Both the alluvium and the glacial outwash material have a mineral content derived from mixtures of the main rock types. Loess is probably only present in patches on the intermediate and high level surfaces. The Old Man Gravels, which are deeply weathered, form the hills in the southern two-thirds of the Depression. The remaining hills are mostly Tertiary muddy sandstones and siltstones with some limestone and coal measures. Indurated sandstone forms a strip of steepland along the eastern side of the Depression. The western steeplands are mainly granite.

Parent material does not affect soil formation to a major degree, as it is overshadowed by factors such as climate. This is shown by the overall similarity of many of the profiles developed on different parent materials under similar climate, vegetation, topography and a similar time scale, for example the yellow-brown earth hill soils described in the next section. Two instances may be cited where parent material is of local importance. Some loess is present on intermediate and high level outwash surfaces. The almost impervious nature of this material (Young, 1967) contributes to the waterlogging of the Okarito series soils on it and it is postulated that this loess has been an important factor in the development of the gley podzols to which the Okarito series belongs. The second instance is also taken from the terrace sequence. A small patch of intermediate level terrace west of the Inangahua River carries a freely-drained yellowish-red soil, classed as a yellow-brown earth and named the McMurray series. Nearby high terraces all carry gley podzols. The colour matches closely with that of the matrix of the Hawks Crag Breccia, a mid-Mezozoic formation that outcrops in the steeplands west of the Depression, and it is presumed that the outwash gravels and hence the soil are derived from this rock type.

Climate

In common with most parts of New Zealand, Westland is broadly characterised by soils which reflect the regional climate. At the Reefton Climatological Station the average annual rainfall is 1919 mm, with precipitation on 186 days per year. The rainfall figure is typical for most of the floor of the Depression but rises with altitude to approximately 3800 mm at the upper limits to which the soil survey extended. The area is on the fringe of the wettest region in New Zealand, and falls within the superhumid mesothermal 1 climate class (N.Z. Soil Bureau, 1968b). It seems probable that comparable rainfall has occurred in the past, although temperatures may have varied considerably (Rigg 1951; Holloway 1954). The main effect of rainfall of this magnitude is the rapid leaching of soluble elements and compounds through the soils almost regardless of the nature of the parent material (Mew *et al*, 1975).

Time

In order to determine the rate of soil formation for the oldest soils in the Depression it is necessary to attempt to establish a datum plane for the start of this process. The maximum age of soils in the Depression will have been governed by the extent to which glacial stripping of the former soil cover took place, or the burying of it by glacial outwash deposits. Assuming that all the pre-glacial soil cover was removed, the most stable sites where soil development is likely to have gone on since, almost without interruption, are the high level terraces, which are thought to have resulted from redistribution of glacial till by meltwaters during ice retreat after its maximum advance in the Piedmont Glaciation (Suggate 1957). Subsequent work by Suggate (1965) includes the Piedmont Glaciation deposits within the Waimaungan Stage, and correlation with the palaeoclimate chronology of Mesolella *et al*, (1969) indicates an approximate age of 230 000 to 300 000 years B.P. for this stage. Soil formation almost certainly began at this time, but may have been interrupted by further glacial fluctuations and the course of development changed by the addition of windblown loess (Young, 1967) and different types of vegetation cover. Thus continuous development leading to the soil group manifest today may only date from the period of loess accumulation, the fine material probably being derived from the low terraces discussed next.

An intermediate date for the start of soil formation on the low glacial outwash terraces (Speargrass Formation) is approximately 20 000 years, by correlation with the Loopline Formation of the lower Grey Valley, which has been radiocarbon-dated (Gage & Suggate 1958). Recent work near Inangahua (Nathan & Moar 1973) has produced a radiocarbon date of 20 200 ± 300 years B.P. from the Speargrass Formation.

On the dissected hill country and steeplands, soils may be subject to rejuvenation by soil creep, but would not necessarily be completely removed in the event of a localised glacial advance. Thus although they can be superficially grouped with soils on Speargrass Formation terraces on the basis of comparable appearance and apparent degree of development, this correlation in terms of time for formation is by no means certain. This bears on the development and distribution of the forest types and will be referred to again.

Thus from a consideration of the four factors discussed above, their relative effects on soil formation may be arranged in a sequence of decreasing importance from climate through time and topography to parent material.

THE SOIL PATTERN

The soil pattern of the Inangahua Depression is characterised mainly by yellow-brown earths on low glacial outwash and post-glacial terraces, as well as on the dissected hill country; steepland soils associated with yellow-brown earths occur on steep terrain. Recent soils occur on the river flats, and gley soils are found in poorly drained locations on the low terraces. Gley podzols occur on the flat surfaces of intermediate and high terraces, with organic soils in small hollows and podzols on terrace edges. Each of these soil groups has distinctive physical and, in most cases, chemical properties which have been summarised in detail by Mew *et al*, (1975), and which may be outlined as follows:

Recent soils

These are represented by the Hokitika and Harihari series which have only weak profile development and are still subject to flooding. Textures are very variable but are predominantly sandy. The two series are separated mainly on the basis of drainage, the Harihari series being more poorly drained and showing iron mottling in the profile. Both series have low levels of plant nutrients except for a high phosphorus content: they are, however, less leached than any of the other soils in the Depression.

Yellow-brown earths

The yellow-brown earths of the Depression are grouped within six series; three on terraces (Ikamatua, Ahaura and McMurray), and three on hill country (Blackball, Inangahua and Capleston hill soils). Broad characteristics of the group are dark brown well-structured topsoils over friable, comparatively thick free-draining yellowish brown subsoils. Silt loam textures predominate. Soil chemical analyses show that these soils are strongly leached and are of very low natural fertility, especially the hill soils. Most of the available nutrients are concentrated in the organic layers. Of the terrace soils, the Ikamatua series, which is on the main post-glacial terrace, is slightly higher in phosphorus than the others.

Gley soils

The Maimai series, occuring on low glacial outwash terrace remnants, is classified as a gley soil on the basis of its permanently high water table. Profiles tend to have dark greyish brown silt loam topsoils over light brownish or olive grey silt loam subsoils. The underlying sandy gravels generally occur within about 40 cm of the ground surface. Stones within the profile frequently have iron-rich weathering skins.

Chemical properties are unknown in the Inangahua Depression but subsequent analyses from the Grey Valley (unpublished) show nutrient levels to be similar to those in Ahaura soils, with less iron movement down the profile.

Gley podzols

The Okarito series represents this group, which is considered to be more closely allied to gley soils in terms of present-day profile morphology than to the podzols, as a result of the field work on which this paper is based. Soils of the Okarito series have brown, possibly peaty, silt loam topsoils over massive structureless light brownish grey or grey silt loam layers, sometimes mottled. A brown to dark brown humus-enriched horizon may occur at the interface between the soil and the underlying iron-cemented gravels. Profiles are usually about 70 cm thick. Nutrient levels are all very low, as is phosphorus retention. Both iron and aluminium levels are also very low.

Podzols

The Waiuta series soils are classed as podzols. They have dark greyish brown fine sandy loam or silt loam topsoils over light grey A_2 horizons of similar texture, on thin iron pans. Beneath these the subsoil is usually brownish yellow and overlies gravels at about 60 cm. These soils are also highly leached. Percentage base saturation is low in A_1 horizons and very low beneath. Phosphorus, iron and aluminium are very low until the pans are reached and then become high to very high.

Organic soils

Organic soils are represented by two series, the Rotokohu series occurring in small patches on the low glacial outwash terraces and the Kini series mainly on high terraces. They both consist of more than 60 cm of dark brown or dark greyish brown decomposed organic matter overlaying gravels or silts at greatly varying depths. The Rotokohu series carries a vegetation cover of flax and/or kahikatea, and is thought to be a mesotrophic peat, in contrast to the sphagnum-covered Kini series, which is probably oligotrophic, although no sampling has been carried out to confirm this.

Steepland soils associated with yellow-brown earths

The following soil series fall within this category: Matiri, Punakaiki, Kaniere and Wakamarama steepland soils. Profiles generally appear similar to those of the yellow-brown earths in stable situations, but soils may be deeper, with buried A horizons; they may lack A horizons themselves, and surface stones may be common. No chemical analyses of the latter three soil series mentioned above are available from the study area, but that of the Matiri steepland soil indicates strong leaching and low nutrient levels similar to the yellow-brown earth hill soils.

THE PRESENT VEGETATION PATTERN

Before European settlement and the subsequent bush clearance for farming and timber production, the forest cover of the Inangahua Depression was almost total. Now unaltered forest is mostly confined to the hilly and steep land. Some virgin forest, and also partially logged or regenerated patches remain on the terrace country, from the river flats to the high level glacial outwash terraces. Most of the remainder of the low terraces is in pasture. Some areas now carrying manuka *(Leptospermum spp.)*, umbrella fern *(Gleichenia circinata)*, and rushes *(Juncus spp.)*, as the main plant species were found to be unsuitable for farming because of their high water table, poor drainage and infertility. These areas are mainly on intermediate and high level terraces locally referred to as "pakihi", a Maori word meaning a clearing in the forest. However it is doubtful if many of the Inangahua areas were natural clearings in the original forest.

The forest pattern in the Depression has been mapped in the course of inventory surveys by the New Zealand Forest Service (unpublished data). Forest types are coded by a letter and number system where "P" stands for podocarps, "B" for beech; these are used in conjunction with a series of numbers, each of which uniquely determines the type in question, (Table 1).

(a) *Terraces*

The main forest types now found in freely drained situations on surfaces below the intermediate level glacial outwash terrace are PB1 and B2. In the former, large well-formed trees, predominantly red beech with rimu and kahikatea *(Podocarpus dacrydioides)* occur, with silver beech as a subdominant species. B2 forest is composed principally

TABLE 1. *Relationship between topography, forest types and soils in the Inangahua Depression.*

TOPOGRAPHY	*FOREST TYPES*	*SOILS*
RIVER FLATS	Predominantly under pasture. Few small areas of nearly pure red and silver beech forest (B 2), some with occasional rimu and kahikatea (PB 1)	Recent soils: Hokitika and Harihari series
TERRACE LANDS		
(i) Main Post-Glacial terrace	As above	Yellow-brown earths—Ikamatua series
(ii) Low glacial outwash terrace	Many areas of nearly pure red and silver beech with occasional groups of large well-formed rimu and kahikatea (PB 1). Some stands of nearly pure red and silver beech (B 2).	Yellow-brown earths—Ahaura series
	Minor areas with clumps of small rimu in association with mountain and silver beech; small kahikatea may be scattered through this cover; some manuka enclaves (PB 3).	Gley soils—Maimai series
	Few small areas with dense small mountain and silver beech in which are scattered silver pine, yellow silver pine, pink pine, rimu, kaikawaka, kahikatea and Hall's totara (*Podocarpus hallii*), (PB 4).	Gley soils—Maimai series
(iii) Intermediate and high glacial outwash terrace	As above, PB 3 and PB 4, in patches. Most of these terraces have been cleared and burnt and no longer carry forest. Instead they are covered in a manuka, unmbrella fern, rush association.	Gley podzols—Okarito series
	One small area of PB 1, red and silver beech, with emergent larg^ rimu and kahikatea	Yellow-brown earths—McMurray series
Terrace edges	Mainly cleared of forest—only very small areas with this soil type.	Podzols—Waiuta series
Hollows in terraces	Small hollows dominated by sphagnum moss	Organic soils—Kini series
HILL COUNTRY	Hard beech with rimu; understoreys of kamahi or quintinia (PB 5)	Yellow-brown earths—mainly Blackball hill soils from dissected Old Man Gravels
	Red and hard beech with emergent scattered rimu; hard beech with rata on ridges; kamahi and/or quintinia locally common (PB 15)	Yellow-brown earths—mainly Inangahua hill soils from muddy sandstones
STEEPLANDS	Some PB 15 as above	Steepland soils associated with yellow-brown earths—Matiri steepland soils, from muddy sandstones
	On limestone country, forest type is very similar to PB 15 but is distinguished as PB 9	Steepland soils associated with yellow-brown earths—Punakaiki steepland soils
	Red beech dominant over silver in almost pure beech forest; hard beech and rata present on drier ridges (B 6)	Steepland soils associated with yellow-brown earths—Wakamarama series from indurated sandstone and siltstone, and colluvium—Kaniere series from granite and colluvium

of red beech with some silver beech. Many of these forest remnants have been partially logged. On the wet intermediate and high level terraces, and also on poorly drained sites at lower levels the forest type is PB3 or PB4. These are known as semi-pakihi associations and both contain mountain and silver beech as sub-dominant species. In PB 3 the main forest tree is rimu with some small kahikatea. In PB 4 yellow-silver pine *(D. intermedium)* predominates, with scattered kaikawaka *(Libocedrus bid-*

willii), pink pine *(D. biforme)* and silver pine *(D. colensoi)*.

(b) *Hill Country*

Two main forest types have been recognised on the hills. They are: PB 5—hard beech mixed with scattered rimu *(Dacrydium cupressinum)* on "sharply dissected gravel country", and: PB 15—red and hard beech mixed with scattered rimu on moderately steep hill country over a variety of soil parent materials. In both PB 5 and PB 15 the understorey is usually of kamahi *(Weinmannia racemosa)*, or locally of quintinia *(Quintinia acutifolia)*. In the latter type hard beech and rata *(Metrosideros umbellata)* are commonly found on ridge crests and may, together with rimu, be occasionally dominant on drier north-facing slopes.

(c) *Steeplands*

Almost pure red beech forest with some silver beech (B 6 forest type) occurs on the steep flanks of the ranges on both sides of the Depression. Hard beech and rata are often present on drier ridges; a few podocarps are interspersed with the beech trees. The steep limestone scarps at the north-west end of the Depression are mapped as PB 9, but this is essentially similar to the PB 15 of the hill country which also extends on to the steeplands in places.

THE SOIL/VEGETATION RELATIONSHIP

At soil group level all the soils of the hills and steeplands are yellow-brown earths or closely related soils, with occasional patches of podzolised yellow-brown earths. Separate soil series have been distinguished on different parent materials but gross morphological and chemical characteristics are similar in many instances. One reason for this is that both beech and many of the podocarps produce acid litters, and through fall from leaves and branches speeds up leaching under high rainfall (N.Z. Soil Bureau 1968b), unless other factors intervene. Forest typing reflects the soil series pattern in some places but not in others. The interaction between topography, forest types and soils is shown in Table 1.

(a) *Terraces*

In the series of terraces from the river flats to the highest level glacial outwash surface there are two

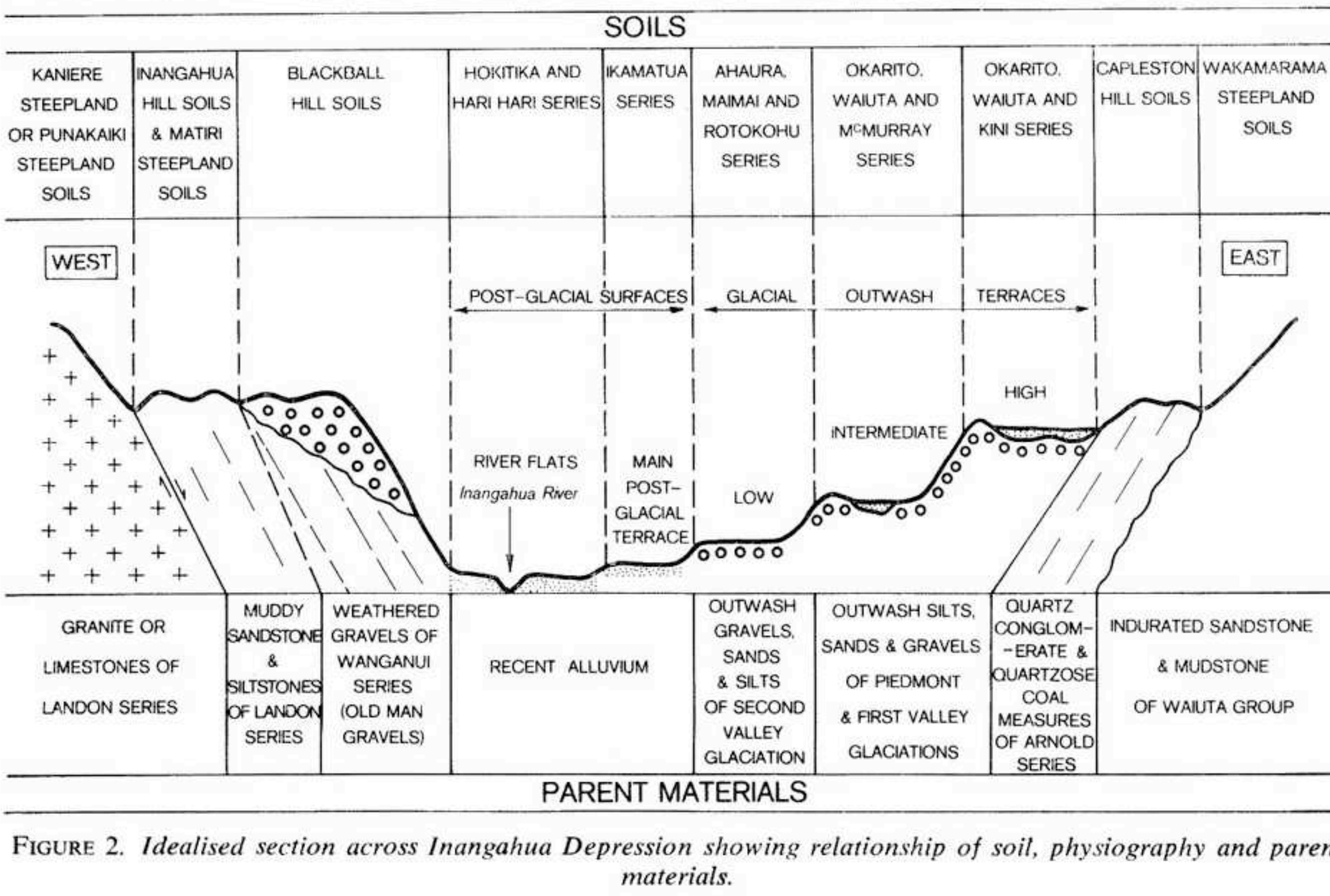

FIGURE 2. *Idealised section across Inangahua Depression showing relationship of soil, physiography and parent materials.*

major breaks in the sequence of soils. The first is where the soils are out of reach of flooding because of height above rivers and streams, and the second is between the low and intermediate glacial outwash surfaces (Fig. 2). Marked changes in physical and chemical properties occur across both breaks.

The recent soils below the first break are subject to fresh additions of alluvium and for this reason profiles show little development. As only small amounts of leaching take place before fresh deposition of material, these soils, belonging to the Hokitika and Harihari series, are the most fertile in the area. The freely drained Hokitika series supports large well-formed red beech trees, with other species subordinate (PB 1 and B 2) in the few patches of forest that have not been cleared for farming. The poorly drained Harihari series formerly carried kahikatea forest.

Between the first and second breaks the freely drained soils are classed as yellow-brown earths. They grade from immature profiles out of reach of flooding for a comparatively short time (Ikamatua series) to mature yellow-brown earths of the Ahaura series showing some signs of iron movement, with accumulation in the underlying gravels. Chemical analyses of these soils show increased leaching from the lower to the higher terraces. Despite the range of profiles, forest types are broadly similar to those found on the river flats. However, poorly drained soils, classed as gley soils of the Maimai series, carry PB 3 and PB 4 forest similar to that found on the higher terraces.

The major break in soil group is located between the low and intermediate level glacial outwash terraces. Above this break, on the intermediate and higher surfaces, soils are predominantly gley podzols (Okarito series), characterised by moderately thick massive, grey, gleyed horizons over humus/iron pans on gravels. Very low levels of exchangeable cations are present in these soils, and whole soil mineralogy indicates over 80% of quartz in most horizons (Mew *et al*, 1975). However, these features apply to soils under a vegetation cover that has been repeatedly burnt and must be regarded as at least partially man-induced in the Inangahua Depression. It is not known whether the soil would have been the same under the original forest, as the patches that remain (PB3 and PB 4) are mostly affected by logging practices. It has been suggested (McDonald, 1955) for sites further south that no change takes place in these soils after bush clearance but studies in progress in the Grey Valley indicate the contrary.

The soil development sequence postulated for the terraces by Gibbs *et al*. (1950) and Kear (1965) is one of increasing podzolisation with time, under forest cover. The type of forest has not been definitely specified, nor has the parent material difference between the low terraces and the higher surfaces been sufficiently emphasised.

With regard to the vegetation sequence on the terraces, there appears to be a relatively good relationship between soil drainage in particular sites and the forest or other vegetation growing on those sites. Soil fertility would seem to be less important in determining the present forest pattern.

(b) *Hill Country and Steeplands*

The occurrence of hard beech (PB 5) on hill country generally coincides with Blackball hill soils from Old Man Gravels. By contrast the PB 15 forest type and the almost identical PB 9 extends over Inangahua hill soils, Matiri steepland soils and Punakaiki steepland soils. The former two are from muddy sandstones and the latter is from limestone. In the same way B 6 forest covers both Kaniere steepland soils from granite and Wakamarama steepland soils from indurated sandstone and siltstone.

HISTORY OF SOIL DEVELOPMENT AND FOREST COLONISATION

To understand the soil/forest relationship it is necessary to consider the history of soil development and forest colonisation. The best starting point appears to be at the time of maximum glacial advance when most previous soils and also the vegetation cover would have been stripped, except possibly for small refugia. The indications are that this took place more than 200 000 years ago. As ice retreated major valleys such as the Inangahua and Grey would have been filled with glacial and outwash debris to a considerable depth (Suggate, 1957). The upper surfaces of these deposits would have been levelled by running water, leaving only a minor imprint of the original kame terraces, eskers and kettle holes. Bordering the surfaces would have been the steeplands, etched by ice flow and subsequent running water. Early colonisation on the high level terrace was probably by tussock grassland followed by manuka and then podocarps (Chavasse, 1962). The latter would tend to be the first forest species to invade because their seed is either bird or wind carried. At this stage beech, with its seed distributed by gravity or water flow, would have been more slowly encroaching on the steeplands with their skeletal soils from small refugia on the Paparoa, Victoria and Brunner Ranges (Holloway, 1954).

Subsequent glaciations in the mountains resulted in fragmentation of the high surfaces by major streams and rivers cutting through them, and the formation of glacial outwash terraces at successively lower levels in the valleys. Running water was at the same time dissecting the hill country to produce slopes available for colonisation by beech species. These could readily reach the sites by seeding into the streams draining the steeplands. Podocarps could also establish from the nearby high level terrace remnants. Soil fertility would at this stage have been higher than at present in the young soils on the hill country in the situation where Inangahua hill soils now occur because leaching had only taken place for a comparatively short time. This, combined with free drainage, would have favoured red beech colonisation (Franklin, 1965). By contrast the young Blackball hill soils would have been much less fertile because the underlying Old Man Gravels were already weathered to a considerable depth. Hence they would have provided suitable sites for hard beech establishment. The accumulation of limited thicknesses of fine textured loess on the intermediate and high level terraces decreased the flow rates of water and leachates through the soil and aided gleying. Rising water tables and falling fertility with time led to a reduction in forest vigour and change in species composition, giving conditions more suited to a mountain beech (Wardle, 1970) and yellow-silver pine association.

Steepland soils locally subject to rejuvenation may today offer comparatively high fertility sites for vegetation change, as do river flats subject to the accumulation of fresh alluvium. However the nearest suitable species is almost certain to fill the gap unless some major event such as a very recent climatic change has taken place which precludes satisfactory growth. Rigg (1951) concluded that there was no re-establishment of podocarps on impoverished pakihi areas near Westport because of a temperature drop at some time prior to European arrival. There is at present no definite evidence of the effect of such a change in the Inangahua Depression.

CONCLUSIONS

Broad conclusions are firstly, that beech and podocarp forest have enhanced the development of yellow-brown earths, podzols and gley podzols under a high rainfall/moderate temperature regime in the Inangahua Depression. Secondly, that there is only a direct relationship between the pattern of forest types and soils over about half the area considered. In this area topography, site drainage, parent materials, site fertility, climate and time interact to link the vegetation closely with the soils. Over the remainder, other environmental effects, such as the competition between different tree species at the time of colonisation, or the overriding influence of climate, are of more importance than the present soil type in determining what forest type exists in a particular situation. Thirdly, that the present distributions of soils and forest types in the Inangahua Depression, both where they coincide and where they do not, can be broadly explained in terms of developmental sequences without recourse to invoking climatic change in the relatively recent past.

ACKNOWLEDGMENTS

The field work for the soil survey of the Inangahua Depression was carried out jointly with T. H. Webb and C. W. Ross, Soil Bureau, Lincoln. Their help is gratefully acknowledged, also that of D. Evans, formerly Forester, N.Z. Forest Service, Reefton, for discussion of the forest/soil relationship.

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