Reply: (1) I think first of all you must realise the personnel of the Conference. I told you that we were charged to prepare a treatise without responsibility other than our belief that what we were doing or saying was the right thing. My good colleague, Mr Duncan, aptly described the conference as "a conference of slaves as opposed to masters". In other words, the delegates at the Conference were not Ministers or members of the legislature of any of the countries represented, or if they were they were not there in that capacity. I think I can say quite definitely the people who signed the report of the Conference signed it willingly and in all good faith. (2) The situation now is that the constitution of the Food and Agriculture Organisation has been presented to Governments and the Governments must decide themselves whether they are prepared to become signatories to that constitution. They may not all sign, but I cannot see that they will fail to do so, particularly as the people who will have to be the suppliers, as it were - the leading nations - will do so. I don't think there will be any doubt that Great Britain, the United States of America, Russia, or China will sign. Therefore, the other countries, many of them South American and Continental, have everything to gain through signing it. That remains to be seen. The Organisation will, however, go on even though they do not all sign the constitution.

Mr R.E.R. Grimmett: Was the Argentine represented, and what is her position likely to be?

Reply: The Argentine is not a member of the United Nations and therefore was not represented at the Conference. What her position will be is hard to say. I personally would not like to offer an opinion at this stage.

Mr W. Metcalfe: Is that true of all neutral countries?

Reply: Yes. Denmark was represented at the Conference, but not officially.

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"SOILS AND FOOD PRODUCTION"

by

N.H. Taylor, Soil Survey Division.
(Read by Dr Grange)

The primary production of a country may be said to depend on three main factors:- the type of soil, the type of farmer, and the type of opportunity given him to produce. These three factors are not entirely independent. Each reacts upon the other.

The type of soil, which is inclusive of climate, topography, and other soil forming agents, exerts a fundamental influence on production, for although it has been often said that in New Zealand we can grow good pasture regardless of soil type, the statement, at its best, is only a half truth, and there are practical limitations exerted by the soil which force the farmer into certain lines of production.

Natural fertility (richness in plant foods) does not necessarily lead to the greatest productivity, in fact many of our best producing dairy soils are low in natural plant foods. They have, however, the advantage of having a moderate capacity to absorb bases, a texture light enough to stand heavy stocking, and an adequate supply of moisture. Such soils are readily improved by manuring, and become progressively more fertile as the years go by.

Any drive towards increased production must be along the lines of what might be redundantly termed "permanent farming". The nation's soils should be utilised to the full, but on no account should they be impoverished.

Part of the duty of the Soil Survey Division is to undertake the stocktaking of New Zealand's soil resources, and to endeavour to understand how our soils are being affected by the use to which we put them. This can be done adequately only after a soil survey of New Zealand has been completed and the necessary information tabulated against the area of each soil type. The following estimates are necessarily based on inadequate information, a state of affairs which it is hoped shortly to correct.

Soil Resources of North Island

Following the completion of the general survey of North Island soils, an attempt was made to summarise the potential fertility of the soil types in map form. The land was divided into six main classes as explained by Grange in his paper "A Basic Scheme for Land Classification".

"Class 1. Level or undulating land, not too elevated, with deep soils and favourable moisture conditions, and which can be converted into high quality farming land.

Class 2. Ploughable land which can only be converted into fair or medium quality farming land on account of some limiting factor to productivity.
Group (a) Soils in which moisture is a limiting factor.
Group (b) Soils in which some other factors such as texture, structure, drainage, elevation, or depth of soil is limiting fertility.

Class 3. Ploughable land which has severe limitations to productivity and requires more investigation before development is attempted.

Class 4. Hilly or steep land which will maintain grass pasture with little or no topdressing. Both topsoil and subsoil are of high fertility, and erosion is not a serious problem.

Class 5. Hilly or steep land of moderate to low fertility. Light topdressing is required to maintain a cover of grass and careful management necessary to prevent soil erosion.

Class 6. Hilly or steep land which has severe limitations to utilisation, such as low fertility or credibility. This class is probably more suited to forest than to grass.

"Limitations that cannot be reasonably remedied are really in the main the basis for classification. They may be due to adverse climate, to shallowness or lightness of the soil, producing droughtiness, to heavy texture making extensive drainage necessary, to the presence of a pan impeding drainage, to the presence of many logs and stumps as on peaty land, to the serious risk of soil erosion, or the extreme poverty of the soil in plant nutrients, particularly on hilly and steep country."

Examples of the soils in the various groups are:-

Class 1. Brown loams of Taranaki and Waikato, the soils surrounding Palmerston North, the alluvial flats of Hawkes Bay and Gisborne, and the best volcanic lands of North Auckland.

Class 2a. The sandy soils of Foxton District.

Class 2b. The pumice soils of the Rotorua-Taupo district, and the gumland soils of North Auckland.

Class 3. The soils of exposed uplands such as Kaingaroa Plains, the deeper peaty soils of the Waikato and North Auckland, areas flooded for the greatest part of the year, the ironstone and sandy gumland soils of North Auckland, and dry gravelly river flats.

Class 4. The fertile papa hills of Gisborne, Hawkes Bay, and Taihape districts, and the limestone hills of North Auckland.

Class 5. The yellow forest soils extending from Waikato Heads to Raglan, the better sandstone and greywacke hills of North Auckland, and the partly pumice-covered sandstone and papa hills of Hawkes Bay and Gisborne.

Class 6. The steep land of the Tararua, Ruahine, Raukumara, and Coromandel ranges, and the steep land of eastern Taranaki. Also included in this group are the hilly lands of low fertility, such as the gumland hills of North Auckland, and the poorer pumice hills of the Central North Island.

Grange set out a preliminary estimate of the areas of the six classes in the North Island, as follows:-

Class 1.	3,760,000	14 per cent
Class 2.	2,505,000	9 " "
Class 3.	1,879,000	7 " "
Class 4.	2,071,000	7 " "
Class 5.	2,757,000	10 " "
Class 6.	14,740,000	53 " "

In an endeavour to estimate how these soils lie within the land districts of the North Island, the areas of each class within a district were roughly computed by dividing the map into squares. Grange's totals of each class were taken as correct, and the acreage of each class was proportionally distributed to each land district in accordance with the approximate estimation made. For all land districts other than North Auckland, the total area thus obtained was within 5% of the Year Book total. For North Auckland the error is 8% too low. The figures obtained are shown in Table 1. They are not accurate enough to be used for other than general deductions.

TABLE 1:

Approximate Areas of North Island Soils in Different Land Districts. (Acres)

	Class 1	Class 2a.	Class 2b.	Class 3	Class 4	Class 5	Class 6
N.A.	660,000	-	630,000	383,000	195,000	573,000	1,340,000
S.A.	1,118,000	-	871,000	1,086,000	104,000	968,000	3,900,000
Gis.	175,000	-	155,000	53,000	387,000	243,000	2,690,000
H.B.	561,000	7,000	226,000	66,000	328,000	223,000	1,480,000
Tar.	436,000	15,000	159,000	26,000	57,000	149,000	1,590,000
Wgn.	810,000	233,000	209,000	265,000	1,000,000	601,000	3,740,000
Total	3,760,000	255,000	2,250,000	1,879,000	2,071,000	2,757,000	14,740,000

In Table 2. are given the stock carried in each land district in 1900 and 1940, together with an estimate of the comparative carrying capacity of the soils of Classes 1, 2, 4, and 5. The comparative carrying capacity is based on the following figures which are meant to represent averages which can be attained by moderately good farming methods:-

Class 1: $\frac{2}{3}$ cow.
Class 2: $\frac{1}{2}$ cow.
Class 4: 3 sheep per acre.
Class 5: 2 sheep per acre.

TABLE 2:

Estimated Comparative Carrying Capacity of Classes 1,2,4, & 5. North Island Soils compared with Stock carried on All Soils in 1900 and 1940.

Land District	Dairy Cows 1900	Dairy Cows 1940	Estimated Carry Cap: Classes 1 & 2b. soils	Other Cattle 1900	Other Cattle 1940
N.A.	42,355	381,173	650,000	108,686	346,999
S.A.	28,305	612,847	1,035,600	114,217	546,040
Gis.	4,777	50,530	168,400	40,030	295,032
H.B.	13,662	63,404	449,300	92,063	340,654
Tar.	77,023	240,351	343,700	109,541	167,111
Wgn.	80,828	252,588	609,700	208,638	633,995
Total	246,950	1,600,893	3,256,700	673,175	2,329,831

The figures show that the great expansion in the dairying industry over the past forty years is not likely to be arrested for the want of land adapted to dairying.

TABLE 2. (Continued):

Land District	1900	1940	Estimated cap. of Classes 2a. 4 & 5 soils.
North Auckland	412,359	1,088,958	1,731,000
South Auckland	472,205	2,317,162	2,248,000
Gisborne	1,194,881	2,339,297	1,647,000
Hawkes Bay	3,327,364	4,149,251	1,451,000
Taranaki	283,329	760,555	514,000
Wellington	4,308,034	6,525,652	4,901,000
Total	9,998,172	17,180,875	12,492,000

In Table 3. the data is reduced to sheep units for purposes of comparison.

TABLE 3:

Estimated Comparative Carrying Capacity in Sheep Units of Classes 1, 2, 4, & 5. North Island Soils compared with Sheep Units carried in 1900 and 1940.

Land District	1900	1940	Estimated cap. of Classes 1, 2,4, & 5 Soils
North Auckland	1,101,233	4,763,992	5,631,000
South Auckland	1,098,904	8,178,404	8,461,600
Gisborne	1,333,663	3,822,605	2,657,400
Hawkes Bay	3,777,588	5,891,291	4,146,800
Taranaki	1,183,631	2,871,105	2,576,200
Wellington	5,627,554	10,577,160	8,559,200
Total	14,172,573	36,104,557	32,032,200

The results indicate that in all districts except North Auckland and Auckland, increased dairying is likely to take place at the expense of the sheep population.

In North Auckland the present stock could be carried with ease on the Class 1, 2, 4, and 5 soils and, without using Class 3 and Class 6 land, there is room for a 20% expansion. Similarly in South Auckland there appears to be room for a 3% expansion along these lines. This expansion, however, will depend on adequate supplies of water being available. Particularly does this apply to North Auckland where in many places water supply is a limiting factor in dairy production.

Figures for Gisborne suggest that a high proportion of the stock is carried on Class 6 soils, and the same applies in a lesser degree to Hawkes Bay and to Wellington. The question arises as to whether production from such lands can be indefinitely maintained.

Expansion of production in North Auckland and Auckland districts can still take place to some extent in the old fashioned way of bringing in unfarmed and partly farmed lands with known and well tried methods of farming. In other land districts, however, increase in production appears to call for a more intensive use of the soil resources.

Soil Resources of South Island.

For the South Island the soil information at present available is incomplete, for field surveys have been conducted over only about two-thirds of the South Island, and most of this is on a reconnaissance basis. The following data is prepared from information compiled from surveys by officers of the Cawthron Institute in Nelson, and C.S. Harris, A.C.S. Wright, H.S. Gibbs, and J.D. Raeside in the remainder of the South Island.

The soils of these areas are tentatively divided into eight main classes which are here denoted by letters to avoid confusion with the North Island classification.

Ploughable Land:

- Class A. Heavy flats and wet land - used for dairying and fattening.
- Class B. Medium flats. Good silty loams and clay loams: Used for cropping and fattening.
- Class C. Good light plains and rolling hills - used for cropping and fattening.
- Class D. Light gravelly plains and poor rolling downs - used for store sheep and some fattening.
- Class E. Poor to very poor rolling and flat land - unsuitable for use without further investigation.

Unploughable Land:

- Class F. Moderately steep to steep hill land - used for breeding and store sheep.
- Class G. High country runs - used for store sheep.
- Class H. Mountain tops and hill country covered by rainfall forest or scrub and unsuited to pastoral use.

(The irrigated areas of Central Otago are included in Class A.)

Table 4. shows approximate estimates for each class in the different land districts, and Table 5. shows the stock carried on these soils in 1900 and 1940.

TABLE 4:

Estimated Areas of Soils of Different Classes in Land Districts of the South Island. (In Acres)

Land District	Class A	Class B	Class C	Class D	Class E
Nelson	91,000	9,000	20,000	38,000	200,000
Marlborough	3,000	32,000	55,000	10,000	-
Canterbury	101,000	220,000	1,100,000	720,000	-
Westland	20,000	-	-	120,000	200,000
Otago	50,000	250,000	500,000	100,000	-
Southland	100,000	400,000	300,000	50,000	100,000
Total	365,000	911,000	1,975,000	1,038,000	500,000

TABLE 4. Continued:

Land District	Class F.	Class G.	Class H.	Estimated Capacity of Classes A,B,C,D, F,H, in sheep units
Nelson	101,000	25,000	3,916,000	614,000
Marlborough	500,000	1,200,000	1,000,000	1,271,000
Canterbury	1,260,000	4,000,000	2,400,000	6,622,000
Westland	-	-	3,500,000	140,000
Otago	2,000,000	4,200,000	2,600,000	6,183,000
Southland	500,000	150,000	5,400,000	3,408,000
Total	4,361,000	9,575,000	18,816,000	18,238,000

TABLE 5:

Stock Carried on All South Island Soils in 1900 and 1940.

Land District	Dairy Cows		Other Cattle		Sheep	
	1900	1940	1900	1940	1900	1940
Nelson	10,241	34,284	18,609	37,585	275,566	448,027
Westland	4,357	14,500	11,434	31,341	28,553	87,559
Marlborough	4,189	14,130	8,347	27,090	789,218	1,145,583
Canterbury	37,568	73,561	55,698	105,293	4,516,955	5,225,945
Otago	43,121	47,001	65,180	69,190	2,514,672	3,948,902
Southland	25,990	65,652	51,812	82,631	1,232,078	3,026,984
Total	125,466	249,128	211,080	353,130	9,357,042	13,883,000

When thinking of increased production two outstanding problems claim the attention. On the nine and one half million acres of high country (Class G.) surveys have shown that at least one half is seriously eroded, and that any attempt to improve conditions will be accompanied by a reduction in the stock carried. The productivity of a great part of these lands has probably been falling for many years, but in Table 5. this is masked by the increased stocking of the plains.

On the plains (Class B., C., and D. lands) moisture is a limiting factor, and the possibility of increased production from irrigation appears to be good.

Some Soil Problems Affecting Production.

Soil is a constantly changing body. It is impossible for the farmer to use the land, and for the soil still to remain unchanged. Where farming and soil conditions are nicely adjusted, the change is early seen in the soil profile. For example, on all good dairy farms, whether the soil was originally the heavy loams of the Manawatu, the lighter loams of Taranaki and Waikato, or the gumlands of North Auckland, the same soil processes are in operation and a new type of profile is gradually being formed. With the raising of the base status of the soil, worms have become active, and

their casts, brought to the surface, gradually bury the crowns of the grasses and clovers which perpetually renew themselves by vegetative reproduction. In some old fields the grasses are now almost entirely re-rooted in worm casts. At the other end of the scale we have evidence of maladjustment on many of our grazing lands, where diminutive lenses of humus, built up beneath each grass tuft, are separated by slowly widening patches of bare ground.

Adjustment of soil and farming conditions is necessary if production is to be increased or even maintained.

All land which is regularly cultivated tends to lose humus. Investigations into orchard lands in North Auckland and into the cropping lands of Canterbury and Otago, show that this danger is very real. It is comparatively easy to get increased production from cropping soils by drawing on the soil reserves, but sooner or later the soil becomes exhausted. Raeside quotes analyses indicating that on some South Canterbury soils the humus has fallen by at least 50%.

Owing to the low natural phosphate of most of our soils, dairying has grown up hand in hand with the practice of topdressing with phosphatic fertilisers, as evidenced by Table 6. Even on land where past topdressing has considerably increased the phosphate status, continued topdressing appears to be necessary to maintain production at a high level. The true role of topdressing is inadequately understood, and more work should be done to elucidate the problems involved.

In 1940, New Zealand manufactured 501,000 tons of superphosphate; a quantity equivalent only to a dressing of 1.6 cwt. per acre over the Class 1 and 2 lands of the North Island.

In the past a not inconsiderable part of this superphosphate has been misused. Added phosphates are best utilised by the plant if the soil is 60% saturated with exchangable bases, and where the soil is naturally acid and but poorly supplied with bases, dressings of lime should be given before soluble phosphates are applied. Similar results are, however, obtained by continuously topdressing the land with soluble phosphates. The active alumina and iron in the soil is precipitated by the phosphate, and the calcium in the superphosphate gradually increases the base status of the soil. This is a slow and costly procedure, but one followed by all too many farmers.

FERTILISERS IMPORTED AND LOCALLY PRODUCED.

	1900	1940
Organic manures (including bonedust)	18,014 tons	4,069 tons
Guano	9,935 "	24,210 "
Other manures, including basic slag and North African phosphate	12,103 "	34,324 "
Superphosphate	-	501,000 "
	40,052 tons	563,603 tons

There is need for a much greater production of ground limestone. In 1941 the total North Island output of lime was 269,000 tons, and Grange has shown that three times this amount is required to give even the farmed ploughable lands the desired annual dressing. In North Auckland where the lime requirement is greatest, the shortage is still more acute.

Investigations conducted in the Waikato and in North Auckland, show that topdressing with phosphate has been accompanied by a steady impoverishment of the soil magnesia and, to a lesser degree, in potash. The drop in magnesia is far greater than the amount removed in farm products, indicating that induced leaching has taken place. Serpentine Super is playing a valuable role in restoring the soil magnesia reserve, especially in areas like the Waikato where the reserve is not very high.

With hill country farming, the most oustanding soil problem is soil erosion, and this problem must be solved before we can be sure of maintaining steady production from these lands. Particularly does this apply to Class F. lands of the South Island, and to the farmed Class 6. lands of the North Island.

New Zealand has large and valuable, though by no means unlimited soil resources, and she has the farmers who, if the post-war years provide the opportunity, will not fail to increase the output of our primary products.

DISCUSSION

Mr G.H. Holford: In Class 1. has there been any differentiation between inherently fertile land, such as Hastings etc., and the areas of induced fertility, such as the Waikato? They are rather grouped together there. I think you will find that the inherently fertile land is not over about half of what you have shown in Class 1.

Reply: They are all lumped together. That is done for simplicity. We found we could get numerous divisions, but we thought it best to start with something simple. You could divide Class 1. into the land with natural fertility, such as Heretaunga and Kairanga, and the lands with induced fertility.

Dr C.P. McMeekan: Why is it that we appear to have carried four million more sheep units in 1940 than we are really capable of carrying? What is the reason for the discrepancy of the estimated total and the actual total of 36 million for the North Island?

Reply: This is largely due to the fact that Class 6. is carrying sheep and we have not put them in. This class - the problem soils - occupies half the North Island.

Dr I.L. Campbell: In a popular movement in New Zealand just now there is quite a lot said about the utilisation of waste organic matter. Could the speaker give us any idea to what extent that material would be available and whether it could be used to improve any particular soil types? In the Compost Club reports and propaganda there is a great deal about town organic waste in general. I am wondering if any application can be made to soil types in farming practice?

Reply: That is a big problem. In Canterbury the organic matter in the soil is on the low side and that is what gives a hard soil in the summer. Any efforts to compost there on an extensive scale are well worthwhile. It becomes a problem in farming if you have dairy cows on the land. In the North Island the humus supply is good, but we believe in composting which can be done economically. In the towns there is really no need for such an extensive scheme; waste should not go out of our homes. We advocate composting wherever possible.

Dr F.B. Shorland: In the estimation of the potential per cow production I see that on the 30% of ploughable land in the North Island Mr Taylor estimates that production could be doubled. I should like to know what estimations are made regarding the use of fertiliser. Does that mean that extra production would be achieved by the use of additional fertiliser? What is the limiting factor. In other words, is it assumed that, to get that extra production we need extra fertiliser, or does it mean that we need extra people to work on the land?

Reply: I think it means both. Mr Taylor has mentioned the increase in North Auckland. That means mainly application of phosphate and of lime, and it means more workers too. When Mr Taylor takes two-