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THE SOILS OF NEW ZEALAND

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New Zealand has a complex soil pattern. This is because of the great diversity of parent soil materials, the changes in topography, the wide range of climatic conditions with the associated changes in vegetation, and the short, swift and erratic rivers. Indeed, the soil types are so interwoven that a soil survey map of most districts is like a patchwork quilt or Joseph's Coat of Many Colours.

The main zonal soil groups of the temperate regions are represented and, in addition, there are many areas of intrazonal and azonal soils. Within each group there are many separate soil types and these are further sub-divided into phases on the basis of the depth of the profile, the presence of stones or the degree of leaching. The main groups are:—

Zonal: Podzols and Podsolic Soils.
Brown Loams.
Highland and Lowland Tussock Soils.
Yellow-Grey Loams.

Intrazonal: Meadow Soils.
Peaty Soils.
Rendzinas.

Azonal: Skeletal Soils.
Recent Soils.
Man-made Soils.

Podzols and Podsolic Soils:

These soils represent the major zonal group in New Zealand and occupy the greatest area of farming land. The conditions under which they are produced have been outlined in a previous article. All grades of podzols are represented in New Zealand and vary from slightly podsolized through moderately podsolized to the mature podzols of the pakihi and the gumlands. They have been developed on a wide range of parent materials and under different forest and tussock associations.

The most common profile is one with a layer of acidic partially decomposed organic matter, over grey to black rather sandy topsoil, over yellow clayey and often iron-stained subsoils. In the advanced stages traces of a pan appear.

They all require heavy initial liming followed by top-dressing with phosphates and, in some cases, potash.

Brown Loam Soils:

These are a group of zonal soils derived mainly from volcanic materials and they show degrees of leaching from

very slight to marked. They all contain much iron and because of this, possess a characteristic brown colour and have a granular structure. They are free draining, easy working, warm soils which have a marked capacity to fix phosphates in unavailable combinations. The least leached members of the subgroups are used for dairying, fruit growing and market gardening but the most leached, which includes the "Ironstone Soils," have not yet been satisfactorily developed. They require liming and, above all, regular applications of phosphates.

It is interesting to note that it was an endeavour to prevent the rapid fixation of phosphates by these soils that led to experiments in which the basic rock, serpentine, which itself has a strong affinity for phosphate, was mixed with superphosphates.

The Yellow-Grey Loams:

These soils are produced from parent materials rich in lime and although they have been developed in areas where leaching occurs they still retain a rather high level of fertility, especially in Hawke's Bay and Wairarapa. Those in Manawatu are more leached and link the group as a whole to the podzols while those of Hawke's Bay link the group to the rendzinas.

They are developed on rolling country and where they have a calcareous mudstone base they are liable to slipping in wet weather. They require liming and topdressing with phosphates and the most leached often need mole drainage as well. They are mainly used for sheep farming or, in the wetter areas, for dairying.

The Tussock Soils:

This is a zonal group of soils which is peculiar to New Zealand. Some of its members show, by their leaching, affinity to the podsolic soils, while those developed in the very low rainfall areas of Central Otago have affinity with some of the arid soils. They have been subdivided into two groups: the lowland tussock soils and the highland tussock soils. The latter subgroup is further subdivided into soils of the high and low rainfall sections.

The lowland tussock soils have been developed in comparatively recent times on fine loess-like materials under a rainfall of 25-45 inches and a dominantly tussock vegetation. They are widely distributed on the East Coast of the South Island and include the most intensive mixed cropping and fat lamb raising areas of the country. The soils are nearly all silt loams and the value of these soils for farming is determined by the depth of the soil overlying

the shingly subsoil. The stony soils, which are severely affected by drought, are often referred to as "light Plains land." Their use for farming is limited by the temporary nature of most pastures and by the high costs of frequent cultivation. They are being developed in Canterbury for irrigation. The deeper soils are suitable for a wide range of crops and those with over three feet of soil are used for all cereal and pulse crops.

The natural fertility of these soils varies according to their age and their depth. Since most of them are derived from greywacke they are deficient in lime and phosphate but are moderately well supplied with potash. These soils had an excellent granular structure when first ploughed but through consistent cultivation many of them have deteriorated in this respect.

The highland tussock soils are found inland in the basins and on the plateaux of the low ranges. The low rainfall subgroup includes rather coarse textured soils which have been only slightly leached, if at all, and these are well suited to irrigation. They are represented in the upper reaches of the main rivers of the East Coast of the South Island and in Central Otago. These soils are subject to severe winds and water erosion when the protective tussock cover is opened up by overgrazing with sheep and rabbits and by burning.

The high rainfall subgroup includes the soils produced in the wetter districts of inland Otago and Southland. These soils are leached and subject to rapid erosion under conditions similar to those given above.

Meadow Soils:

These soils are produced where the free drainage of water is impeded and are developed most typically in areas where the water table rises to near the surface during the late winter and early spring months. The topsoil is usually a dark silt loam and overlies a rather finer textured clay which is a grey-blue colour stained with pockets and streaks of iron. They often have a layer at a depth of 9-15 inches in which the iron deposited from the water is concentrated as iron pellets or "Shot."

True meadow soils are usually found near the Coast though soils with similar characteristics appear in the leached yellow-grey soil group in the Manawatu and in the podsolic group in the rolling downs of Canterbury and Southland.

All of these soils require drainage and most of them, because of the stiff clay subsoil, are suited to mole drains. When developed they are well suited to permanent pastures

but in the drier districts their rather high natural fertility has led to their use for spring sown crops.

Peaty Soils:

These are produced where the decomposition of organic matter is slowed down by the exclusion of air through the excess water present. Limited decomposition results from the action of anaerobic organisms. Peats produced by the gradual filling in of basins or shallow lakes tend to be mixed with mud and to be rather well supplied with lime and plant foods while peats which are produced on convex surfaces (e.g., Rukuhia) tend to be rather sour and impoverished. The basin peats usually have a succession of vegetation passing from raupo and flax to shrubs and culminating in forest trees which produce the very best deposits (e.g., Marshland), while the convex peats are usually in sedges and manuka and are of poor quality and difficult to develop.

Only small areas of peats are suitable for development and they require drainage followed by consolidation and heavy manuring. Some of the sandy peats require additional potash and those in parts of the Waikato require the application of copper to maintain healthy stock.

Rendzina Soils:

Small areas of rendzina or rendzina-like soils are found in North Auckland, Southern Hawke's Bay and the limestone belt of Canterbury and North Otago. Here the parent material is a rapidly weathering calcareous rock and the profile has a dark, often black, topsoil containing fragments of limestone overlying shattered rock. Under intensive leaching they may develop podsolic characteristics.

Skeletal Soils:

These are very young soils formed on steep mountain country mainly by physical weathering of the rock faces.

Where the parent material is derived from shales they may contain much clay but where it comes from harder sandstones, schists and volcanic rock materials the soil is thin, often unstable, and with low reserves of plant foods and organic matter.

The soils of this group make up a large proportion of the total area of the country and although they have a low value for agriculture or for forestry the protection of these soils against erosion is one of the major problems of the Catchment Boards.

Recent Soils:

These, too, are young soils and their properties are still dominated by the nature of the parent material. They

may be divided into two groups according to the transporting agencies.

(a) The volcanic group associated with the eruptions of Tarawera and more recently, of Ngauruhoe.

(b) The alluvial group produced by the main rivers.

The upper reaches of the rivers tend to produce coarse textured stony materials while finer sediments are deposited near the coast.

Many of the recent soils produced from alluvial materials must be classed among the most productive in the country, but they are often subject to serious flooding, e.g., Manawatu, Heretaunga, Waikato, Taieri and Inchclutha. Where the coarser materials have been enriched by wind blown sediments from the river beds the soils further away from the outlets are also fertile. This is well shown by the soils on the south bank of many Canterbury rivers. There are also thin stony soils and shingle ridges through the deeper soils.

In districts with a reliable high rainfall such as Westland the thin soils are ideal for development, but on the drier Canterbury Plains the finer textured silt loams and even clay loams are preferred.

Man-made Soils:

These are of interest because of their history. To the Maori race the kumara was a staple food and it grew best in an open, free draining, warm, fertile soil. Where such a soil did not occur naturally, the Maoris made one on a suitable terrace or slope. They carried stones and sand in woven baskets on their shoulders, often for miles, and added a new topsoil of about 9 inches in depth. Then, to enrich it, they piled and burned manuka on it. Such soils are spread along the Waikato river and in the Waimea West area of Nelson, and even today they contain considerable reserves of plant foods.

ACKNOWLEDGMENT

The maps and much of the basic material on Soil Groups and their characteristics which are used in this article have been taken from two articles by Dr. L. I. Grange, published in the New Zealand Journal of Agriculture in April, 1945, and June, 1946.

PROJECTS AND QUESTIONS

1. Prepare from the piece maps published in the articles mentioned, complete maps of the main soil types in the North and South Islands and colour appropriately.

2. Take each crop grown in your district and give the best soil type [as expressed on the basis of average yield]

SOILS OF NEW ZEALAND

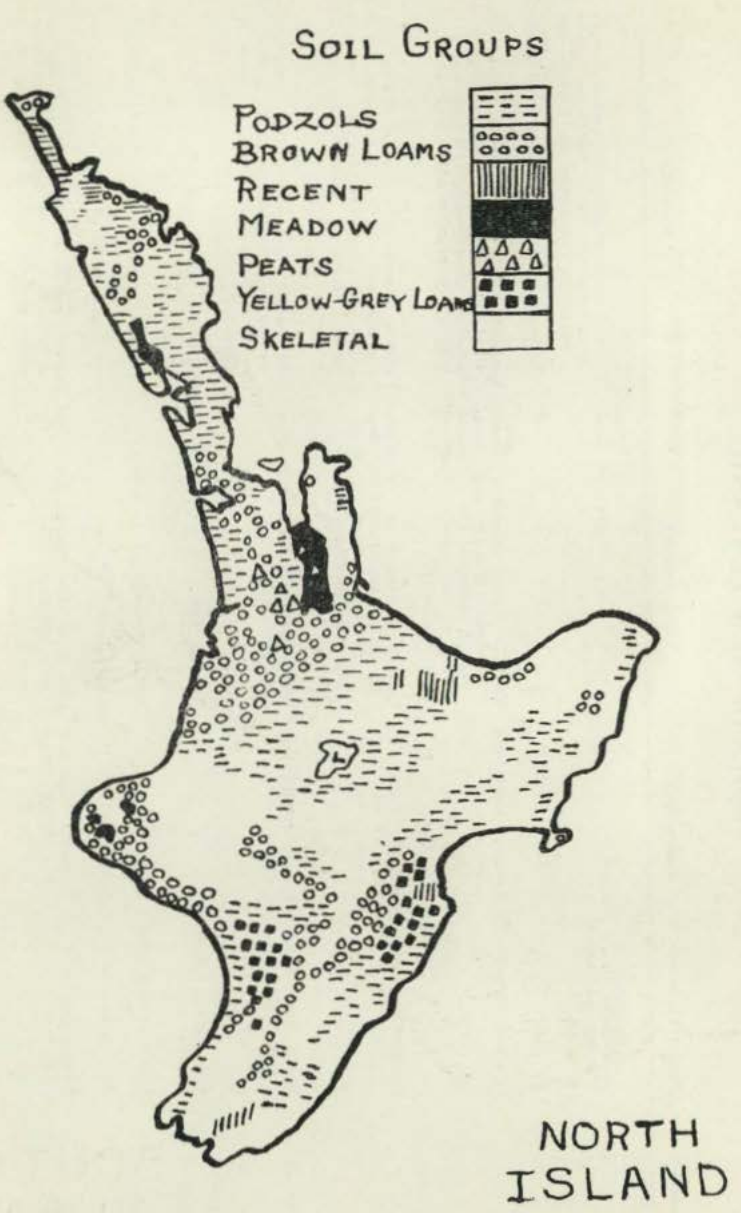
Soil Group:	Parent Material:	Vegetation:	Distribution:	Remarks:
Podzols (a) On Pumice.	Rhyolite pumice from Taupo ash.	Bush and scrub.	Central N.I. Plateau.	Sandy soils subject to drought.
	Kaharoa ash.	Bush and scrub.	Rotorua; Tauranga; Whakatane.	Require consolidation and topdressing with cobaltized superphosphate because of deficiencies of cobalt and phosphate.
(b) On Sedimentary materials & young & immature stages.	Coastal sands.	Coastal scrub.	West Coast N.I.; Manawatu; Raglan and Northland.	Sandy soils subject to drought. Require lime and phosphates.
	Calcareous sandy mudstone.	Forest.	King Country; Wairarapa.	Fertile soils.
	Loess, sandstone & mudstone.	Coastal broadleaf and black beech scrub.	Sounds, Upper Wairau; Kaikoura; foothills of Canterbury; Grey Valley; Nightcaps, Tuatapere, Waikaia districts of Southland.	Dark grey-brown topsoil, over yellowish subsoil. Require rather heavy liming and topdressing.
Semi-mature stage 40"-70".	Sandstone & greywacke.	Forest.	Northland.	Heavy textured soils which require heavy liming and phosphate.
	Granite, greywacke and sandstone.	Scrub, tussock and beech forest.	Nelson; Westland; Catlins.	Thin grey topsoils over yellow grey subsoils. Very poor soils which require heavy liming and topdressing.
Mature stage 70"-180".	Sedimentary rocks.	Formerly Kauri forest, now scrub and fern.	Northlands.	Gumlands. Fully impoverished soils developed under heavy forest. Only those with loamy topsoils and without real hardpans can be developed by very heavy liming and manuring.
	Granite.	Formerly mixed forest, now pakihi vegetation.	Golden Bay; Karamea and Coastal Westland.	Pakihi. Properties similar to gumlands. All have impervious hardpans and waterlogged topsoil.

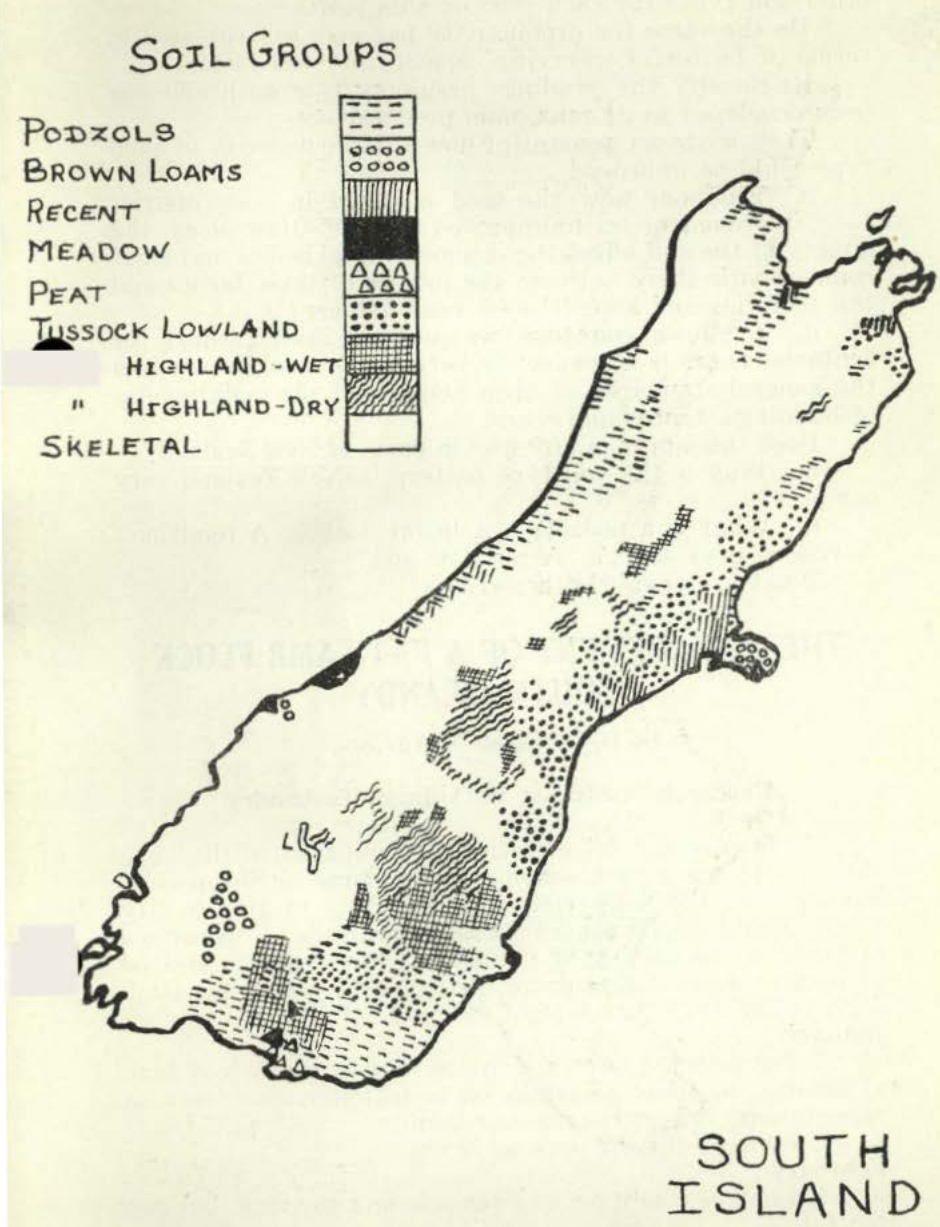
SOILS OF NEW ZEALAND

Soil Group:	Parent Material:	Vegetation:	Distribution:	Remarks:
Brown Loams. (a) Yellow - brown Loams 40″-80″.	Volcanic Andesite ash and Greywacke.	Originally forest & scrub.	South Auckland; Western Taranaki; Dannevirke; Takapuna; Wairarapa on rolling downs; East Bay of Plenty; North Gisborne; Ohakune & Taihape.	Brown granular soils with high capacity to fix phosphates. Require lime and phosphates especially on wetter areas. Natural fertility varies according to locality. Used for dairying, fruit growing and market gardening.
	Glacial and alluvial sediments of Greywacke and granite.	Totara and beech forest.	Lakes District S.I.	
(b) Brown Granular Clays 50″-80″.	Volcanic ash.	Forest, scrub and fern.	Northland between Dargaville and Kaitaia; Waitakere districts; Coromandel; Waikato on rolling country.	Brown granular topsoil with high capacity to fix phosphates. Natural fertility varies according to degree of leaching but with top-dressing these soils are good for dairying and market gardening.
(c) Red-brown Loams 40″-70″.	Volcanic basalt & scoria.	Forest and poor scrub.	Northland; Banks Peninsula.	Younger soils can be developed by liming and top-dressing but older soils are extremely acid and impoverished, e.g., "ironstones."
Tussock Soils. (a) Lowlands 25″-40″.	Loess and loess-like sediments.	Tussock grassland.	Rolling downs and terrace land in Marlborough, Canterbury, Otago and Southland.	Dark grey to black silt loam topsoil over yellow subsoil. Depth of profile varies from a few inches to several feet. Thin soils are severely affected by dry weather and are used for sheep farming and deeper soils for intensive farming (mixed). All respond to lime and phosphates.
(b) Highland 13″-35″.	Mica Schist and Greywacke.	Silver. blue and hard tussock.	Inland basins and plateaux of Mackenzie County & the upper reaches of the main S.I. rivers.	Usually light coloured coarse textured soils. Subject to erosion. Fertility is high on the lower rainfall areas but rather low in the high rainfall areas.
(c) Highland 30″-60″.	Mica Schist and Greywacke.	Snow and red tussock association.	Inland basins and high plateaux of Otago and Southland.	Dark brown topsoil over yellow subsoil. Deficient in lime and phosphates and subject to erosion.

SOILS OF NEW ZEALAND

Soil Group:	Parent Material:	Vegetation:	Distribution:	Remarks:
Yellow - grey Loams 30″-45″.	Calcareous mudstones and sandstones.	Forest.	Hawke's Bay; Wairarapa and Manawatu.	Where the parent material contains much lime these soils are fairly fertile and need only phosphates, but where the lime is low they tend to produce slight pans and to require drainage as well as liming and topdressing.
Meadow.	Alluvial deposits.	Sedges, rushes and flax.	Hauraki Plains; Waikato; South Taranaki; Ruawai and Awanui in Northland. Coastal areas of Canterbury, Westland and Southland.	Soils with high water table in winter. Usually silt loams over mottled clay. Require drainage and often liming and topdressing. They are very productive after development.
Peats.	Organic materials.	Sedges, raupo, manuka, flax, forest trees.	Lowlying areas of Waikato, Hawke's Bay, Northland, Bay of Plenty, Canterbury, Westland and Southland.	Fertility depends on nature of the plants forming the peat and its lime content. Woody peats are usually better than fibrous peats. Require drainage, consolidation and careful manuring.
Skeletal Soils.	Rocks and mountain ranges.	Forest, scrub, and alpine plants.	High country throughout New Zealand.	Thin topsoil over rocky subsoil which varies in quality according to the type of rock. Erode easily and tend to revert to scrub in wet districts.
Recent. (a) Volcanic.	Rotomahana mud, 1886.		Rotorua East.	Fertile grey sandy loam.
	Tarawera ash, 1886	Scrub.	North and east of Tarawera.	Droughty gravelly sands of low fertility.
	Ngauruhoe ash.	Scrub.	Ngauruhoe.	Poor coarse textured soils.
(b) Alluvial.	River deposits.	Tussock grassland to scrub and forest.	Plains of the main rivers in both Islands.	Fertility varies from that of the thin gravelly soils to that of the deep rich silt loams. Includes the best soils of New Zealand.


SOIL GROUPS
PODZOLS
BROWN LOAMS
RECENT
MEADOW
PEATS
YELLOW-GREY LOAMS
SKELETAL
NORTH
ISLAND


SOIL GROUPS
PODZOLS
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RECENT
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TUSSOCK LOWLAND
HIGHLAND-WET
" HIGHLAND-DRY
SKELETAL
SOUTH ISLAND

a top mark of 10 [on a scale of 1-10] and then grade all other soil types for each crop on this scale.

Do the same for productivity per acre as expressed in terms of butterfat, carrying capacity or wool yield.

Re-classify the gradings assuming that each soil has been developed to its maximum productivity.

Then write an account of how the productivity of each type could be improved.

3. Find out how the land is taxed in your district —on improved or on unimproved value. How does the quality of the soil affect the income of local bodies and what connection is there between the income of these bodies and the facilities and amenities of your district?

4. In those countries which have been farmed for centuries there is a connection between the soil groups and the general standards of farm homes and the maintenance of buildings, fences and roads.

Does this apply in any way in parts of New Zealand?

5. Why is the soil type pattern in New Zealand very complex?

6. What is a podzol? A brown loam? A rendzina? A yellow--grey loam? A meadow soil?

What are their characteristics?

THE MANAGEMENT OF A FAT LAMB FLOCK (SOUTH ISLAND)

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(This calendar of operations is published in the hope that it will serve as a scheme for a course in Sheep Husbandry. At the same time it should help to give to city teachers and pupils some idea of the variety of operations involved in the raising of fat lambs. We would be pleased to publish a similar calendar for a North Island fat lamb farm or for any other type of farming.—Editor.)

January

1. Put selected ewes and lambs on best green feed such as lucerne, or wean all lambs on to fattening feed such as rape, lupins, Italian ryegrass or turnips.

2. Crutch, dip and dose all lambs.

February

1. Control condition of ewes—fit and thriving, but not too fat.

2. Place rams on good pasture.

3. Select breeding ewes. Examine carefully teats and udder.

4. Dipping.

5. Footrot—examine and trim feet. Put through foot bath. Return to a paddock which has been spelled for three weeks.

March

1. Flush ewes on special feed.
2. Provide extra feed for rams.
3. Crutch ewes—a light pre-tupping crutching.
4. Check on footrot.

April

1. Turn rams out.
2. Raddle rams for lambing groups, changing colour every 17 days.
3. Check activity of rams.

May

1. Take rams out about end of month.
2. Dispose of empty ewes.
3. Vaccinate ewes for pulpy kidney—first injection.
4. Commence winter feeding programme for hoggets and ewes.
5. Drench hoggets for worm control.

June

1. Winter feeding. Feed for 100 ewes for 100 days—4 acres green feed, 4 tons good hay, 40 tons of roots or equivalent.

July

1. Winter feeding—increase the ration during cold weather.
2. Crutch ewes. Clip round and forward of the udder.
3. Draft off the poorer ewes for special treatment.

August

1. Winter feeding—improve the quantity and quality of the ration to control pregnancy toxæmia and milk fever.
2. Vaccinate ewes for pulpy kidney—second injection.
3. Draft ewes into lambing groups. Place the first group on the best feed.
4. Provide lambing pens.

September

1. Lamb the ewes on to green feed.
2. Watch for outbreaks of milk fever—have the necessary equipment on hand.
3. Draft off the second lambing group.
4. Continue supplementary feeding.

October

1. Lamb marking. Mark in temporary yards on clean pasture. Mark only fit and thriving lambs.

2. Vaccinate lambs for pulpy kidney.
3. Watch for scour in ewes. If parasitic, treat with Phenothiazine; if dietetic, control with dry feed.

November

1. Rotational grazing of pastures.
2. Supply dry feed if necessary.
3. Dip ewes and lambs together in Derris dip (if necessary).
4. Shear hoggets and rams.

December

1. Maintain good supplies of feed and water.
2. Shear ewes.
3. Dip rams.
4 Crutch lambs (if necessary).
5. Sell the first draft off the mothers.

ANSWER TO CORRESPONDENT

What is Silt?

From the soil scientist's point of view, silt is one of the fractions into which the mineral portion of the soil is divided during mechanical analysis. It forms an intermediate grade between the inert sand particles and the reactive clay particles. On the international scale it includes the particles within the size range of .002 to .02 millimetres; in the United States the range is .005-.05 millmetres. The silt fraction includes particles with nuclei of comparatively unweathered minerals of quartz and the felspar group coated with clay of secondary origin from weathering. Silt has properties somewhat similar to those of clay but to a lesser degree. It is not flocculated, and thus rendered less sticky by the use of lime, nor do frost and cultivation induce the crumbly condition which can be produced with clay. Silt imparts to dry soil a floury feel, and to wet soil a smooth plastic feel.

The term "river silt" has no scientific meaning. It is generally used to describe any soil deposited by a river overflowing its banks. Such a soil may consist largely of sand; it may contain little of the silt of the soil scientist.

BOOK REVIEW

THE SOILS THAT SUPPORT US—Chas. E. Kellogg.—

The MacMillan Co., New York

(An introduction to the study of soils and their use by men.)

This is the first book on soils we have seen which we

can recommend as equally suitable for the agriculture, geography and social studies classes of secondary schools. It is written for the general reader, the student, or the scientist who wishes to know something about the nature, use and conservation of soils, who needs a broad view, and who has not the time nor the inclination to be initiated into the mysteries and jargons now apparently inseparable from advanced physics, chemistry, geology and biology. The general philosophy behind the book is exemplified by this quotation from the preface: "But beyond its interest as natural history, the soil lies at the very foundation of our existence as cultural beings."

While the introductory chapters on soil building, the parts of a soil, life and the soil, the hydrologic cycle, and the various great soil types will be of general interest and of special value to the agricultural teacher, it is the second part of the book which breaks new ground in such a way as to make it almost indispensable to the social studies library. Commencing with man as a nomad, his relationships to the soil are traced, stress being laid on the influence the character of the soil has had on human culture. "Men adopted certain practices, certain modes of living, and certain ideas because of what they must do to make a livelihood from the soil. In turn, the culture coloured their notions of the soil. Frequently it has happened that great cultures have developed and civilizations flourished, only to lose their adjustment to the soil." A useful chapter on "Soils for Different Crops" draws attention to the dangers of over-specialization and also to the desirability of farm families producing more food at home. "A garden with small plantings of a wide variety of vegetables, fruits and flowers is as interesting as it is useful."

Cultivation, fertilizers and lime, and the control of water are all described in relation to different soil types. Then the author turns to answering the question, "When do soils wear out?" preparatory to two chapters on "Planning the Use of Soil" and "Soil and Our Future." In connection with these problems he stresses that, "On different soils, people must use entirely different methods not only as individual farmers and gardeners, but also as communities. . . . People on any soil must have sufficient freedom to adapt their ways to the local conditions, else the people and the soil both are bound to deteriorate."

He shows how the older civilizations developed largely on one general type of soil: the Egyptian on the alluvial soils along the Nile; the Classical on the red soils around the Mediterranean; the Arabian on the soils of the deserts and semi-deserts; and the Western on the light-coloured,

forested soils of Western Europe, North-Eastern United States, Eastern Canada, and parts of Australia and New Zealand. Dr. Kellogg claims that "Great cultural ideas seem to be born in the nursery of unspoiled rural landscapes. It is in the city that styles and dogmas develop, but the course is set before cities are built, by men with roots in the soil. . . . The emphasis of the city seems to be more upon engineering, money and power than upon living and growing. . . . The 'business of farming' has replaced the 'art of agriculture.' 'Soil' becomes 'land' or real estate. The cities tend to dominate the people on the land through their control of finance and politics, and country people now look to the city for nearly all education, culture and amusement."

In commenting on the problem of soil erosion, Dr. Kellogg again stresses the social aspect. "The remedy for soil depletion must come along with a remedy for the social problems that are responsible. Soil erosion is an important symptom of bad relationships between people and soil, just as a headache is often a symptom of some more fundamental illness. Civilizations can hardly be said to have declined from soil exhaustion—soil exhaustion is more a result of the decay of the people, of the civilization."

In conclusion, the author makes an appeal for the adjustment of agricultural people to the soil upon which they live. He asks for a combination of what he calls liberalism and science. "If by liberalism one means a system of economic and political institutions that gives the greatest opportunity for individual self-development without special privilege to any; and if by science one means the objective unbiased study of our environment and our relationship to it and to one another, in order to predict the results of actions; then the perfection of these two concepts must lead to a secure future for both soil and people."