
SOILS OF THE GISBORNE-EAST COAST DISTRICT AND THEIR PROBLEMS FOR PASTORAL USE

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The Gisborne-East Coast district consists mainly of steep hill country, with many small areas of rolling land on hilltops and strips of terrace and river flats in the valleys. The hill country extends to the coast in headlands 500 to 1,000 ft high separated by numerous valleys with steep sides. Valleys are narrow except those of large rivers, especially the Waipaoa River and associated tributaries which have formed the Gisborne Plains. The range of soils in the district is fairly small, but changes are very frequent and the pattern is complex. Both the pattern of soils and high relief of the landscape are due principally to the geological history of the East Coast, which is outlined in the following paragraphs.

Gisborne district is situated on the side of a large rising fold of the crust of the earth. This fold emerged from the sea many millions of years ago and has since risen in stages to form the mountain ranges west of Waikaremoana and Matawai. As the fold rose, more and more of the marine sediments on the eastern side were converted into land. Thus from the western ranges toward the east coast, rocks are successively younger, less compacted, and less tilted. The hard greywacke sandstone of the Raukumara Range grades eastward into brittle argillite which in turn grades into massive mudstone and then interbedded mudstones and sandstones. In the northern end of the district the fold did not emerge from the sea until the mudstones and sandstones were deposited and these rocks continue around the core of older rocks to the Bay of Plenty. Basalt was erupted in two places in Matakaoa County and now forms Pukeamuru Mountain and the coastal range between Hicks Bay and Cape Runaway. The distribution of the rocks of the district is shown in the 1957 **Geological Map of New Zealand**.

About 500,000 years ago there was a fairly long period without uplift when valleys became wide and terracing was extensive. Plateaux remnants of this period are clearly seen at Te Araroa, Matawai, and Ardkeen. Since then the land has risen 500 ft above sea level, which is an uplift of at least 1 ft per 1,000 years. The period may well have been less, in which case the rate of uplift has been greater, particularly in the last 50,000 years. Each uplift

increases the energy of streams for deepening their beds, and after this occurs the next stage is widening of the valleys. Widening means repeated removal of the soil mantle by erosion, and hence the effects of uplift are felt by soils hundreds or thousands of years after the actual land movement. In the East Coast many streams are still in the early stages of widening, and near headwaters some are vigorously deepening their channels. Hence the large proportion of steep and very steep slopes with massive rock close to the surface (skeletal soils).

In many -valleys the cycle of deepening and widening has not yet extended back to the ridges, and the steep and very steep slopes occupy only the land adjacent to streams. Upper slopes consist of high terrace, rolling, or hilly land on which the soils are not formed from the underlying sedimentary rocks but from volcanic ash showered over the East Coast from eruptions in the Rotorua-Taupo region. Road cuttings through easy slopes near Waikaremoana or Matawai show at least twelve layers of volcanic ash, but not all of these are found near the surface. Six soil-forming deposits have been separated, all consisting of pumice, and their surface distribution is shown in Fig. 1. Boundaries represent the outer limit of 3 in. of ash deposit as estimated from soil observations on flattish land. Within such boundaries there are many slopes where the ash is shallower or is absent as a result of subsequent erosion. The soil-forming deposits of volcanic ash have been classified as follows:

1. Whakatane-Waihi ash. This comprises a number of fine sandy pumice deposits overlying sedimentary materials on many sites from Tutira to Cape Runaway. The eruptions are estimated to have occurred 5,000 to 20,000 years ago. Soils formed from this ash occur in small areas north of Tolaga Bay where they are mapped in sets 52, 52H, 56b, and 56bH of the North Island Soil Survey (N.Z. Soil Bureau 1954).

2. Waimihia ash. This consists of fine pumice sand over pumice gravel erupted between 2,500 and 3,000 years ago. Pumice gravels are weathered to a yellow colour and are fairly evenly graded. Soils formed from this ash occur near Tutira and on Mahia Peninsula. The materials also contribute to many soils inland where later ash deposits are shallow.

3. Taupo gravelly ash. This ash is the first of three soil-forming showers erupted from Taupo approximately 1,700 years ago. It forms the surface soil on **many** upland areas from Tiniroto east to the coast and north-east to Tolaga Bay and has been known as Gisborne ash. Pumice gravels are very uneven in size and shape and particles are usually white inside, indicating little weathering.

4. Taupo sandy ash. This material was erupted a short time after the gravelly ash and measurable amounts did not reach

beyond Tiniroto. It is soil forming on areas westward from Tiniroto and Wairoa to the edges of the Taupo silty ash and Kaharoa ash.

5. Taupo silty ash. This is a product of the final phase of the Taupo eruption and is the soil-forming material over large areas of the Rotorua-Taupo district. In the East Coast it is not mapped east of the Matahaura district and middle section of the Mohaka River. The ash is generally finer in texture than (4), but contains large pieces of white pumice.

6. Kaharoa ash. This is a white pumice sand erupted from a source on or near Mt Tarawera about 800 years ago. Shallow deposits (3-6 in.) of this shower extend over a narrow zone 15 to 20 miles east of Waikaremoana.

The vigorous erosion of the hill country has produced large quantities of debris. Some of this debris has been deposited on valley bottoms to form river flats and much has been carried out to sea. In sheltered bays around the coast, sand and gravel have accumulated in ridges parallel to the shore with swamps in depressions between ridges and inland of them.

The sedimentary rocks, the volcanic materials, and the alluvium derived from them are converted into soils by the action of climate and plants and soil organisms. At altitudes below about 1,000 ft the generally mild, humid climate is very favourable to rapid and continuous growth of plants. This is demonstrated at Manutuke by pasture production of 12,000 lb of dry matter per acre per year. It means rapid development of soil and circulation of nutrients to assist the maintenance of soil fertility. Moisture limitations on plant growth are not common and occur mainly on steep, sunny faces and sandy soils near the coast. On lands above 1,000 ft the climate is cool, the rates of decomposition are slower, but the intensity of leaching is higher. Hence soils tend to be poor and erosion is more serious on the Wharerata, Raukumara, and Huiarau Ranges. Such soils are little used for pastoral purposes.

Although soil development is rapid, the influence of climate and plant life is less important than the physical and chemical composition of the parent materials. In most soils of the Gisborne-East Coast district fragments of the parent rock occur near the surface and are decomposing in the zone of plant roots. This feature is due to the extensive widening of valleys, flooding of river flats, and relatively recent deposition of volcanic ash. In these circumstances the soils can be described in three divisions—skeletal soils, pumice soils, and soils from alluvium.

Soil Descriptions

Skeletal soils cover most of the hill country of Gisborne district. They are shallow soils recently formed from massive rock materials

and their properties depend chiefly upon the physical and chemical composition of the underlying rock. Details are given in soil bulletins of North Island (N.Z. Soil Bureau 1954) and Matakaoa County (Gibbs, 1954).

Skeletal soils developed from fine-grained rocks such as **mudstone**, argillite, and basalt (see fig. 3) are moderately fertile and generally capable of growing good pastures with known methods of management. Their problem is not fertility but stability. Shallow slips occur from time to time and expose bare rock. Massive **mudstone** or basalt weathers fairly rapidly and a new cover of grasses can be obtained within a year or so. Although this erosion gives problems of stocking and fencing, it is not considered to be serious from the soil point of view. But on skeletal soils formed from sticky **mudstone** or brittle argillite the slipping is serious because it is deeper and is repeated again and again. Plant cover does not have a chance to regenerate, the slips develop into gullies, and these grow until slopes become less steep and the slipping less frequent. On the sticky mudstones, soils develop very broken surfaces that are extremely difficult to use efficiently for grazing.

Skeletal soils developed from coarse **grained** rocks such as greywacke and sandstone (see fig. 3) are less fertile than the soils from the fine-grained rocks and they give serious problems for pastoral use. With understocking, pastures are invaded by fern and shrubs; with over-grazing the amounts of sheet and slip erosion are increased. Rock surfaces exposed by slipping weather slowly and the new soils lose much of their primary fertility during the early stages of soil formation. If these skeletal soils are farmed with areas of alluvial or pumice soils, problems of pasture maintenance are not so difficult, but without this support from other soils the dual problems of fertility and stability are usually too severe for pastoral farming **and these** skeletal soils are better kept in forest. Furthermore, these soils occur mainly in the upper catchments of rivers where maximum protection of slopes by dense vegetation is required to lessen the severity of flooding and sedimentation on the valley bottoms.

Pumice soils are found in moderate to small sized areas of terrace, rolling, and hilly lands throughout the district (see fig. 3). They are friable, sandy or gravelly soils that drain readily yet generally retain sufficient moisture for plants. Physically these pumice soils are excellent for pastoral purposes, but chemically many of them are poor and unbalanced, especially in regard to trace elements. The chemical differences can arise from the initial composition of the volcanic ash, and identification of the particular ash shower is the first stage of an investigation. Other differences can be acquired through the local conditions of climate

and vegetation during soil formation. Thus soils from Taupo gravelly ash in the Te Karaka and Tiniroto districts are richer than those in the Matawai and Wharerata districts because of the more intense leaching under the wetter, cooler climate of the latter districts. On the other hand, soils developed from Taupo shower materials near the coast obtain considerable additions of trace elements such as sulphur in sea spray and they tend to be more fertile than average for the pumice soils.

Another class of pumice soil is found where the volcanic ash is shallow and tree roots have penetrated into chemically richer materials underneath. This has happened on the outer margin of pumice distribution such as at Mahia Peninsula and Hicks Bay or on many hilly slopes inland. Plant nutrients have been brought up from below by the trees and dropped back on the surface, where they become blended with the pumice and produce a moderately fertile topsoil. This enrichment was well marked under puriri forest. Unless grass roots also penetrate into the underlying materials, the benefits of the forest vegetation will gradually fade and the soils become similar in composition to those derived from deep pumice.

Soils from alluvium include not only the soils of river flats but also those of associated swamps, coastal marshes, and beaches. In these sites on valley bottoms the rates of drainage are a major factor in the properties of the soils.

On river flats there is a wide range in textures. Gravelly and sandy soils are common near the fast running Awatere, Waiapu, and Waioeka Rivers. Drainage is rapid, but the high rainfall makes the moisture limitation less critical for pastoral purposes than similar soils in Hawke's Bay or Wairarapa. The main handicap is liability to flooding with the consequent limitation to use and improvement.

Silty soils are extensive in valley bottoms of moderately to slowly running streams such as the Uawa, Waipaoa and Wairoa Rivers. Near the stream channels they are free-draining, deep, friable soils rich in plant nutrients. Such soils are suitable for a wide range of uses. Under pastoral use their main limitation is the weak structure which is easily broken down by traffic when the soil is wet.

Slow-draining silty soils occur in basins away from the river channels or bordering hillsides. In these places soils are wet for weeks at a time. Their subsoils are pale grey and the alternate soaking and drying produces a dense subsoil. Although the content of plant nutrients is similar to the free-draining silty river flats, the excessive water limits the kind and amount of plant growth. Surfaces are hard in dry periods, soft in wet spells, and poach badly under traffic. In these soils drainage is essential to provide

a better air-to-water balance for root growth. The extreme effects of excessive water are seen in small depressions where the soils are always wet and topsoils become peaty.

Very free-draining soils are developed on the beach ridges and too little water is the chief limitation to pastoral improvement. Where irrigation is available the soil can be made highly productive. Salt marshes are impounded behind some beaches, but until the salts can be removed from the soils the areas cannot be used for pastoral purposes.

The pattern of the soils from alluvium is very well demonstrated on the soil maps of Gisborne Plains by Mr Pullar. Detailed descriptions are given in his bulletin which is to be published early next year.

Soil Problems

Under pastoral use the following problems arise:

Flooding and surface poaching on river flats	}	Soils from alluvium
Too much water on swamp lands		
Too little water on coastal dunes		
Too much salt on coastal marshes		
Nutrients on rolling and hilly lands		Pumice soils
Stability and fertility on steep and hilly lands		Skeletal soils

The problems of flooding, too much or too little water and too much salt can be overcome by engineering methods and need no explanation. The others are more complicated and merit a brief discussion.

Surface poaching is a widespread problem of grazing on many soils when they are wet. It is common on medium and heavier textured soils of river flats and swamp lands of the East Coast, partly because soil particles are only weakly or moderately aggregated and partly because they contain high swelling clays. On wetting, surfaces soften up readily and are easily poached, causing local packing, baring, and unevenness in the surface soil as well as broken roots and crushed leaves of pasture plants. These combine to lessen pasture growth, the amount varying with such factors as the content of silt and clay, the degree of aggregation, the nutrient content of the soil, and the period of wetness and intensity of traffic. Figures for particular soils and treatments have been given by Gradwell (1954) and Edmonds (1957). To meet this problem investigations have been and are being made into (1) the process of poaching, (2) the improvement of wet strength of aggregates, and (3) the increase in rate of infiltration of water through the surface soil. Unfortunately, no practical results for pastoral use have yet been obtained. Hence it is important to lessen the occurrence of poaching by reducing stocking rates on

susceptible soils during wet periods and to use careful management after the excessive water has disappeared.

Nutrient Problems. On the skeletal and "alluvium" soils the main deficiencies for growth are phosphorus, nitrogen, and possibly sulphur. These are satisfied by superphosphate or a similar fertiliser. Total analyses indicate adequate reserves of most other elements and development of other nutrient requirements seems unlikely to be sudden or serious for a long time yet.

On the pumice soils the nutrient situation is more complex. In the early stages of pasture development superphosphate gives excellent growth, but in many places stock do not thrive unless cobalt is also supplied. Later on, the responses to superphosphate are weak and trial plots have demonstrated a need for small additions of copper, boron, potassium, or sulphur. In one area the molybdenum content of soil and pasture is too high for stock health and copper has to be added to obtain healthy grass (Cunningham, 1955). These nutrient problems arise through the nature of pumice and its youth from a soil formation point of view.

Pumice is only the "frothy" fraction of molten rock and compared with average sedimentary rocks it is enriched in silicon, sodium, and potassium, but deficient in copper, cobalt, nickel, iron, vanadium, calcium, and magnesium. While the total amounts of these elements may be sufficient for plant growth, a big proportion of each is not available. Over most of the area pumice soils are less than 2,000 years old and consist mainly of sand and fine gravel. Only the surface of the particles has been decomposed into compounds accessible to plants. The demands of rapidly growing plants may quickly exceed the amount of an element in the surface skin and a deficiency occurs until replacements arrive from decomposition. Hence, deficiencies may develop suddenly in pumice soils and may be more evident in some years or months than in others through the influence of climate on rate of decomposition and rate of growth. Deficiencies may also be caused through fixation of nutrients by compounds of iron, aluminium, or other products of weathering.

These potential problems do not mean that pumice soils should not be farmed; they have excellent physical properties and much information on their nutrient problems is available from experiments and trial plots of the Department of Agriculture. Where established farming practices do not appear to give satisfactory results the local farm advisory officer should be consulted for more information.

Also no farm in Gisborne district is located entirely on pumice soils. On hill country practically every paddock consists of a

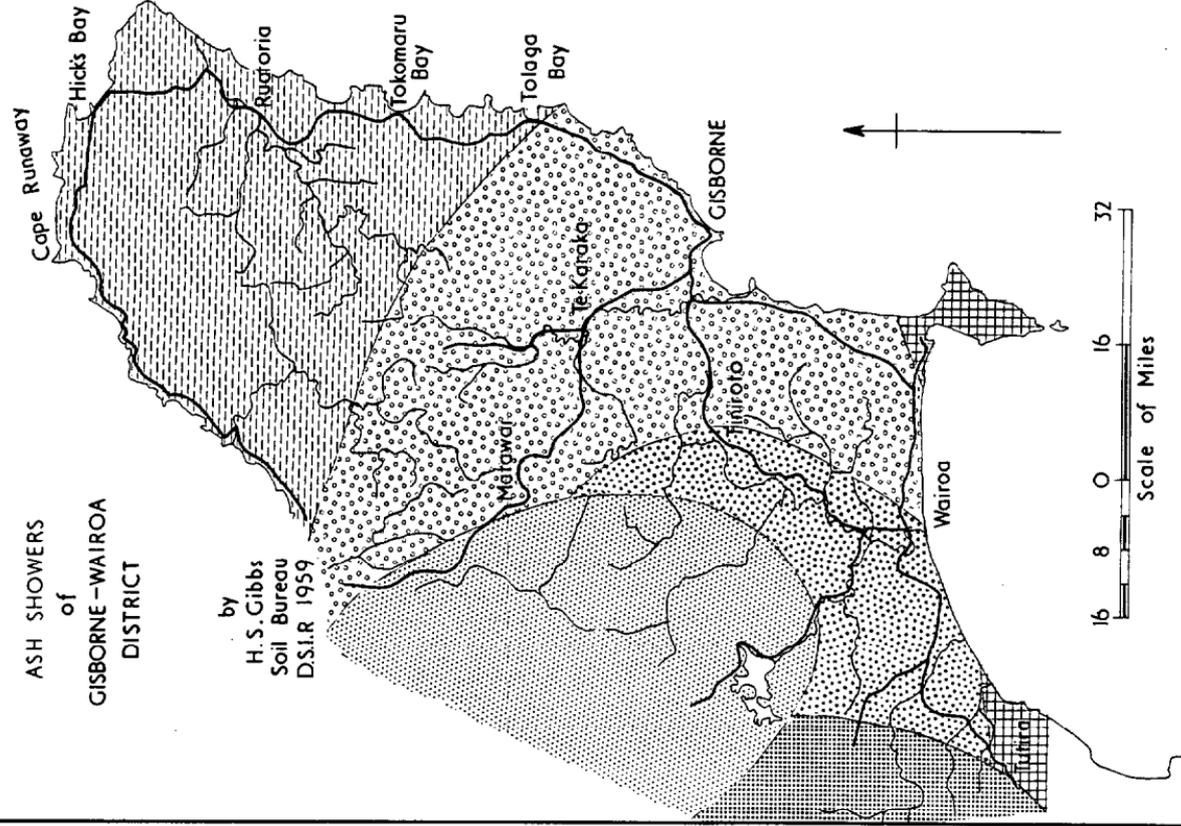
mosaic of pumice and skeletal soils with some having river flats as well. Cobalt deficiency is rarely seen because stock can generally obtain sufficient from pastures on other soils to compensate for the shortage on the pumice soils. Furthermore, the transfer of nutrients by dung and urine tends to raise the level of nutrients on the pumice soils. While this equalisation of nutrients appears to be sufficient to prevent deficiencies at low rates of stocking, it may not be so at the higher rates used with aerial topdressing. On a hill country farm it is very difficult to assess the over-all supply of nutrients from the soils and to separate their effects from those of disease, breeding, seasonal climate, or other features of farming. Nevertheless the potential deficiencies of the pumice soils should be kept in view when examining pastures and stock. The nutrient problems on pumice soils cannot be solved by adding a wide range of metals in the hope of applying the one or two in short supply. Soil is not an inert material and the addition of unnecessary elements may increase the plant demands on another (not added in equivalent amounts) and so cause a deficiency. Pumice soils are sensitive to changes and hence are liable to such nutritional upsets.

Instability is the chief problem of the skeletal soils and has been described by Pullar and Metsers (1956). It is due primarily to the repeated uplifts of the district during its geological history, but especially in the last 500,000 years. Only the main rivers in their lower reaches are past the stage of cutting into their beds. Even then, in the meander stage, rivers impinge on hill slopes and undercut them. Downcutting and undercutting both lead to progressive retreat of adjacent slopes which is expressed in Gisborne district by various forms of slip erosion described in the bulletin on Soil Erosion in the North Island (Grange and Gibbs, 1947).

Another factor in the instability is the softness of many rocks and their content of high swelling clays. On soft rocks like mudstone the rate of downcutting and subsequent adjustment of slope is much more rapid than on hard rocks like greywacke, with the result that there is a greater supply of eroded material per period. Where slipping is shallow and the exposed material rapidly covered in vegetation the greater rate of erosion does not seem serious. But where slipping is deep and continues around the edges of the first movement a serious problem exists and it is fairly common on soils from brittle argillite in parts of the Waipoua, Waiapu, Awatere, and Waikura Valleys. A similar and equally serious problem exists on the soils developed from the high swelling clays (bentonitic) and on shatter belts along fault

ASH SHOWERS
of
GISBORNE-WAIROA
DISTRICT

by
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Soil Bureau
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LEGEND

- Whakatane - Waihi ash
- Waimihia ash
- Kaharoa ash
- Taupō gravelly ash
- Taupō sandy ash
- Taupō silty ash

Fig 1

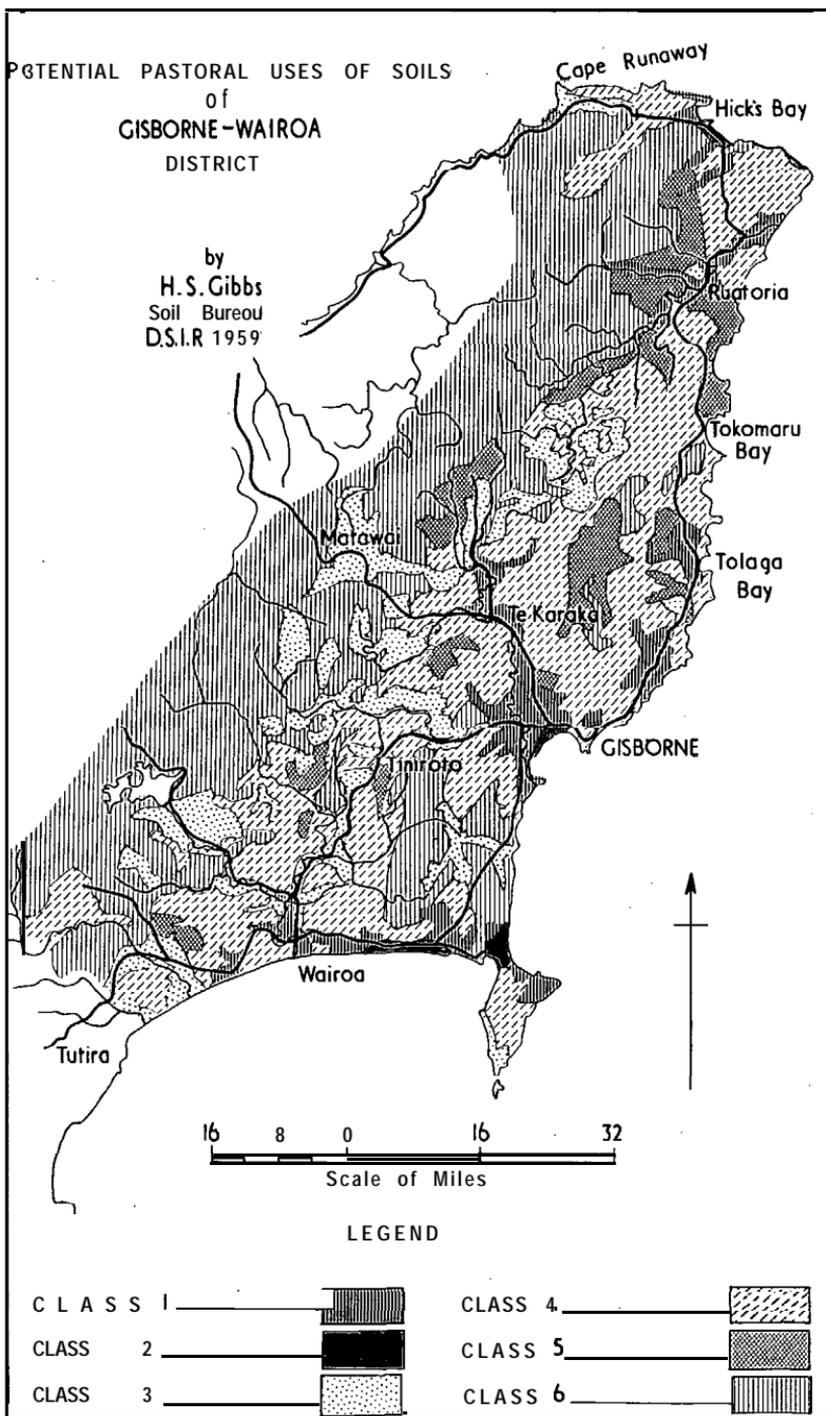


Fig 2

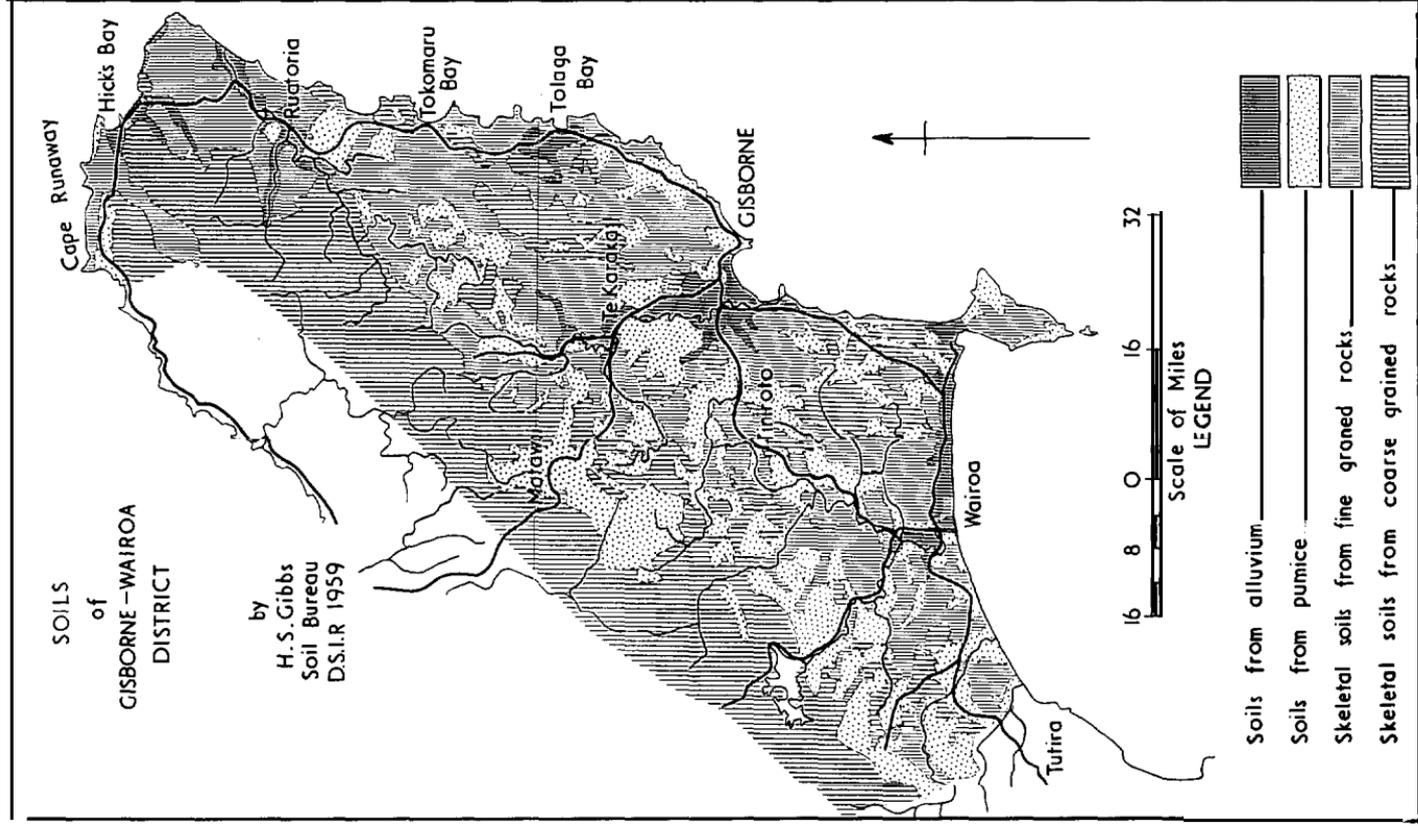


Fig 3

lines. Movement is slow but frequent and generally seated below the reach of plant roots,

The native vegetation of the unstable slopes was forest and under that forest there were soil and rock movements similar to those of the present day. But the over-all rate of erosion was slower because primary movements were fewer and secondary effects (gullying) were slower over an equal period. The aim should be to lessen the number of primary slips and the rate of secondary erosion to that occurring under the native vegetation. With topdressing and careful management, pasture can do this satisfactorily on the skeletal soils from mudstone and basalt but not yet on soils from sandstone and greywacke. The major problem arises with the skeletal soils from argillite and bentonitic mudstone on which pastures can be grown without difficulty, but serious erosion is likely to develop with little warning. Practical measures to deal with this and other kinds of erosion are described by Mr Todd (p. 48) .

The location and importance of problems of fertility and erosion can be demonstrated from soil maps. This was shown in the Soil Bureau bulletin on Matakaoa County (Gibbs, 1954) where soil types were grouped into classes based on soil properties concerned with the problem and using the general experience of the Department of Agriculture in the interpretation. A similar map (Fig. 2) has been prepared for the Gisborne-East Coast district on which six classes are recognised—classes I, II, and III on flat and rolling land and classes IV, V, and VI on hilly and steep land. Details of the classes are as follows:

- Class I: Soils of flat and rolling land that can be converted into high quality pastoral land (river flats and better pumice soils).
- Class II: Soils of flat and rolling land that can be converted only to moderate quality pastoral land owing to inadequate or excessive water (sand dunes and swamp lands).
- Class III: Soils of flat and rolling land that can be converted only to moderate quality pastoral land owing to fertility problems (poor pumice soils).
- Class IV: Soils of steep and hilly lands that by established farming methods can support grazeable pastures without serious erosion (skeletal soils from massive mudstone and basalt).
- Class V: Soils of steep and hilly lands that by established farming methods can support grazeable pastures but are liable to serious erosion (skeletal soils from argillite and sticky mudstone).
- Class VI: Soils of steep and hilly lands that are unable to maintain pasture owing to low fertility and serious erosion (skeletal soils from sandstone and greywacke).

In the area comprising Matakaoa, Waiapu, Uawa, Cook, Wai-kohu, and Wairoa Counties the individual totals are:

Class I: 388,000 ac	Class IV: 1,111,000 ac
Class II: 19,000 ac	Class V: 302,000 ac
Class III: 116,000 ac	Class VI: 923,000 ac

334,000 acres of class VI soils are at present in forest.

This estimate shows that the Gisborne-East Coast district is primarily hill country (80 per cent) and that of this area there are 1, 111,000 acres (50 per cent) well suited to pastoral farming. For this purpose also the areas for classes I, II, and III may be added, making a total of 1,634,000 acres of the region that can be permanently used.

This total provides a valuable basis for considering industries and services connected with pastoral farming. For example, if a third of each farm received 2 cwt of superphosphate each year the annual requirement of superphosphate would be 54,000 tons.

The cleared areas of class VI land are situated mainly in the Wharerata and Ahititi districts and in the western ranges. This land is best kept in forest.

The 302,000 acres of class V land is the chief problem for pastoral purposes. While it is fertile enough to maintain pastures, its instability is dangerous both for the loss of grazing on the home farm and for the inundation of flat land with water and debris. Aside from this problem there is plenty of land to provide a sound and prosperous future for the district.

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DISCUSSION

- Q. (D. A. Campbell): Mr Gibbs mentioned that there were one million acres of usable grassland. What is the area of the remainder?
- A. (H. Gibbs): I estimate it at 2,500,000 acres, of which the unfarmable inland greywacke ranges are 1,000,000 acres.
- P. D. Sears: While pugging does damage pastures, reversion of pastures due to lack of grazing is often a more serious problem. *Poa trivialis* increases where grazing is inadequate. Grazing is necessary to maintain ryegrass-white clover pastures.
- A. (H. Gibbs): I agree that we must have grazing but there should be some lessening of grazing when soils are saturated. I am looking at the problem of winter management from a purely soil point of view. The grazing need not be abolished but should be kept down when conditions are really wet.
- Q. (J. O. H. Tripp): Has *Phalaris tuberosa* been used as a remedy for pugging?
- A. (H. de O. Chamberlain): No, this grass has not been used. It resists poaching but has other disadvantages.
- E. C. Ayson: Much of the hill soils are covered with a layer of varying depths of ash. Even a shallow layer of pumice ash will support pasture but nutrient deficiencies associated are widespread.
- A. (H. Gibbs): Yes, once the fertility brought up by forest from the underlying mudstone has faded the grass cannot replace it unless it can root more deeply. Nearly all the hill country has a coating of pumice and wherever this occurs there are nutrient problems.
- Q. (H. Woodyear-Smith): The Greywacke soils behind Palmerston North have been developed. What is the difference between the Palmerston North greywacke and the greywacke of this district?
- A. (H. Gibbs): There is no difference—they are similar materials but the coating of ash on local soils reduces fertility and of course increases the erosion factor. Up to the level of about 1,000 feet above sea level, as in the Manawatu, these soils can be farmed quite well provided there are areas of better soil to go with it.
- Q. (C. E. Iversen): Do these poor hill soils respond to super?
- A. (H. Gibbs): The hill soils coated with pumice usually respond to super for a year or two but then the response fades out due to the deficiency of other elements which limit pasture production. Copper, sulphur, boron or potash are required in different areas. Local plot trials are required to predict the responses in each area.
- A. (H. de O. Chamberlain): We have obtained good responses to a mixture of all the elements mentioned by Mr Gibbs. Where there has been no previous topdressing at least 4 cwt/acre of super is required in the first dressing to do any good at all. The second dressing should be 2 cwt. Subsequent dressings of phosphate may be lighter but should be accompanied by the mixture of other elements.
- A. (H. Gibbs): Farmers should not rush in and use all elements but should treat this matter cautiously as too much of any one element may cause trouble. For instance, near Wairoa the Taupo gravelly ash has excess natural molybdenum in it and copper has to be added to correct it.