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rivers carved their way down into the underlying rock and carried out the products of this geological erosion to

The factors of ter-

set from the Canterbury Plains.

mature. Slope has also played a part in soil formation on the Canterbury Plains (see Fig. 2).

a few of the numerous other types will be mentioned in passing.

The greywacke plains is the soil profile, which is a Section through topsoil, subsoil, and the underlying parent material. In which the soil has been formed, i.e., the kind of section one sees in a road cutting or in a post hole. The factors which determine, the kind of Profile formed at any given spot are:

(a) Parent rock: Most of Canter-

(b) Slope: On steep slopes the soils are constantly, being rejuvenated by volcanic action. Both the young and the mature soils are striving to master the erosion which removes the soil altogether. Gentle slopes and

(c) Climate: Rainfall varies from 25 in. near the sea to 40 in. along the foot of the hills and to over 200 in. on the top of the Alps. Greater rainfall on the same parent material, slope, and age causes greater leaching of plant foods.

(d) Plant and animal life: Native vegetation consisted of:

1. Dry land: Poa and festuca tussocks. Manuka, New Zealand broom; occasional cabbage trees.

2. Swamp: Raupo, niggerhead, phormium flax.


Domestic animals and man have caused loss of topsoil through erosion on the plains as well as on the downs and hills. Heavy cropping is known to cause a deterioration in soil structure and a drain on plant nutrients, thus tending to fail in fertility; but declining yields, which should be readily seen, are offset by better seed, manuring, etc., thus obscuring tempor-

(e) Time: Last, the soils are greatly influenced by the time for which the other factors-parent rock, slope, climate, plants, and animals—have been-acting-upon them: Thus the oldest parts of the plains, midway between and highest above the rivers, have been much more leached of their plant foods than the younger soils at lower levels near the rivers (see Fig. 1).

Soils

Soil maps of parts of Canterbury have already been published. Bulletin No. 92 of the Department of Scientific

C. S. Harris, Senior Pedologist, Department of Scientific and Industrial Research, Christchurch.
IDEAL SECTION THROUGH A CANTERBURY RIVER FAN SHOWING AGES OF DEPOSITS AND SOILS

Fig. 2

IDEAL SECTION THROUGH A CANTERBURY RIVER FAN SHOWING AGES OF DEPOSITS AND SOILS

Fig. 1
and Industrial Research deals with 10,000,000 acres of South Island "high country," most of which supports, or used to support, tussock vegetation. Roughly half this area lies in Canterbury, where 8 widely different kinds of soil have been recognised and mapped. High country, for purposes of investigation, is a misleading term, that is, only one kind of soil present. These soils differ from each other as to their colour, texture, depth, chemical composition, altitude, climate, plant cover, and erodibility. When these differences have been so clearly demonstrated it is unfortunate that some research workers and others continue to use that archaic, omnibus term "high country" when they could refer to the soils present by the names that have been given to them. There are few who would refer to the many different soils on the Canterbury Plains as merely "plains soils."

**Bulletin No. 66** of the same Department covers 21,000 acres of the western slopes of Akaroa Harbour. On the hills 10 soil types are recognised, indicating how parent substance, vegetation, slope, rainfall, etc., all play a part in forming different soil types.

A soil map and text covering Ashburton Plains were published in the 1935-36 annual report of the Soil Survey. It was followed by a farm management map of the same area by Mr. J. R. Fleming (Department of Scientific and Industrial Research Bulletin No. 58) which shows the very close correlation between type of soil and type of management. This soil map has proved to be a useful background for the carrying out of further surveys on the plains.

In the 1936 annual report of the Soil Survey appears a detailed map of the Levels Plain. There are other miscellaneous publications dealing with various aspects, e.g., linen, flax, erosion on the downs, etc., but I do not propose to outline them here.

Field work on a survey of the plains between Herbert in the south and Waipara in the north (more than 5000 square miles) is now completed, but some months' office work is still required. It was hoped to release advance copies about the middle of 1949. These will be available to institutions—like Government departments, Lincoln College, and the local catchment boards, but they will not be available to private individuals until they appear in printed form.

The soils of the downs have been divided into 15 series, but only 10 occupy any great area of land. These 10 series are derived mainly from wind-deposited glacial silts, and are formed in the same manner as most of Banks Peninsula. A cut across the downs near Timaru shows that near the sea the effect is intense and a consequence, that beyond the "pan" gradually disappears, fertility falls off, and the silt-loam subsoils become more acid.

**The soils of the plains** consist of 31 different series, many of which develop into further types and phases. Fig. 3 shows a very generalised picture of the growth of soil. The effect upon the parent substance, the soils (silt-loam subsoils) become more acid.

1. The Waimakariri series is chiefly sandy loams of varying depths to stones. Fertility is limited by dryness, but where more silt occurs in the profile, moisture retention is better, good yields of grain are obtained. The driest part, which carries hajgrasses, Stipa, etc., are well suited to the growth of subterranean clover.

2. The Motukarara series occurs near Lake Ellesmere and contains salt, but in most other characteristics it resembles the Waimakariri. Near the lake, where salt content is highest, the nature of the parent material is not as well suited to the growth of subterranean clover.

3. The Papanui and Kaiapoi series are similar to Waimakariri except that they contain adequate moisture, and are therefore much more fertile. Papanui consists of sandy loams and Kaiapoi of silt loams, and both can maintain good permanent pastures. The fertility is high, but most pastures contain a great deal of brown top.

5. The Taumata series is common practice; but further trials should be carried out to see what can be done in this line. The fertility is very high, but most pastures contain a great deal of brown top. The Kairaki and Waikuku series occur on the coastal sand dunes. Near the sea, the dunes are eroding freely, but inland, the texture of the profile and moisture available by dryness, but where more silt occurs in the profile, moisture retention is better, good yields of grain are obtained. The driest part, which carries hajgrasses, Stipa, etc., are well suited to the growth of subterranean clover. But in most other characteristics it resembles the Waimakariri. Near the lake, where salt content is highest, the nature of the parent material is not as well suited to the growth of subterranean clover.

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5. The Taumata series is similar to Kaiapoi except that it contains moisture in excess, which causes crop failure. The soil is quite excellent for a clover pasture, each which have been grown in grass for more than 25 years. Top dressing does not appear to be a common practice, but further trials should be carried out to see what can be done in this line. The fertility is very high, but most pastures contain a great deal of brown top. The Kairaki and Waikuku series occur on the coastal sand dunes. Near the sea, the dunes are eroding freely, but inland, the texture of the profile and moisture available by dryness, but where more silt occurs in the profile, moisture retention is better, good yields of grain are obtained. The driest part, which carries hajgrasses, Stipa, etc., are well suited to the growth of subterranean clover.

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GENERALISED SOIL MAP: PORTION OF CANTERBURY PLAINS
Survey Department. Additional data compiled by C. S. Harris from soil maps prepared by Department of Scientific and Industrial Research.

**LEGEND**

1. Waimakariri
2. Motukarara
3. Papanui and Kaipoi
4. Taitepu

5. Taumutu
6. Kairaki and Waikuku

**RECENT TO YOUNG GROUP**

7. Papanui and Templeton
8. Ladbrooks and Springston
9. Temuka

10. Chertsey and associated series

**IMMATURE GROUP**

11. Lamore
12. Ruapuna

**PODSOLIC GROUP**

**ORGANIC GROUP**

Traced by G. H. Morgan 1948.

Fig. 3
older than the foregoing, and show a more distinct development of topsoil and subsoil. They are very slightly leached of plant foods.

7. The Paparua (sandy loams) and Templeton (silt loams) series are both very fertile; where the profile is deep, but Paparua is too dry to support permanent pastures where stones are near the surface. The profiles are frequently cropped, and probably short-rotation rye grass would perform useful function in ensuring Farmers to leave paddocks long enough in a high-producing pasture to let the soil recuperate.

8. The Ladhrooks and Springton series are those deep counterparts of 7 above and should both be able to carry permanent pastures. Fertility is high and leaching frequent.

9. The Temuka series may be regarded as a wetter stage of Ladhrooks and Springton iron pan occurs in places. Fertility is slightly lower than that of Taitapu and, from the chemical determinations that have been made, one would expect a better response to lime on Temuka than on Taitapu.

10. The Chertsey and associated series lie higher above the rivers than any of the foregoing, leading to plant nutrients to proceed further, fertility is lower, and lime requirement is higher. Many areas are shallow and silt loams. Subterrenean clover has a place; but the deeper parts yield heavy crops except in the driest seasons. In bygone times great quantities of dust from the river-beds were lifted by strong north-west winds and deposited over the plains. This dust is3in. high, but the sediments become finer as distance from the rivers increases. Waimakariri and Paparua series both received a heavy dressing of sandy material, but Chertsey series being further away from the rivers, received a top dressing of more silty materials. The Chertsey series being further from the rivers, received a top dressing of more silty materials. Because the prevailing dry wind was from the north west, we find that the southern banks consist of deeper and more fertile soils than do the northern banks.

11. The Lismore series lies on the tops of the oldest parts of the river fans, midway between the rivers (see Fig. 1). It is in point of area, the most important on the Canterbury Plains. Between the Waitaki and Waipara Rivers there is about 675 square miles (approximately half a million acres) of this series of which some 400 square miles is soil about 12in. deep. The remaining 275 square miles are about 6in. to 8in. in depth, as at Burnham. Topsoils are brownish grey to light grey, subsoils are yellow, and textures are silt loams throughout. Because this area has been exposed to leaching by rain-water for the longest period, plant food content is low and acidity is high.

Chemical figures indicate an initial lime requirement of 2 to 3 tons of carbonate, but in two or three cases only have farmers applied such heavy initial dressing. Unimproved pastures are brown top and hair grass. Mr. Leitch in his paper will no doubt include Lismore series with others under the heading of light lands, and those who make the trip to the Winchmore Irrigation Station, which is on the inland extremity of the river fans. The soils are leached to about the same extent as Lismore, but the higher rainfall enables pastures to outlast Lismore paddocks in a dry seasonically every requirement, but it can be greatly simplified for any given purpose.