THE IMPROVEMENT OF LIGHT LAND UNDER IRRIGATION ON THE CANTERBURY PLAINS

THESIS
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CANTERBURY UNIVERSITY COLLEGE
UNIVERSITY OF NEW ZEALAND
J.L.N. MOORE
Frontispiece.
The chequer board pattern of the improved dryland farms of the Canterbury Plains.

V.C. Browne Photo
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The light land of the Canterbury Plains consists of alluvial soils of the fans and terraces, having shallow and stony profiles less than eighteen inches in depth and resting on free draining gravels. The soil moisture status of all these soils is below the optimum for plant growth for various periods depending upon the particular soil type and the area in which it is located. The period is, on the average, from one to two months, but in drier areas near the coast, it may be as long as five months.

The water table of these soils is usually at a depth greater than thirty six inches from the surface.

The area of light land is by no means continuous, but extends from the Timaru plateau in the south to Amberley in the north. The eastern boundary is the Pacific Ocean, while the western boundary coincides with the 35 inch isohyet. The reason for drawing the latter boundary line, is that inland of the 35 inch isohyet, showers are regular and there is no appreciable drought period such as is experienced further seawards. The presence of the foothills, backed by the high country to the west, tends to have an orographic effect on rainfall, thus ensuring adequate precipitation.

Large, terraced alluvial fans are associated with each of the major rivers which flow across the Canterbury Plains. The Ashley, Waimakariri, Rakaia and Rangitata rivers all rise in the greywacke ranges to the west. The gravels, sands and silts which have been deposited by these rivers are very thick. The surface has a general slope from the sea to the foothills.

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For other definitions see Appendix I.
FIG. 1 LIGHT LAND ON THE CANTERBURY PLAINS.

[Source: D.S.I.R. Soil Bureau Maps, analysed.]
of thirty to forty-five feet per mile. All the soils found on the fans are derived from the greywacke material. The fans were built up to their present height when the rivers were overloaded with sediment at a time when the land was higher, and severe glaciation and acute frost action occurred. The main structural units of the Canterbury Plains are four in number. These are, the alluvial fans of the great rivers, the depressions between the fans, the present river beds, and the coastal lowlands consisting of sand dunes and peat swamps.

The alluvial fans of the Waimakariri, Rakaia and Rangitata rivers form the initial structure of the Plains and supply the key to the distribution of soil types. These vary from the porous stony surfaces of the upper fans, with their thin veneer of silts to those richer silt and swamp deposits lying within the junctions of the fans, and it is at the junction of these major fans that the smaller streams such as the Selwyn and Hinds rivers (Fig.2.) which rise in the foothills, occupy the interfAN depressions as consequent streams.

With the exception of the Waimakariri river which deviates somewhat from the general south-easterly direction of the others, and which shows a marked tendency to aggrade its lower channel, the Canterbury rivers follow more or less permanent courses. Within the beds, the water courses meander laterally, but in time of flood, they may extend from bank to bank. The material of the valley floor is gravel, often very coarse, but successive submerging of the flood plains leaves a surface film of finer sands and silts.

The coastal lowlands consist of sand dunes and peat swamps of varying sizes in areas all along the coast from Timaru to Amberley. This type of country is particularly evident in the area to the north of the city of Christchurch.
Light land constitutes the bulk of the area covered by these types of land, with the exception of the peat swamp areas which are heavy land.

The climate of the area has two main outstanding characteristics. The rainfall increases from the coast inland, and the area is subject to drought conditions.

The average annual rainfall of the Canterbury Plains is about 27 inches near the coast, while there is an increase towards the foothills to about 45 inches. The gradient is steeper near the hills, where, in the last six miles the rainfall increases from 35 inches to 45 inches. Fig. 3 shows this increase from the sea inland towards the hills. November to January is normally the wettest quarter of the year, while September and October have comparatively high values at Methven, where the north westerlies as they increase during the Spring give appreciable rain. Nearer the coast, the amounts falling with such rains decrease rapidly.

Prolonged dry conditions are likely to occur at any time of the year in areas of light land, but more especially in August or September. In order to understand such conditions, the following definitions are used.

**Absolute Drought:** is a period of at least fifteen consecutive days to none of which is credited 0.01 inches or more of rain.

**Dry Spell:** is a period of at least fifteen consecutive days, to none of which is credited 0.04 inches or more of rain.

**Partial Drought:** is a period of at least 29 consecutive days, the mean daily rainfall of which does not exceed 0.01 inches.

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FIG. 3. INCREASE IN PRECIPITATION FROM THE COAST INLAND.

FIG. 4.
NUMBER OF DAYS OF DRY SPELLS AND DROUGHTS FOR MID-CANTERBURY STATIONS OR WINCHEMORE, ASHBURTON AND LYNNFORD (FIGURES TAKEN OVER A PERIOD OF 10 YEARS). (HINT: "WATCH OUT" TO WORK)

KEY
- Absolute Droughts.
- Dry Spells.
- Partial Droughts.
The frequency with which these droughts and dry spells occur is shown in Fig. 4. The longest partial drought recorded was one at Lynnford near Hinds, (Fig. 2,) lasting for 88 days, commencing on 9th July, 1915 and having a total rainfall of 0.85 inches during the period.

Apart from minor exceptions, there is a tendency for a predominance of drought conditions in late Winter and early Spring. Above all, it is the fluctuations in rainfall from year to year that cause degrees of dryness or drought, and the occurrence of this drought period is very often not predictable. In addition, fluctuations in annual rainfall are often considerable, as Fig. 5 shows for three Canterbury Stations. Most of the hot dry days in the areas of light land are associated with very dry and gusty north-westerly winds. Consequently, the amount of moisture contained within the soil, falls below the optimum required by plants during the major portion of each growing season. Further, the growing season enjoys a higher rainfall than the dormant season. There are two reasons for this. The moisture which can be stored in the soil is only three-quarters of an inch on light land, and the rate of evaporation exceeds the rainfall from October onwards, because of low humidity and the prevalent north-westerly winds. The consequences are that, despite the summer rainfall, the reserves of available soil moisture carried over from the winter period are soon depleted and fall far below the requirements for maintaining a good vegetative growth.

The soils of the area of light land shown in Fig. 1 are light stony silt loams that originally supported a range of vegetation from tussock grasses to swamp plants. The parent material of all the soils is the greywacke rock, which has been eroded from the mountain system to the west of the Plains, transported and deposited by the rivers. The soil rests on closely packed greywacke boulders, gravel and sands. Further,
Eight inches of grey-brown stony silt loam, mixed with weak medium crumb, and some very weak granular structure. It is very friable and powdery when dry.

Eight inches of light brown-yellow stony silt loam, very weak, coarse subangular blocky structure, friable, moderately compact and massive.

On loose brown gravel and stones in a matrix of gritty silt loam.

FIG. 5. AVERAGE ANNUAL PRECIPITATION FOR PAPARUA, ASHBURTON AND WINCHEMORE SHOWING FLUCTUATIONS FROM YEAR TO YEAR. [FIGURES FOR 1941, 1945 AND 1948]

most of the soils have mixed with them, loess blown from the dry river beds, and to a lesser extent contain alluvium deposited by the rivers. Consequently, some soils are more fertile than others, as their phosphate and lime contents are higher. The loess deposits all consist of silt and therefore the resultant soils are practically all silt loams, but the sand, silt and clay content varies, and their depths range from nine inches to three feet. The alluvial soils are chiefly silt loams too, but sands and clay loams occur in some localities. Many light soils are low-lying and have a high water table. 4

The light soils are characteristically nondescript in that soil colours are drab and pale, and there is very little change between the topsoil and subsoil. More detailed observations reveal subtle colour changes ranging from pale grey to pale brown in topsoils and light yellow-brown in subsoils. The essential features of soils on light land are shallow powdery topsoils and slightly compacted powdery subsoil. Furthermore, pebbles, stones and boulders may be present in varying proportions (Figs. 6 & 7) throughout the soil matrix but invariably there is a sharp break between the soil proper and the gravel substratum. 5

Some examples of the soil types which are included under the general heading of light land, would include the most widespread soil type on the Canterbury Plains - Lismore Stony Silt Loam. This soil type is developed on fine stony alluvium, that contains very small quantities of loess. It is shallow, very freely drained, and of low fertility. It has a low capacity to retain moisture and dries out early in summer, to the detriment of crops and pasture lands. A soil profile of this type is shown in Fig. 8. 6

4 Ibid., p. 27.
5 For further information see: Vucetich: op. cit.
6 Information from (Unpublished) "Report" of the Soil Bureau of the D.S.I.R.

FIG. 7. Light stony land poorly grassed, Westerfield area, mid-Canterbury.
For the most part, Lismore Stony Silt Loam lies on flat or very generally undulating land, and, except in some places where the land is broken, the areas are ideally suited to irrigation by border dyke methods. Where boulders and large stones occur, the land is difficult to work, and in these places too, the soil requires greater quantities of water. This is because this soil type has a high permeability and because the soil dries more rapidly where boulders occur. A further limit to production is the low inherent fertility, but it has been found that when the soil is irrigated, the pastures respond well to artificial fertilisers.

The poorest soil type under the classification of light land on the Canterbury Plains is Lismore Very Stony Silt Loam. It is shallower than Lismore Stony Silt Loam, varying in depth from four to twelve inches. Further, it is stonier and more subject to drought. Under dry conditions, pastures quickly deteriorate giving way to Hairgrass, Danthonia, Sweet Vernal, Browntop and Suckling Clover. A typical profile of Lismore Very Stony Silt Loam is shown in Fig. 9.

The soil lies on gently undulating and flat land suitable to the construction of border dykes, but it is very freely drained and hence requires greater quantities of water to secure results similar to those than can be obtained with less water on Lismore Stony Silt Loam. Furthermore, it is of low fertility and for the best results, any irrigating has to be accompanied by dressings of superphosphate and lime.

These two soils - Lismore Stony Silt Loam and Lismore Very Stony Silt Loam - are the most extensive types on the Canterbury Plains, and represent the real "bones" of the light land. There is a correlation between the occurrence of these soil types and the location of the major

7 See Chapter V p. 39.
8 Soil Survey, op. cit.
Six inches of light grey-brown very stony silt loam, weak with a fine crumb structure, and a few very weak lime granules. It is very friable and powdery.

Four inches of dull brown-yellow very stony silt loam, very weak with a medium subangular block structure. It is very friable.

On loose brown sandy gravel and stones, with a gritty silt loam matrix.

Fig. 9. Soil profile of Lismore very stony silt loam.

[Source: Unpublished report by NZR Soil Bureau]

Fig. 13. Trend in wheat acreages and yield per acre for New Zealand 1940 – 1955.

C.E. Kerr's Kerrytown on the Levels scheme. Note the border ditches to the left and right of the homestead block, and the border dykes in other paddock.
irrigation schemes that are in operation or those that are planned. (Figs. 10 & 11.) They are widespread on two Mid-Canterbury schemes at present in operation - the Ashburton-Lyndhurst and the Mayfield-Hinds schemes - on two of the proposed Mid-Canterbury ones - the Rakaia and the Valetta-Tinwald schemes - and on parts of the proposed Central Plains and Oxford schemes. The proposed Barrhill scheme is located on heavy land and here the soil type is classified as Barrhill Sandy Loam.

On the Levelled Plain, the dominant soil type is Templeton Shallow Silt Loam, a type which is light land because it extends to the very shallow depth of eight inches. The soil is subject to drought, and in most years, the pastures suffer from the lack of moisture in Summer and Autumn. Both the land and the soil are well suited to irrigation by border dyke methods, and by this means, production can be increased markedly.

These three soil types, Lismore Stony Silt Loam, Lismore Very Stony Silt Loam and Templeton Shallow Silt Loam, are representative of light land on the Canterbury Plains. All are shallow soils subject to drought, but all respond well to liming, to artificial fertilisers and most important of all, to irrigation.

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9 Ibid.

10 See Chapter V p. 39.
FIG. 10.

THE POOREST AREAS OF LIGHT LAND ON THE CANTERBURY PLAINS—

Lismore Stony Silt Loam

Lismore Very Stony Silt Loam

[From D.S.I.R. Soil Bureau Survey Maps]
CHAPTER 11.

DRYLAND FARMING ON LIGHT LAND.

Today, there are few farms on the light land of the Canterbury Plains that have not been improved. On some, the poor type Danthonia-frowntop pasture swards still exist, but they are not truly representative of the Plains' pasture lands. The tendency has been towards an improved type of dryland farming. Unimproved farms on light land averaged between 600 and 1400 acres in area, and carried under one ewe per acre. Furthermore, the traditional dryland crop, wheat, is no longer predominant on the light lands of the Canterbury Plains.

It is obvious that a great change has taken place in the farming of light land but there are still some farms which have not been improved, and it is possible for a farmer to earn a good living from such land, providing the holding is large enough. Therefore, to assist in the understanding of light land and its present day uses, an historical study of farming on the Canterbury Plains is required.

There have been several major periods of farming on the Canterbury Plains, during each of which, the areas of light land have played an important part. Extensive pastoralism followed the period of initial settlement until this gave way to the period of bonanza wheat farming. This in turn was superseded by a mixed farming economy, and subsequent changes have been modifications and improvements of this system.

The vegetative cover of the Plains at the time of initial settlement was sparse Fescue tussock and Danthonia. This was utilised by the earlier

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12 Ibid. p.2.
13 Loc. cit.
settlers for the grazing of sheep on an extensive basis, and this system of farming forms the first period of agriculture on the Canterbury Plains. In Mid-Canterbury, for example, the whole area was originally divided into thirty-four runs. On these runs, sheep rearing was concentrated on the better lands, while the light land was used as winter run-off country. It was a period above all in which the pioneering spirit predominated with little emphasis on farm management.

In time, this practice of grazing sheep was modified as the large runs were broken up and forage crops were introduced. Also, the open Plains country was suitable for ploughing and by 1851 there were 5,000 acres of wheat on the better land. In the ensuing five years, this figure was to double. But in 1861, the rush of population came with the discovery of the goldfields in Otago, and the country could not grow enough wheat for its requirements. Another result of the goldrush was that workers in the wheat fields of Canterbury felt the urge to go prospecting for gold and the wheat area declined still more because of a shortage of labour. During the next ten years, New Zealand was largely an importing country, and it was not till 1871 that the tide turned, and Canterbury once again grew more wheat than that which could be locally consumed. The concentration of wheat growing on the better soils on the Canterbury Plains took place rapidly and by 1869, was growing by far the greatest acreage of wheat. As yet wheat growing had not encroached on to the light land.

15 Loc. cit.
17 Ibid., p.5.
18 Ibid., p.5.
19 Ibid., p.5.
In these early days, without mechanisation, the painstaking processes of planting, harvesting and threshing had to be done by hand. However, by the 1860's the back-delivery reaper was common and mechanical threshing machines, driven first by horses and then by steam, had appeared. These familiar sights died hard, being conspicuous features of the Plains' landscape, along with the stack and stock. Many of the ancient machines persisted. Tractors were introduced in 1920, tin mills in 1926, and header harvesters in 1929, but even comparatively recently, the traction engine and threshing machine were to be seen at work in the paddocks, or more likely blocking the shingly Canterbury roads.

Wheat growing on the Canterbury Plains assumed a great degree of importance in the 1880's and 1890's. However, it suffered a rapid decline in its relative importance after 1900. The 1880's were a period of financial depression, and although prices were very low, wheat growing paid better than anything else. In addition to this, the cultivation of wheat had become mechanised by the introduction of the drill and binder, and thus large wheat growing farms came into existence. "Longbeach" estate in 1879-80 had 3,000 acres under "grain" with 120 working horses and 20 ploughs of two or three furrows working in one field. "Springfield" estate near Methven, grew wheat on a comparable scale, while many others approached it. This was the greatest period of wheat farming on the Canterbury Plains. However,

20 Ibid., p.5.
21 Ibid., p.5.
22 Tin Mill: A modern mechanical threshing machine.
23 Hilgendorf: op.cit., p.10.
24 Ibid., p.9.
wheat now began to be grown on areas of light land that were unsuited for its cultivation, because the fertility of the land was heavily depleted and yields per acre had begun to decline.

A new development in industry was to play its part in the evolution of the Canterbury Plains farm of today. This was the advent of the frozen meat industry, an innovation which determined that fat lamb raising was more profitable to the farmer than wheat farming. Thus, wheat growing began to decline in deference to other farms of agriculture. Also, other important developments diverted emphasis away from this one-crop exhaustive wheat-growing economy. The rise of the dairy industry following on the clearing of the bush in the North Island, tended to divert attention away from Canterbury. These new developments supported a growing population who were, of course, independent of wheat growing for a livelihood, and thus the area of wheat per unit of population, declined. It may be truthfully stated that the peak of the wheat industry was reached in 1883, when the export total for the country as a whole attained the figure of five million bushels.25

From this time, a decline set in and wheat growing tended to spread more and more on to unsuitable light land, where the same land was used for wheat growing, either continuously or in very close rotation. Part of the land that is today occupied by Lincoln College was cropped with wheat for thirteen years in succession, after being broken in from tussock.26 This practice was characteristic of many Plains farms at the time immediately preceding the advent of refrigeration. Furthermore, as there

25 Ibid., pp.10-11.
26 Ibid., p. 12.
were no manures and little rotation of crops, the wheat yield continued to decline.

By the end of the century, the tide had turned against wheat production. The fat lamb trade was established in the early 1890's, rape was introduced as a regular crop, and the rotation of crops once introduced, checked the fall in wheat yields and turned it into a rapid and continuous rise.27

The declining yields of the 1880's led to a selection of lands suitable for wheat growing, so there was a tendency to avoid light land that was incapable of producing at least thirty bushels of wheat per acre.28 However not all the light land was taken out of wheat. This was a subsidiary influence, and there is little doubt that the great advance in yield in the first years of this century provides one of the most spectacular examples of the advantage of mixed farming on an area such as the Canterbury Plains.

A further decline in wheat production occurred in 1916, 1917 and 1918 when yields were only 21.6, 23.1 and 24.2 bushels per acre respectively.29 These years contributed to the general decline already begun several years earlier. Obviously, the inroads that mixed farming had made into this one-crop exhaustive economy had begun to have their effect. Furthermore, in the years 1917, 1918 and 1920, there were onsets of frost and rust, and although these also occurred after the decline had commenced they helped to accentuate its magnitude.30

27 Ibid., p.12.
29 Ibid., p.13.
These events also coincided with a further great expansion of the dairy industry in the North Island. The attention which was diverted from Canterbury is shown in the livestock figures for the years 1900 to 1920. The number of dairy cows tended to increase, while sheep numbers did not show much appreciable increase.

There were also other causes contributing to the decline in the yield of wheat. For instance, there was the exhaustion of soil fertility even under the rotational cropping which was being practised at the time. The use of superphosphate was begun at Lincoln College in 1903, but its popularity spread slowly until 1910, by which time it was in common practice. From 1910 to 1920 it continued to be used increasingly, while the wheat yields were declining, but it was probably not sufficiently general to maintain the fertility of the wheat-growing land. Wheat growing also showed a tendency to be less frequent on light land, the better areas of heavier land being used more.

After 1920, there occurred a steady rise in the wheat yield. Good Spring rains preceded the harvests of 1927, 1928 and 1929, assisting the growing of wheat on the better land. In addition, after the Depression of the 1930's, the very high yields were helped by favourable seasons, since no cultural operations could have produced such high yields in unfavourable weather. Other factors contributed to the general improvement in yields especially on light land, and three of these are important. The widespread use of tractors, allowing early, deep and frequent cultivation of land intended for wheat, was a great boon to Canterbury farmers. As the period between harvest and seed time was so short, the

31 Ibid., p. 13
32 Ibid., p. 15
land was frequently so hard that horse labour was unable to do all the work required. Consequently, the tractor came in as a valuable adjunct at this time. The tractor was able to deal rapidly with the loamy soils of the Plains when they were in the best condition for working. The tractor also induced deeper ploughing, so its influence in the agriculture of the area is noteworthy.

The introduction of superphosphate on to light land was beneficial to dryland crops, and later most important in the cultivation of irrigated crops. Finally, better wheat seed and better varieties of seed were being introduced. Much research had gone into the seed that was being used, and the evolution of new strains by the newly formed Wheat Research Institute did a great deal to foster the growing of better crops.

It is characteristic of the past twenty years that the decline in wheat growing has been offset by increased wheat yields. However, the diversification of farming and the emergence of the Canterbury Plains' mixed farm, virtually saw the end of the widespread wheat farming on the poorest of the light land. The increase in the acreage of permanent and short rotation pastures has been the result of much extensive research by the Grassland Division of the Department of Agriculture at Palmerston North into Subterranean Clover, Perennial Rye-grass and White Clover.

The sharp decline in the wheat acreage following the very high price season for wool in New Zealand during 1951 and 1952 is evident in Fig. 15. This is seen in the substantial decrease in 1952. The following season was an increase, but since that time, the area devoted to wheat has declined year by year. The decline in wheat acreage is a feature of each county of the Canterbury Plains (Fig. 14.)


KEY TO COUNTIES:
1. Kowhai, Rangiora, Eyre.
3. Ashley, Oxford, Towera, Malvern, Selwyn.
4. Ashburton.
5. Geraldine.
6. Levels.

[Source of Figures:
This historical resume of dryland farming shows that there have been several major periods of farming on the Canterbury Plains. At first there was the era of the pastoralist, grazing his flocks on the few natural grasses and induced poor-type pastures. Next, there grew up the one-crop exhaustive wheat-growing economy. Later, there was the rise of mixed farming, spurred on by the inauguration of refrigeration in the 1880's, and finally, the improvement of dryland methods under good husbandry, the use of fertilisers, superphosphate, pure seed, disease control and the introduction of the tractor.

An important fact emerges from these conclusions. Unimproved dryland farming has been superseded by an improved type of dryland farming. Today, there are very few acres of light land on the Canterbury Plains that have not been influenced by the improved techniques of modern farming. Some farms however, are still characterised by rough, parched, poor pasture associated with the Danthonia-Eragrostis swards. (Fig.15.) But with the transition to a mixed farming economy, a gradual change has come over the light free-draining lands of the Canterbury Plains, a change which is reflected in the landscape of today.

Portions of the Valetta area (Fig.2.) of Mid-Canterbury offer an example of unimproved light land. This area is located between the Ashburton and Hinds rivers from four to ten miles west of the main trunk railway, and covers an area of some 12,000 to 15,000 acres.34 This type area occurs again in the Hinds-Coldstream area, in the Orton district south of the Rangitata river and again at Bankside, north of the Rakaia river.35 (Fig.2.)

34 Whatman: op. cit., p.2.
35 Loc. cit.
FIG. 15  A 400 acre paddock of poor pasture on light land, Valetta area, mid-Canterbury.

In the Valetta area, the size of holding is up to 1500 acres in area which is nearly four times the average size of the Plains' mixed farm.\(^{36}\) Generally the existing pasture sward is used with the addition of sufficient winter feed to maintain the flocks of sheep. Consequently some fields of fodder crops are present. But the dominant feature is of wide expanses of pasture land. Indeed, some of the paddocks are as large as 400 acres (Fig.15) or as big as most improved Plains' farms located on light land. Stones are found in abundance on all paddocks, while second growth scrub, gorse and broom are evident on areas which have been neglected. Shelter belts are present, bordering many fields, with large clusters of exotic pines near the farmsteads. This pattern at Valetta is generally representative of extensive farming on unimproved light land.

The characteristic soil type in the Valetta area is Lismore Stony Silt Loam.\(^{37}\) It consists of very light, fluffy, light brown topsoil about six inches deep, mixed with varying amounts of shingle and small stones, all on gravel. In its unimproved state, the pasture is mainly Danthonia, some hard tussock \((\text{Festuca novae-zealandiae})\), latagouri, flatweeds and moss. The soil has a low inherent fertility, and the carrying capacity is from one half to one ewe per acre.\(^{38}\) For this reason, limitations have been placed on the amount of development that is profitable for a farmer to carry out. The soil has a low water-holding capacity, while it is also susceptible to grass grub attack.

\(^{36}\) Ibid., p.2.

\(^{37}\) See Chapter 1, pp. 6-7.

\(^{38}\) Whatman: op.cit., p.2.
This is poor land, neglected because of its inherent disadvantages.

From this example, it can be seen that there are severe physical limitations to dryland farming. The farmer on this type of country is always in fear of a drought between late Spring and mid-Autumn. His standing flock must be regulated to the dry months of the year. This means that in the wet months, the pastures can not be efficiently controlled. They become long, stemmy and unpalatable in early summer, while during the remainder of the summer and autumn, they are burnt up, and hence overstocked. The result is the weakening of the pasture, especially the clovers, and finally, the deterioration of grasses and clovers, with their replacement by weeds such as Catsear, Hairgrass and Sweet Vernal.39 Seven to eight hundred acres is the minimum size for a farm on this light land, as smaller units tend to be uneconomic.40

These characteristics of unimproved dryland farming on the light land of the Canterbury Plains are today limited to only a few small areas. The great majority of farms have been improved, are smaller and much more productive.

39 Ibid., p.4.
40 Stewart: op.cit., p.3.
CHAPTER III

IMPROVED DRYLAND FARMING ON LIGHT LAND

From the beginning of the twentieth century, most Canterbury Plains' farms on light land have evolved systems of farming to suit the physical conditions, and today are achieving a reasonable standard of production of wool, meat, cereals and small seeds. Under the improved system of farming, a fifty per cent increase in production over pure dryland farming can be achieved. The use of lucerne, subterranean clover, the improvement of pasture species, the use of lime, superphosphate and D.D.T. have all been factors in this intensification of farming on the light soils of the Canterbury Plains. An improved dryland farm is much smaller than an unimproved dryland farm, being a more economic unit, and more typical of the mixed farm of today.

Within the area of light land delimited in Fig. 1, most farms have been improved, the great majority falling within the category of "improved dryland farming." These farms are typical of the Canterbury Plains' landscape today. This chapter deals with these, while farms associated with irrigation are discussed in Chapter IV.

An improved dryland farm has the appearance of being "farmed" in contrast to an unimproved dryland farm. The holdings are very much smaller, being on the average 350 to 400 acres in area, while individual paddocks are also very much smaller, generally from 30 to 50 acres in area. The gorse fence is still present, but later subdivision under improved techniques is evident from the number of wire fences and wooden gates within this pattern. Shelter belts also show this feature of the old and the more recent in that the one lining boundary fences are old and have usually been decapitated, while newer ones are to be
found within the farm. (Fig.16.) The species is *Eucalyptus radiata*
but macrocarpa, poplar and bluegum are distinctive in some areas
particularly in South Canterbury.

The pasture swards on an improved dryland farm are better, both in
appearance and in their longevity. The ploughed paddock is not such a
common sight on these farms today. With improved techniques, pasture
renewal becomes less frequent, and more permanent pastures and short
rotation pastures are present. Furthermore, weed invasion is not so
obvious here as on unimproved land, there being fewer thistles, browntop,
sweet vernal and other poorer type grasses. Another feature of these
farms is the presence of lucerne in particular, and other fodder crops.
These stand out in an aerial photograph very well as black patches on
the patchwork quilt pattern of the Plains.

Farm buildings show a marked increase in numbers. The old original
homestead may still exist, but within the farm these may be one or even
two additional dwellings, for the extra labour. Newer and larger
woolsheds and sheepyards show the fact that larger flocks have been
introduced. In addition, barns and implement sheds are usually present
in larger editions than on unimproved farms. Farm buildings and transport
facilities show much greater development on improved dryland farms.

It is important to note that under this system of farming, the
carrying capacity has risen by at least fifty per cent. A four hundred
acre farm here can usually carry 800 to 1000 ewes,40 a figure which is
much greater than on unimproved farms. Greater returns from such a farm-
ing system are only natural with the use of better techniques.

40 Whatman: op. cit., p. 4.
What then are the factors which have influenced these great changes? There have been two main developments which have proved beneficial to improved dryland farming techniques. One is the introduction of subterranean clover, and the other, the increased use of lucerne as a feed crop.

Subterranean clover was first introduced after the Depression of the 1930's, as soon as farmers were in a position to improve the carrying capacities of their property. It was first used at Lincoln in 1937, and Lincoln Agricultural College showed the way to a brighter future for improved dryland farming on light land. It was not long before farmers realised that the intelligent use of subterranean clover, together with increased liming and topdressing programmes was reflected in their increased carrying capacities, and also improved financial returns. Of fourteen farms in mid-Canterbury which were examined, seven had developed the use of subterranean clover, lime and superphosphate and seven had not. Fig. 19 shows the carrying capacities of these fourteen farms.

**Fig. 19. CARRYING CapacITIES OF FOURTEEN MID-CANTERBURY FARMS.**

<table>
<thead>
<tr>
<th>No. of farms</th>
<th>Total area (approx)</th>
<th>Total No. of ewes</th>
<th>Carrying capacity- ewes per acre</th>
</tr>
</thead>
<tbody>
<tr>
<td>Farms with subterranean clover, lime and superphosphate</td>
<td>7</td>
<td>10,000</td>
<td>13,220</td>
</tr>
<tr>
<td>Farms without subterranean clover, lime and superphosphate</td>
<td>7</td>
<td>5,000</td>
<td>4,060</td>
</tr>
</tbody>
</table>

The features of management on these better class farms, the productive capacities of which are so much better than others is related to the successful use of subterranean clover. A steady
increase in the area devoted to subterranean clover has led to a more efficient management of the flocks. In addition it also means a basically more fertile farm as time goes on, providing the farmer with insurance against recessions in prices and the drought period.

Besides these benefits, the initial effect of subterranean clover on light land must be mentioned. Its ability to absorb lime and superphosphate is its greatest advantage. It builds up the fertility of the land which can thus carry better permanent pastures, surely a big advantage to the farmer on light Canterbury Plains' land.

The value of a new crop, lucerne, was also realised. Mr. V. Leach speaking at a conference in Christchurch in 1948 said:

"There have been successful attempts to grow lucerne on the Canterbury Plains, and it seems particularly suited to light plains country. It could be used to good effect..."

Lucerne along with lime and superphosphate was to contribute much to the improvement of light land on the Canterbury Plains. Fig. 18 shows the distribution of lucerne in New Zealand in 1952, and it is important to notice that although Canterbury has the greatest area in lucerne, the percentage of the land sown in lucerne falls far below that for the east coast of the North Island and for Otago.

Over a number of years, there has been a steady increase in the area devoted to lucerne in the South Island, and in particular on the Canterbury Plains. This has been offset by a reduction in the North Island. The potential of this fodder crop on the Canterbury Plains mixed farms is stated by experts to be very considerable.

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43 Department of Agriculture, Economic Division, Christchurch.
could well support five to ten per cent of their area in this crop. Undoubtedly, this could be possible, because the value of lucerne lies in its permanence, its yield per acre, its high feed value, and its availability when other foods are in short supply. On the Plains, roots and hay are usually exhausted by August and the flush of grass does not come till late October and early November. Lucerne, commencing growth in late August and early September, can thus bridge this gap and will carry stock in excellent condition.

When once established, a stand of lucerne may last for many years, but the period depends on such factors as soil conditions, weed infestations and the treatment the stand has received in the way of fertilisers, lime, grazing and cutting. Under the most favourable conditions, lucerne crops have been known to last up to thirty years. But on the light land of the Canterbury Plains, the yield generally declines after five or six years. In addition, several cuttings are made each year, depending on the speed of growth, but under irrigation six or seven cuttings per season are not uncommon.

Lucerne heads all hay crops from the point of view of feed value. Its palatability, high protein and calcium content, place it in a class by itself. When converted into hay, lucerne becomes a most valuable reserve supply of food suitable for all classes of stock, and, for grazing purposes, may bridge vital gaps in the food supply especially during dry weather.

44 Hadfield: op. cit., p. 147.
45 Loc. cit.
46 C.E. Kerr's Property, Kerrytown, South Canterbury on the Levels Irrigation Scheme.
47 Hadfield: op. cit., p. 147
48 Loc. cit.
An outstanding characteristic of lucerne is its ability to withstand drought which is so detrimental to farming on light land. The plant develops a tap root that is capable of penetrating to a great depth in the soil, thus having a large supply of moisture on which to draw. Therefore, it is essentially a plant suitable for an area such as the light Canterbury Plains' land. Yet, while it is true that this tap root can draw on supplies of moisture deep in the soil, the fact remains that the bulk of the feeding roots remain near the surface, and to obtain really high yields ample moisture must be available, either from rainfall or from irrigation. The amount of water required is affected by the rate of surface evaporation, by the nature of the soil and its ability to hold moisture. There is also a diminishing return in relation to water supply. Excess of water is wasteful and may be injurious to both plant and soil.

These two crops, subterranean clover and lucerne, have had a great influence on the improvement of dryland farming, especially on this light land of the Canterbury Plains.

Four other factors have had a marked influence on the improvement of dryland farming on light land. Improved pasture seed strains have been introduced, lime and superphosphate are now in extensive use and D.D.T. is used to control grass grub attacks.

Prior to the improvement of pastures, Perennial Ryegrass, frequently with the addition of Drought, was almost the only species sown. The pasture mixtures now being sown on light land contain White Clover or Montgomery Red Clover or Subterranean Clover in addition to Perennial

49 Ibid., p.135.

50 This following information is taken from an unpublished article by C.P. Whatman: "Farming In Ashburton County."
Ryegrass. As well as Perennial Ryegrass, other species such as Cocksfoot, Timothy and Dogstail are grown. The improvements that have taken place in strains of the species have had a large effect on the productivity and longevity of the pastures. Few pastures are now sown with uncertified strains of the more important grasses and clovers.

One factor that has contributed to the improvement of light land has already been mentioned incidentally. This is liming. Fig. 19 shows the increase in total usage of lime in Ashburton County over a period of twenty years. The plains are fortunate in being relatively well supplied with lime of satisfactory qualities from deposits in the foothills to the west of the Plains. Cartage is therefore entirely down-country, making for more economical distribution. In Ashburton County, where local works alone are responsible for approximately 60,000 tons of the present supply, production could be increased up to a potential, with existing equipment of some 80,000 tons per annum. The balance of the lime used in mid-Canterbury, 40,000 tons, is brought in from outside the district, mainly from Oamaru, but considerable quantities also come from South Canterbury. 51

Consequently, lime has been an important factor in the improvement of dryland farming on the light land of the Canterbury Plains.

Artificial manures such as superphosphate in its various forms, account for by far the greater part of the manure used. The increased use over the last twenty years has been substantial, but frequent usage allows for only one-third of one hundredweight per acre of improved land per annum. This situation is most unsatisfactory, and most farmers in order not to exceed their quota, can afford to dust the land with superphosphate only when the crop is being sown. Despite the fact that

51 The majority of the lime comes from quarries located on the fringe of the South Canterbury Downland, ones such as Cave and Limestone Valley.
FIG. 18. DISTRIBUTION OF LUCERNE IN NEW ZEALAND IN 1952.

AREA IN LUCERNE BY LAND DISTRICTS.

PERCENTAGE OF THE TOTAL AREA OF FARMS IN LUCERNE.

FIG. 19. INCREASE IN USE OF LIME IN ASHBURTON COUNTY, 1935-1955


[Source of figures: Unpublished article by C.P. Whatman, "Farming in Ashburton County"]
both the sulphur and phosphate content of most of the light land is very low, the response to superphosphate has been very marked.

Finally, the light free soils of the Canterbury Plains have always been particularly vulnerable to damage from grass grubs (Costelytra Zealandia). Many of the difficulties associated with holding grass on the Plains have been due to damage by these grubs, or by the caterpillars of the Eucanis species (Parina caterpillar). The availability of economical treatment such as D.D.T., to protect pastures against these pests has been an important factor in the progress of improved dryland farming on light land.

By the use of subterranean clover, lucerne, improved pasture species, lime, superphosphate and D.D.T., the light land of the Canterbury Plains, has received a boost enabling the farmer to increase his carrying capacity. Although he still has very little protection from drought, under these farming conditions, the carrying capacity is on the average 2.3 ewes per acre, which represents an increase of over 100 per cent over unimproved dryland farms on light land.

Likewise, the landscape is much different. Closer subdivision, more improvements round the farm, and the adoption of many improved techniques, has given the characteristic checker-board pattern as seen from the air, to these farms. The final step in intensification of these farms remains to be discussed, that of irrigation.
The final stage in the development of light land is that of irrigation. With increasing pressure on resources, irrigation seems to hold the answer to major increases in production. This development will continue despite the high cost of land preparation and of carrying water to the farms. Additional subdivisions of holdings have occurred with the adoption of irrigation and will become more frequent as development proceeds. In addition, extra buildings will be required for the smaller subdivisions. This process of intensification will in time change the landscape of the light land of the Canterbury Plains.

Whereas in Central Otago there is not enough water for the irrigation schemes, in Canterbury, this situation does not exist. The difference between the Canterbury Plains' irrigation schemes and schemes in other countries, is that the snow in the high country melts in the early summer and fills the three main Canterbury rivers (the Waimakariri, Rakaia and Rangitata) with a good flow, at the time when water is needed most. The potential is enormous, especially because up to the present, only one snow fed river, the Rangitata, has been tapped for irrigation. The other two still flow unused to the sea.

In addition to this factor of a plentiful water supply there is the feature of a fairly uniform sloping surface, thus obviating the necessity for the water to be pumped out of the rivers on to the land. All the Canterbury schemes at present in operation are gravity-fed. Except in some areas, such as the sandy areas between the Waimakariri and Rakaia Rivers, the land is generally suited to irrigation by border dyke methods.
In the early days, water was the limiting factor to production on light land. Just as the development in the past of these thirty plains was based on adequate water races for stock, the future development depends almost entirely on water for crops and pastures, and on a change over to new irrigation farming management.

As the adaption of a soil to irrigation depends to a large extent upon its physical nature, it is therefore desirable that the irrigation farmer should have a clear conception of the characteristics of the soil with which he is dealing. If a soil has a low capacity to hold water, then the organic content must be built up first before irrigation can be made profitable. This is usually done by growing several crops of subterranean clover and then ploughing it under.

Water exists in the soil in three conditions - hygroscopic, capillary and gravitational. The water under each of these conditions is of the same chemical composition, differing only in the force holding or moving it.

At ordinary temperatures, a very thin film of moisture adheres to the soil particles and this moisture can not be driven off except by the application of great heat. This is called hygroscopic moisture and is not used by the plant.

When water is applied to the ground, either in the form of rain or irrigation a portion runs off the surface, leaving the remainder to soak

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into the soil. A certain proportion of this water in the course of its passage through the earth is retained on the surface of the soil particles and in the interstices, and does not drain away. This is termed "film" or "capillary" water. Capillary water is the form used by the plants, but even in the driest conditions, they are unable to use the total amount of film water present in the soil. The aim of irrigation is to prevent the loss of this water, and the manner in which this is most easily accomplished is by periodically stirring the surface of the soil with cultivators, and so forming a soil mulch. Thus, capillary movement of water to the surface is retarded and little loss of moisture occurs through evaporation.

Gravitational or free moisture saturates the soil, filling the spaces existing between the soil particles. It moves downwards into the subsoil under the influence of gravity until it reaches a fixed level, where the pore spaces are already full of water. The level varies considerably in different locations. In some, it may be many feet, in others, within a few inches of the surface, while in some cases, it is at the surface. The level of free water is called the water table. This water can be utilised by the plant when it is below the layer of root growth, but sufficiently near the surface to be drawn up by capillary attraction to the upper layers of the soil. Whenever it is so near to the surface as to saturate any portion of the soil penetrated by roots of crops, it may be regarded as unavailable, injuriously affecting growth in most crops, in that it shuts off the needed supply of air, making the soil cold, and thus preventing the formation of nitrogen. Further, its presence promotes the formation of compounds, poisonous to plants, retards the decomposition of organic matter and produces other conditions unfavourable to crop growth.
Another important facet of irrigation is what is known as "the duty of water." This expresses the relation between a given quantity of water and the area which it serves. However, the duty of water in crop production is based on the necessary losses of moisture in the soil, whether by transpiration through the leaves and stems of the plant, by capillarity and consequent evaporation or by surface or underground drainage. The aim of irrigation then, is to limit water losses from such sources. The more successful the farmer is in this respect, the more the duty of water will be improved.

It was realised by experts in the last century that irrigation was the answer to combating the drought period which is such an anathema to farms on the light land of the Plains. As early as 1876, open water races had been proved successful and in the same year a deputation urged the Ashburton County Council to adopt a scheme to supply the Ashburton and Rakaia Plains with water. Later that year, the Council voted £10,000 towards the project for water supply, after a poll of ratepayers had been taken. The following year a preliminary survey was carried out, and work on the first section of this large scheme was begun at Pudding Hill in 1880. This led to the creation of 2,270 miles of water races that supply almost every paddock with water for stock. This aspect of the Plains, the stock water race, has been dealt with in an earlier survey.

In 1886 the Ashburton County Council first discussed a scheme to irrigate five blocks of land of a total area of 396,000 acres, taking

57 Loc. cit.
58 Leadley: op. cit.
water from the Rakaia, Rangitata and North and South Ashburton Rivers.\textsuperscript{59}

The following year it was decided by the Council to undertake experiments on irrigation at Elgin on a 90 acre block which became known as the "Irrigation Farm." The demonstrations were successfully carried out, as dictated in a motion carried in 1890 at the County Council's Meeting:

"...that the benefits derived from irrigation having been clearly demonstrated, the Council is of the opinion that further experiment is not necessary...." \textsuperscript{60}

In 1891 pamphlets were published on a scheme to irrigate the land between the Ashburton and Rakaia rivers with water taken from the Rakaia river that was to be diverted through a tunnel eight and a half miles long, commencing near the Rakaia Gorge bridge. These pamphlets also suggested schemes to augment the flow of the South Ashburton river by tapping Lake Heron, and to irrigate land north of the Rangitata river by tapping the river lower down than at the present intake. \textsuperscript{61}

In 1893, the manager of Acton Estate suggested a scheme of irrigation that was operated successfully two years later. The Ashburton County Council inspected the system and saw the benefits on irrigated blocks of land. In addition, much good research work on irrigation of a very practical nature was carried out at Seafield by members of Lincoln College and the Lands and Survey Department. \textsuperscript{62}

Much irrigation was carried out by private individuals in ensuing

\textsuperscript{59} "Irrigation, the proposed scheme for irrigating the Plains at Ashburton County," Report of County Council and County Engineer, May, 11th, 1886.

\textsuperscript{60} "Minutes," Meeting of Ashburton County Council, 4th Aug., 1890.

\textsuperscript{61} "Water put to work," \textit{op.cit.}, p.14.

\textsuperscript{62} \textit{Ibid.}, p.16.
years, but very few efforts were made towards large scale schemes. In more recent times, the successful irrigation trials at Levels and Minchmore achieved similar results to those in Central Otago, where arid land has become productive pasture land. Valuable work was also done in the interests of irrigation by Lincoln College and the Canterbury Progress League.

On 27th October, 1933, the Ashburton County Council met other Local Bodies and Departmental representatives to discuss the irrigation of the plains between the Rangitata and Rakaia rivers. This meeting had three results. A soil survey was completed, a farm management survey was made, and the present irrigation schemes were planned and commenced.

It was recognised very early in the proceedings that irrigation was primarily an agricultural problem, and as a result a conference was called by members of the Public Works and Agriculture Departments. It was decided to appoint three qualified agricultural experts who would be consulted by the Public Works Department during the construction and the early operation of the scheme, but who would come under the control of the Irrigation Officer of the Department of Agriculture.

In October 1933 also, a topographic survey was carried out in mid-Canterbury to ascertain the suitability of the land for irrigation. This survey was extended to South Canterbury in 1937 and later to North Canterbury. At the same time a soil survey was completed by the Soil Survey Branch of the Department of Scientific and Industrial Research.

63 Loc. cit.
64 Interview with Mr. W. C. Stafford, Timaru, 2nd. Jan., 1957.
65 "Water put to work," op. cit., p. 6.
In addition, accurate records were made of the river flows at established gauging stations, water levels were recorded and conclusions about dependable river flows were made by correlating this information with levels in the past. Research into the depth of ground water on the Levels and Geraldine Counties were made but World War II caused a cessation of this work in mid- and North Canterbury. Soil moisture measurements were conducted over a number of years in mid- and North Canterbury to determine the degree of deficiency of soil moisture on various soil types at differing levels. In addition, American-type meteorological stations were established to record humidity, rainfall, temperature, evaporation and wind speed.

As a result of information disclosed by these investigations, it was decided to construct the Rangitata Diversion Race between the Rangitata and Rakaia Rivers (Figs. 11 & 39). Work on this project then went ahead. The race was protected by means of check-gates and by-wash structures. There is one of the latter at Montalto corner eleven miles from the intake, and at the South Ashburton River nineteen miles from the intake (Fig. 20). Another by-wash structure is located at the North Ashburton river, thirty-one miles from the intake (Fig. 21). These are primarily for protecting the race, and the surrounding countryside from flooding in the event of an unforeseen contingency. This third construction is also used in connection with irrigation of the Ashburton-Lyndhurst area and for the power installation at Highbank. When water is required for irrigation, the check-gate is lowered to impound sufficient water for flow into the Ashburton-Lyndhurst and Mayfield-Hinds main races. Also, the last eleven miles of the race to the powerhouse penstock is designed to impound water up to a fixed maximum height so as to provide the powerhouse with a greater head for short periods and greater flow from
FIG. 20. Siphonic spillway from Rangitata Diversion Race into the South Ashburton River.

Photo by the author.


Photo by the author.
FIG. 11. CANTERBURY PLAINS IRRIGATION SCHEMES.

KEY

EXISTING SCHEMES

1. Ashburton - Lyndhurst
2. Mayfield - Hinds
3. Levels

PROPOSED SCHEMES

4. Oxford
5. Central Plains
6. Barrhill
7. Rakaia
8. Valetta - Tinwald
9. Orton
the normal full flow of the race. If water accumulates above this
length's capacity, it is automatically spilled over into the North
Ashburton river (Fig. 21). 66

Devices called siphons are employed to by-pass steep, unstable
country at Surrey Hills, between the Hinds and South Ashburton Rivers.
This siphon is one and a half miles in length and the pipes are twelve
feet in internal diameter. 67 These were made at the actual site and the
pipes for the siphons under the rivers were also made here. Their size
created much difficulty with regard to their transport.

In this scheme, it was recognised by the planners that irrigation
had priority while power was to be incidental. From September to April
when water demand for irrigation does not equal the capacity of the
race, the difference is used for power. (Figs. 22 & 23) For the
remaining months of the year, the Highbank power house has the full flow.
This situation was vital to power supply before Roxburgh Hydro Electric
Power Station started distributing power to the South Island grid. The
situation was such that the months when Highbank had the greatest flow
of water were the months that coincided with the period of greatest demand
for power.

Once the Rangitata Diversion Race had been completed and the water,
had begun to flow, the development of the irrigation schemes went ahead.
But up to the present, (1st Nov., 1957) only two irrigation schemes have
been developed in mid-Canterbury using the water from the diversion race.
They are the Ashburton-Lyndhurst and Hayfield-Hinds schemes (Fig. 11).
A third scheme in South Canterbury — the Levels — is fed from the Opihi
River.

66 Ibid., pp. 8-11.
67 Ibid., p. 11.
FIG. 23 A. Highbank Power House.

Photo by the author.

FIG. 23 B. Highbank Power House.

Photo by the author.
The Ashburton-Lyndhurst irrigation scheme is located in the area north of the North Ashburton River and to the west of the main trunk railway. The soil here is dominantly Lismore Stony Silt Loam, with small areas of Eyre Stony Silt Loam, thus showing that the area is light land typical of the Canterbury Plains. The gross area commanded by this scheme is 64,000 acres, which is subdivided into about 150 farms averaging 450 acres. The water supply is drawn from the Rangitata Diversion Race and distributed through 150 miles of races. Irrigation commenced in the 1944-1945 season, after the land had been prepared for the farmers by the Public Works Department. Since then the rate of development, although far greater than that of the other schemes, has not been up to the expectations of those who planned this scheme. For instance, the area border dyked by 31st March 1956 was only 15,034 acres, or less than half of the 32,000 acres which were originally intended for irrigation. Of this area, however, 4,054 acres is State owned and developed land acquired since the scheme commenced, and only 11,980 acres have been border dyked on private holdings. Whereas the State has border dyked approximately sixty per cent of its land within a few years of its being acquired, private irrigators have border dyked only twelve per cent of the privately-held land. It has been calculated from the figures of peak water usage over a period of eight years, that the amount of water available from the Rangitata Diversion Race for this scheme could be used to irrigate 45,000 acres instead of 32,000 acres as was originally contemplated. However, of the three schemes in operation on the Canterbury Plains, the Ashburton-Lyndhurst is the one scheme which has produced the best results.

68 Report of the Inter-Departmental Committee on "Irrigation in Canterbury," to the Minister of Public Works, 1953.


70 Report to Minister, op. cit.
The Mayfield-Hinds scheme is located between the Rangitata and Hinds Rivers (Fig.11.). The soil type is predominantly Lismore Stony Silt Loam, but the prevalence of boulders and stones is greater here (Fig.24). The gross area of the scheme is 88,000 acres.71 The original intention of the Public Works Department's planners was to draw water from a separate intake on the Rangitata River, but the resort to temporary means has meant that the scheme still draws its water from the Rangitata Diversion Race. There is now no question of a separate intake being constructed, as it would cost approximately £1,000 to construct. It was calculated from experience on the Ashburton-Lyndhurst scheme that the original water would irrigate sixty-five per cent of the gross area now included in the scheme. Irrigation was commenced in the 1948-1949 season and by 31st March 1956, 4,176 acres had been border dyked. Despite this slow development, irrigation has proved most successful and in the 1955-1956 season above, 1,226 acres were border dyked in this scheme.72

The Levels Irrigation Scheme has been operating the longest of the three on the Canterbury Plains, but in comparison with the two mid-Canterbury schemes, the potential is not great. The soil is light plain's land, but differs from the majority of mid-Canterbury soil types, in that it is Templeton Shallow Silt Loam. The gross area of the scheme is 12,800 acres, which is subdivided into 112 farms averaging 115 acres. Water is drawn from the Opihi River at Pleasant Point, and distributed through fifty three miles of races.73 Unlike the Rangitata River, which is snow-fed and thus provides a good flow at the time of the year when water is most wanted, the Opihi is not snow-fed and has a tendency to

71 Ibid.
72 Ministry of Works Reports op.cit.
73 Report to Minister, op.cit.
FIG. 2.4 Head ditch on Mayfield-Hinds Irrigation Scheme, near Mayfield.
dry up during the drought period. Irrigation began in the 1937-1938 season, but the rate of development is slow and the area border dyked over the twenty years from 1937 totals only ten per cent of the area commanded. 

In one further aspect too, the Levels scheme contrasts with its mid-Canterbury counterparts. All the ditches were dug by unemployed labour during the Depression of the 1930's. No machinery, not even the ubiquitous bulldozer, was used. There was however, a certain amount of contract work let to various companies. The scheme above all, provided useful work for the unemployed men who were paid very good wages - ten shillings per day.

These then are the present irrigation schemes on the Canterbury Plains. The completion of the Rangitata Diversion Race, (Fig.39) the first stage in the dual purpose scheme for the greater use of water, marked the dawn of this new era in mid-Canterbury. Energy which would normally have remained in the riverbed of the Rangitata was diverted into a controlled smooth running stream through to the terraced right bank of the Rakaia from which it dropped quickly as a surging torrent to generate power at Highbank Power Station (Fig.22 & 23). Alternatively, this water can be diverted along reticulating races to flow over thirsty pastures and irrigate desiccated soil. Also, in South Canterbury, the Levels scheme, smaller but necessary, is enabling farmers to increase the numbers of stock on their properties.

All these schemes irrigate light land and are the prime reason for the increase in average carrying capacity by 100 per cent. This does not mean though that programmes of liming and manuring are made.

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74 Ibid.
75 Interview with Mr. C.E. Kerr, Kerrytown, 11th Jan., 1957.
superfluous. Indeed with more water being put on to this light land, increased leaching follows, and so greater lime replacement is necessary.

Furthermore, none of these Canterbury schemes requires storage of water. In some schemes in other countries, water that falls as rain during the wet season must be conserved and stored for use months later during the dry season. The factor that limits the area that can be irrigated is the volume of storage that can be provided. On the Canterbury Plains, there is no such limiting factor. Ample water is available in the larger rivers and schemes can be designed to take a great proportion of the flow out of these rivers for use on the land. Once an intake has been installed, the diversion races and distributing channels can carry water continuously for turning on to the land whenever it may be required during Spring, Summer or Autumn.

The construction of intakes and diversion races involves large sums of money but irrigation has proved its worth in Canterbury. In 1917, F.W. Furfett wrote in the Journal of Agriculture:

"....irrigation in New Zealand must have a great future...." 76

This statement is applicable to the light land of the Canterbury Plains today and the three irrigation schemes at present in operation are precursors of others which will follow.

CHAPTER V.

TECHNIQUES USED IN IRRIGATING LIGHT LAND

There are two main methods used in irrigating the light land of the Canterbury Plains. These are the border ditch system and the border dyke system. Two other methods, wild flooding and overhead sprinkle and pipe systems are not found very frequently. Today, wild flooding is rarely used in controlled irrigation, while overhead sprinkler systems are too expensive because of the large areas involved. These play a minor role in Plains' irrigation. The construction of the first two main methods require special implements, which have become a necessary part of irrigation farming.

The border ditch system as used on the Canterbury Plains, involves the construction of a head ditch across the high side of the field. This ditch must be on one fairly flat grade, so that if dammed in one place, it will back up the water to discharge into two or more of the branch ditches. In this way, a film of water is spread evenly over the whole land. (Fig.25). This system is not dominant in any of the areas where irrigation is carried on, but where it does occur, it is easily noticeable. Indeed, from the air, it stands out very clearly (Fig.12). Border ditching has proved to be very useful in irrigating uneven portions of fields, or on land where the soil has impeded drainage.

The border dyke system is the one found most frequently on the Canterbury Plains. It is undoubtedly the most efficient system, and although expensive in initial costs, it is in the long run, the most economical.

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77 Tennant and Marks: op. cit., p.47.
78 Ibid., p.50.
FIG. 25. DIAGRAM OF A BORDER DITCH SYSTEM OF IRRIGATION.

Instead of leading the water down the field and distributing it in smaller ditches as with the border ditch method, it is put on to the land direct from the head ditches. The border ditches are replaced by small levees, ridges or borders six or seven inches high, running down the direct slope of the land and dividing it into strips. For operating, a large flow is let into the top end of the field. It spreads into an even film of water a few inches deep, and confined between the borders, it travels right down the full length of the strip watering the land in that strip evenly and thoroughly (Fig. 26).

It might appear that this method would over-irrigate the top end of the strip and leave the lower end under-watered. However, the amount of water which soaks in at any point is not dependent upon the depth which may be passing over the surface at that point, but rather upon the length of time during which free water of any depth has been resting on the surface. Almost as soon as the supply is cut off, the film at the upper end, being a few inches deeper and so having more velocity, runs forward leaving the surface there uncovered. Its progress at points lower down becomes much slower. It therefore takes longer to run off these lower points, and this happens to compensate for its not having reached these lower points so soon when the water was first let on to the strip.

In contrast to the border ditch method, the whole essence of the border dyke system is speed and precision in flooding the borders. It is

79 Loc. cit.
80 Loc. cit.
81 For further information see: Ibid., pp. 50-56
FIG. 26. DIAGRAM OF A BORDER DYKE SYSTEM
OF IRRIGATION.

[Source: R.B. Tennent and J.R. Marks "Irrigation.
Dept. of Agr. Bulletin No. 100, Wellington, 1930, p. 31]
the only really scientific method applied, and is one which has proved most effective on Plains land where all irrigation schemes are gravitational. Also, unlike the border ditch system, the border dyke method does not constitute an obstacle to tractor and implements when the field is under cultivation, nor do stock run the risk of injury by falling into ditches situated on the field.

Wild flooding is a very old and very haphazard method of irrigation. It is included here because it was practised by many farmers on the Ashburton-Lyndhurst and Levels schemes when these schemes were first constructed. Today, it is not recommended as a suitable technique for irrigating this light land. This is because it has been realised by the experts at Winchmore Irrigation Research Station, that it is not so much a matter of putting water on to the land but of knowing how much different types of land require. This, the "duty of water," has already been discussed.

The two very modern irrigation techniques of pipe irrigation and overhead sprinkler systems are not found very much on the light land of the Canterbury Plains. This is because they involve a larger capital outlay than the two main methods, and are more applicable to areas of intensive agriculture such as is found on the Waikana Plains of Hawkes Bay. The few farmers who use overhead sprinkling in Canterbury do so for the purpose of irrigating fields of small seeds. The areas involved in the major irrigation schemes of today and of tomorrow, are of such magnitude as to preclude all thought of extensive use of these techniques.

The border dyke method then is the most efficient way of irrigating the light land of the Canterbury Plains. Indeed it is ubiquitous on all areas of this land. I have had the distinct advantage of discussing this matter with a number of the specialists at Winchmore in the course of my work on this project. They have all been enthusiastic about the possibilities of expanding the use of this technique on this land, particularly if it is part of a larger scheme of irrigation. Their enthusiasm is based on their experience of using this method on the Ashburton-Lyndhurst and Levels schemes, where it has proved to be a very effective means of irrigating this type of land. They believe that with the right planning and management, the border dyke method can be used to great advantage on the light land of the Canterbury Plains.

32 Correspondence with G.K. McPherson of the Irrigation Research Station, Winchmore, Mid-Canterbury.
present schemes, and under State fostering has become very popular and most efficient.

The irrigation of the land also requires certain special implements. The State prepared much of the land for the Ashburton-Lyndhurst scheme, using graders to level the land and construct border dykes (Fig. 27). Today, a farmer can hire a Ministry of Works grader at a cost of £2-0-0 an hour, or buy and use his own leveller. This machine is automatic and is hydraulically operated. This machine is used quite frequently, because, although once border dykes have been made they are permanent features, the land must be re-levelled after ploughing. In addition to a leveller, a machine known as a ditcher has to be used for constructing the head and waste ditches (Fig. 35) and for keeping them clear. Most farmers too have a small mower to control the undergrowth on the bottom and sides of ditches, and on ground adjacent to the races.

The border dyke system of irrigation and a few additional farm implements have revolutionised the landscape and economics of a great many farms on light land. Indeed, many of the effects of this special type of irrigation remain to be increased in future years.
FIG. 27  **IRRIGATION: LAND PREPARATION.** A Ministry of Works grader levelling land on the Ashburton-Lynnhurst Scheme.
FIG. 28. **IRRIGATION: LAND PREPARATION.** A farmer levelling land with his own equipment - Ashburton-Lyndhurst Scheme.
FIG. 29. **IRRIGATION**: Letting water into a border dyke - Ashburton-Lyndhurst Scheme.
30. IRRIGATION: Letting water into a border-dyked strip, Levels Scheme.
FIG. 31. IRRIGATION: Letting water into a border-dyked strip, Levels Scheme.
Note the use of the canvas dam.
FIG. 32. **IRRIGATION:** Irrigation by border-dyke method.
FIG. 33. **IRRIGATION**: A trial at Winchmore. Water being applied to ten year old pasture.
FIG. 34. IRRIGATION: The results of irrigation. A ten-year-old irrigated pasture at Winchmore shows little deterioration or weed invasion.
CHAPTER VI.

THE EFFECTS OF IRRIGATING LIGHT LAND

The irrigation of light land on the Canterbury Plains has had many effects on the area. The landscape in many places is characterised by water races, especially the Rangitata Diversion Race, and by border dykes and ditches. Irrigation has had effects on such things as field size, shelter belt planting and farm buildings. Seepage is also another factor which has to be considered. Finally, irrigation has had effects on the farm economy because of increased carrying capacities and better pasture production.

The main races of the three irrigation schemes (Fig. 37) and in mid-Canterbury, the Rangitata Diversion Race, are very conspicuous features of the landscape, especially when they cross an artery of communication or dive under a river (Fig. 36). The Rangitata Diversion Race is a dividing line between two distinct landscapes. To the west are brown parched fields of poor pasture while in very many areas to the east are lush green pastures and irrigated lucerne crops.

The individual farm also shows certain features which set it off from neighbouring improved dryland farms. There are the head ditches and waste ditches which border the farm on the upslope and downslope fences of fields (Fig. 12). Then there are the border dyke and border ditches on the paddocks (Fig. 12). These are more obvious on some farms than on others, depending on the size of the individual fields. Border ditches, although not so numerous as border dykes stand out clearly from the air as ditches of water running down the fields, while the border dykes stand out as ridges (Fig. 12).

With the rising prices for wool after the Second World War, farmers on some of the smaller holdings, previously recognised by the Department
of Agriculture as uneconomic, have been able to obtain satisfactory returns from their land and maintain a reasonable standard of living.

"Much of this progress can also be attributed to irrigation, for it is significant that development on the larger holdings has not kept pace with that on smaller farms. With the more rapid progress towards full irrigation, development calls for more farmers and for smaller farms. There is the important fact too, that extensive re-patterning of farm boundaries will be necessary to ensure full utilisation of all available water." 83

Little actual subdivision of existing farms has taken place, but there is a great difference in farm and field size between the areas that have been irrigated for a considerable length of time, and the unirrigated areas. On the Levels Plain, 16 to 25 acres is the average size of a field on an irrigated farm, while the average farm size is 115 acres. However, on the Ashburton-Lyndhurst scheme, 30 to 40 acres is the average field size, while the size of farms averages 450 acres. Although there is this great difference, the contrast between unimproved dryland farms and irrigated farms is considerable, 800 acres being the minimum size for a dryland farm on light land. But farm size and field size on irrigated farms are not very different from that on improved dryland farms, the average figures being nearly the same. There is, though a great difference in farm size within the two irrigation schemes in mid-Canterbury.

If it is assumed that 42,000 acres here could be held in 350 acre irrigation units, then there would be an increase from the present number of 400 units to 1200 units.

It is the recognition of these facts that induced the State to subdivide holdings which they themselves wished to irrigate. This was carried out at Winchmore Irrigation Research Station, at Newlands Farm Settlement, and is at present being carried out on the proposed Valetta-
Tinwald scheme. Reduction in farm and field size is an obvious indication of the process of intensification, which is occurring on the Canterbury Plains. This increase of production within an occupied area will be discussed later.

The construction of new buildings follows the intensification caused by irrigation. New hay sheds are a feature which appear very soon on the landscape. Fig. 38 shows a new hay shed on a South Canterbury farm capable of holding 2800 bales. It is just under one quarter full, 665 bales having been obtained from the first cut of a 16 acre paddock of irrigated lucerne. Another new building on many farms is that of an additional house for extra labour. Irrigation development assumes no appreciable increase in labour supply, but here is concrete evidence of a trend towards the splitting up of holdings. The farmer and his son can no longer manage all the work on a farm which has adopted irrigation, and so additional labour must be sought. The alternative is to divide the farm into more easily manageable lots.

Machine sheds do not seem to be built to house the extra implements needed for irrigation. Either an existing shed is cleared to make room, or more often this valuable equipment is left in the open to rust and depreciate (Fig.35).

Another farm feature which demands increased attention if intensification is to proceed is that of the shelter belt. On the Canterbury Plains, the need for these has always been great especially in the late spring and late summer. Attempts to grow exotic pine shelter belts are evident on the Mayfield-Winds scheme, an area exposed to the vagaries of the north west and south west winds.

Seepage is another important effect of irrigation. The raising of the water table has caused some alarm among farmers in areas of mid-
FIG. 35. A leveller on C.E. Kerr's farm Kerrytown, Levels Scheme.
Canterbury where farms are located seawards of the main trunk railway. So far little evidence has been forthcoming to indicate that this is likely to be a major problem. In South Canterbury, the Levels scheme has been blamed for the swampy nature of the country further seawards, but the area has always been in this condition.

Increased carrying capacities on better pasture swards have been the hallmark of irrigation development on light land. Not only have farmers now an insurance against drought conditions, but also pastures under irrigation do not require renewal every two to three years as they do without irrigation. Some last for as long as ten years as has been proved at Winchmore Irrigation Research Station (Fig.34).

Carrying capacities are more than doubled under irrigation. Indeed some outstanding results have been achieved by individual farms. Carrying capacities of up to ten ewes per acre have been obtained, but tests and trials at the Winchmore Irrigation Research Station show that a two or three fold increase is more representative as an average increase under irrigation.

At present farmers on the Canterbury Plains buy sheep replacements from farms on the foothills. Under irrigation, there has been an increasing tendency to breed flock replacements on the actual farm and also to supply wethers for fattening on the farms. Furthermore, under irrigation the Plains would absorb all available cattle and make it worthwhile for foothill farmers to breed replacements for the area. If this were properly handled, the irrigated light Plains could produce fat cattle for the Addington Stock Market for the greater part of the year.84

84 Ibid.
Fig 36

The Rangitata Diversion Race crosses the North Ashburton River by means of a siphon.

V.C. Browne Photo
FIG. 37. A main race on the Levels Irrigation Scheme.

FIG. 38. A new hayshed on C.E. Kerr’s farm, Levels.
The reduction in the acreage of cereals which was discussed in Chapter II, has been brought about partly as a result of the increased use of irrigation. The changeover from dryland farming with cereals occupying a large area, to a mixed farming economy based on fat lambs and small seeds has been, in the main, influenced by economic conditions. There have been the high prices for wool since World War II and the decline in cash returns for wheat. Irrigation, however, is best suited to the watering of pasture and feed crops such as lucerne, so possibly there is a correlation. The farmer on the light stony Plain's land can now feel assured of good pasture growth and good returns from sheep. Previously, when his land was ploughed and sown in cereal crops, soil deterioration was a big concern. Today, a more constructive farm economy has resulted.

Irrigation then has had many effects on the light land of the Canterbury Plains. Not only do certain landscape features such as water races, border dykes and border ditches characterise the area, but subdivision of holdings, reduction in field size and an increase in farm buildings have followed. Finally, despite certain unfavourable aspects such as seepage, the economy of the farm has received a boost by means of increased carrying capacities and better pastures.
SECTION C.

CHAPTER VII.

THE COSTS OF IRRIGATION

Probably the main obstacle to extensive irrigation development on the light land of the Canterbury Plains is the enormous cost involved in land preparation. Although the ditches and border dykes are permanent features on the landscape once an area has been reticulated, maintenance costs can be considerable. Another explanation for the slow development of irrigation is the fact that most farmers are enjoying a high standard of living today without the use of irrigation, despite the fact that income tax exemptions have been offered for farm improvement.

As early as 1878 extensive works had been carried out on the Canterbury Plains to irrigate the lands lying between the Waimakariri and the Selwyn Rivers. The estimated value of the land was £2-0-0 per acre, the cost of irrigating was two shillings per acre and the value then rose to £10-0-0 per acre.\(^85\) Today costs have soared so that £4-14-0 per acre for land preparation is the average cost.\(^86\) For example land preparation costs on the Ashburton-Lyndhurst scheme between the years 1947-1952 amounted to £26,912 for 13,416 acres, the cost per acre being £3-12-5 per acre.\(^87\) In the early stages of irrigation on the Plains, it was the practice to prepare the first four acre block free of cost, but this was later discontinued. The rate charged to the farmer covers the full cost of the plant including maintenance, operators' wages and holiday pay. The cost of the preliminary survey and design work are not

\(^{85}\) F.W. Furkett: op.cit., p.449.

\(^{86}\) Report to Minister: op.cit.

\(^{87}\) See figures Appendix II.
charged to the farmer. The difference between the total cost of land preparation and what is recovered from the farmer is added to the capital cost of the scheme.

The capital cost of the schemes to the country can now be accurately stated. The cost of installing the Rangitata Diversion Race was £1,195,436, and the total cost inclusive of maintenance as at 30th June 1952 was £2,943,564. The capital cost on the three irrigation schemes up to the same date was £1,748,129.88

Water charge agreements are already in existence covering portions of the Levels and Ashburton-Lyndhurst schemes. The Hayfield-Hinds scheme water sales continue to operate on a demand basis. That is, no flat rate is charged, the farmers being charged only for what they use. The present water charges are four shillings per acre foot on contract and six shillings on a demand basis. Initially the rates were only two shillings and sixpence and three shillings, the figures being fixed at this low level in order to encourage irrigation. The charges were raised in 1948 despite some opposition from farmers. The present agreements run to 1964, and from 1948 to 1953 there was an initial development period during which the charge payable under agreement applied to the whole assessed irrigable area of a farmer's holding and is payable irrespective of whether the full quantity of water is used or not.89

All water which is used in excess of the contract quantity is charged at contract rates.

So, not only is the farmer charged for land preparation, but he also has to pay his share of water used in the whole area, unless the scheme is operated on a demand basis. But in addition to these, the expenses

88 See Appendix II.
89 Report to Minister, op.cit.
The Rangitata Diversion Race north of where it crosses the north branch of the Hinds River,
of pasture establishment, new subdivisional fencing, extra stock water races and provision of culverts have all to be met. Where new buildings are required for extra labour or for subdivision, the overall cost might well exceed £20-0-0 per acre. Additional stock have to be purchased or bred, and further plant is required, the cost of these two being approximately £11-0-0 per acre. It is little wonder then that most farmers are reluctant to borrow even small sums for capital development. Most seem to prefer to keep their programme to such a level that they can meet the cost out of revenue and can claim most of the development expenditure as a deduction for income tax purposes. From these facts, the conclusion which can be drawn is that farmers doubt whether the extra capital outlay with existing high costs will be offset in the future by the added value to the farm and by the extra income that irrigation will bring. Therefore without the whole-hearted support of the farmer, extensive irrigation development can not be carried out.

Heavy capital costs then would seem to be the main obstacle to development of irrigation. The progress which has been made in improved dryland farming on light land described in Chapter III has meant that most farms can provide a good living for the farmer and his family. It is little wonder that the apathetic attitude to irrigation exists. In addition, the State when constructing irrigation schemes has had to consider seriously the charges made to farmers, since the authorities are the losers financially. Such things as an "availability rate" with regard to water charges have had to be considered. The authorities argue that as water costs amount to only 2.5 per cent of the total expenditure under irrigation, any increase in water charges would not only be justified, but it would hardly be felt at all by the individual farmer.

Yet irrigation has been proved at Winchmore Irrigation Research
Station (Fig.40) and at Newlands Farm Settlement to pay handsomely.

One farmer[^90] who settled at Newlands relied entirely on borrowed capital to start off. He borrowed £8000 on a mortgage and £2000 on demand and seasonal finance. After small losses during the first two seasons, he finished up on 30th June 1954 with a credit of £427 in the seasonal account, after repaying the mortgage on demand and reducing the principal mortgage by £1,202. By the 30th June 1956, the principal mortgage had been reduced to £6,424 but the seasonal or demand account had been increased to £2,038 and the capital account showed a credit of £5,925.

The total overall cost of development was £31-0-0 per acre. If this man were to sell his property today he would realise approximately £15,000.

The schedule[^91] gives the estimated 1956 cost for the purchase and development of the farm at £65 per acre, including new buildings, for a ten year development period, a fair portion of the cost would be met from profits[^92].

Costs of irrigation installation then are very high but not prohibitive under the present prevailing economic conditions. Maintenance costs can be high too, but these do not in any way compare with the initial costs. Finally despite the fact that many Plains' farmers are enjoying a high standard of living on improved dryland farms without using irrigation, the figures show that the gain to the farmer who adopts irrigation is very considerable. Not only he, but also the whole economy will be favourably affected by extensive adoption of irrigation on the light land of the Canterbury Plains.

[^90]: Mr. A. Farmer, Newlands.

[^91]: Table V, Appendix II.

[^92]: The results of Mr. A. Farmer's irrigation development as taken from an unpublished report by Lands & Survey Dept. 19th Nov. 1956.
Fig 40. Winchmore Irrigation Research Station. Note the border dykes surrounding the settlement.
CHAPTER VII

THE FUTURE FOR IRRIGATION ON THE LIGHT LAND OF THE CANTERBURY PLAINS.

"More water was used on the three Canterbury Irrigation Schemes during the week ending February 3rd, 1957 than in the same week of last year, when Canterbury suffered an unusually prolonged drought. In the week ended February 3rd, 3996 acre feet of water were used compared with 1206 acre feet in the week ended February 5th, 1956 and there were 169 farmers irrigating compared with 95 last year. In the weekly period last year, however, there were falls of rain throughout the province, one of the rare falls last summer, which caused a temporary sharp drop in the amount of water used. In the latest period under review there were also small falls of rain in the districts of the Ashburton-Lyndhurst and Levels Plains schemes. So far this season, however, the total use of water has amounted to only 14,226 acre feet compared with 54,278 acre feet at the same time last year. ³²,³

This report indicates that irrigation on the Plains is being utilised more and more as time goes on. Despite the initial high cost of irrigation development, many farmers once they have irrigated two or three paddocks, have prepared others for irrigation.

A report by officers of the Department of Agriculture in August 1944 says: "The pasture which has been irrigated has actually deteriorated very little, if at all, during the seven years the area has been under irrigation. The sward is still an excellent one, and is decidedly superior to any average second-year pasture on similar class of country which has not been irrigated. Provided management of the pasture in the matter of topdressing, irrigating and method of grazing is continued as in the past, there is no reason to suppose that the sward would deteriorate to any appreciable extent for some considerable time...." ³⁴ This report goes on to list some of the proven facts of irrigation on light Plains land. On the area irrigated the carrying capacity has been increased from one to six sheep per acre, the original outlay in preparing the land and establishing permanent pastures is paid for in the first year, while the expense of re-sowing pastures every three years is obviated. Other


conclusions which this report presents are more obvious. A substantial increase in the weight of wool and lambs is obtained, on these light soils which respond well to irrigation. Heavy crops of lucerne to combat the drought period, can be readily obtained under irrigation. The report concludes: "It does not require a great deal of imagination to envisage the benefits which would accrue to the individual farmer, the rural and urban sections of the country and the nation as a whole, of every farm providing it were able to be reticulated to an irrigation scheme developed on the same lines." (i.e. as the mid-Canterbury schemes.)

Irrigation schemes on the same lines as the three already in operation are in the future plans for irrigation of the light land on the Canterbury Plains (Fig.11). These are, the Valetta-Tinwald scheme which is due to start operation in 1950, the Rakaia scheme, the Orton scheme, the Central Plains scheme, and the Oxford scheme. These are all part of a long-term plan by the State and some may not be completed for another fifty years.

The Valetta-Tinwald scheme is one which over the last three years has been prepared by the Ministry of Works. Some of the poorest land in Canterbury is located in this area between the Hinds and Ashburton Rivers. The soil types are predominantly Lismore Very Stony Silt Loam and Lismore Stony Silt Loam. The Scheme is to be fed from the Rangitata Diversion Race and water will be supplied from this source by March of 1958. The Lands and Survey Department hold some 5,000 acres of land in this area and it is intended to construct a scheme to supply water for a portion of the Land's Department block and also for a limited number of private farmers in the surrounding area. Percolation losses in the early years of operation may be high but it is considered that irrigated pasture land will gradually build up a surface humus layer which will reduce the rate

95 Correspondence with G.K. McPherson, Irrigation Research Station, Winchmore.
of percolation. The estimated cost of this scheme is £1,079,000 or £24.19 per acre.

The proposed Rakaia scheme (Fig. II) extends between the Ashburton and Rakaia rivers and from about the main railway line to the coast. The soil is predominantly Lismore Stony Silt Loam in the south and Chertsey Shallow Silt Loam further North with small areas of Templeton Silt Loam interspersed. The gross area of holdings is 140,300 acres while the net area commanded by the scheme is 126,300 acres. The estimated cost is £2,240,000 or £17.72 per acre. The soils and physiography are favourable and the ground water level is nowhere near the surface. The intake is planned to be built on the Rakaia River about six miles above the main road bridge. The design of the intake however, constitutes a considerable engineering problem, because of the nature of the riverbed. A complete layout of this scheme was proposed in 1947 and a detailed list of structures and quantities made. From these, an estimate was prepared based on unit rates taken from costs of construction of existing schemes. The figures quoted above, then, will probably be too low on present rates. The Rakaia Scheme, however, differs from the other mid-Canterbury ones in that the State held a poll among farmers within the irrigable area to see whether irrigation was acceptable to them. The proposal stipulated that 75 per cent of the farmers must agree otherwise the scheme could not be put into operation. As less than 75 per cent of the farmers agreed it would appear that the Rakaia Scheme will have to wait for several years. The poll though, did bring forth a definite statement by the State concerning new schemes and their inception.

96 Report to Minister, op.cit.
97 Ibid.
98 "Irrigation, Procedure For New Schemes," Announced by the Prime Minister, 20/10/54.
It reads:

1. "Where any group of farmers wishes to have an irrigation scheme or extension proceeded with in terms of the general policy - namely, where the owners of 75 per cent of the irrigable area to rating on an average basis sufficient to cover operating costs and at least one quarter of the capital charges (spread over a period of forty years, including the ten year development) - they should apply to the District Commissioner of Works, Christchurch.

2. The District Commissioner of Works will refer the application to a District Interdepartmental Committee on Irrigation. This committee, if they consider the proposal to be satisfactory will refer it to the Commissioner of Works.

3. The District Commissioner of Works will consider carrying out a preliminary survey in order that the farmers may know the probable cost per acre.

4. It is now up to the farmers to appoint representatives charged with the task of obtaining the necessary percentage of agreements to the setting up of an irrigation district, i.e. 75 per cent of the irrigable area.

5. The Minister of Works can now consider authorising a detailed survey of the proposed scheme.

6. The survey being satisfactory, steps will be taken to have the area declared an irrigation district.

7. The rateable area of the irrigation district will now be defined.

8. The prospective rate-payers in the irrigation rating district will now be given a final opportunity of deciding by ballot, whether or not they definitely wish to have the scheme proceeded with. If they do, Cabinet will be asked to consider authorising the necessary expenditure to enable the work to be put in hand."

This report then, dictates a State policy which is more rigid and conservative than that referring to earlier schemes. Previously the State installed the irrigation schemes first; now they are to be constructed only after a majority of farmers in the area have agreed to use the water to be provided.
The third proposed scheme on the light land of the Canterbury Plains lies to the south of the Rangitata River, to the north of the Orari River and from the Arundel bridge to the coast, (Fig.11). This is the Orton scheme and is going to irrigate areas dominantly of Lismore Very Stony Silt Loam and Lismore Stony Silt Loam. Originally it was proposed to construct a siphon under the Rangitata River to supply both the Mayfield-Hinds and Orton Schemes. The cost of such a venture almost precludes the construction of the whole scheme. It is land however, that sorely needs a boost. It is poorly grassed land, dry and parched in the late Spring and Summer, but in a season when the rainfall is above the average the possibilities of the area can be visualised. However, the surface is cut up by depressions and only approximately 50 per cent could be border dyked at reasonable costs. The total cost of this new scheme was estimated in 1953 to be £817,000, but what is required is a detailed economic analysis, taking into account the capital charges that will be involved. It would appear that the construction of this scheme is far in the future because of the prohibitive cost.

The last two irrigation schemes planned for the light land area of the Canterbury Plains are the Central Plains scheme and the Oxford scheme (Fig.11). The proposed Central Plains scheme lies between the Rakaia and Waimakariri Rivers and extends from about the 750 foot contour to the heavy land along the coast. The soil is predominantly Lismore Stony Silt Loam and Lismore Very Stony Silt Loam and also consists of various other soils of the fan margins and low terraces. There are also several sandy patches within the proposed scheme, patches which would be very difficult to irrigate by border dyke methods. The Central Plains scheme comprised two sections each of which would be supplied from a separate intake, serving the county as far as the Selwyn River which runs through

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99 Report to Minister, op.cit.
the middle of the area.

The southern section intake would be located on the Rakaia River about one and a half miles below Highbank power station and would be similar to the Rakaia scheme intake. It would be possible to get water out of the river here by running the race along a series of terraces only one of which would appear to present any difficulty.

The northern section intake is to be situated at the mouth of the lowest gorge of the Waimakariri River and would involve the construction of a tunnel about 1900 feet long. The main race at the intake would climb the river terrace and then extend across to the Selwyn River. This intake would also serve the Oxford scheme.

One factor which would have to be accomplished before this area could be irrigated is effective drainage, as much over-saturation would ensue once irrigation is introduced. This contrasts markedly with other areas which have been irrigated in Canterbury. On this proposed Central Plains scheme, there is a great range of productivity in the soils, from comparatively highly productive cropping farms down to almost desert conditions. The vegetation is also variable and includes 13,000 acres of the Selwyn Plantation Board forest.

The cost of the intake here was estimated in 1953 to be £881,000 and this sum was allocated to the Central Plains and Oxford Schemes. This was done in proportion to the estimated final net area which will be served by the two schemes. This scheme, however, is an expensive one, and an estimated total sum of £2,377,000 or £17.3 per acre will have to be spent.100

The last proposed scheme on the light land of the Canterbury Plains is the Oxford scheme. This proposal was the result of a strongly-supported

100 For further information see appropriate section in Report to Minister, *op. cit.*
petition from farmers between the Waimakariri and Ashley Rivers. An investigation showed that the country between the Waimakariri and Eyre Rivers was a very good irrigation proposition, but high ground water conditions exist over a large part of the country north of the Eyre River. There are, though, large areas here which would benefit from irrigation and these should be irrigated when there is an effective drainage system on the lands which are periodically overflowed by ground water. Therefore before the area can be reticulated for irrigation, the drainage problems must first be solved.

The land as far as the Eyre River is very dry and the physiography is favourable with at least 75 per cent suitable for border dyke irrigation. There is, however, an area of approximately 20,000 acres of the Eyrewell State Forest included in the gross area shown which is excluded from the estimate. As has been mentioned the intake could be combined with the northern intake for the Central Plains scheme. That water would be taken from the settling basin and conveyed under the Waimakariri River by a siphon about twenty chains long. The siphon and the main race should possibly have sufficient capacity to serve some of the area to the north of the Eyre River and thus allow room for extension of the scheme when the drainage problems have been remedied. The gross area of the scheme is 57,781 acres, but the net area only 34,660 acres omitting the area occupied by the Eyrewell State Forest. The total cost of this scheme was estimated in 1953 to be £675,000. Careful consideration though will have to be given to the economies of constructing the combined intake large enough to serve the ultimate development taking into account the probable time lag between the reticulation of the several sections. If an intake has to be built to serve one section only, the cost per acre may be considerably higher than the above figures. 101

101 Ibid.
The soil Bureau of the Department of Scientific and Industrial Research estimates that the area of alluvial soils in Canterbury where lack of soil moisture is a limiting factor to production exceeds one and a half million acres, a figure which is a gross area and includes roads, railways and townships. The figures mentioned here are in terms of the net irrigable area. Much of the Soil Bureau's one and a half million acres must be excluded on account of engineering, considerations, rigorous climate or high ground water levels in adjoining areas. The remaining figure of 750,000 acres does not necessarily cover all the land that will after detailed investigation be found suitable for irrigation. Estimates show that extra production to the value of over £4,000,000 can be secured annually with the whole 750,000 acres irrigated. It may also be stated that primary production on Canterbury Plains light land areas over the last fifty years has been relatively static. While there is scope for some improvement by the adoption of better improved dryland farming methods, the long term development of farming is undoubtedly dependent on the adoption of irrigation.

The Report to the Minister of Public Works which was submitted by a committee in 1953, and which was not seen by the Minister, is possibly the crucial document concerning the irrigation of light land in Canterbury. Besides describing schemes and deliberating on future schemes, the Report has several important recommendation to make. Perhaps the most important of these are the advocacy of local control instead of surveillance from a centralised authority in Wellington, and the recommending of research into automatic irrigation.

Local control with regard to irrigation in Canterbury would seem to be better than centralisation which leads to inefficiency. It is the "man on the spot" who knows best in these matters. However, control of existing
schemes through a central Government agency such as the Ministry of Works would appear to be justified at the present time. This system is due to come under review when present contracts expire in 1964. Under local control the difficulty would be in the willingness of the County Councils or Catchment Boards to accept the responsibility. If local authorities are not prepared to accept the responsibility then the Ministry of Works is probably the best Department to handle it. However, the inter-Departmental Report on Irrigation recommends that Head Office representatives of the Department of Agriculture, Lands and Survey, Scientific and Industrial Research, Treasury and Works should advise the State on policy matters and plan the systematic irrigation of future Canterbury irrigation schemes. The report concludes by stating that local administration should come under advisory committees representing irrigators in each district.

The second main recommendation, that of automatic irrigation is one which looks far into the future. The construction of intakes and diversion races involves large capital sums. In times of drought, when there is a maximum demand for water, farmers must, if all the water is to be used, be willing to apply water at any time throughout a twenty-four hour day. If the intakes are to be closed for twelve hours at night or the water allowed to flow out of the waste races, the area that can be served by a scheme must be halved and the cost for each acre served, doubled. This situation will not arise until a major portion of the irrigable land within a scheme is developed for watering by border dyking or other means. Although some farms studied in the Ashburton-Lyndhurst scheme have already had experience of irrigating at night, it is not generally realised that when a scheme is fully developed, night irrigation will be a necessity if charges are to be kept within economic limits. What is required is automation, a device that will turn the water on to and off the land while
the farmer sleeps or while he is engaged on other work on the farm. The savings to the farmer in water charges and labour cost that could be derived from using automatic equipment are considerable. There is an immediate need for research into the development of automatic irrigation devices suitable for Canterbury conditions.

The 1953 Report also recommended that more co-operation between the Departments of Agriculture, Scientific and Industrial Research, Lands and Survey and the Ministry of Works would greatly assist irrigation proposals, that the Rangitata Diversion Race should be fully used with little further capital being spent on it, that the Lands and Survey Department should purchase more land for development and especially for the construction of pilot farms in order to study the economics of irrigation farming. It suggests too that the quantity charge for water used be discontinued in favour of an availability rate on land served, that rating on an acreage basis was sufficient to cover operation and maintenance costs and it recommended that special considerations for income tax exemption be applied to irrigation farms.

An important factor to consider in the light of the future of irrigation is that of increasing population. On the basis that the population of New Zealand will be three million by 1975, livestock units will have to increase by 2 per cent per year. The progress in attaining the necessary level of primary production for three million people must entail development in all districts and in particular in Canterbury. The major factor that could achieve the desired level of production in

102 Scott and Stuart: op.cit.
Canterbury would be the development of irrigation on light land. The figures for increased livestock production are shown in Appendix III, Table 1.

In comparison with other forms of land development, irrigation on the light land of the Canterbury Plains appears to be one of the least attractive forms of land development, but as the area of North Island scrubland capable of any development becomes exhausted, irrigation development may not be at such a disadvantage. Population also enters into this question in that the North Island has the majority, and attention would be concentrated here first.

Irrigation makes possible the introduction of modern intensive farming on land hitherto farmed on an extensive scale. It is a pre-requisite to the adoption of controlled rotational grazing, top-dressing with lime and fertilisers, growing of high-production fodder and root crops, dairy and pig farming, fat lamb raising, vegetable and small fruit growing, and smaller and more efficient productive farm units.

Another advantage of irrigation was seen after the Second World War when ex-servicemen were requiring farms. Even with some subdivision, there are still not enough farms on which to settle men under the Rehabilitation Scheme. With increased irrigation in the future, further subdivision will be necessary and thus more farms will become available. It has been estimated that additional settlement for 1,400 to 2,000 farmers could be made, if subdivision followed more extensive reticulation. Indeed smaller farms and more of them will undoubtedly be the rule in the future.

The possibilities of an extension of dairy farming on to light land can also be envisaged for the future. Indications are that an 80 acre
dairy farm run by one man with extra labour for watering and hay making should produce 12,000 pounds of butter fat, per year. Dairying would however, create certain problems including the provision of adequate water for stock, for washing purposes and the provision of factories. Such prospects for dairy farming are within the foreseeable future, the experimental dairy farm at Winchmore Irrigation Research Station and several individual farmers having proved this.

Therefore, despite high initial costs, irrigation of the light land of the Canterbury Plains must be of ultimate national value. Its primary purpose is to combat drought periods and to enable stock and pastures to be carried through dry seasons. This means that the winter period will become the limiting factor. The effects of irrigation have been discussed in Chapter VI and it is clear that a great change is going to take place if widespread irrigation schemes, such as the ones mentioned above, are to be constructed.

Not only is there going to be a widespread geographical change on the light land of the Canterbury Plains, but also, with the widespread adoption of irrigation, a complete change in attitude on the part of the farmers, who, by tradition are cultivators. Under irrigation, they must begin to think in terms of grassland farming and how to gain full utilisation of pastures. The substantial community and local benefit will be reflected not only in the landscape, but in increased local prosperity and the development of new industries. As a result of the improvement of the areas of poor light land, the Canterbury Plains may some day become one of the most closely settled and richest areas in New Zealand, thus reclaiming the honour which was lost at the end of last century.

103 Mr. K. Hampton, Levels.
The Canterbury Plains landscape of the future? Compare this fully border-dyked farm with the surrounding country.

V.C. Browne Photo
APPENDIX 1.

OTHER DEFINITIONS OF LIGHT LAND.

The definition of C.G. Vucetich which is used in this thesis is supported by R. Scott and R. Stuart in their work on "The Problems of Light Land In Canterbury," and is the most accurate one available. The two which follow are less accurate for a study of this kind.

1. Stoniness of the soil has been offered as one definition. For instance, the fact that the Levels area (Fig. 2.) in South Canterbury has fewer stones and boulders in its topsoil than the topsoil in the Valetta area (Fig. 2.) of mid-Canterbury does not necessarily mean that it is not light land. The question of degree arises here. How many stones and boulders need there be before the land can be classified as light?

2. Another definition which is used by many farmers and some Department of Agriculture advisers is that of tractor draught. If the land yields easily to the plough, it is classified as light, but if it is at all difficult to turn over, then it is regarded as heavy land. This definition is more applicable to farms other than those on the Canterbury Plains.
APPENDIX II

TABLE I COST OF LAND DEVELOPMENT

ASHBURTON - LYNDHURST SCHEME

<table>
<thead>
<tr>
<th>Season</th>
<th>Private Development cost/acre</th>
<th>Lands &amp; Survey Area cost/acre</th>
<th>Agriculture Department cost/acre</th>
<th>Average cost/acre</th>
</tr>
</thead>
<tbody>
<tr>
<td>1944-5</td>
<td>£2- 8- 5</td>
<td></td>
<td></td>
<td>£2-16- 8</td>
</tr>
<tr>
<td>1945-6</td>
<td>2-14- 6</td>
<td></td>
<td></td>
<td>3- 3- 1</td>
</tr>
<tr>
<td>1946-7</td>
<td>2- 4- 9</td>
<td>2- 8- 8</td>
<td>3-14-10</td>
<td>2- 8- 2</td>
</tr>
<tr>
<td>1947-8</td>
<td>2-16- 4</td>
<td>3- 6- 2</td>
<td>5- 3- 4</td>
<td>3- 1- 5</td>
</tr>
<tr>
<td>1948-9</td>
<td>2-14- 3</td>
<td>2-13- 0</td>
<td>11- 6- 8</td>
<td>2-13- 4</td>
</tr>
<tr>
<td>1949-50</td>
<td>3-10- 8</td>
<td>3-10- 8</td>
<td>3-10- 8</td>
<td>3-10- 8</td>
</tr>
<tr>
<td>1951-52</td>
<td>5- 2- 1</td>
<td>5-2- 1</td>
<td>5- 2- 1</td>
<td>5- 2- 1</td>
</tr>
<tr>
<td>1952-53</td>
<td>5- 5- 4</td>
<td>5- 5- 4</td>
<td>5- 5- 4</td>
<td>5- 5- 4</td>
</tr>
<tr>
<td>1953-54</td>
<td>5- 4- 8</td>
<td>5- 4- 8</td>
<td>5- 4- 8</td>
<td>5- 4- 8</td>
</tr>
</tbody>
</table>


TABLE II COST OF LAND DEVELOPMENT

MAYFIELD HINDS SCHEME

<table>
<thead>
<tr>
<th>Season</th>
<th>Private Development cost/acre</th>
<th>Lands &amp; Survey Area cost/acre</th>
<th>Average cost/acre</th>
</tr>
</thead>
<tbody>
<tr>
<td>1948-9</td>
<td>£4-17-10</td>
<td>£4-16- 2</td>
<td>£4-16-11</td>
</tr>
<tr>
<td>1949-50</td>
<td>3- 3- 7</td>
<td>3- 9- 9</td>
<td>3-11- 1</td>
</tr>
<tr>
<td>1950-51</td>
<td>3- 3- 10</td>
<td>3- 8- 10</td>
<td>3- 6- 9</td>
</tr>
<tr>
<td>1951-52</td>
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<tr>
<td>1952-53</td>
<td>3- 7- 4</td>
<td>4-11- 2</td>
<td>3- 7- 4</td>
</tr>
<tr>
<td>1953-54</td>
<td>4-11- 2</td>
<td>4-11- 2</td>
<td>4-11- 2</td>
</tr>
<tr>
<td>1954-55</td>
<td></td>
<td>6- 2- 0</td>
<td>4- 4- 0</td>
</tr>
<tr>
<td>1955-56</td>
<td></td>
<td></td>
<td></td>
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TABLE III COST OF LAND PREPARATION

<table>
<thead>
<tr>
<th>Season</th>
<th>cost/acre of Private Irrigation</th>
<th>Average cost/acre</th>
</tr>
</thead>
<tbody>
<tr>
<td>1951-2</td>
<td>£3-6-7</td>
<td>£3-6-7</td>
</tr>
<tr>
<td>1952-3</td>
<td>3-6-9</td>
<td>3-6-9</td>
</tr>
<tr>
<td>1953-4</td>
<td>4-11-10</td>
<td>4-11-10</td>
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<tr>
<td>1954-5</td>
<td>4-15-8</td>
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<tr>
<td>1955-6</td>
<td>4-14-4</td>
<td>4-14-4</td>
</tr>
</tbody>
</table>


TABLE IV DETAILS OF COST ON THE THREE IRRIGATION SCHEMES

<table>
<thead>
<tr>
<th>Name</th>
<th>Gross Area Commanded</th>
<th>Net area for which water available for full irrigation in acres.</th>
<th>Total Capital Cost</th>
<th>Capital Cost Acre</th>
</tr>
</thead>
<tbody>
<tr>
<td>LEVELS</td>
<td>12,800</td>
<td>11,520</td>
<td>£88,164</td>
<td>£7.65</td>
</tr>
<tr>
<td>ASHBURTON-LYNDHURST</td>
<td>64,000</td>
<td>45,000</td>
<td>£1,133,782</td>
<td>£25.2</td>
</tr>
<tr>
<td>MAYFIELD-HINDS</td>
<td>84,500</td>
<td>18,000</td>
<td>£526,182</td>
<td>£29.2</td>
</tr>
<tr>
<td>TOTAL</td>
<td>161,300</td>
<td>74,520</td>
<td>£1,748,128</td>
<td>£62.05</td>
</tr>
</tbody>
</table>

Source: "Reports" NDW. 1955-56.
### TABLE V. NEWLANDS FARM SETTLEMENT - AREA 365 ACRES.

**SCHEDULE OF DEVELOPMENT COSTS.**

<table>
<thead>
<tr>
<th></th>
<th>52 Per cent Irrig.</th>
<th>Full Irrig. - New Buildings</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>New Buildings</td>
<td>1. 7.44 to 20. 6.51.</td>
<td>Est. at 1956 Costs</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>30. 6.56.</td>
<td>Est. to 30. 6.58.</td>
</tr>
<tr>
<td></td>
<td>Per Acre</td>
<td>Est. at 1956 Costs</td>
<td></td>
</tr>
<tr>
<td>Fencing</td>
<td>1,203</td>
<td>1,651 4.525</td>
<td>100 1,751 4.798     2,555 7.0</td>
</tr>
<tr>
<td>Irrigation</td>
<td>1,252</td>
<td>2,136 5.852</td>
<td>800 2,936 8.042     3,370 9.234</td>
</tr>
<tr>
<td>Pasture &amp; Lucerne</td>
<td>978 2.679</td>
<td>1,649 4.517</td>
<td>550 2,199 6.024     3,370 9.233</td>
</tr>
<tr>
<td>Sundry Improvements</td>
<td>157 .43</td>
<td>240 .657</td>
<td>160 400 1.095       700 1.917</td>
</tr>
<tr>
<td>Dip &amp; yards</td>
<td>204 .559</td>
<td>204 .559</td>
<td>60 264 .722        270 .74</td>
</tr>
<tr>
<td><strong>TOTAL Improvements</strong></td>
<td><strong>6,860 18.792</strong></td>
<td><strong>9,366 25.660</strong></td>
<td><strong>2,270 11,636 31.875 16,425 45</strong></td>
</tr>
<tr>
<td><strong>Land</strong></td>
<td>1,915 5.25</td>
<td>1,915 5.25</td>
<td>1,915 5.25        7,300 20</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td><strong>£8,775 £24,042</strong></td>
<td><strong>£11,281 £30.91</strong></td>
<td><strong>£6,215 £13,551 £37.125 £23,725 £65</strong></td>
</tr>
</tbody>
</table>

### APPENDIX III

**TABLE I.**

LIVESTOCK NOS. REQUIRED FOR INCREASED POPULATION IN NEW ZEALAND (3,000,000 PEOPLE)

<table>
<thead>
<tr>
<th>Types of Livestock</th>
<th>Present Nos.</th>
<th>Nos. Required for 3,000,000 People</th>
<th>Absolute Increase</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dairy Cows</td>
<td>1,921,435</td>
<td>2,798,500</td>
<td>877,100</td>
<td>45.6</td>
</tr>
<tr>
<td>Breeding Ewes</td>
<td>22,833,442</td>
<td>35,292,600</td>
<td>12,459,200</td>
<td>54.6</td>
</tr>
<tr>
<td>Dry Sheep</td>
<td>12,463,469</td>
<td>19,031,800</td>
<td>6,568,300</td>
<td>52.7</td>
</tr>
<tr>
<td>Beef Breeding Cows</td>
<td>851,369</td>
<td>1,240,800</td>
<td>389,400</td>
<td>45.7</td>
</tr>
</tbody>
</table>

Source: Report of the Inter-Departmental Committee to the Minister of Public Works on "Irrigation In Canterbury," 1953.
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MAPS


