The Proceedings
of the
Lincoln College
Farmers' Conference
1954

A Canterbury Agricultural College Publication
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of the
Lincoln College
Farmers' Conference
1954
Men are never so likely to settle a question rightly as when they discuss it freely.

—Macaulay.
LINCOLN COLLEGE FARMERS’ CONFERENCE
1954

Committee:

Messrs S. C. Bowmar, Gore.

P. P. L. Dillon, Waihopai Valley, Blenheim.

J. H. Grigg, Longbeach, Ashburton.

A. Henderson, South Hillend R.D., Winton.

John Hunt, P.B., Cromwell.

A. C. Hurst, Papakaio.

J. R. Little, Hui Hui, Hawarden.

T. A. McKellar, Pigeon Bay, Banks Peninsula.

G. S. Slater, Hilton.

D. S. Studholme, Coldstream, Ashburton. (Chairman).

Melville Turton, Ashburton Forks.

Dr. M. M. Burns, Lincoln College, Christchurch.

Hon. Secretary,
L. W. McCaskill,
Lincoln College,
Christchurch.
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OFFICIAL OPENING

In welcoming members the Chairman, Mr D. S. Studholme, apologised for the absence of the Right Hon. Mr Holyoake, Minister of Agriculture, who had agreed to open the Conference but was prevented by sudden illness. They were fortunate in having Mr W. H. Gillespie, Chairman of the Board of Governors, to deputise for the Minister, said Mr Studholme. “In this room I would say there is a representative cross-section of the more intelligent members of the farming community. Some of you are here for the first time, others have attended all our previous conferences and your faces are growing familiar. Of the latter I can only repeat what the gardening expert said on the radio: ‘No man who wants to put up a good show can afford to be without his hardy perennials.’ . . . The real purpose of this conference is that the experience of practical, successful farmers can be passed on to others in a wider way than is normally possible. This being so, I want to say a word about the value of this farming experience. When you look round the countryside you are impressed with the large numbers of young farmers, many of them returned servicemen, who are not afraid of hard work, but they lack something only time can give them and that is farming experience. Physically I suppose a man is in his prime at 30; mentally I would say that if anybody has survived 30 to 40 years of practical farming and escaped the madhouse he is probably at his best at the time he gives up the land and cultivates his suburban garden. He should stay longer in the industry and pass his hard-earned information on to others. Two years ago a famous agricultural expert said ‘What New Zealand needs is young pastures, young stock and young farmers.’ I would remind you that many of us have found that pastures established on modern lines last longer than we thought they would. Already Lincoln College is telling us that we do not keep our ewes long enough because ewes produce more twins later in life. Farmers may be past producing twins but they are rich in farming experience. It will be a pity if that experience is lost. . . . Those of you who come here to this conference expect to get something out of it. I hope you will also consider whether you cannot put something into it.”

Professor J. W. Calder, deputising for Dr. M. M. Burns, the Director of the College, who was unable to be present, said: “I would like to assure you that the College authorities welcome the close association that exists between farmers and this institution. We have the responsibility of training the young generation of farmers and professional agriculturists and we feel that the confidence we secure by having visits from representative farmers from different parts of New Zealand helps us considerably so far as our main responsibility is concerned.

“This conference has become an agricultural forum where farmers and scientists together discuss major problems facing agriculture today. That makes us all the more sorry that we are not able to supply you with the full facilities that such an organisation requires. We would like to provide you with a better hall; perhaps some time in the future the farmers might provide one. It is very pleasant to see among the audience old friends of the College, and to them and all of you we do extend a very cordial welcome. We
feel that your attendance here is in some measure an expression of your confidence in the College and the work it is doing."

Mr W. H. Gillespie, M.P.:

"I want to express my pleasure at having the privilege of deputising for the Minister of Agriculture on this very important occasion. I am sure that all of us deeply regret the fact that he is not able to be here personally to perform this opening ceremony. I hope you all agree with me when I say the post of Minister of Agriculture is the most important appointment in the Government as it affects our general economy. It is by the wise direction of our agricultural policy that we can attain good conditions for everyone in this fair land of ours.

"Mr Holyoake asked me to read to you a speech which he had prepared and I readily agreed to do that. He asked me to convey to you his sincere regret for his absence and to express to you his congratulations on holding such a conference.

"On my own behalf and on behalf of the College Board of Governors I want to welcome you to the College and to wish you well in your deliberations. As farmers who are trustees of the soil we should do everything possible in our power to improve it. I think that is one of the reasons why you have gathered here to discuss the various problems which crop up from day to day. . . . I was glad to hear your Chairman say that you were going to discuss matters from the practical viewpoint. You must all have the ability to take from the research and the practical side of farming which is carried out here those things which will fit in to the system which you employ on your particular farm where you alone can organise and carry on the work. I always believe that no farmer can be successful unless he works to a system which he directs fully and absolutely . . . . I have much pleasure in declaring this Conference officially open."

The address prepared by the Minister of Agriculture and read by Mr Gillespie on his behalf was as follows:

"During the three-quarters of a century which have elapsed since its inception as the School of Agriculture in 1880 Canterbury Agricultural College has always been in the forefront of rural education in the widest sense. That outstanding figure, Mr W. E. Ivey, the first principal, speaking at the opening ceremony, looked clearly forward when he said:

"The agriculture of this colony is in a transition state; the army of 'strippers' is gradually spreading over the country further and further from the centres of population and shipping ports, leaving behind them lands which will in the future want farming and not 'cropping.' . . . But the man who succeeds the 'stripping' in the occupation of the land must be a man of knowledge, of observation, and of experience. It is men of this class that form the backbone of a successful agricultural community, and it is to the problems of producing men of this class that our endeavours should be directed. . . ."

"The thoroughly practical side of Mr Ivey's contribution to New Zealand's agricultural development may be well realised when it is recalled that not only did he demonstrate by his teaching and his management of the College farm that the solution of the pressing problem lay in better cultivation, rotation of crops, and manuring but he was responsible for the introduction to the country of turnip growing, disc harrows, the hay sweep, and the cream-separator.

"His plan for legal measures to protect farmers against adulterated manures led to the passing of the Manure Adulteration Act, 1892 (subsequently the Fertilisers Act), the first of its kind in the
world. He was particularly interested in developing the use of fertilisers. Previously farmers had used small quantities of local bonedust and some imported rock phosphate and Peruvian guano. Mr Ivey introduced superphosphate to Canterbury in 1881, importing his own supplies at £9/10/- a ton. He laid out various trials to demonstrate its advantages and from the experience he gained he was able to prophesy a great future for phosphatic fertilisers. Today New Zealand uses over 600,000 tons of superphosphate a year.

"An early member of the College staff with Mr Ivey was Mr George Gray, who lectured in chemistry here from 1883 until his retirement in 1915. He was another enthusiastic advocate of the use of fertilisers and did a great deal of valuable work in the analysis of soils and fertilisers. He lost no opportunity of impressing farmers with the need for maintaining the fertility of thin soils through the rotation of crops and the application of fertilisers and lime. Soon after the discovery that legumes could obtain their own nitrogen from the air Mr Gray was strongly urging the use of clovers for raising the nitrogen content of the soil.

"Gray was succeeded in 1915 by Mr L. J. Wild, later headmaster of Feilding Agricultural High School and now pro-chancellor of the University of New Zealand. During his time at Lincoln, which he left in 1922, Mr Wild did valuable work in the field of applied research, adapting the newer methods of soil analysis to New Zealand soils. He also contributed usefully to the technical literature on soils and fertilisers in New Zealand.

"The work of such men as Ivey, Gray, Wild and their colleagues is typical of the way in which Lincoln College has served agricultural education and the farming community.

"This service has taken two forms. There is firstly, of course, the teaching of students who, on completing their degrees or diplomas, bring to their work for New Zealand agriculture the fruits of their experience of research and applied science. There is secondly the helping of farmers and the handing on to them of the wealth of information which advances in scientific research can place at their disposal.

"These annual farmers' conferences present an excellent example of the important work which is being done in strengthening the bridge between the scientific research worker and the practical farmer. In this way they can obtain a wider understanding of each other's work and problems and a growing appreciation of their significance.

"The first Lincoln College Farmers' Conference was held in 1951, when the College called a meeting of a group of representative farmers from various parts of the South Island. It was decided that a useful purpose could be served by an annual meeting of farmers designed not for the moving of motions and passing of remits but for the discussion of problems affecting farming in the South Island and the exchange of information and ideas. The limitations of accommodation at the College make it necessary to restrict the attendance to 220, including the contributors to the programme.

"The 1951 Conference was concerned almost entirely with sheep-farming, dealing with such aspects as lambing percentages, problems of lamb fattening, and breeds for hill country. The subjects covered in the three days of the 1952 Conference were the future of arable farming, farm taxation and production, and the conservation of fodder. Last year's conference was devoted to consideration of cattle in South Island farming, dairy farming, rural housing, and farm labour, and factors contributing to the low national lambing percent-
age in New Zealand. A varied programme which promises to be full of interest has been prepared for this year’s conference.

“Although this is only the fourth of these annual conferences, they have already proved to be of inestimable value. The subsequent publication of the proceedings makes much useful material permanently available and helps in its dissemination.

“The importance of a conference such as this is obvious when seen against the background of world problems. A rapidly increasing world population without a corresponding rise in food production faces humanity with problems the seriousness of which is not sufficiently widely realised.

“The unpleasant implications of the principles educed by Malthus 150 years ago are looming ever more ominously. No man can afford to regard a starving world with equanimity. As farmers of one of the principal food-producing countries of the world our duty is clear. Production must be increased to the utmost and to this end the scientific researcher and the practical farmer must work together.

“Full advantage must be taken of the opportunities presented by such a conference as this with its potentialities for the fruitful union of science and practice.”
FOOTROT IN SHEEP

ANATOMY OF THE SHEEP’S FOOT

G. G. Thomson, Lincoln College

The disease under discussion is footrot in sheep. Disease of a tissue can be defined as any deviation from its normal structure or function. Footrot affects the feet of sheep so that in order to understand the changes which take place it is essential to have a clear picture of the structure of a normal foot.

The sheep has a cloven hoof. That is it has two claws or digits bearing the weight of each limb. The horse family has only one digit to each limb. Between the two claws of the foot is a cleft known as the interdigital space. Bridging the cleft is a tough, hairless skin which can be softened by moisture or mechanically damaged. Above the cleft there is a sac-like gland which produces a waxy secretion. The function of this gland is not known. Each claw is identically constructed so only one need be described.

Fundamentally each claw consists of a bony structure around which is placed a boot-like structure which we call the hoof. This covers and protects the end of the limb. It also acts as a shock absorber to the body of the sheep. The outer part of the hoof is merely a specially thickened portion of the skin. Like normal skin this modified tissue is made up of two layers. The outer horny layer is hard, tough and protective. It is devoid of nerve endings and so is quite insensitive. It is actually manufactured and nourished by the inner layer, which is called the matrix. The matrix has nerve endings and is sensitive. Anything affecting it causes pain. Footrot does this.

The framework, around which the digit is built, is made up of three short bones placed end to end. They are called the phalanges. The first and second phalanges are cylindrical in shape while the third is the same shape as a typical hoof. Only the third and part of the second are contained within the hoof wall. The first phalanx articulates with the cannon bone and the joint so formed corresponds with the fetlock joint in the horse. The second phalanx articulates with the first and the third. Each joint is a typical movable joint with cartilage and a joint capsule. Ligaments hold the bones in place. It is of interest to note that in foot abscess of sheep these joints can be affected, becoming very painful. They are slow to heal. Footrot organisms do not affect them. Attached to the third phalanx are two important tendons. At the front is the extensor tendon which extends the digit, and at the back the deep flexor tendon which bends the digit backwards. These tendons are surrounded by lubricating sacs called tendon sheaths. They are sensitive and in cases of foot abscess may become affected, giving rise to swelling and pain. They are, however, not attacked by footrot organisms.

At the back of each hoof and on a level with the third phalanx there is a mass of spongy tissue known as the digital cushion. This mass of tissue acts as a shock absorber; it can be distinctly felt by the fingers on pressing the bulb of the heel.

The matrix of the hoof is firmly fixed to the whole surface of the third phalanx, to part of the second phalanx and to the digital
It is sensitive due to its nerve endings and is well supplied with a fine network of blood vessels. The main vessels supplying this network run down the front and back of each leg. At the fetlock joint they divide into numerous branches until they form an almost complete network of small capillaries covering the whole of the matrix. In addition to producing and nourishing the outer horny walls the matrix firmly holds them to the bones. It is possible however to separate the outer wall from the matrix. This does happen in bad cases of footrot. The wall may become completely separated and fall from the end of the digit, leaving the bony structures covered only by the matrix and the deep layer of the wall. A new outer cover is grown again in many cases.

As mentioned previously, the matrix is the tissue of the foot which nourishes the horn-producing cells. Its parts are named differently depending on their position. For example, there is a thick band of matrix tissue which completely encircles the hoof wall in the region of the coronet. This is called the coronary matrix. It makes the wall grow in a downward direction. In cases where the wall grows down faster than it is worn away, for instance on soft ground, the wall becomes deflected underneath the sole. The lamina matrix is closely applied around the sides of the third phalanx. It is thrown up into numerous folds, or laminae, which run in an up-and-down direction. These folds fit closely into corresponding grooves of the outer wall, thus firmly holding it to the underlying structures. This matrix makes the wall grow in an outward direction thus providing the thickness to it. The solar matrix, as you can guess, produces both the sole tissue and the pliable, thinner cover over the bulk of the heel.

For descriptive purposes the hoof is divided into the wall and ground surface. The inner surface of the wall of both claws touches only at the posterior end. Friction at this point often causes damage allowing the entrance of footrot germs. The outer wall is divided into three regions, the toe, quarter and heel. The wall is thickest at the toe and gradually becomes thinner at the heel. Running around
the wall just under the coronet is a small band of resin-like material called the periople. Its function is presumably to protect the hoof against excessive moisture or excessive drying. The ground surface is made up of the sole which is pointed at the toe and spreads out behind where it forms the bulb-like heel. The heel is covered with soft, thin tissue.

PRESENT KNOWLEDGE OF THE DISEASE
J. W. McLean, Lincoln College

Definition

Footrot is a specific contagious disease of the feet of sheep and goats, the primary cause of which is an organism called *Fusiformis nodosus*. It is characterised by a spreading infection which causes a separation of the horn from the soft tissues of the foot and by a distinct tendency to persist in the absence of treatment.

Economic Importance

From the point of view of economic importance, footrot is undoubtedly the most important disease with which the sheep farmer has to contend. This is due not only to loss of condition and loss of wool and of lambs but also to the disruption of farming operations caused by the need for continuous treatment and the added difficulty of handling affected sheep.

Incidence and Distribution

The disease is widespread throughout most of the sheep-raising country in New Zealand. Its incidence is higher where the rainfall is high and where intensive stocking is practised on the more highly productive lands.

Susceptibility

In general Merino sheep appear to be more susceptible than other breeds. Crosses with the Merino are somewhat less susceptible and English breeds are the least susceptible. This resistance observed in English breeds is a resistance to initial infection only. The course of the disease, once established, is about the same in all breeds. Sheep of all ages are susceptible. Rams appear to be more commonly affected than ewes or wethers.

Description of the Disease

The characteristic lesion is a spreading infection under the horn tissue of the hoof which leads to a detachment of the horn. Although the appearance of affected feet may vary somewhat, in outbreaks the disease usually takes a fairly well defined course. It commences as a mild inflammation of the skin between the claws. This is soon followed by a break in the skin-horn junction. From here the infection spreads rapidly under the horn tissue working round the heels to the sole. In about a week the sole becomes detached and the process extends to undermine the horn of the wall so that finally the hoof is attached only at the coronet. There is little formation of pus. A small amount of exudate is present however and this has a characteristic smell. Usually both claws are affected. The disease is of long duration, recorded cases having lasted up to three and a half years. A few cases may recover spontaneously after several months.

Although the above describes the typical lesions found, it is important to remember that the disease can exist in the feet in two
other forms which are more difficult to recognise clinically. For example it has been shown that the infection can remain for many months in mild lesions taking the form of hairless, moist, slightly-inflamed lesions of the skin between the claws. In addition there may be present in the hoof small pockets of infection partially or completely covered by horn tissues which are not observable unless the feet are carefully pared. The characteristic symptom is lameness in one or more feet, the degree usually varying with the severity of the lesions. Loss of condition soon follows and this may predispose to other diseases. It is important however to remember that the disease may be present in sheep which show no sign of lameness whatsoever.

**Cause**

The primary cause of footrot is the organism *Fusiformis nodosus*. Unless this organism is present the disease cannot occur. Before typical lesions develop, infection with another organism, *Spirochaeta penortha*, must occur. *Fusiformis nodosus* is a very strict parasite, that is, it lives in or on living tissue. It will not survive more than a few days away from the feet of affected sheep or goats. Pastures which have been kept free of sheep for a period of one week in dry weather and two weeks in wet weather are therefore free of infection. The infectious agent is carried over from one season to another or from one place to another in the feet of affected sheep. The short period that it does remain alive in the soil, however, is sufficient to enable the infection to be transferred indirectly from the feet of infected sheep to those of healthy ones; this, of course, is the normal method of spread within the flock.

**Predisposing Causes**

Before the infectious agent can gain entry, some break in the continuity of the skin or horn of the foot must take place. Common factors causing this are grit or dirt lodged between the claws causing mechanical abrasion; softening of the horn tissue and overgrowth followed by cracking of the hoof under damp conditions of soil and pasture; and possibly simple maceration of the skin by moisture. Another possible cause of injury to the feet is the penetration of the skin by the immature forms of one of the worm parasites in sheep, *Strongyloides papillosis*. The condition known as "scald" which consists of a mild inflammation of the tissues between the claws is frequently followed by footrot. It is believed, however, that this condition is a distinct entity and can occur in the absence of footrot.

**Diagnosis**

In outbreaks, the disease is usually diagnosed by clinical examination. If any doubt exists a definite diagnosis can be made by the demonstration of *F. nodosus* in suitable stained smears taken from the margin of the lesions with the healthy tissue.

**Differential Diagnosis**

The condition most likely to be confused with Footrot is Foot Abscess or digital suppuration. In this condition however there is considerable swelling of the tissues above the foot and the discharge of large quantities of pus from sinuses opening between the claws or around the coronet. One claw and one foot only are usually affected and the disease mainly affects grown sheep. Scabby mouth or Contagious Ecthyma when it affects the feet may be confused with footrot. As a rule, however, mouth lesions are present and there is no
involvement of the horn tissues of the foot. Other conditions likely to be confused with footrot are: non-specific wound infections; local infection with the "arthritis" organism, *Erysipelothrix rhusiopathiae*; and founder or laminitis.

**Treatment**

Treatment consists of thorough paring of the feet and the removal of all underrun horn tissues for the purpose of exposing the diseased tissue to the action of suitable antiseptics. The importance of this part of the treatment cannot be overstressed. Damage to healthy tissue should be reduced to a minimum, but in searching for all pockets of infection some injury to healthy tissue is almost unavoidable. Antiseptics may be applied in a footbath or as hand dressings. The substances commonly used are bluestone or copper sulphate, formalin, certain proprietary preparations containing arsenic, and more recently chloromycetin.

**Blue stone** is used in concentrations varying from 1 lb. to a gallon as a means of prevention, to 3 lb. per gallon for treating affected feet. It has the disadvantage of staining the wool and there may be a risk of causing chronic copper poisoning. Its antiseptic action in addition is weakened by the presence of organic matter in the foot bath.

**Formalin** is probably the substance of choice. It is used in concentrations of two per cent. as a means of control and five per cent. for the treatment of affected sheep. When it is used as a hand dressing, ten per cent. solutions may be used but this is unnecessary and may be injurious if used at higher concentrations than this. Its strength in a footbath is not appreciably reduced after a period of a week.

**Arsenic** has the one advantage of being cheap. It is somewhat irritant and the greatest care must be taken to see that it is not used above the recommended strength. Footbaths containing it should be covered so that stock do not drink from them.

**Chloromycetin.** Recent reports from Australia indicate that a ten per cent. solution of chloromycetin in methylated spirits painted on to the foot with a one-inch paint brush has given good results. The cost per foot is somewhere about one shilling. After application the sheep are allowed to remain on a hard dry surface for several hours before being turned into the paddock. At the moment it would appear that any superiority which this material shows over formalin does not compensate for its higher cost. Concerning treatment in baths there is still some divergence of opinion concerning the concentration of solutions to be used, the time that the sheep should stand in the bath and the frequency with which treatment should be received. In general however it would appear that efficient treatment is obtained when strong solutions of bluestone or formalin are used if the antiseptic is allowed to come in contact with the foot for a period of ten seconds. This would normally be obtained by walking the sheep through an ordinary foot bath. Care must be taken to see that affected feet are put into the solution. Under dry conditions, treatment should be repeated at an interval of one week. Under wet conditions it may be advantageous to treat twice a week. Generally speaking little purpose is served by repeated treatments unless the feet are re-examined and, if necessary, further paring done.

**CONTROL AND ERADICATION**

The following important facts concerning footrot make possible its control by eradication of the infection:

1. The infectious agent can live away from the feet of affected sheep for not longer than two weeks. Therefore any area which has
been free of affected sheep for two weeks must be completely free of infection.

2. Sheep with obvious footrot are easily recognised and with a little trouble and experience the chronically affected sheep, with mild and sometimes hidden lesions which may carry the infection for many years, can also be identified.

3. The great majority of diseased sheep can be completely cured and those which do not respond to treatment can be destroyed.

Armed with this information farmers can design a plan of eradication to suit the particular conditions of their own properties. Since it is easiest during the dry season of the year when the trouble is least common, eradication should be undertaken then. The procedure is to turn up every sheep on the farm. Those with obvious footrot should be segregated. All feet must be trimmed in a search for possible carriers. Any slight malformation of the hoof or unevenness of the claws should be immediately suspected. In cases of doubt the suspicious-looking sheep should be placed with the infected ones. Sheep passed as perfectly healthy and sound should then be put through the footrot bath (ten per cent. bluestone or two per cent. formalin) and turned out into a paddock which has been spelled as recommended. Affected and suspicious cases are then put into a hospital paddock where they can be treated at the regular and frequent intervals recommended earlier. After complete recovery the sheep from the hospital paddock should be run through the bath and placed for a period of two weeks in a convalescent paddock. If after two examinations at weekly intervals they show no further signs of the disease, they may be run through the footrot bath once again and returned to the main mob. This procedure is continued until a few individuals which persist in breaking out afresh are left. These should be slaughtered. All purchased sheep brought on to the property, particularly rams, should be regarded with suspicion. They must be examined and given the treatment outlined above before being admitted to the flock.

Where there is any significant amount of footrot, eradication is a tedious and difficult task which must be carried out with meticulous attention to all the small details involved, but it is possible to free a farm completely of the infection. Then the major concern is to keep the strictest watch for any break in the isolation of the farm lest the infection be reintroduced.

CONTROL OF FOOT-ROT IN SHEEP

J. F. Filmer, Director, Animal Research Division, Department of Agriculture

The title, “The Work of the Department of Agriculture,” which appears on the programme, was not of my choosing. A more correct title would be “Why the Department of Agriculture has not done more work on foot-rot.” Perhaps we could compromise and call my talk “The Control of Foot-rot.”

As you have learnt from Dr McLean, foot-rot is an infectious disease, the infecting organism is known and so is the way in which infection is spread. In such cases, there are three possible ways in which the control of an infectious disease can be tackled,

a. Sheep can be prevented from coming into contact with infection.
b. Sheep can be made resistant to infection.
c. Infected sheep can be treated as soon as infection is recognised.

Let us look at these three methods separately and in the reverse order.
Prompt Treatment

Many New Zealand farmers have had some experience of treating foot-rot and most of them know that treatment consists of efficient paring of the infected foot and the subsequent bathing of the pared foot in an antiseptic solution. The most important part is the efficient paring and unfortunately this is also the hardest part. All of the diseased tissue must be exposed by removing all the horn that overlies it. No antiseptic has proved of any value in treating diseased tissue from which the horn has not been removed. Foot paring is a backbreaking job, but some of the means of restraint which are available, do make it a little easier. These vary from a piece of rope to an elaborate revolving four-cradle holder.

Leg and Neck Rope

This simple device seems to have originated in Victoria. It consists of a loop of rope about half an inch in diameter. This is passed around the legs above the hocks and the free end is brought between the legs, below the portion crossing in front of the hocks and up over the head with the knot behind the neck. The length is such that the hind legs and head are pulled towards each other. If properly applied, the sheep cannot struggle and if placed upon its side, cannot rise.

Bag on Rail

This comes from Tasmania. One end of a wheat sack is nailed to the top rail of a fence and two spikes are driven through it about eleven inches apart. Through the other end is threaded a steel rod about fifteen inches long and the corners of the sack are folded in and sewn in place so that two inches of the rod projects from each end. The sheep is pushed against the sack, the free end is brought up under its belly and lifted up, carrying the sheep so that the rod can be passed over the spikes. The sheep is thus suspended on its side at a
convenient height, with its legs projecting horizontally. The measurements may be on the small side for Romney sheep.

New Zealand Sheep Chair

This was devised by a Hawkes Bay sheepfarmer (N.Z. Journal of Agriculture 1945, 70, 623). The illustration is sufficient to describe this, the dimensions being: Base 2ft 6in. long and 1ft 6in. across, uprights 1ft 8in. high.

The Kelgie Sheep Handler

This is another New Zealand device into which sheep can enter from a race and which can then be inverted, leaving the sheep on its back securely held in a handy position for foot paring. This is fully described and illustrated in the New Zealand Journal of Agriculture 1944, 72, 343.

The B.W. Sheep Holder

This is a patented N.S.W. invention. It consists of four cradles in which sheep are held on their backs. The device can be rotated, sheep being loaded at position 1, pared at positions 2 and 3 and a final inspection at position 4.

Paring requires both secateurs and sharp knife and it must be thorough. Bleeding should be avoided as far as possible but all under-run horn must be removed. Secateurs and knife should be immersed in a reliable disinfectant solution between sheep. In summer, feet get very hard. They are softer if sheep are mustered before sunrise and standing in water prior to paring also helps.

Antiseptic Solutions

A number of antiseptic solutions have been used in treating foot-rot. The most satisfactory have been bluestone and formalin solutions. Bluestone is very effective but has the disadvantage of staining the wool and it is now rather expensive. Formalin is equally effective and cheaper. Ten per cent. solution has been recommended, but recent work suggests that a five per cent solution is quite satisfactory.

Portable foot-rot baths are commonly used in Australia and have the advantage that they can be used anywhere. A convenient size for trays is 6ft x 3ft x 4in. and any number of these can be placed end to end. Wire mesh can be used in the bottom to give a foothold. They are not suitable for bluestone but are quite satisfactory for formalin.

Recently good results with a 10 per cent. solution of chloromycetin in methylated spirits have been reported from Australia. This solution is applied to the pared feet with a one-inch paint brush. In three small New Zealand trials, the following results were obtained:

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<thead>
<tr>
<th>PERCENTAGE RECOVERIES</th>
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<tr>
<td>10% Chloromycetin</td>
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<td>10% Formalin</td>
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<td>4% Formalin</td>
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<td>Methanol Spirits</td>
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<th>Trial 1:</th>
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<td>1 treatment</td>
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<td>2 treatments</td>
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<td>96</td>
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<td>90</td>
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<td>68</td>
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Chloromycetin is thus about equal in efficiency to formalin. It is very expensive but may prove valuable for treating affected sheep in the paddock.
So far no drug has proved superior to bluestone or formalin and no drug has proved to be of any value unless the foot has been thoroughly pared. Injections of antibiotics and sulpha drugs have proved ineffective.

The position in regard to treatment may be summed up by saying that treatment is fairly effective but very arduous.

**Prevention**

Obviously what is wanted is a means of preventing foot-rot. The usual method of making an animal resistant to an infectious disease is by vaccination, but this is only effective in diseases where immunity follows recovery from an attack of the disease. Obviously this is not the case in foot-rot, and consequently, there is no prospect of an effective vaccine becoming available. In some diseases, diet or heredity affect an animal's resistance to infection. There is no evidence that either is of any importance in foot-rot.

We are left then with the third method of control, preventing sheep from coming into contact with infection. This is the method officially recommended in Australia and New Zealand and it is based on the knowledge that the infective organism cannot live for more than a few days away from a sheep's foot. A description of this method has been published in some detail (N.Z. Department of Agriculture Bulletin No. 325) and I do not propose to bore you by repeating what you can read at your leisure. Briefly the steps are:

a. Every foot of every sheep must be carefully examined and all affected sheep removed from the flock.

b. The clean sheep go through a foot-rot bath into paddocks which have been spelled for at least seven days.

c. The affected sheep are either disposed of or treated and none of them is allowed to rejoin the flock until it is certain it has been cured.

This method has been used successfully by a few farmers in New Zealand, but most farmers find it too hard to operate. It usually breaks down because some infected sheep are not detected and the infection spreads rapidly from these to other sheep in the same paddock. I have not been able to convince some of my own staff that it is a workable method. Consequently, although I know from personal experience that it can be made to work, I had decided that it was not likely to solve the foot-rot problem in New Zealand. Then, recently, I read what was being done in Western Australia and Tasmania. In both these states, foot-rot has been made a notifiable disease and infected properties are quarantined and removal of sheep from them, except for slaughter, is prohibited. Perhaps because of this, the eradication methods have proved very successful.

In Western Australia, the campaign for the control and ultimate eradication of foot-rot was commenced in 1949. Since then, 239 properties have been quarantined and 119 of these have been released following upon the eradication of the disease. In Western Australia, only a portion of the state is infected and it is possible to buy clean sheep from other areas. Some farmers have disposed of their whole flocks and bought in clean sheep. However, 53 farmers are known to have eradicated foot-rot by segregation and treatment or slaughter of infected sheep.

In Tasmania, a general policy of eradication backed by compulsory quarantine of infected properties, was introduced in 1939. Today, only 31 properties are quarantined on account of foot-rot and a departmental official has stated that it should be possible to eradicate foot-rot from Tasmania within two or three years. He also stated,
“The farmers' organisations in Tasmania strongly support quarantine and other measures for the eradication of foot-rot.”

A few Tasmanian examples of eradication are of interest:

a. Eradication commenced early in 1949 on a property of 40,000 acres, carrying 31,000 sheep; 8,000 sheep were found to be infected, 2,000 of these were sold and the remainder concentrated on 1,500 acres. Portable tents, foot-baths and yards were used. Feet were pared and put through bluestone or formalin solutions at intervals of three weeks. Cases uncured after two or three treatments were put into a separate mob. No new cases were detected after the end of 1949 and the property was released from quarantine in June 1950.

b. Foot-rot was introduced by some imported rams on to a farm carrying 1,800 sheep and in the winter of 1946, 250 were found to be infected. Seventy of these were sold fat, and the remainder treated. Clean sheep were foot-bathed about once a fortnight and the infected group twice a week for three months, by which time the outbreak had been cleared up.

c. Eradication started on a property carrying 10,000 sheep, in January 1947; 1,300 sheep were infected. Six men were employed whole time for three months, by which time the disease had been virtually eradicated. Since then, only three suspicious cases have been seen and these were destroyed.

It is apparent from the experiences in Western Australia and Tasmania that foot-rot can be eradicated. On the other hand, after several wet seasons, the foot-rot position in Victoria and New South Wales is now about as bad as it is in New Zealand. This caused Australian veterinary authorities to meet and discuss the whole problem last year. After hearing evidence from departmental veterinarians from all the states, they agreed on a foot-rot control programme which does not differ in any material way from that advocated in New Zealand.

The position may therefore be summed up as follows:

a. Foot-rot can be eradicated by the procedure recommended in Australia and New Zealand.
b. This is laborious and requires very careful supervision.
c. There appears to be no reasonable chance of discovering an easier method of eradicating foot-rot.
d. Because of the considerations outlined in a., b., and c., New Zealand sheep farmers have the unenviable choice of eradicating foot-rot the hard way or continuing to live with it.

FOOTROT ERADICATION
D. Alderton, Gore

Introduction

In 1945 I purchased a 584-acre property in the West Otago district. The farm had a sunny disposition and consisted of rolling, quick-drying ridges with small areas of flat land and some swamp. It would classify as good second-class country, but was in poor condition barely carrying 800 ewes and 300 dry sheep, that is two adult sheep per acre, also sundry horses and cattle.

My two main observations on the health of the sheep were—
1. A very low incidence of footrot, and
2. A high incidence of worm infestation.
The latter was so bad that odd lambs were dying before weaning time. The worm trouble was very soon brought under control by an improved system of sheep management, and a ewe drenching programme, but the footrot, being of low incidence, no steps were taken against it except for the paring and dressing of obviously infected feet during crutching operations.

That was in 1945. By 1952 the property was carrying 1,400 ewes and 450 dry sheep, that is 1,850 adult sheep as compared with 1,100 in 1945. These stock figures are important because as the pastures became more lush through liming and top-dressing and the sheep numbers increased, so too increased the incidence of footrot.

By 1949-50 footrot on the property was becoming or had become a major problem and was obviously affecting production. The trouble was most evident in the winter and spring when sheep were either on turnips or on the soft spring grass. Ewes badly infected were producing lighter, tender and cotted fleeces, were far more prone to sleepy sickness and, in odd instances, had not sufficient milk to rear the undernourished lambs they produced. Also they made management more difficult and all work with them was trying and slow through their inability to move around freely. Every low-country sheep farmer has no doubt experienced the inconvenience and loss of time entailed handling lame ewes when part of a mob of active free-moving sheep.

One may ask when infection was becoming serious by 1949-50 why was it not until 1953 that a footrot eradication programme was carried out? I will answer that question this way. During my years as a farmhand and shepherd on the heavy flat land of West Otago I had had a long and painful apprenticeship in the art of footrotting sheep. Under the existing order of treatment the word footrot had associated with it the prospect of hard and back-breaking work. Furthermore, the job was never really finished and, as sheep were usually only treated once, no accurate observation of the results of this work was possible. Footrot was always present and it only needed a foot to become slightly scalded for the disease to quickly take hold again. This had been my experience and I wanted better results than that for my labours. I found the answer to my requirements in Bulletin No. 325 N.Z. Dept. of Agriculture prepared by Dr. J. F. Filmer and I determined that when I tackled the footrot problem it would be done under the basic directions laid down by him.

Facilities

The facilities available on my property for the handling of sheep were fairly typical of the average sheep farm in the district. The sheep yards had no conveniences for footrotting. The woolshed was small and badly lighted and was designed solely for the purpose of taking wool off sheep. The only way sheep could be footrotted was to drag them out on the shearing board, pare and dress the feet and then put them out of the porthole into a concrete-floored counting-out pen. From there they went out into a yard which was, as often as not, fairly muddy. The shed had this advantage over the sheep yards in that if you were lucky enough to get the sheep in dry you could footrot on wet days, but as soon as they were done they had to go outside and stand in a wet pen and then go out into the yard. There were no facilities for segregating footrotty sheep from sound ones and, in wet weather, no way of keeping the feet of treated sheep out of mud for any length of time. In short it was obvious to me that I was going to get nowhere with a footrot eradication programme with my existing facilities and I was not prepared to carry on treating footrot year after year with no lasting results.
Planning of new facilities

I mentioned before that my woolshed was small, badly lighted and in general very inconvenient so I decided I would have to build a new shed and convert the old one back into a manure and seed shed for which it was originally designed.

But I didn't plan a woolshed, I planned a sheep shed and these are two vastly different things. Most sheds are designed solely for the purpose of removing and handling wool off the sheep.

I envisaged four very important uses for my new shed.

1. The harvesting of wool off the sheep with the emphasis on after-shearing care of the sheep.
2. For hand culling and sorting of sheep (particularly show sheep).
3. For the treatment and ultimate eradication of footrot.
4. As a recreation facility for boys and girls of all ages.

Now this plan, gentlemen, is the new sheep shed and before going on with the specific footrot facilities I would like to briefly explain how the shed was planned.

Firstly, you will note it is at one end, the wool room end, a two-storeyed structure. A suitable site had to be selected for this type of shed and an ideal one was found adjacent to the homestead. Briefly, the lower storey is designed solely for the after-shearing care of sheep. The sheep are delivered directly under the shearing board by these two semi-circular shutes to the branding pens and a big chaff feeder is built in to provide hard nourishing feed. Sheep can then be either kept in the shed or let out as weather permits.

The second use is for the hand culling and sorting of sheep. You will note that the shed grating area is laid out round a well-lighted and central sorting pen. This greatly facilitates handling of sheep, particularly when sorting and grading sheep for show purposes.

The fourth use is for recreation facilities. All bins in the woolroom were made either folding or completely detachable allowing a clear floor space of approximately 24ft x 40ft, ideal for holding a dance or as a playing area. I can assure you that kiddies have a wonderful time sliding down the shutes. Gentlemen, this fourth use of the shed should not be ridiculed as it is of great practical importance to the young folk on the farm.

Now back to footrot. You will notice that from this centre sorting pen a narrow race runs towards the outside wall. In this race is a ramp rising approximately 1ft above floor level. At the end of the ramp and on the same level is installed a Kelgie sheep handler. The race holds two sheep and the handler of course one, which means that three sheep are put into the race at once, the first sheep going forward into the handler. Enough space is allowed for sheep released from the handler to turn and proceed down the side of the shed into a 14ft concrete bluestone trough. A good sprinkling of hay was put into the trough with the bluestone, the result being that sheep walked in more confidently and the splashing of liquid bluestone was reduced to a minimum. At the end of this trough is a stop gate with a swing gate at top of ramp to meet it so that sheep can either be directed down below or retained on the top floor. The bluestone solution is mixed in an old 30 gallon copper super heater set in a corner near the handler and the solution is fed straight into the trough as required through a copper pipe. A piece of No. 8 wire running the length of the trough through ¼ in. piping and fastened to the stop gate is so adjusted that the operator can work this gate from the sheep handler. So much for the footrot facilities.
Planning the operation

The whole operation was planned with the assistance of Mr C. Martin, the local Livestock Instructor, Department of Agriculture, who gave active assistance throughout, and was based on the information available to us in Dr. Filmer's Bulletin.

The basic knowledge around which the whole operation was planned was this:

Footrot is caused by a specific germ which cannot live off its host for more than a week.

This germ can be positively killed if exposed to a sufficiently-strong bluestone solution.

If all germs are killed footrot will not recur unless the germ is re-introduced from outside sources.

It was evident from the start that the operation would be a major one requiring high priority entailing as it would the handling of every sheep on the property, many more than once. It was decided that the best time to tackle this problem was in the late autumn when all surplus sheep had been disposed of, when the incidence of footrot appeared at its lowest ebb, and when it could be combined with the ewe-flushing programme before mating. This operation was planned weeks before the work was actually started. Feed requirements made this imperative.

If I may refer you to this map I will explain the planning of the operation. Firstly, I decided that the sheep would be handled in four mobs, and in this order:

1. 30 rams (Woolshed paddock).
2. 400 retained ewe and wether lambs (Bee paddock).
3. 350 2th ewes in (Rush paddock).
4. 1,050 mixed age ewes in (Hay paddock).

This meant the use of four paddocks convenient to the site of operations but completely separated from the clean receiving pad-
docks. Provision was made for two hospital paddocks, one for the lame rams and the second and much larger one for the lame females.

Four receiving paddocks were then decided on and these were kept free of sheep for from three weeks to a month for two reasons:
1. To clean them of the footrot germ, and
2. So that there would be a plentiful supply of feed for the flushing operation.

The planning of the segregation and delivery of these animals to and from the shed was made easy because the shed has three doors, one to be used to bring in all sheep in their order. A small door for loading sheep on to a lorry was available to take away the sound rams and thereafter all infected rams and ewes to the hospital paddocks. The third door from the lower part of the shed was to be used by all sound sheep going to their respective paddocks. Under these conditions there would be no chance of treated, sound sheep being recontaminated by walking over ground or through an entrance used by unsound sheep.

The operation

Now I think the best way to tackle the next stage is to tell you exactly what we did and then afterwards to enlarge on our activities in the light of what we learned. Footrotting actually commenced on 9 April when 30 rams were brought in and put through the sheep handler. All feet were very carefully pared down and 15 out of the 30 sheep were found to be infected with footrot. Some of the old rams were very difficult to do with great horny feet very much out of shape. It was whilst doing these we first appreciated what an important part the sheep handler was to play in the operation. The rams were then taken to the clean and hospital paddocks provided for them. Secondly, the ewe lambs were brought in and paring of feet commenced, but these were done on the grating as, being smaller than ewes, they could move about too much in the handler. We found the lambs' feet difficult and slow to do with great horny feet very much out of shape. It was whilst doing these we first appreciated what an important part the sheep handler was to play in the operation. The rams were then taken to the clean and hospital paddocks provided for them. Secondly, the ewe lambs were brought in and paring of feet commenced, but these were done on the grating as, being smaller than ewes, they could move about too much in the handler. We found the lambs' feet difficult and slow to do particularly when they started to harden, as the knife had a nasty habit of turning under the hard horn and slicing into the quick. After about 50 lambs had been done with no sign of footrot I decided we were doing more harm than good and altered our tactics. Foot paring ceased and facilities were used to allow the lambs to by-pass the sheep handler and be held eight at a time in the bluestone for a period of approximately one minute. This greatly facilitated the operation but I would not have been nearly so pleased with myself if I had realised what the outcome would be. These lambs were all sent out to their clean paddocks. Work then commenced on 350 two-tooth ewes through the sheep handler. A thorough job of paring was done here and all sheep were held for a few minutes in the bluestone solution. The patent to enable the gate at the end of the trough to be open and shut from the footrot cradle was proving a wonderful time-and-labour-saving device. All infected sheep were marked, the clean ewes going down the ramp to the lower area and the infected ones being retained on the top floor of the shed. All were held on the grating for at least an hour before being let outside. Approximately 20 of these young ewes were found to be infected and these went to the main hospital paddock whilst the balance followed the hoggets out of the bottom door to their clean flushing pasture. This left 1,050 mixed aged ewes to be done and it was in this mob that we struck the bulk of the infection, much of it in a very advanced stage. Throughput of sheep slowed down considerably, some ewes with more than one infected foot taking as long as ten minutes each. Exactly 142 of these mixed age ewes had footrot, many of them being severe multiple cases. At
the end of the operation we had 162 female sheep in the main hospital paddock of approximately ten acres, the balance being all on flushing pastures.

Operational problems

This resumé of what was done all sounds simple and straightforward enough but I want now to go back over the operation and explain some of the problems faced and their effect. The decision not to pare all lambs' feet was cardinal folly and could have immediately ruined the whole operation.

Later findings showed how wrong we were and why it is imperative that every digit of every foot of every sheep must be thoroughly examined.

However, the decision was taken and for two main reasons.

1. The difficulty and time involved of paring small tender feet without deep cutting.
2. The fact that no lame lambs were observed.

I will deal first with the paring trouble. Experience showed us that only small numbers of sheep should be brought into the shed at one time, certainly not more than two hours' work in lambs. The horn of the foot must be soft for fast and precise footrot work.

Secondly, the knife must be kept very sharp for lambs and drawn always towards the thumb as a positive control on its movement. I do not like the use of secateurs. They will not work close enough to be able to remove all dead tissue and if the horn of the foot is not allowed to become too dry and hard, the good sharp knife will very effectively remove all under-run horn in one operation thus speeding up the work. Thirdly, we learned to our cost, that all infected sheep are not lame and the apparent lack of distress on the part of a sheep should never be taken to denote the absence of footrot. On many, many occasions we found that active sheep were badly infected but owing to protective horn growth they could move about without discomfort, no doubt polluting the pastures with footrot germs as they went.

By experience we learned that the most reliable guide to an infected foot was not the shape of it but the feel of it in the hand which held it.

The pastern should feel cool and supple to the touch. The sensation of heat and dryness should immediately arouse suspicion and this foot must be exactingly pared as, irrespective of its shape, there will be some severe irritation present to cause this condition.

It is important to realise that as far as the footrot eradication programme is concerned it is a job for an expert. So much depends on the detection and efficient uncovering of diseased tissue that, with inexperienced or unreliable labour, the operation would have little chance of success.

Another real problem presented itself, and that was whether to allow all sheep to just walk through the 14ft bluestone trough or to hold for a few minutes. Of sheep freshly brought in, footrotted, and held in the trough, quite a number urinated and this dilution of the bluestone mixture could have had serious repercussions if not effectively combated. To counteract this I made the bluestone solution stronger than 1 in 10 and, as a further safeguard, sprinkled quite a few pounds of powdered bluestone into the trough each day. Dilution was so heavy at times that not much solution was required to be added each day. So much does the operation depend on the effectiveness of the germ-killing agent that I could not bring myself to allow sheep to walk, run, or in some instances, just bound through the
trough. I would like Dr. Filmer to give a ruling as to whether it is necessary to hold or to just walk through.

The bluestone handling facilities proved very effective. The handling of bluestone in tins or basins can be an awkward and inconvenient job and I would strongly recommend some system like that which I described previously.

Next we come to a very important point. Just what part did the Kelgie Sheep Handler play in the operation? It would be most difficult to overestimate its value and the importance of its being permanently and conveniently set up inside the shed. Otago and Southland farmers will remember that April last year, during which month this footrot eradication programme was implemented, was atrociously wet. If the sheep handler had not been installed inside, the way it was, the job would never have been completed. A difficult and disagreeable job was made easy and actually became almost a pleasure. There was no weather worry and of course no need to shed the sheep the night before. It was just a matter of bringing the sheep in when ready to start operations. On days when there has been no drying I have done a full day's work with sheep dripping with dew or white with frost when shedded.

No matter how wet the sheep or how filthy the day the job went on with the operator working in comparative comfort.

In fact the wet conditions greatly facilitated the work, as the feet were more easily pared and stayed softer longer, because of the moisture running down the legs to the hooves. Another most important benefit was that the operator, because of the comparative ease of the work, could put in longer hours, and during last year's operation, when time was getting short, I often went back into the shed at night and carried on. One can't imagine that being done under the old arduous system.

Plenty of light is essential round a footrot cradle. Light to attract sheep into it, and light, both natural and artificial, to assist the operator. I would recommend the lay-out as shown in the shed plan.

Treatment of infected sheep

I will go on to give details of the handling of the sheep in the hospital paddocks. The infected rams had been brought in during a convenient lull in the ewe programme and most of the 15 appeared to be cured. These were put through the bath and joined with the clean rams. The balance went back to the Hospital paddock. Immediately after the ewe programme was finished the remaining infected rams were brought in again and all but two were declared cured. These two appeared to be still bad cases and, as they were aged sheep, were returned to the Hospital paddock and later killed for the dogs.

On Tuesday 28 April the 162 sheep in the female hospital paddock were all brought back into the shed and after being carefully examined and if necessary treated, were put through a 30 per cent. solution of bluestone. The success of the initial paring and treatment was now apparent, and of the 162 infected sheep, 95 were classed as cured, and put into an intermediate paddock. Sheep which had had footrot and had been cured, were not returned direct to their respective mobs because of the possibility of the cure not being complete. Sixty-seven sheep which still showed signs of active footrot were returned to a fresh hospital paddock.

On Wednesday 6 May, the 95 sheep were brought in from the intermediate paddock, examined and put through the bluestone bath. One of these which had had a very bad foot did not appear to be cured, and was kept out to be sent to the freezing works. 67 sheep
were brought in from their hospital paddock, examined and treated, and put through a 30 per cent. solution of bluestone. On this occasion 33 sheep were classed as cured and put into the intermediate paddock. 34 were considered to still have footrot, and four of these, together with the one from the intermediate paddock, all being classed as incurable were sent to the freezing works for killing. Thirty sheep were thus retained in hospital paddocks.

On Tuesday 12 May all sheep from the intermediate paddock were examined, put through bluestone and, as all were considered cured, they were returned to their respective mobs. In the case of sheep in the intermediate paddock from this stage on, they were retained there for a period of observation, then examined and if cured, put through bluestone finally, and returned to their respective mobs. Thirty sheep from the hospital paddock were again put through the cradle, 14 were classed as cured and, after usual treatment, put into the intermediate paddock. Sixteen sheep were not cured, six of these were put through the bath, and 10 which were infected mainly with exposed proud flesh at the toes brought about chiefly by severely-cut toe veins, were dressed with a proprietary footrot paste containing bluestone and bandaged. Sixteen sheep were then placed in a hospital paddock.

By Tuesday 19 May 5 sheep had been returned from the intermediate to the hospital paddock because of incomplete cures. 21 sheep required examination and treatment that day. The 10 bandaged feet were soft enough to pare easily, and after paring they were put through the 30 per cent. bluestone solution, and for the next four days were held and fed in the shed on the grating. The other 11 sheep were classed as cured and entered an intermediate paddock.

On Tuesday 26 May the 10 remaining sheep were put through the treatment procedure, and of these six were definitely cured, and four were held for further treatment. These four were all cases of proud flesh protruding through the horn of the hoof at the toes, and were subsequently cured with bluestone. It was on this date, approximately six weeks after the project was begun that, for the first time, no active footrot was observed, and the footrot elimination project was at an end, or so we hoped.

Time problem

It can be seen that the programme was not an easy one and that it spread over some considerable period of time. We found that we had not anticipated such a time lag from start till finish and a dangerous situation arose regarding feed both in the mixed-age ewe-holding paddock and in the main hospital paddock. It is possible that, because of this feed situation, an odd ewe forced its way from the holding to the flushing paddocks without treatment. Time planning should allow for one operator to do no more than 100 sheep a day on an average and enough feed should be assured to prevent shortage in the holding paddocks. Similarly a reasonably reliable estimate should be made of infected sheep numbers so that the hospital paddock is of sufficient size. Of course holding paddocks become available as hospital or intermediate paddocks after they have been clear of sheep for over a week.

Results of operation

It will be appreciated that after such a painstaking operation a very close watch was kept on both hoggets and ewes. Sheep showing lameness were caught and examined and, for some time, only scald or injury was evident. Then one day a lame hogget was caught and disclosed a typical case of footrot. No doubt now as to the folly of our previous treatment of these animals.

Drastic measures were indicated and taken.
They were moved en masse to the Woolshed paddock, the knife was sharpened like a razor, and every sheep was subjected to the detailed examination and paring which should have been its lot in the first instance.

Twenty cases of footrot were discovered amongst this mob of active and well-conditioned hoggets and these were isolated and cured. Imagine the chaos caused to the whole programme if these hoggets, going always ahead of the ewes in the winter, had been allowed to spread the disease over the whole turnip ground.

A close watch was still kept on the breeding ewes which, by this time, were all together cleaning up the available grass before turnip-ting commenced. Then one day in July a positive case of footrot was discovered. The ewe was isolated and cured. Four other cases were so treated during the winter and then, owing to the pressure of seasonal work and approaching lambing, vigil waned and eventually ceased.

*It was now obvious that that which we had set out to do had not been achieved. That is the complete eradication of footrot from the property.*

**Breakdown?**

Where did the breakdown occur? I cannot answer that question. I can only mention possible causes.

Perhaps odd infected sheep, because of feed shortage forced their ways to paddocks containing clean ewes.

It could have been, though not likely, the fault of too much dilution to the bluestone at some time.

Perhaps a foot, in the early stages of infection, was missed and passed through the trough without complete saturation.

I am inclined to favour this third reason as some cases are extremely difficult to pick without detailed and expert examination.

I am sure the ewes were not re-infected by the ewe hoggets whose feet were not originally pared, as there was complete segregation of these sheep until after the hoggets were re-done.

The fact remained that after all this work I still had footrot.

However, in the light of subsequent results I would be the last to suggest that the operation was a failure.

Very beneficial results have been most obvious all season. A record lambing percentage; heavy and even fleeces at shearing time with less breaks and cots; less tail in lambs at weaning; pleasure and less waste of time in driving of all sheep on property. So much for the operations of 1953.

**This year's activities**

The good, though incomplete, results of last year's operation left me satisfied that footrot eradication was more more than a pipe dream and in support of those views the whole operation was initiated again this year. In all 1,900 sheep were treated and of these 103 were sent to hospital paddocks as definite or suspect cases. It would be legitimate to comment that from 197 active and suspect cases in 1953 the number had dropped only to 103 this year.

Not a very complimentary figure to the success of last year's work.

Well, gentlemen, I can assure you that the disparity was far greater than it actually appears. Only very few of the 103 cases this year were positive cases of footrot, the great majority being scalds or only suspects.

As an instance of the difference in the actual work this year I
recall that last year I estimated that 100 sheep was quite a good day's footrotting. This year I did as many as 165 in a day, and lightly crutched them as well. These comparative figures emphasise the improvement in the foot health of the sheep over the year.

Just a word about the light crutching in conjunction with the footrotting. It is a job I always do before flushing and last year all sheep were put through the shed twice, once for crutching and once for footrotting. The combining of the two jobs this year, not only saved time and effort, but also indelibly marked all ewes which had been through the sheep handler. This was an invaluable safeguard as any untreated sheep breaking through into a treated mob would have been immediately conspicuous. Not one such case was found. It is too early yet to assess final analysis of the second programme but if results are only cumulative on those obtained last year I shall have good cause for gratification.

Summary

I would summarise thus:

1. Make sure facilities are of a standard to ensure reasonable chance of success.
2. Plan operation well in advance giving particular attention to feed requirements and cleanliness of receiving paddocks.
3. Ensure that job has highest priority of farm work whilst so engaged.
4. Use only reliable and competent labour.
5. Pare all feet conscientiously, removing all under-run horn and diseased tissue but without undue wounding of sound tissue.
6. Watch strength of bluestone solution.
7. Ensure complete segregation of treated and untreated sheep at all times.

Conclusion

In conclusion I would like to pay a tribute to those people who made possible in one way or another a footrot eradication programme. Firstly, the research officers who discovered the germ which caused footrot, defined its habits, and detailed the steps necessary to free sheep of this germ. Without this technical knowledge a programme such as I have described would have never even been contemplated. Secondly, the local officers of the Department of Agriculture who assisted in all ways to ensure the success of this major and beneficial undertaking.

As a farmer, I think it pertinent to ask why, of the thousands of farmers on whose property the scourge of footrot is taking an incalculable toll each year, are only a comparative few responding and making all this research worthwhile? Of what profit is this knowledge if it is not actually put into practice where it will get results.

I feel the answer lies in facilities and not in indifference. It would be a poor husbandman indeed who could be indifferent to such an obvious scourge to his flock and reducer of his bank balance.

As I pointed out previously, under the old order and using average facilities, the dragging out, holding, and footrotting of perhaps 1,500 heavy sheep was a task to have daunted the stoutest heart. This year, using the facilities I have described I did the whole job on my own except for two days' assistance with the lambs.

More than once I have seen eyebrows raised when I have mentioned the cost of my shed.
I can assure you, gentlemen, that the results I am getting from the use of the footrot facilities alone will pay for the whole shed in a very few years.

If farmers could be encouraged to so improve their sheep handling facilities that the hard work was taken out of footrotting, I am sure that the result would be a widespread and well-rewarded campaign against this crippling disease.

I feel that in the successful promulgation of a footrot eradication programme a farmer will be showing due recognition of the splendid work of our research officers, giving pleasure and profit to himself, and also making a substantial and practical contribution to the increasing prosperity of his country.

DISCUSSION ON PAPERS

Mr A. Grant, Waimate: Are there any statistics as to the financial loss to this country through footrot?

Mr R. H. Bevin (Economic Service of the Meat and Wool Board): We have no information that could be called statistically sound. We do know that footrot is the worst disease we have.

Mr Pilbrow, Ashburton: Supposing you have actually picked out all the sheep that have footrot, treat them and apparently cure them. It still appears that there will be odd sheep which develop a pocket of footrot inside the hoof, even though the hoof is completely healed over and apparently sound. That sole will apparently grow for about two or three months and then break out as footrot.

Dr. Filmer: You can completely cure footrot. There is no doubt about that. The best way of minimising the risk of sheep not being completely cured is to inspect the sheep every time you bring them in. I am not very much enamoured of the idea of just running the affected sheep through a footrot bath regularly. I believe it is better to bring them in once a week and inspect all the feet and I am sure that the first two or three times you do that with a mob of infected sheep you will find some that require paring. It does not matter how careful you are the first time you will miss some of the under-run horn. I believe if you inspect once a week and remove horn at that stage you will overcome the difficulty. If you don't, and just run the sheep through the bath there is a real risk of some of those little pockets having horn growing over them.

Mr Polhill, Orari Gorge: Could we carry the germ from infected yards on our boots or on animals or tractors passing through?

Dr. Filmer: It is possible, but in my experience and that of others it is not an important way of spreading footrot. I would not deny the possibility of a germ being carried on a person's or a bullock's foot and transferred that way but you have to have a lot of coincidences for it to happen. Someone has to tread just where the germ is, the germ has to remain on the foot until it is planted somewhere else, the sheep has to tread exactly where the germ is and the germ has to find its way into the sheep's foot.

Mr T. P. Shand, M.P., Kaikoura: One point which Dr. Filmer made which is of deep interest to all of us is the problem of legislative action. I think all of us who are on the hill country realise that any such action in New Zealand at the present time would be disastrous. For instance, I would be isolated immediately. I sell nothing but store stock so my year's crop of lambs and ewes would have to
be slaughtered on the property. Such a state of affairs is representa-
tive of the hill country of both islands. We have not yet reached the
stage where we could contemplate such a step.

I feel the first legislative step would be the barring of the sale
of sheep with footrot in sale yards. I may be wrong but I believe
that if that were done this year it would put every sale yard in the
country out of operation. We cannot do that yet. Any action must
come from the farming community themselves. I look forward to the
day when we can take action but we have to campaign against foot-
rot until we reach a stage where we can take legislative action with-
out damage to the whole industry. I have a hill-country property
which has a deep valley with good dry country on the tops and Eng-
lish grasses on the heavy bottom land. I have all the inconveniences
for handling footrot you could imagine. There is only one way into
the shed and only one way out. The English grass country carries
three sheep to the acre in a 60-inch rainfall. Under these conditions
footrot spreads like wildfire. I had footrot ever since I came back
from the war but cleaned it up by 1948. We got a stranger in our
ram paddock in 1952. There was no man on the place with experi-
ence with footrot and I wasn't even told that the sheep were lame.
As a result we had to treat 3,000 out of a flock of 4,000 sheep. Last
time I went through the ewes there were two suspects and one defin-
ite case. I did it by treating the sheep in the shed and keeping them
there until they were quite free of footrot. Most of us are not in the
fortunate position of having a new wool shed, but perhaps we could
adapt our present shed. I have feeders right round inside the shed
and feed them on moose nuts, hay and water. Merino wethers will
take moose nuts after three days if you put chaff with them. Using
the shed I can treat sheep in any sort of weather. No hospital pad-
docks are needed and it is not expensive as it is only a few minutes' work in the morning for someone to fill up the feed troughs.

Mr Laidlaw, Kaikoura: Are arsenical preparations irritant
eough to cause or encourage the start of foot abscess and what is
the treatment?

Dr McLean: So far as I know if arsenical preparations are used
at the recommended strength they will not injure the foot. It is only
when the concentration gets above that, that injury occurs. As far
as the treatment of foot abscess is concerned it is much more difficult
to cure than footrot. If it can be picked in the very early stages dur-
ning acute lameness, it is possible by paring the foot to open the
abscess and release the pus so that it can drain downwards and act
as an ordinary open wound. It won't spread any further. If the foot
is kept clean and the hole kept open no further treatment is neces-
sary. What often happens is that the pus commences to gather, is
imprisoned in the hard horny foot and breaks out somewhere above
the coronet. In this case if you can see where the abscess is about
to burst, you can lance it in order to allow the pus to escape. The
wound then should be treated as an ordinary open wound. The pus
is squeezed out and the cavity syringed with antiseptic. You can
make up a solution of sulphanilimide in liquid paraffin and squirt
into the clean wound. Then keep the sheep on a dry, clean surface
such as the battens in the woolshed. Another procedure is to pack the
infected foot with crude cod-liver oil and then bandage with bandages
soaked in cod-liver oil. If left on for one to two weeks the foot
abscess will often be found to be cleaned up. Where the tissues are
extensively damaged and where the infection has got into the joints
or tendon sheaths or has attacked the ligaments or tendons, then it
is going to take very much longer. Often the tendons are so dam-
aged that the fetlock drops right to the ground. In many of these
cases the foot is left permanently injured. Early cases sometimes respond to penicillin. Half a million to a million units of penicillin in one injection have proved successful.

There is no simple method of preventing foot abscess but we can reduce the chance of injury to the foot by paring or other ways of keeping the foot sound. If a few cases of foot abscess turn up it is wise to get all the sheep in and have the feet trimmed. The organism which causes foot abscess is a very common one and often found in sheep dung.

Mr Smith, Oamaru: Why is foot abscess more prevalent in rams than in ewes?

Dr. McLean: I don't know of any reason except that when we turn rams out we carefully examine them beforehand. After mating they are taken out, not carefully examined, and kept in paddocks where they don't make a nuisance of themselves. Often we don't look at their feet until the next mating season, so that the horn tends to become a little overgrown, may crack and the chances of getting infection of foot abscess are increased. Possibly also since rams are heavier and the feet not correspondingly larger more stress is placed on them and they are therefore more susceptible to injury.

Mr Bruce, Ashburton: We have heard and we know that the main way to get rid of footrot is by hard work first and last—it does not seem to matter what substance we use so long as we do the job properly. In Mid-Canterbury we are rather perturbed because a substance, "Thiovac," which has given us good results, has been barred from sale by the Stock Remedies Board. Many farmers claim great success with it—possibly I will admit because it is expensive and therefore they have done the hard work more carefully. It seems a pity that if it gives such good results we cannot still use it.

Dr. Filmer: I am no longer a member of the Stock Remedies Board. It is a statutory board set up under the Stock Remedies Act and its job is to examine the formulae of all remedies submitted for registration and it decides in its wisdom whether or not registration should be granted. I don't even know whether the Board has finally decided not to register "Thiovac." I have nothing personal against it but I know nothing that would suggest that it is any better than some of the remedies recommended to you today.

Dr. Filmer: I know of no such means that will prevent or cure footrot. If anybody does he can make a tremendous amount of money.

Mr Butcher, Broadfields: Is there anything in feed that will increase the spread of footrot among sheep? I have noticed that where sheep are fed on heavy white-clover pasture or on lupins, that footrot seems to spread more quickly. Do you think that the quantity of nitrogen in these feeds would have any effect?

Dr. Filmer: I have no evidence that feed will increase the incidence of footrot. Sheep on rich clover pasture are usually grazing under conditions where footrot spreads very rapidly.

Mr Scott, Timaru: Is there any chance of infection by the use of dirty lorries for transport? A clean mob might be carried after a contaminated mob.
Dr. Filmer: There is a very real risk of spreading infection that way.

Mr Mulligan, Ashburton: We were fortunate in being able to clean up a mild attack and now have a bonus of £1 a head if anyone can find a case of footrot. So far we have been lucky. Enthusiasm is paramount. Time is the second factor and the third one is hard work. We have evolved a box into which we put all our sheep for inspection. We mark only the healthy ones, leaving the infected ones to be marked only when they are passed as sound. An infected sheep is isolated straight away; that is essential. We find very useful a movable bath which we trail round behind the truck and put up at a suitable gateway anywhere on the farm. This is no good for the hills but is grand for flat country since it enables you to keep the sheep away from the main yards. Paring is essential. If there is a lot of blood about don't worry—put the sheep into the hospital paddock, the blood will dry up and the sheep can be treated again later.

Mr Croft, Amberley: I have had footrot (that is, my sheep have had it) and I have cured it both times. It took almost two years each time. Paring is the main thing but I think there should be the very minimum of blood. The biggest job is to pick out and identify the clean sheep from the ones that are not quite clean. That was where we failed in the first year each time we had footrot. I think perhaps Mr Alderton also was too quick the first time.

Mr Buckenham, Dunsandel: Has anything been done in the way of trying to breed sheep with better feet? I think you will agree that some sheep have much worse feet than others.

Dr. McLean: From the work of Dr. Beveridge in Australia it has been found that some individual sheep are quite difficult to infect with footrot artificially. Some sheep, by some mechanism or other, are more resistant to footrot than are others. As to selecting these and breeding from them, I don't think anything has been done. On general grounds I would agree that sheep with normal, sound, well-shaped feet are less likely to become infected than those with weak, small, deformed feet. I would advise the sheep breeders here today to pay a good deal of attention to the kind of feet their sheep have.

Mr Oliver, Hororata: I breed fat lambs. I have to buy my replacements and I have to go on the open market where they are sold irrespective of the condition of their feet. Can anyone tell me where I can buy footrot-free sheep?

Mr Carpenter, Fernside: It has been assumed by most speakers that by examining sheeps' feet you can detect those which are not affected by footrot. We have found that with the greatest care there will still be a few that slip through undetected. Could Dr. Filmer outline a programme that would enable us to overcome this?

Dr. Filmer: Undoubtedly that is one way in which the eradication scheme may break down. I know of no magic way of getting over it. I would make the suggestion that when you are going through your sheep, separate those with footrot from those that are clean. Don't bother to treat infected ones at that stage. Spend more time in picking out the clean sheep. Just shift the infected ones into quarantine. If you still make a mistake the only thing I can suggest is to do as Mr Alderton did—keep an eye on your clean sheep after you have put them out and look carefully for lame ones. If you detect any, bring them in. If you find a sheep with footrot in any paddock, bring all the sheep in and go through the whole procedure again.

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Mr Robinson, Amuri: What is Dr. McLean's chief objection to kerosene? A lot of people in our district are using kerosene in preference to bluestone, and having very good results.

Dr McLean: I have no objection to your using kerosene at all. As a veterinary surgeon I have a general objection to the use of kerosene for all sorts of complaints that it is used for on farms—greasy heels, lice, blow-fly strike and a few other odds and ends. I think there are better things than kerosene and in general it is too irritant and causes damage to the skin.

Mr Little, Hui Hui: What precautions can a clean place take to prevent even the slight risk of infection that you mention? Is there any way of sterilising a yard after you have had infected sheep in it?

Dr. Filmer: Leave it alone for a week.

Mr Jebson, Rangiora: Although kerosene might be quite useful for cleaning up footrot I think using it neat is very unsound. One farmer who thought he had footrot in his hoggets ran them through kerosene three or four times a week with no reduction in lameness. On examining the feet of those which were lame, very definite burns due to kerosene were found in the cleft. We have been sold the idea of planning footrot eradication campaigns, and we have been told about the many aids which make the job easier. It should be remembered that these aids are purely aids and in themselves are not essential for the eradication of footrot.

Mr Turton, Ashburton Forks: I have found that you can cure footrot. What I would like to know, is that once you have it cured what is the next thing to do? I put my sheep through every three weeks using a weak solution of formalin. Am I doing the right thing, or would I be better to leave them alone altogether?

Dr. Filmer: There is no need to do anything with your footrot-free flock except to keep their feet trimmed if they need trimming. I don't see any advantage in putting clean sheep through a foot-rot bath but you must be careful with new sheep brought on to the property.

Mr Turton: Some years ago I thought the Act was amended so that you were not allowed to offer sheep with footrot for sale. To my mind the only way to clear the thing up is to ban sheep with footrot from sale.

Dr. Filmer: I am glad the question of legislative control has been raised. I want to make my own position clear. I told you what had been done in Western Australia and Tasmania. I didn't advocate legislative control in New Zealand; neither as an official nor an individual would I advocate it unless the industry wanted it. I would not want to be the official in charge of legislative control unless a lot of people asked for it.

Mr Hurst, Papakaio: The Chinese way of keeping people right is to pay the doctor when the people are well. I pay my men extra wages when the sheep are clean. In regard to legislation that is a question for the Federated Farmers. If they can do it in Australia, we can do it here, just as we cleaned up scab years ago. Sheep owners should be given until 1960 to clean up their properties and then legislation should be brought in.

Mr Nutt, Motukarara: Is there any connection between the incidence of foot abscess and of foot rot? Among the foot-rotty sheep I cleaned up last year I had six cases of foot abscess. Would foot abscess be due to the damage done to the foot during treatment?
Dr. McLean: I would say that in most outbreaks of footrot there are invariably a few cases of foot abscess. The injury done to the foot which allows the original infection of footrot and the further injury done by the footrot organism itself leads on occasions to the entry of the foot-abscess organism. It is possible to get foot abscess by itself in the complete absence of footrot.

Mr Topp, Waipara: Can the footrot germ remain dormant in the hoof of a dead sheep?

Dr. Filmer: I don't know how long it could live there and I don't think it would be of any great importance. When the sheep is dead its foot stays put. It could not affect the grass except within a few inches of it. It would not be a very important source of infection.

Mr Hoy, Ashburton: Farmers are sometimes confused about a crescent-shaped area on the outside wall of the hoof found when paring a sheep's foot.

Dr McLean: The condition is called Clover Burn, Dry Separation or sometimes Shelly Hoof. It takes the form of a crescent-shaped lesion on the outside wall and it represents a region over which the horn tissue of the wall has separated slightly from the tissues underneath. It doesn't smell like footrot and it is not footrot. The lesion, when opened, is fairly dry and it is not infectious to other sheep.

A speaker: Several speakers have said today that the knife is the best instrument. The problem with the knife is the hardness of the outer foot. At times, for instance after rain, the horn is very soft; at other times secateurs can hardly cut through it. Could you use the footrot bath to soften the horn?

Dr. Filmer: There is no question about the difficulty of handling very hard feet with a knife only. Personally I like to have both secateurs and knife. I think I do more work with the secateurs than the knife but I would never be without a knife. It is a matter of individual preference. The hardness of the horn does vary tremendously with moisture and for this reason it is worth while mustering sheep before sunrise in the summer. If you can afford the time to stand them in water that is worth while, but they have to stand in it for some time to make any real difference.

Mr Alderton: It is my opinion that if you are handling hard feet with secateurs you are liable to do more harm than good. They can have a bruising effect and that is why I favour the knife. In Southland there is usually enough moisture in the grass to keep the feet soft. I have had no trouble in paring with the knife no matter how misshapen the foot. With a very hard foot you can bruise the horn if you are not careful.

Mr Bevin: Mr Alderton raised a point of great importance, the assistance he had from Mr Martin, the Stock Inspector in his district. For those who are inexperienced in footrot the calling in of the Stock Inspector should be one of the first essentials. The connecting link between the research worker and the farmer should be the Stock Inspector. No matter what you do you must plan well ahead.

Chairman: We have had footrot. In our campaign against it we found ourselves in complete agreement with what has been said in this hall today, in particular, the way that you pare the sheep's foot is 99 per cent. of the problem. Every little crack and cranny has to be opened up.
SOIL TESTING

SOIL TESTING FOR MAJOR AND TRACE ELEMENTS

A. F. R. Adams, Lincoln College

When asked to give the opening talk for this session on Soil Testing and Trace Elements I wondered if I could possibly say anything which had not been said before, and probably better, for so far as soil testing and trace elements are concerned we could, I think, adapt a well-known saying, thus—never before have so many people talked so much about so little. Despite this, you are here in numbers once more to hear about these things and all I can hope is that what I am about to say has been arranged rather differently from other versions you may have heard and that I may be able to clear up some of the misconceptions you may have concerning the value of soil testing.

The aspect of soil testing on which this talk is based is of course the testing or analysis of soils for the purpose of assisting the farmer, usually in one of two ways. Firstly, to diagnose some problem of plant or animal nutrition, or secondly, to advise generally on the liming or fertiliser programme, usually for lime, phosphate and potash. These two functions are closely related and both have the ultimate aim of improving productivity so as to bring maximum net returns.

There are of course other aims of chemical soil analysis such as assistance in the correct classification and mapping of soils, research projects of a fundamental nature and various others but these need not concern us here.

Since all plants, and through plants, animals, derive their sustenance from the soil it is logical to go to the soil when we strike problems of malnutrition in them, and the approach through soil analysis has interested workers in the agricultural field since the beginnings of agricultural chemistry about a century ago, though the development of advisory soil work is of much later origin.

An early realisation in soil work was that the total quantity of any element in the soil often mean very little in relation to the amount plants could obtain from that soil, or, to put it another way—a soil could contain quite a large amount of phosphate yet plants grown on it could suffer from phosphate deficiency. It was apparent therefore that there were at least two fractions of phosphate in the soil, some readily available to plants, some not, and it is this available fraction which we must endeavour to extract and measure. The same concept applies not only to phosphate but to all elements and is expressed above in its simplest form since the division between available and non-available forms is largely an artificial one. Thus the phosphate associated with the organic matter, which is normally considered lost to plants, is being rendered soluble slowly but constantly by the bacteria. Now, when we consider that crop needs vary—thus, root crops and clovers need more phosphate than cereals—that animal needs vary—thus horses do not suffer from copper deficiency whereas sheep and cattle do—and that soils themselves are very differently constituted, we begin to realise that any attempt to measure with one extracting solution the amount of an element available to a wide range of plants, and hence animals, is not quite as simple an undertaking as it might at first appear.
The essential elements

Let us look now at the elements supplied from the soil which are concerned in the satisfactory growth of plants and animals. For plants these are calcium, magnesium, nitrogen (very commonly in New Zealand supplied from the air via the legumes), phosphorus, potassium and sulphur which are known as the major elements, and iron, manganese, boron, copper, zinc and molybdenum, which since they are needed in much smaller quantity are commonly called the trace elements. For animals the same major elements are needed, but of the above trace elements boron is not required and deficiencies of zinc and manganese seldom occur. Two other elements are however necessary for stock which do not appear necessary in plants. These are cobalt and iodine.

In order to keep this subject of mineral nutrients in its right perspective, we would be well advised to remember that there are many other factors involved which help to govern the ability of a soil to produce at high levels. Thus the soil must be well aerated, a condition which cannot be fulfilled if the water table is too high; yet it must also be sufficiently well supplied with water; indeed the lack of water is probably the greatest single factor limiting the world production of food. The soil temperature must be adequate, for no amount of fertiliser will make a plant grow if the ground is too cold. Poor crop yields or pasture establishment may also result from poor seeds, incorrect preparation for sowing, sowing too deeply and from the effects of weeds, insects and diseases.

It is obvious therefore that a deficiency of mineral nutrients is but one of several reasons for the poor growth of plants and animals, for as with plants, the well-being of animals is governed by many factors other than the supply of these mineral elements.

Sampling the soil

No soil test can be of value unless the area under test is properly sampled. It is not uncommon for a paddock to contain more than one soil type. These should be sampled separately. Again, the paddock must be sampled in at least twelve places, even in a small paddock. These sub-samples are then mixed to give a sample truly representing the conditions of that paddock. In cases of good and bad patches separate soil samples should be taken, also samples of the crop can frequently be of great assistance in such cases. As to the depth to sample, the top three or four inches is usually taken for pastures; the depth of cultivation in a worked paddock. A sub-soil sample is often of value.

Having obtained the sample the aim, as previously mentioned, is to determine the "available" amount of the elements for which we are testing. It does not greatly matter if the solution used extracts all or only a known fraction of the amount available, provided that the accepted levels for deficiency are adjusted accordingly. Thus we find two extractants widely used for phosphate in New Zealand, which extract quite different amounts from the same soil. This is allowed for in the response levels; in one case it is one-hundredth of one per cent., in the other about one-quarter of this. The tests themselves must be simple and quick, mainly for reasons of cost and ability to put through large numbers, and while improved techniques and instruments have very considerably assisted in the accurate measurement of the quantity of, say, phosphate or cobalt in a solution, the value of such improvements is wasted if we do not know what this amount means in relation to the possibility of a growth response or an improvement in health of animals.

Soil Tests

We come then to the tests themselves. To what extent can they
help us? What do the results mean; and again I stress the importance of this, for the interpretation of the results is probably the hardest task of the advisory man.

**pH. Lime Requirement and Calcium**

The term pH, well known to most farmers, is used to express on a simple scale the acidity or alkalinity of a soil. Seven is the neutral point at which a soil is neither acid nor alkaline; the lower the pH the greater the acidity; the higher the pH the greater the alkalinity. A range of 4-8 would cover most New Zealand soils, the great majority falling between 5-7, which means that they are acid to a greater or lesser degree. The accurate determination of pH is quick and reliable and the pH value is the most useful single figure of all tests. We know, for example, that a strongly acid soil needs lime and is probably deficient in nitrogen, phosphate and molybdenum, whereas if the pH is greater than 7 boron, manganese and other nutrients may become locked up—the capital is still there but the rate of turnover is greatly diminished. It is the one test which the farmer himself can carry out with some measure of success. Now the better types of grasses and clovers and indeed most crop plants do best in a soil of only slight acidity and hence it has been usual with acid soils to assess the amount of lime needed to raise the pH to 6 or a little higher. This is done by means of a test based on the pH determination which also takes into account the texture of the soil, for the amount of lime needed to raise the pH of a clay loam from 5-6 is twice or three times that needed for a sandy loam. Again this test is simple and quick and serves its purpose quite well. At the same time as reducing acidity, liming normally ensures an adequate supply of calcium, but occasionally the situation arises where both the calcium test itself is low, yet the soil has little or no lime requirement. In such cases a light dressing of lime is recommended.

Now all this is very simple and straightforward, but of recent years a little nigger has appeared in the lime pile. Its name is molybdenum and, as you all know, on some soils it has been found that an ounce or two of this material, usually applied as sodium molybdate, will stimulate clover growth especially and hence pasture growth generally, to as great an extent as does liming. Now the interesting point is that most of the affected soils are quite acid and it is now apparent than when we lime, one of the effects we bring about is the release of locked up molybdenum, for molybdenum alone of the trace elements becomes more soluble with increasing pH. This is probably the reason for some soils of high pH continuing to respond to lime. The spectacular results which have sometimes been achieved with molybdenum are causing a good deal of thought to be given to our well founded ideas on liming, but although our understanding of the effects of molybdenum is increasing, it would be foolish to alter radically our established and well-proven practices which have served us so well, in favour of something we know relatively little about. On the other hand if the molybdenum is wholly absent from the soil due to an inherent lack in the soil’s parent rock, then no amount of liming can possibly remedy the position and molybdates must be added. Moreover, no amount of molybdenum can remedy a deficiency of calcium. Further points on molybdenum will be dealt with later.

**Phosphate**

More attention has been given to the assessment of the phosphate status of soils than to any other nutrient and the published methods are legion. This is not because of any innate cussedness of the chemist but simply reflects the world-wide importance of phosphate
and emphasises what has been said earlier, that no one extractant is satisfactory for all soils or crops. Nevertheless the method most widely used in New Zealand is reasonably satisfactory, about 80 per cent. of soil tests giving agreement with field trials. There is little doubt that some of the anomalous results with superphosphate have been due to the failure to appreciate the value of the sulphate contained in super to the extent of roughly half its weight as calcium sulphate or gypsum. Attention was drawn to this when Grasslands Division officers at Palmerston North continued to obtain responses to superphosphate on soils adequately supplied with phosphate. By applying sulphate and phosphate separately, we at the College have shown that both play an important part in the satisfactory growth of rape and in the establishment of vigorous clover. Of six trials in the tussock hill-country, using surface-sown clovers, we have found that sulphate is of roughly equal importance to phosphate in three of them, that it is of greater importance in two and of much less importance in the other. It is obvious therefore that we must now regard super as a dual fertiliser supplying phosphate and sulphate and that in many cases the sulphate is every bit as valuable as the phosphate.

Potassium

The test for potash is equally as satisfactory as that for phosphate in that it gives agreement with field trials in about 75 per cent. of cases. Again the anomalous cases are gradually being cleared up. It has long been known, for example, that some soils give a certain potash test and that after considerable cropping, and hence removal of potash, will again give the same potash value, indicating of course that the supply is constantly being replenished, e.g., Canterbury soils contain a particular clay called illite, which seems to have very large reserves of potash which become slowly available. Work is at present being conducted on a test which may well prove useful in measuring this potash-supplying power of a soil.

The tests covered so far are those most commonly provided by soil-testing services here in New Zealand and elsewhere. They have been thoroughly tested against planned field trials and on the whole give results which can be interpreted with a good chance of success. Because of this and because of the success which has attended the widespread use of lime and phosphate, which are undoubtedly the things most commonly needed in this country, there is perhaps a tendency to regard these minerals as the only ones that concern us. This tendency is dangerous if only for the reason that it is well known that as one deficiency is corrected, thus increasing production and the removal of nutrients, another element becomes the limiting factor. If we take Southland as an example, the use of lime and phosphate has achieved wonderful results, yet it is a fact that many farmers having boosted carrying capacity to a high level are now finding it hard to maintain animal health and fattening rates. The problem may be one of management, possibly involving internal parasites, or it may be that having satisfied the need for lime and phosphate something else has become limiting. It is not easy to decide which of these possibilities is the cause; that in itself needs investigating and if it is the latter, then it is the job of someone to set about planning research to track it down. To some extent, this is being done and it is thought that cobalt deficiency, to a greater or lesser degree, may well be part of the story. Thus one step forward has been taken, but I think you will agree with me that there is a need for further work on this problem. However I am sure you will also agree that we should not say that the liberal use of lime and super was wrong simply because it appears to have created another problem.
Nitrogen

As one of the “Big Three” (nitrogen, phosphorus and potassium), nitrogen is needed in large amounts by all plants since it is the building stone from which protein is constructed.

The total amount of nitrogen in the soil (both organic and inorganic) averages on well-managed New Zealand soils about 0.2 per cent. or 4000lb. per acre plough depth, but of this the mineral nitrogen, which is the fraction available to plants, is probably only 40lb. per acre in any one year, the remainder being intimately associated with the organic matter in a form not available to plants. The mineral nitrogen comprises two forms, ammonium and nitrate, both of which can be used by plants, but since in most well-aerated soils added ammonium and organic nitrogen are rapidly oxidised by bacteria to nitrate, we end up with nitrate, which is water-soluble and easily leached out, as the principal source of supply to the plant, the amount actually present at any one time being the difference between the amount being produced by the bacteria and the amount being removed by the growing crop and by leaching. Hence even a nil test during the growing season does not necessarily mean that the soil is deficient in nitrogen; it may simply be that the removal is as fast as the replenishment. Now soils under pasture have their main proportion of mineral nitrogen as ammonium (1-5 p.p.m.) with very little (1 p.p.m.) as nitrate and both levels remain fairly constant, whereas arable soils have a low but fairly constant level of ammonium and a much higher and very variable amount of nitrate (2-40 p.p.m.), the amount depending on such things as temperature and rainfall.

Nothing has so far been said about legumes which are capable of deriving virtually all their nitrogen from the air. There are few places in New Zealand where white clover cannot be grown well and when you consider that, under good conditions, the best strains of this plant can fix nitrogen free of charge equivalent to a dressing of a ton of sulphate of ammonia per acre per year, and that under grazing conditions virtually all of this is returned to the soil to feed the grasses, the value of clover in a pasture is obvious. We in the Soils Department are convinced that the use of nitrogen on pastures of reasonable clover content can be justified for only one of two reasons: firstly, as an aid to a grass seed crop, and secondly, as a means of forcing some extra growth during certain periods of low production, notably early spring and late autumn.

With other crops the need for nitrogen is, in my opinion, better judged visually from the colour symptoms or by the use of a so-called plant-tissue test in which a fragment of leaf or stem is tested for nitrates. Such a test is useful for cereals for example.

A soil test can be useful for measuring the nitrogen level in garden or greenhouse soils, especially as a guide to base fertilising before planting, but each use of the test will be a special application for a special situation. In other cases total nitrogen, which is closely dependent on the organic matter content, is of little use unless we know how fast it is being made available, although some workers consider there is a relationship between it and the yield of nitrogen in crops. Testing for nitrate gives only the result at the time of testing. It gives no indication of the amount of nitrogen likely to be available over the season, which is what we want to know.

Magnesium

This is an example of a neglected element. It is seldom added in normal fertiliser practice, although needed by plants in relatively large amounts and we are therefore fortunate that most of our soils
contain an adequate supply. Magnesium deficiency is likely to occur as time goes on, for the following reasons:—

1. The supply in the soil is gradually being depleted by crops and by leaching.
2. Long continued use of phosphate can cause losses of magnesium from the soil.
3. The continued use of limestone containing very little magnesium will in the same way accelerate the loss.
4. Heavy potash dressings can cause an upset in the balance of potassium and magnesium and induce deficiencies of the latter. This commonly occurs with tomatoes grown under glass and is readily detected by the colour pattern produced in the leaf, a method equally satisfactory for most broad-leaved crops, but not so easily applied to narrow-leaved plants.

Magnesium deficiency in animals does occur, but is very seldom, if ever, due to a straight-out lack in the diet. In most cases it is due to a physiological upset within the animal, about which very little is known.

Magnesium is usually estimated in the soil by a method similar to that for calcium, and it may be found necessary to devise a further test to determine the magnesium-supplying power of the soil, in much the same way as for potassium. Whatever method is used, so little work has been done in correlating the results with plant responses that interpretation would be difficult. For example, particular attention would have to be paid to the ratio of potassium to magnesium. Should a deficiency occur, the use of serpentine super would probably supply enough magnesium to satisfy the immediate needs of the crop.

Sulphur
This again is an element, neglected for many years, which is now beginning to take its rightful place, especially in connection with brassicas and legumes, as already mentioned. In Australia its importance to legumes has been proved over large areas and in North Otago the Department of Agriculture has obtained some outstanding results with it, especially on the "tarry" soils overlying limestone. Of its role in animal nutrition I will have a little to say when I deal with copper and molybdenum.

In the soil sulphur behaves in a similar manner to nitrogen in that it is very largely bound up with the organic matter and has to be "mineralised" by bacteria to sulphate before plants can use it. Again, like nitrate, sulphate is water soluble and hence easily leached from the soil. It is directly connected with nitrogen in the plant in a manner similar to molybdenum. Thus in legumes it is necessary for the effective utilisation of nitrogen within the plant, and because of this, sulphur-deficient clovers exhibit symptoms of nitrogen deficiency, being pale in colour. It is unlikely, for the same reasons as those covered under nitrogen, that a satisfactory soil test will quickly be evolved. It is more likely that plant analysis will provide a better answer, but in any case a deficiency is unlikely to occur on soils which receive regular dressings of super; here one will need to watch that super is not being added simply for the sulphate it contains! Elsewhere we have as yet little information to guide us; all we can do is try it.

Trace Elements
At long last we come to the smaller fry, small only in terms of quantity, for they are by no means any less important than their better known companions. I intend to cover these in much the same manner as I have done with the major elements, namely, by indicating
possible satisfactory soil tests, if any, or if not, giving alternatives. In the case of some I will summarise our knowledge of their effects on plants and animals.

Iron

A deficiency of iron in plants is normally associated with high pH soils (greater than 7), but not all such soils are deficient. It may also occur on acid soils containing abnormally high quantities of other metals (but only very rarely), so that in general it is very unlikely to occur on acid soils. In any case, no satisfactory soil test has been devised to determine the amount of iron available to plants. One reason for this is that plants often suffer from iron deficiency on soils containing abundant soluble iron. In animals a deficiency is normally associated with an anaemic condition, which is far better diagnosed by an examination of the blood. As with many of the trace elements, a deficiency in plants can often be picked up from the symptoms produced in the leaves.

Manganese

In soils of pH lower than 6.5 the supply of available manganese is normally adequate for all plants. Above this pH manganese may become deficient, more especially in soils containing high amounts of organic matter.

In strongly acid soils the level of available manganese may become sufficiently high to be toxic to plants. This is a possible explanation of the poor growth of clovers on very acid soils. Relatively simple soil tests can be used to predict deficiencies but these require very careful interpretation in relation to both soil and crop, as the sensitivity of different crops to a deficiency varies considerably, oats for example, being very sensitive. Tentative levels of manganese in the soil for both deficiency and toxicity conditions have been established, but at the moment these can at best be regarded only as a rough guide. Visual symptoms are a good indication in many crops.

So far as manganese deficiency in animals is concerned, it is very doubtful whether any disorders occur in animals other than poultry, although from Ireland there is a claim, not fully substantiated, that stock health is poor on pastures very low in manganese. The requirements of the larger animals seem to be very small and are normally satisfied by ordinary diets.

Zinc

Zinc deficiency has been reported in fruit trees in this country on soils of pH 6.6 to 7.4. No proven case has been reported in other crops in the field in New Zealand although the possibility of a deficiency is always with us. Zinc deficiency seriously affects pasture growth on some Australian soils. Virtually no work has been done in New Zealand on the availability of zinc in the soil and in the cases mentioned above, the deficiencies were suspected from the symptoms exhibited by the trees and confirmed by responses to zinc sulphate sprays, and by the difference in zinc content of sick and normal leaves. No naturally occurring deficiency of zinc in animals has been reported, although such a condition has been experimentally produced.

Boron

As stated in the introduction, boron is needed only by plants, and diseases due to a deficiency of boron, which are always more severe in a dry season, are well known in New Zealand. Especially so are mottle-heart or brown-heart of root crops, and corky-pit of apples. A range of other fruits as well as hops and celery are also
affected. Overseas, notably in parts of U.S.A., lucerne and the clovers suffer from a deficiency, but rather surprisingly I think, these crops seem to be almost free from the complaint in this country so far as we are aware, although we have had evidence of a response in one of the College paddocks. In most crops the symptoms of a deficiency are so characteristic that no further test is necessary, but the usual measure of availability of boron in the soil, which decreases with increasing pH, is the amount soluble in water. This test, which needs careful techniques, hardly comes into the category of a quick test and the results do not always correlate well with the incidence of the disease, but it would seem that a figure of 1 p.p.m. should be adequate. Better results are obtained from the boron content of fruits or leaves, with due attention to the type of crop. Care should be taken with applications of borax to the soil, since amounts only slightly more than necessary for correction of the disease can easily be toxic.

Copper and Molybdenum

These two elements will be dealt with together, since in discussing their importance to animals it is virtually impossible to discuss one without the other. They may be likened to Siamese twins and together they form a classical example of the importance of the balance of nutrients.

The incidence of copper deficiency on crops or pastures is rare in New Zealand though not unknown. Of infinitely greater importance is the effect of a deficiency on animal health and as a result of a great deal of work both here and overseas on the problem, much is known concerning the deficiency symptoms, the functions of copper in the body, the cures and the areas in New Zealand where the disease occurs. The facts covering these points for New Zealand conditions have been published widely; briefly, there are two common types of copper deficiency involved, one due to a straight-out lack of sufficient copper in the diet and the other where a slight copper deficiency is accentuated by the presence of too much molybdenum in the feed. The explanation of the latter case is that the excess molybdenum has the dual effect of reducing the amount of copper stored in the body and of impairing the effectiveness of the copper which is retained.

These two categories satisfactorily cover most cases of copper deficiency but there are others which are not explained so simply. Recent Australian work has brought to light another complicating factor, namely sulphate. It has been shown that sheep on feeds of high sulphate content, such as lucerne, excrete in the urine a great deal of molybdenum which consequently does not accumulate in the body, whereas on low-sulphate feeds the molybdenum can build up to high levels. Hence it is apparent that sulphate exercises a powerful effect on the storage of molybdenum in the animal body and therefore presumably on the storage of copper also. Such a mechanism could explain how copper deficiency can occur on feeds of normal copper content.

Molybdenum deficiency of plants has been mentioned previously in the section on lime-requirement, where its main function in pasture, namely the stimulation of clovers, was explained; the same applies of course to lucerne. Its purpose in brassicas which have an even higher requirement of molybdenum is also connected with nitrogen, but rather differently from the main function in legumes in that it is needed to enable the plant to make effective use of the nitrogen the plant has already taken up from the soil. This applies to all non-legumes and indeed to legumes also, in which molybdenum therefore plays a dual role, but the need for the bacteria is far greater than for this second role within the plant itself. Many other crops have
been shown to respond to molybdenum, including wheat and oats, but those most commonly affected are the pasture legumes and the brassicas.

Work on molybdenum has proceeded apace since its importance was realised and hundreds of trials have been laid down by the Department of Agriculture alone, from which much useful information is accumulating. Attempts were quickly made to devise a soil test which would measure the molybdenum available in the soil and from tests with six different extractants, one was eventually chosen as giving reasonable correlation with plant responses in the field. The interpretation of this test has been modified recently since it was found that the pH of the soil and the nature of the crop must also be taken into consideration. For example: a figure of 0.10 p.p.m. would probably be sufficient to grow good pasture at a pH of 6.5 but not at a pH of 5.0, while both soils would be deficient for brassicas. Thus within the space of a few years, pure research work coupled with extensive field trials have changed the position from one of "no soil test for molybdenum" to one where a test is in use which at least gives a fairly good indication of the likelihood of a deficiency in pastures and crops. All credit is due to the officers of the Department for the progress which has been made, and although the test is rather complex for routine use as an advisory test on very large numbers of samples, many hundreds of soils have been tested.

It is apparent that the requirement by plants for molybdenum is very small, but information on this point is scarce. A figure of 0.1 p.p.m. may be somewhere near the mark.

There is no doubt in my mind that molybdenum has an important part to play in many parts of New Zealand, more especially in marginal land and hill-country areas which need lime to such an extent as to be economically impossible. Some success has already been achieved in such areas, where the introduction, satisfactory growth and maintenance of a fair proportion of the better clovers is the first essential in their improvement. It seems likely that the use of small amounts of lime, say 5cwt, in conjunction with molybdenised super and clover seed will often yield the desired result. A point to be remembered about molybdenum is this: it has often been found that in cases where clovers are sown with molybdenum, no response is apparent for some time—often a full season, whereas responses on established clover are often seen in a week or two. One reason for this is because the molybdenum cannot exert its main function until the clover plant has become nodulated, and this takes time.

**Cobalt**

Necessary only for animals, so far as is known, and then only in very small amounts, the story of cobalt in relation to animal health in New Zealand is a fascinating one, too well known to need repeating. The amount of cobalt in the soil depends largely on the material from which the soil is derived, and the amount available to plants can be reduced by heavy lime applications, although if the lime contains appreciable cobalt as do some Southland limestones, then a temporary rise in cobalt content of the pasture occurs. Attempts to use soil tests have not met with much success in this country although a figure of 2 p.p.m. of cobalt soluble in strong acid fits a large number of cases. A test much used in Scotland with apparent success uses weak acid extraction and a response figure of .25 p.p.m. Strangely enough it does not appear to have been thoroughly tried out here. One probable reason for the lack of interest in soil tests is the fact that a deficiency of cobalt is better assessed from pasture levels, but here again, due to variation over the season and other factors the test is not entirely satisfactory. Another is that the amount of cobalt in the liver of animals correlates well with incidence of the disease.
This method seems without doubt the best measure of cobalt deficiency or sufficiency though for practical usage it has the disadvantage of necessitating the death of at least one animal.

Iodine

A deficiency of iodine is usually associated with low soil and pasture iodine, but certain crops contain compounds which can induce the condition of goitre regardless of the iodine content of soil or plant. Simple iodine deficiency is peculiar in that an outbreak may occur in one season, be absent for several more, and then reappear, not necessarily on the same farms as previously. No simple soil test for iodine content has been evolved.

Summary of Soil Tests

Having dealt with all the mineral elements essential to plants and animals I would like to summarise the information I have presented in terms of the methods available for diagnosing deficiencies or excesses on an advisory basis, before concluding with some general remarks.

For pH Lime requirement and Calcium. Present soil tests can be regarded as satisfactory in the great majority of cases. The same holds for Phosphate and Potash. For Nitrogen, quick soil tests are not in general very satisfactory. Plant-tissue tests better for some crops. Magnesium—soil test figures reliable, but not sufficient known about it to enable sound interpretation. Sulphur—insufficient knowledge to recommend any laboratory method; field trials best at the present time.

Trace Elements

Iron. For plant deficiencies pH and visual symptoms as good as any other method. For animals—blood test.

Manganese. Soil test a useful guide but a combination of pH, type of soil and visual symptoms probably better. Deficiency in large animals unlikely.

Zinc. In view of the lack of work on zinc, no soil test can be recommended. Plant analysis a guide. A deficiency in animals seems very unlikely.

Boron. Rather complex soil test quite a good guide in conjunction with pH. In crops, symptoms and analysis of normal and sick fruits or leaves should enable positive identification.

Copper. No satisfactory, quick soil test has been devised, but plant analysis coupled with clinical symptoms and analysis of animal organs gives satisfactory results in most cases.

Molybdenum. Soil test a useful guide in conjunction with pH and nature of the crop, but rather complex. Plant analysis is simpler but information is lacking on a satisfactory level in plants.

Cobalt. Soil test a rough guide but again complex. Better results obtainable from the analysis of pasture and animal organs, and from drenching trials.

Iodine. Of occasional interest only. Pasture and soil tests a fair indication, but clinical symptoms best.

Expression of results

A matter deserving some attention is the method of reporting the results of soil tests. For example we find the values for the major elements being expressed as percentages, as parts per million, as milligrams per cent. and as milli-equivalents per cent., and while for the chemist the last is the best method of expression for calcium and potash, and percentages or milligrams per cent. the best for
phosphate, I feel that the mind of the farmer is confused when con­fronted with a figure of, say, 7 when there is little or no indication of what it means. One method which has been used to overcome this confusion is to set a “normal” level for each nutrient, but in my opinion we do not know enough about many of the elements to enable this to be done and hence further confusion results. In any case such levels should differ for different types of soil. For plant analysis this method has some value for certain nutrients.

To my mind all the farmer wants to know is: do my soils need lime or phosphate or some other thing, and if so, how much, and this can be met quite satisfactorily by expressing the results in terms of “deficient or low, average or normal, and not deficient or high.” For the trace elements it is usual to express the results in terms of parts per million to avoid the use of a string of noughts. Probably the best way to understand this usage is to take the figure of 2,000,000lb. as the weight of an acre of soil over a depth of about seven inches. Then each 1 p.p.m. represents 2lb. of nutrient per acre. This method of expression is almost universally used but again from an advisory point of view, it would probably be better to adopt the same categories as suggested for the major elements.

From the summary it should be apparent that many quick soil tests leave much to be desired; in some cases however there are reasonably good tests available but they are often too complex to be considered suitable for advisory work. For example, there is quite a good test for copper which uses a fungus as the measure of availability. This test is being used in New Zealand to assess the copper status of the main soil types, which in conjunction with the almost completed soil classification and mapping of the country will be a very useful working basis for predicting the areas likely to be deficient in copper. The same test is being used in a similar programme to test for available molybdenum. Given sufficient staff and facilities these methods could probably be developed for use in the advisory service. On the other hand, as I have indicated, there are many other methods of detecting deficiencies, all having their advantages and disadvantages, but often far more useful than a soil analysis. To take cobalt as an example—in general, a deficiency can be diagnosed from pasture or liver analysis, and no doubt this has been the reason for the lack of persistence in seeking a suitable soil test. In such a case I doubt if any soil test could give results as satisfactory as these other methods. However if it is felt that there is a pressing need for the full range of elements to be covered by soil tests, much would have to be done since for any soil test, simple or complex, to be of value it must be tested out on a wide range of soils and with different crops. This would necessitate the carrying out of a great many field or pot trials, or both, to cover plant responses, and trials involving animals which are much more difficult and costly, in order to find the soil test giving best agreement with the measured plant or animal responses on different soils. Having selected the most suitable test, because there would almost certainly be some anomalies, response levels for the nutrient under examination would have to be determined. Then with a background of local conditions, previous history and rotations, it should be possible to give sound manurial advice, which should also take into account the likely return for the outlay involved.

It is obvious that such a programme would necessitate many more staff, much work, considerable time and a great deal of money, but if the aim is to develop soil tests for all elements, then it must be done.

My own feeling in this matter is that within the bounds of our present state of knowledge of known deficiency-ailments of plants
and animals, there are few problems that cannot be handled by the various diagnostic methods available to us, but that the fullest possible use is not being made of them. To that extent, considerable expansion of existing services is desirable. Concurrently, more work should be undertaken on those elements at present considered of little importance in New Zealand in order that a sound foundation be laid upon which to build should the occasion arise. I would not therefore base this expansion wholly on soil testing but rather on the search for improvement and better use of the whole range of diagnostic methods be they soil tests, plant or animal analyses or any other.

You may prefer the all-out search for soil methods, but in either case more money must be forthcoming and I submit that if the farmers’ organisations, as those directly concerned, could be persuaded to speak with one voice, they could do much to bring an expanded advisory service into being. In the meantime you could do a little to help yourselves. A field trial kit is available in Australia which, with a few modifications to meet our conditions, would enable you with a little assistance and with the expenditure of a little time and effort to test for the more serious deficiencies limiting plant growth.

And now finally, a few words of reproval. There is a tendency common to all of us to some extent, and at present quite strongly developed in some farmers, to seek for a universal panacea for all farming troubles, just as the earlier alchemists sought the elixir of life. Some years ago it was vitamins, at present it is trace elements, in a few years’ time it may well be hormones—who knows? Your problems are not simple; they will not be solved at the drop of a hat, for the research worker and field officer are not magicians; do not be too eager to accept the preachings of any who claim they are. The high place of New Zealand in the world of agriculture is due in no small measure to the work of its research and servicing organisations; I need only refer to the work on cobalt or the improvements in pasture species as evidence of this, and while it may sometimes appear that these organisations are a little lethargic, I would point out that trials are already under way with vanadium, a new trace element only very recently proved essential for plant growth; in fact I think the trials were down before the proof was announced in the literature.

So, don’t expect a simple soil test, followed by a little of this and that to solve all your problems; don’t overdo the application of trace elements and don’t be too eager to decry the efforts of the existing organisations. Do something about helping them to help you.

SOIL TESTING FROM A FARMER’S VIEWPOINT. I.

H. M. Barton, Carew

Topdressing is investing your money and soil testing will help you get the best interest possible. To get the best results from materials used it is necessary to know what is needed for the job. A good builder does not dump a heap of material on a site and just hope that there will be sufficient of everything. He has everything worked out, and tries to have just the right quantities of materials for the job. The farmer should also find out the requirements of his soil and supply them before he can expect the best return for his investment.

The farm I manage is in the Carew district. The soil type is Lismore bouldery silt loam and rainfall approximately 33 inches. The area of the farm is 1,250 acres divided into 43 paddocks. Prior to a
programme of increasing production in 1947 the stock carried and the cropping programme was as follows:

Cattle:
- 2 Dairy cows.
- 1 Bull.
- 2 Yearlings.
- 1 Calf.

Sheep:
- 1627 Ewes.
- 82 Wether hoggets.
- 22 Killers.
- 35 Rams.

Lambs fattened 1320 = 381 lb. p.a.

Wool 11 lb. p.a.

Wheat
- 100 acres.

Turnips
- 147

Rape
- 76

Young grass
- 61

Hay 50 acres 3,000 bales.

Results in 1953

Cattle:
- 3 Dairy cows.
- 192 Yearlings and calves.

Sheep:
- 1800 Ewes.
- 400 Ewe hoggets.
- 500 Wether hoggets.
- 380 Wethers.
- 38 Rams.

Lambs fattened 3000 = 86 lb. p.a.

Wool 21 lb. p.a.

Wheat
- 18 acres

Turnips
- 139

Rape
- 118

Young grass
- 169

Hay 118 acres 10,000 bales.

Silage 50 acres.

Grass-seed 50 acres.

Soil tests were first taken in 1951 and showed that only one paddock on the farm had sufficient lime, phosphate and potash. The Department at that time advised sampling three paddocks, one that had had heavy dressings of lime, one light dressings and one that had not had any. The paddock history book was brought out. I have found that it is impossible to remember for long just what treatment each paddock has had, so a farm history is kept. The history of the three paddocks was as follows:

D. 4 tons lime since 1938 and 11cwt. super in that time.

Y. 21 tons lime in the past 10 years, with 7½cwt. super during the last 6 years.

K. 1 ton lime and 2cwt. super in 1945, and 1cwt. super with rape in 1950.

Soil analysis gave the following results:

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<th>Ca.</th>
<th>Phosphate</th>
<th>Potash</th>
<th>V.H.</th>
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<tbody>
<tr>
<td>D</td>
<td>6.3</td>
<td>10</td>
<td>10.4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Y</td>
<td>5.3</td>
<td>9</td>
<td>8.0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>K</td>
<td>5.3</td>
<td>5</td>
<td>2.0</td>
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As a result of these tests 800 tons of lime was applied that year, followed by an average of 150 each year previous to sowing down to young grass. Every paddock on the farm has now received its third ton of lime per acre, which has raised the pH level of the farm up to 46
6.0 to 6.4. Calcium tests are now 10 or better. Although phosphate had been applied spasmodically up to that time, it is only during the last three years since the tests were taken that all grass land has been topdressed at the rate of 1 to 1\(\frac{1}{2}\)cwt super each year. This has raised the phosphate to the satisfactory level of 9 to 24.

For instance:

Paddock Y quoted above is now pH. 6.4, Calcium \(\geq 10\), Phosphate 14.

Paddock K quoted above is now pH. 6.2, Calcium \(\geq 10\), Phosphate 10.

It has also been during these last years that I have been using D.D.T. for the control of grass grub and subterranean caterpillar. Before the use of D.D.T. there was always one-sixth of the farm very badly damaged by grub and the remainder, except for the young paddocks, not very good. Only one paddock on the farm has grub damage showing to any extent today. That is one where D.D.T. was applied during the dry autumn of 1952 and no rain fell before stock were shifted on to it. The discovery of the usefulness of this material as a control for grass grub and porina caterpillar has been one of the greatest aids to increased production. The men who discovered the deadliness of these poisons against these two plagues of the grassland farmer deserve the highest praise. D.D.T. has saved between £600-£1000 per year on this farm.

Our soil type is fairly even over the whole farm, so when testing the usual thing is to test several paddocks from good, medium to poor. By studying the farm history book and the test reports, it is possible to know the requirements of the rest of the farm. The tests I have found need to be interpreted by someone who knows the country on which a farm is situated and the type of farming and previous history of the farm.

There is one paddock which has puzzled me as well as visitors. It was sown down in 1951 with the usual grass mixture for the farm that year. The first year the paddock was all the same, the following year the outside of the paddock was ryegrass, Mont. red, the centre ryegrass, Mont. red and white. This year the outside is ryegrass, sweet vernal and some white while the inside is still good ryegrass Mont. red and white. Outside long and tufty, inside grazed down. Sheep and cattle both preferred the centre. The whole of the paddock should have received the same treatment, 1 ton of lime at sowing down. Because of super shortage that year it was not possible to use any when sowing, but it has been topdressed with about 1cwt. super each year since.

Recent tests have shown—

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<th>Ca.</th>
<th>Phosphate</th>
<th>Potash</th>
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<tbody>
<tr>
<td>Outside</td>
<td>5.9</td>
<td>10</td>
<td>12</td>
<td>M.</td>
</tr>
<tr>
<td>Centre</td>
<td>6.2</td>
<td>&gt;10</td>
<td>&gt;10</td>
<td>V.H.</td>
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</table>

As the economy and living standards of New Zealand depend so heavily upon our grasslands, only the best should be sown. The cost of sowing down permanent pasture is so high today that it seems to me foolish not to give it the best of treatment and protection possible. Soil testing is the best and cheapest way of finding out that treatment. It is one of the essential "musts" in good farming.

Trace elements I have not as yet played with as so far I have not seen the need for them on this property. In my opinion they need to be tried very cautiously but not forgotten. Our biggest problem now is not to grow the feed, but to cope with it. This farm is not yet producing its maximum under the present organisation.

To those very courteous and helpful men, the Fields Officers of
the Department of Agriculture, thanks are also due. Their work has put more money in the coffers of the country than is generally realised. There are not nearly enough farmers making use of the services of the Department. Their advice is free for the asking.

SOIL TESTING FROM A FARMER'S VIEWPOINT. II.

H. M. Carr, Waikari

Since 1919 I have been farming a small grazing run in North Canterbury, up to 2,560 feet high, mostly tussock, with a little cocksfoot, but predominantly danthonia.

Some 200 acres is undulating ploughable paddocks, at about 800 to 1000 feet above sea level, some very steep with many rock outcrops. Practically all rocks have been cleared away over the years and damage to the grass mower from stones is now practically non-existent.

There is limestone country quite handy but none on my property.

Over a period of 32 years average annual rainfall 28 inches with the lowest at 20.5 inches. The driest month is March.

When I took over, danthonia had complete charge of the paddocks, and sheep would starve on them, and did. With the aid of a horse team, I grew turnips and had very good crops on the old danthonia turf. It was then the practice to sow down a good mixture of grasses and clovers, with a good commercial ryegrass predominant. Within three or four years, this would be back to danthonia, due to lack of fertility.

Dr. Weston of this College (who had my figures) used to tell me that the expense of my paddocks would break me, and they nearly did.

I looked around for an answer.

We were hearing of the results of lime in Southland, but of course Southland had the rainfall. Canterbury was much too dry. The Department of Agriculture advised me to try lime on a small paddock of lucerne, which was yellow, stunted and struggling to exist. As there was an outcrop of lime in a cutting on the roadside not far away, I picked and barred out several dray loads from the face and carted this lime rubble and spread it with a shovel on four strips across the paddock.

The following year the limed strips were the only portions of the paddock worth cutting, having at least six times the bulk of material of a dark, rich green.

The rate of spreading was at least 25 tons per acre. I then limed the remainder of the paddock by the same method, some 250 tons being spread, ranging from powder to two-inch lumps, with the same good results.

At that time it was thought that, although much improved results were obtained in lucerne, pastures were another story, and I well remember when Lincoln College did not advocate lime on subclover.

At first about 5cwt. of lime was sown to the acre on pastures, with not very heartening results and it was really some years before real results were apparent. Lime dressings were then made heavier and certified ryegrass and Mt. Barker sub. seed, with cowgrass, white clover, cocksfoot and crested dogstail, were sown with one cwt. of super.

These paddocks which now have all been heavily dressed with
lime and about 1 cwt of super per year, have remained down, predominantly ryegrass and sub clover, up to 19 years and are still producing heavily.

Last spring, the top camp portion of a certain paddock that had been down for nineteen years, was ploughed up owing to the inroads of barley grass. Prior to this the plough had not been out of the shed for years.

Incidently hay has been cut from this paddock of 25 acres every year since it was laid down, with the exception of one year, when a heavy crop of perennial ryegrass was harvested.

This taking of a ryegrass seed-crop, on my class of steep country, which is difficult and costly to renew, was unwise, as it let away to early seeding, unwanted grasses such as goose grass and barley grass. I have not attempted harvesting another seed crop (with the exception of sub. seed) as I consider a good permanent pasture is more to be desired.

All hay and ensilage made has been fed back on the paddocks from where it was taken. Any paddock not cut for hay has been topped. Paddocks originally carried about one sheep per acre—they now carry six, plus cattle, horses and rams, all the year round.

Beef cattle are kept for control of paddocks in the flush season, being held on rank growth, particularly on sheep camps, by means of the electric fence, and sent off fat.

The tussock country carries about half a ewe to the acre, but this could be stepped up considerably if lime or some substitute could be sown economically.

Last year £5 per ton was paid for sowing lime per plane, on some trial portions on the tussock, crossing molybdenum super and straight super areas. So far there is no apparent improvement.

In the spring of last year, I was called on by a person wishing to do soil testing at £2 per paddock, and having heard so many conflicting opinions on trace elements, I was curious to know what recommendations I would get.

I decided to do eight paddocks, all heavily limed, up to 8 tons per acre over the last 10 to 15 years, and one tussock block that had never been limed.

It surely sounded as though a new era of farming had dawned, where a few ounces of some trace element would cure all stock ailments, produce heavy wool clips, all lambs fat off their mothers and an increased carrying capacity.

In due course I received the results of the soil tests, followed afterwards by a visit from another representative, who explained the results from each paddock. I was definitely told that I was killing my farm with kindness and that I did not require any further lime for a considerable number of years. All I wanted were certain trace elements, which they could supply. I was blinded by laboratory science and phraseology, but so far I am not sufficiently convinced to take any action except to seek further information.

I was told that my tussock country, which had never had lime, was too high in calcium, while the paddocks were much too high! The unlimed native country they said was the nearest to the ideal of any of the tests. This so-called ideal portion carries one twelfth of the stock of the paddocks in half the condition and with a much lower wool clip.

I was told that the pH of the paddocks was much too high, and they were all out of balance and that my stock should have footrot and lots of other things due to some deficiencies. Footrot I've never had on the place.
Imagine my dismay and bewilderment. I had strived for years to grow good pastures and increase carrying capacity.

What are we farming for? To produce the utmost in the interests of all and help to feed a starving world. With stock ailments at a minimum and with a death rate below two per cent., I feel like carrying on with my present programme and have already put another ton to the acre on one of my supposedly much-overlimed paddocks.

I may be heading for trouble. Time will prove.

I know a farm adjacent to the limeworks that has received over the past 25 years hundreds of tons of fine airborne lime to the acre and this same farm is recognised as one of the best producing farms in North Canterbury of small seeds, wheat, wool and meat.

I know there are many other farmers like myself who have gone in for a heavy liming programme with outstanding results and I can imagine the doubts created in their minds when one or two ounces of some trace element is supposed to be the complete answer.

I asked this soil-testing representative if he could take me to one of his trace-element farms that was producing more than my paddocks (we were in the midst of cutting heavy hay and ensilage crops) but this he did not do.

Last December I wrote to the Agriculture Editor of the "Press" and through him asked the Agriculture Department two questions.
1. Is soil testing and the recommendations made by this firm correct?
2. Is this the complete answer to our stock ailments and carrying capacity?

I'm sorry to say that the Agriculture Department kept absolutely silent on the matter, when hundreds of farmers were so much in doubt, and required a little reassuring.

While all this molybdenum and trace-element propaganda was going on, the demand for lime fell sharply, but confidence is now being restored, thanks in particular to Lincoln College.

As a layman I should think that soil testing has everything to commend it, but this trial and error business, that we farmers are forced to carry out, is definitely costly, wasteful and not in the national interest.

Lime plus super has given great results over many years, with healthy pastures and healthy stock, but if there is a substitute, especially if it is only half an ounce to the acre and a fraction of the cost, then I will be one of the first to scrap lime.

What I require is some economical means of increasing the carrying capacity of my tussock country, which is only over the fence from the high-producing paddocks, and if trace elements are the complete answer, I am quite prepared to adopt them.

I appreciate there are many pitfalls in soil testing and am fully conscious of the great work our scientists have done, and feel confident that we will get greater and better results as theory and practice work closer together.

If we can get the correct analysis, make up the shortages and be sure of the availability of these various elements, then it seems as though the farmer's job would be easy.

So it is up to you Mr Scientist!
DISCUSSION ON PAPERS

Chairman: Can Mr Adams suggest a relatively simple field trial that any of us could do—a sort of standard soil test for certain trace elements?

Mr Adams: There is the type of kit I mentioned as being used in Australia. It consists of a number of packets of mysterious chemicals (you are told what is in each packet). Some of the packets contain all the elements known to be essential; then there are others which one by one leave out one element. You sow these in a series of narrow strips and then sit back and wait to see whether your grass or clover grows any better. You would pick up only major deficiencies that way. If you are depending on visual response, it takes probably a 25 per cent. increase before you can see it. I think that type of kit could be of great use here. Dr Walker, head of our Soils Department, is interested and has suggested we may be able to put up some sort of kit ourselves and supply it at cost to farmers. Information obtained by farmers would be very useful to us here.

Mr Chaytor, Marlborough: Could you tell us something about this latest arrival, vanadium?

Mr Adams: It is another metal, but is not applied as a metal. It is similar to molybdenum and in the soil one would expect it to act in a similar way. It would not necessarily react on clovers as molybdenum does. In trials at present they are using up to one pound of ammonium vanadate per acre.

Mr Samson, Marlborough: I had one peculiar experience with soil tests. Calcium and magnesium were highest on the unlimed areas and lowest on the highly-limed areas.

Mr Adams: Many of the tussock hill-country soils are much less deficient in calcium and have a higher pH than we usually realise. It is not unlikely that tests on tussock country would be higher than those on heavily limed improved country on the flat.

Mr Leitch, Department of Agriculture: I want to emphasise that farmers should be encouraged to do a bit of experimenting themselves. But if they do they must always have a control.

Mr Adams: I endorse Mr Leitch’s remarks. In the field kit I mentioned there is provision for leaving a control strip between every two treatments.

Mr Bowmar, Gore: It seems essential that in the small field plots, in the first season at least, you should have them fenced. If they are under grazing any visible difference is hard to detect.

Mr Adams: That is correct. Not only can you not see the response if grazing is practised but the animals carry the nutrients from one area and deposit them on another which did not have them applied.

A speaker: Is there any worthwhile quantity of molybdenum and sulphur in ordinary lime?

Mr Adams: I don’t think there is any appreciable quantity in New Zealand limestone. The reason for the response of soils which have been limed to further liming is that the additional lime continued to release molybdenum from the soil—it does not add molybdenum in the lime. Basic slag, which has been giving superior results to superphosphate and other forms of phosphate can contain
appreciable amounts of molybdenum. It also contains vanadium. Either one of these may be responsible for its superior results.

Mr Baker, Marlborough: Is there any means of finding out whether we are wasting the phosphorus or the sulphur when we apply heavy dressings of superphosphate?

Mr Adams: When you add superphosphate you add 50 per cent. of phosphate and 50 per cent. of sulphate. In some of our trials the sulphate was more important than the phosphate but in most cases the need for both was there. It may be found that rock phosphate plus calcium sulphate may do equally well as superphosphate. At present superphosphate seems to be the cheapest way of applying either phosphate or sulphate. In Australia in their sulphur-deficient areas they can use calcium sulphate because they get it cheaply. The trials mentioned show considerable doubt on other trials which attempted to compare different types of phosphate. The advantages shown may have been due to the sulphur and not to the phosphorus. There has been considerable interest in the so-called triple superphosphate for aerial topdressing purposes. It has definite advantages in that it contains over double the amount of phosphate that superphosphate contains but if the area is deficient in sulphate, triple superphosphate will not give the desired result.

Mr Grant, Waimate: In the better country of South Canterbury in November and December we see patches of lush grass, mostly Italian ryegrass, dark green and standing above the rest of the paddock. They are obviously urine patches. Do they indicate a deficiency of nitrogen?

Mr Adams: That is almost certainly a nitrogen response. It could be a potash response but in that case it would be more likely that the clovers would show up.

Mr Grant: That country grows beautiful clovers. They become the dominant feature in the pastures.

Mr Adams: It is far easier to get dominant clover growing on low nitrogen soils than on high nitrogen soils. Provided the clovers are not present to such an extent that they shade the grasses to their complete exclusion, the associated grasses will ultimately benefit from the presence of the clovers, especially under grazing conditions.

Mr A. Hurst, Papakaio: I would like to ask Mr Barton what is his system of laying down pasture.

Mr Barton: I generally sow turnips after grass, then rape, then back into grass. The mixture is 25lb. ryegrass, 3lb. red clover, 2lb. white clover, some dogstail and a little cocksfoot. I sow in January and graze it fairly soon, say two inches, and fairly quickly.

Mr Pilbrow: With lime and superphosphate we have been doubling and trebling the carrying capacity. It is not now a question of growing the grass but using it. Farmers find their stock not doing so well and look to trace elements as the cure. Are the faults in our stock due to a lack of these elements or is it largely a matter of management?

Mr Adams: That is a very sticky question. In some cases it is due to management and we need a lot of work done on that. For instance some farmers have been helped by increasing the numbers of cattle. In other cases it may be trace elements, especially where
by heavy topdressing we have satisfied the lime and phosphate requirements. Something else then becomes the limiting factor.

**Dr. McLean:** I agree with both speakers that one of the major problems is utilising feed properly. On the College farm we have apparently excellent pastures but the stock people tell us the animals don't do well on them. It is apparent we need a lot of detailed investigative work.

**Chairman:** Should we not be warned about the use of trace elements indiscriminately? I heard of one case where one man put on molybdenised superphosphate by contract. The contractor put on too much. The result was a lot of dead sheep. One wonders how much of the molybdenised superphosphate applied in the last year in Canterbury was really necessary.

**Mr Adams:** In the paper I stressed the importance of not overdoing the application of trace elements. With regard to molybdenum, if used at 2 oz. to the acre, in no case has pasture examination revealed any danger to stock. But there are certain soils, especially those with a tendency to copper deficiency, where extra caution is necessary. With regard to the sheep poisoned after topdressing, mentioned by Mr Studholme, they may have been put on before the material was washed off the grass into the soil. You must allow this to be done.

**Mr Leitch:** How often should molybdenised superphosphate be used?

**Mr Adams:** I think Mr Leitch can answer his own question better than I can. He has the voluminous reports of his Department at his disposal. I think the majority rule today indicates that once every three years is probably sufficient. The effects of molybdenum appear to last for three years.

**Mr Turton, Ashburton Forks:** We have to hand it to Mr Carr. He did not tell you he topped the Hawarden ewe fair for a number of years. I would like to congratulate him.

**Mr Oliver, Hororata:** I would like to get the results of his detailed soil analysis from Mr Carr. Was he told his soils were deficient in a lot of elements? Was Mr Carr actually sold a pup?

**Mr Carr:** I have the analysis in my pocket. There is a definite shortage of certain things, iron was one; that was the reason why I should have had footrot. When I said I had no footrot, the gentleman said "Of course you are in North Canterbury—on this undulating country you would not get it so readily." I'm not decrying soil testing but I think in some things we've jumped a bit hastily. I had heard so much about what was being done and advised I thought this was the cheapest way to find out. Was I sold a pup? Yes, and it cost me £18.

A speaker, Nelson: We have an excess of molybdenum. Would you advise us to use a copperised lick or drenching or topdressing with copper?

**Mr Adams:** I don't think it matters what method you use. Probably the most easily and economically applied is copperised superphosphate. The problem with licks is, "Will all the animals lick them?" Drenching is an awful job. Unless you are obviously getting animal troubles I would forget about it.

**Mr Jarman, Darfield:** Does not the pH test of soil alter during
the year? I know a man who had his soils tested and repeated three months later. Every time he was a fraction lower than the first time.

Mr Adams: I would stress the necessity for proper sampling. You can't go into a paddock and take one small sample and do a test and say that is the story for the whole paddock. You can get wide variations out of small areas, especially if you have more than one soil type in the paddock. Depth is also important. The second inch may often be a unit lower than the top inch. The usual practice is to sample down to three inches as most of the pasture roots are in that zone. On arable soils we sample down to the depth of working.

Mr Bowmar: Have you ever come across a case of over-liming? I know in areas in England they have put on 40 tons to the acre.

Mr Adams: Southland has been investigated as far as this suggestion is concerned. While it does seem as if in some cases they are running into a deficiency of cobalt due to overliming, the evidence does not seem very concrete one way or the other.

Mr Hurst: Would you comment on the nitrogenous manures to sow in the spring to get a good flush of grass for ewes?

Mr Adams: Nitrolime and introchalk we can take together. Both were concocted with the idea of overcoming the disadvantage of sulphate of ammonia which in large quantities tends to make the soil acid. Blood has rather less nitrogen than either, and blood and bone has less nitrogen still. Provided the weather is not too cold you will get a quick pronounced flush with nitrolime and nitrochalk. With blood and blood and bone the release of nitrogen is too slow. Nitrophos contains both nitrogen and phosphate. At present it is dearer than the others but of course adds phosphate as well. It should be quite a useful fertiliser.

Mr Leitch: Regarding the question of overliming, I would suggest it becomes a question of economics. If you have got your soil to a pH of 6-6.5 then it seems unnecessary to keep piling lime on at £2 an acre, especially in preference to superphosphate. I think it becomes a question of maintenance liming at three to five year intervals or when the pasture is ploughed and resown. Before continuing to lime heavily I think we should consider spending the money on phosphate. I don't say we shouldn't use lime. We'll always need to. I think Mr Carr has proved his point as far as over-liming is concerned; he has put on large quantities and his stock have not suffered. It seems he didn't really need to do anything about trace elements.

Mr Johnston, Oxford: Mr Carr is looking for some means of increasing the carrying capacity of his tussock blocks. Supposing he found it, would it have a detrimental effect on those good disease-free sheep of his?

Mr Carr: I keep the hoggets in the paddocks on the highly-limed country from weaning till Christmas, then they are turned on to the hill. The ewes are brought into the paddocks for the year before they go as cast-for-age ewes.

A speaker: What facilities for soil testing can the Department of Agriculture offer?

Mr Leitch: The cost is £1 per sample for four samples. Additional samples are 10/- per sample. That is, on a paddock basis. We may take 10 to 15 samples within a paddock but you pay £1 for the testing of the composite sample from that paddock (or 10/- for every additional paddock after four). We also test for molybdenum at an additional cost of 15/-.

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FARM SHELTER AND FARM FORESTRY
THE EFFECTS OF SHELTER BELTS ON WIND FLOW
AND SOME ASPECTS OF THE SHELTER RECEIVED

W. T. Wendleken, New Zealand Forest Service

I begin this discussion on shelter belts composed of trees and tall shrubs grown closely together by stating some principles; basing my conception of shelter as being both close protection to stock from driven rain, wind blast and etc., as well as the more distributed shelter to a whole field of crop, pasture or fallowed land. The aspects of shelter to houses, to sheds and yards, of snow drift and melt control, of water run-off control and of weed-seed trapping are not specifically touched upon. The principles are:

1. The greatest shelter is to the leeward side of the belt and the effect extends to about thirty times the height of the belt, with possibly 20 'H' being the limit of practical effectiveness. (An 'H' unit is the horizontal equivalent of the mean tree height.)
2. The area protected to the leeward is proportional to the height of the belt.
3. The greatest degree of shelter is found immediately to the lee of the belt.
4. The greatest area afforded shelter is found when the wind strikes the belt at right angles.

Firstly, the statements I make regarding air flow are concerned with shelter belts which are compact below, so that only small amounts of air can penetrate the belt from ground level up to 20 or 30 feet. The belts may be permeable or penetrable above this level without materially affecting or reducing the sheltering efficiency. The belts in question all have a definite profile in cross section, the essence of which is an inclined surface.

Secondly, the examples I quote to demonstrate efficiency in giving shelter, that is in raising production, are taken for the second aspect of shelter which I mentioned, and being distributed shelter, where crop or grass weights can be measured and compared with controls grown in the open. I leave it to you gentlemen with your practical experience to assess the value of shelter for livestock, especially say pre-lambing shorn ewes, when the shelter takes the form of a dense belt, windproof to ground level.

A shelter belt with complete impenetrability, constructed as example A, and when obstructing a ground level wind of 30 miles per hour flowing at right angles to it, produces the following effects in the air flow.

If the wind is increased to 60 miles per hour, the effective reduction greater than 25 per cent. in the wind speed extends to approximately 30 'H' units provided that there is not too much penetrability in the upper levels of the belt. However at this point of 30 'H' units distance there is a tendency for induced turbulence in the upper layers of flowing air to buffet downwards and even reach ground level, with the result that effective shelter extends only to about the limit of 65 per cent. of the wind speed. Beyond this point there is a very rapid falling off in degree of protection.
In plan view, the picture is somewhat reversed, for with the 30 m.p.h. wind the area protected by the same shelter belt is greater than with a 60 m.p.h. wind and the area for any given degree of protection is greater.

From this it will also be seen that if a belt is short, its ability to shelter a proportionate area behind it is lessened. In this example, and with a 60 m.p.h. wind, the presence of a high latticed structure in the form of loose crowned trees such as tall Eucalypts or Poplars will prevent the sideways ventury effect considerably. Similarly, the extension of the belt as a wing at right angles to the main belt, even for only 2 'H' units, almost completely protects this area which receives full wind blast or even an accelerated air flow.

When the wind strikes at other than a right angle the area and degree of protection are both lessened more or less in proportion to the acuteness of this angle. Because winds do not blow consistently from a common point on the horizon and in order to make sure that the fullest benefit possible is being got from any planted belt, these should be as long as possible, and at least 40 'H' units long on flat ground. For complete shelter in practical terms, parallel belts should be 20 to 25 'H' units apart and for trees reaching to 60 feet this means every 400 to 500 yards. If a slightly lesser distance is chosen, there is an increased cumulative effect whereby the second belt receives winds of less than normal force, and consequently its value in giving a higher degree of shelter is increased.

If gates or stockways are needed the gaps should be angled away from the general wind direction in order to avoid funneling a ground draught across the area which normally receives the greatest degree of shelter. The gaps should be as narrow as possible.

For comparison with the one or two row shelter belt found com-
monly in Canterbury, frequently of *P. radiata* open below and presenting a vertical face to the wind I show in diagram form the type of wind flow which is induced to illustrate their efficiency.

On the other hand, a dense hedge or low shelter belt cuts out the ground draught, but gives little distributed effect because of its low stature and the induced turbulent air flow which rolls over the top.

To sum up under this heading, an analysis of the degree of effectiveness per tree for each 'H' unit of the shelter belt length can be expressed numerically as shown below.

<table>
<thead>
<tr>
<th>Type of Belt</th>
<th>Index of Protection (2)</th>
<th>Effectiveness per Tree (3)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A. 5 trees.</td>
<td>18.7</td>
<td>*0.87</td>
</tr>
<tr>
<td>A. 10 trees.</td>
<td>*22.4</td>
<td>0.56</td>
</tr>
<tr>
<td>B. 10 trees.</td>
<td>20.0</td>
<td>0.62</td>
</tr>
<tr>
<td>C. <em>P. radiata</em></td>
<td>12.0</td>
<td>0.49</td>
</tr>
</tbody>
</table>

(2) *Area under the curve protected.
(3) *(Index of Protection).
(No. trees per 'H' unit).

The effect of the reduced air flow between the belts, on other factors of the local climate is significant for the growth of all farm crops. The temperature of the air close to the ground and of the upper soil layers is increased except where cool air escapes from the belt during early spring and summer mornings. The humidity, both relative and absolute, is higher between the belts than in the open;

![Wind Flow about an Open Shelter Belt](image)

and this is due to the transpired and evaporated water vapour not being dissipated into the upper air layers and despite the higher temperatures between the belts. In areas where harsh conditions exist, and this may take the form of semi-aridity as induced by winds, as for example the north-west winds of Canterbury, the higher temperature which exists in the shelter of the belts does not contribute to increased evaporation or transpiration as much as does the free passage of air over unsheltered ground.

Gamokhinia, a research worker on the Ukraine steppe, shows that the intensity of transpiration by oats is less in sheltered fields than in the open, while the yield of grain is higher.
Table I.

### C.C's of Water Transpired per Gram of Dry Weight.

<table>
<thead>
<tr>
<th>Date</th>
<th>Open Steppe</th>
<th>Sheltered</th>
</tr>
</thead>
<tbody>
<tr>
<td>27 May</td>
<td>15.44</td>
<td>12.6</td>
</tr>
<tr>
<td>12 June</td>
<td>9.48</td>
<td>6.44</td>
</tr>
<tr>
<td>13 July</td>
<td>2.92</td>
<td>2.16</td>
</tr>
</tbody>
</table>

Yield of Dry Weight: 2.28 (At Karmeno, where approximately 16 inches of rain fall each year).

Table II.

<table>
<thead>
<tr>
<th>Distance</th>
<th>Winter Wheat Cwts./Acre</th>
<th>Spring Wheat Cwts./Acre</th>
<th>Oats Cwts./Acre</th>
</tr>
</thead>
<tbody>
<tr>
<td>10-53 mtrs.</td>
<td>7.8</td>
<td>5.5</td>
<td>5.4</td>
</tr>
<tr>
<td>53-96 Mtr s.</td>
<td>5.2</td>
<td>4.6</td>
<td>2.8</td>
</tr>
<tr>
<td>96-138 mtr s.</td>
<td>2.6</td>
<td>3.6</td>
<td>2.2</td>
</tr>
</tbody>
</table>

Yield of varying Distances from Shelter Belts. (At Omske, where approx. 26 inches of rain fall, season cold).

In some of the above experiments, winter frost and/or summer drought caused complete failure only in the unsheltered controls.

With perennial herbs, two years old and cut for hay, Kernzin, in 1937, reported as follows, from experiments at Gurel.

Table III.

<table>
<thead>
<tr>
<th>Lucerne/Clover</th>
<th>Grass/Clover</th>
</tr>
</thead>
<tbody>
<tr>
<td>Open</td>
<td>13.8</td>
</tr>
<tr>
<td>Sheltered</td>
<td>30.9</td>
</tr>
</tbody>
</table>

Kermeno, working with semi-permanent grass/legume pasture, reports as follows:—

Table IV.

<table>
<thead>
<tr>
<th>Age</th>
<th>Sheltered</th>
<th>Open</th>
<th>Increase</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 year old</td>
<td>4.5</td>
<td>3.9</td>
<td>0.6</td>
</tr>
<tr>
<td>2 year old</td>
<td>9.2</td>
<td>7.7</td>
<td>1.5</td>
</tr>
<tr>
<td>3 year old</td>
<td>9.0</td>
<td>6.3</td>
<td>2.7</td>
</tr>
<tr>
<td>4 year old</td>
<td>7.9</td>
<td>4.8</td>
<td>3.1</td>
</tr>
</tbody>
</table>

The general conclusions of most workers in Denmark, the U.S.A. and Russia are that:—

1. Various strains of cereals and forage grasses, root crops and legumes react in different ways.
2. Shelter belts raise the production of root crops 85 per cent. average. 175 per cent. in dry years.
3. In general, the influence of belts on production is markedly greater if technical efficiency is high, and this may be shown by the following table:—

Table V.

<table>
<thead>
<tr>
<th></th>
<th>Open Grown</th>
<th>Sheltered</th>
</tr>
</thead>
<tbody>
<tr>
<td>Before 1932</td>
<td>0.92 cwts./acre</td>
<td>1.6 cwts./acre</td>
</tr>
<tr>
<td>After 1932</td>
<td>2.2 cwts./acre</td>
<td>5.8 cwts./acre</td>
</tr>
</tbody>
</table>

(Average yield for all farm crops. 1932 taken as the year when modern farming methods became general practice in U.S.S.R.).

I conclude by saying that type 'A' with its high degree of effectiveness per tree and the possibility of extending the belt to incorporate timber production, is the most desirable form of belt struc-
ture that I know of for general farm use. In addition it is possible to design, plant and grow belts of this form and consider in the framework quick growing subordinate species for immediate shelter; principal species of greater age and usefulness for permanent shelter and to so manage the stand of trees that timber production can go on without reducing the protective value of the belt at any time. With such a profile as I have outlined the risk of windthrow to any of the trees is so reduced that the chance of damage to the belt becomes only a faint possibility.

It should be clear that soundly-planned shelter belts naturally increase production of feed as well as give better living conditions for livestock. Poorly-designed shelter belts might be useless or even worse than useless; considering the ground they occupy. Competent, on-the-spot technical advice, where all questions relating to the land occupied, fencing, species and shelter required can be discussed and answered is usually necessary.

FARM SHELTER
D. Deans, Darfield

The climate of Canterbury, especially in the spring when the lambing is on, is subject to very sudden changes. It may be blowing a strong, very hot nor-wester and then suddenly turn to the sou-west with heavy driving rain and sometimes sleet or snow. Under these conditions very heavy losses have occurred during lambing. If we look back and try to visualise the plains before the early settlers came here we would see nothing but a vast plain covered mostly with a sparse growth of tussock and the only trees might be an odd patch of manuka and here and there a cabbage tree. Certainly near the coast in places there were large areas of swamp which were useless to stock until they were drained and cleared. Now, if we take a run across the country we will see well-planted farms with stock contentedly chewing the cud under the trees; also a nicely planted homestead. Also we see one or two farms with a house put behind a belt of pines with practically no other trees, the sheep standing in heaps in the middle of the paddock with their heads together trying to get some shade from the sun. It is my opinion that we should have plenty of shelter on farms.

I would put the planting into three groups. Shelter belts, timber, and planting round the homestead, the main one being the first, as a number of farmers may not have the finance to do much in these two other groups.

The most useful tree for shelter belts is undoubtedly the *Pinus insignis* although macrocarpa is also quite good, but harder to establish and much slower growing. On wet heavy ground Lombardy poplar is useful and, if planted close together, will stop a lot of wind even with the leaves off. Hawthorn is used quite considerably, although not much in Canterbury.

Most shelter belts are put facing east and west, which means that they cut out the nor-wester on one hand and sou-wester on the other. Nearer the coast it is a good idea to have some wind breaks against the persistent nor-easters. Fencing is the greatest cost in planting and wherever possible the belt of trees will be put against an existing fence which means that only one other has to be erected. To ease the cost I use old coils of cyclone which are of no further use for turnip breaks; these with plenty of intermediates and good sound gum stakes make quite a good and lasting fence.

I have tried three different types of shelter belts. Firstly, three rows of pines with one of Lawsoniana on the sou-west side with the
idea of eventually cutting out the inner rows of pine for timber. The idea of having the Lawsoniana is that the stock are not supposed to eat it, thereby giving shelter right to the ground; however the sheep have trimmed them up nicely. I might say here that I took down the fence on the south side and let the stock in; a mistake. The big wind in 1945 blew down most of the pines as they were not topped. The second belt was of two rows of pines which I have kept topped to about 15 feet. This makes quite a good wind break and probably gives a quicker shelter than the single row, but is harder to keep topped and also, as the trees get older the inside branches die and are of no use for cutting out the wind. Also the double row takes up more ground.

The single belt seems to me the best. For one thing it takes up less paddock and is very easy to keep trimmed and topped. I might say here that topping the trees makes them grow much thicker and also cuts out the wind better than the high spindly ones as these swing in the wind and let it through. Also they will very often blow over in the nor-west gales.

Having decided where the shelter belt is to go you would mark out your fence line and proceed to put it up. Where sheep only are in the paddock I find four feet on either side of the trees is sufficient space to stop them from getting at the young trees; for cattle a greater space, say six feet, and probably an extra barb on top of the fence. The trees I put at four feet apart.

There are several ways of planting, but I find the best is to cut out a block of turf about a foot square and then chop up fine the earth in the hole. To get the best results this should be done a month or so before planting. The trees will arrive from the nurseryman in bundles and should they not be planted straight away, they should be taken out and ditched in the garden until wanted. Don’t plant when the ground is too wet or when it is frosty. I think June, July and August are the best months. When planting you will find the roots are flattish like a man’s hand and should be put in the hole with the roots facing nor-west and the stem in the corner opposite. Cover them with some of the loose soil in the hole and put the square of turf back and press down firmly. This method I find as good as any. The reason for putting the turf back on top is to stop the stems from swinging in the wind and thereby loosening the roots, which is fatal to the trees.

When the trees get to about eight or ten feet high, cut the tops off them, otherwise they will run up into spindly trees and will be harder to keep in order later on. Some of the longer lateral branches may also be shortened. I am trying an experiment in a wet hollow in the hill where the ground is too wet for pines. I have planted willows and poplars interplanted with flax to give bottom cover. So far this idea seems to be working quite well.

There are one or two points in connection with the above. Don’t take away the fence when the trees have matured as the stock will eat the lower branches and let the wind through. If you should get a heavy snowstorm some of the branches can be lopped off and fed to the sheep if hay is not available. In the lambing season I put a cyclone fence out about two chains from the shelter belt; on the sunny side, and if it comes a bad storm, a mob of lambing ewes can be put in there until the storm is over. It is not advisable to put too large a mob in as there will be a big muddle of lambs and a lot of mis-mothering when they are let out.

Another form of shelter, mainly shade, is to fence off the corner of a paddock and plant a macrocarpa which will form good shade on a hot day as the branches spread out. On my property I have a lot
of gullies with flax in them and about August I put willow and poplar cuttings in the middle of the flax bushes and these form good shade.

I will only touch briefly on the second and third groups as a good many people have their own ideas about these. In the second group, if the farmer has a bit of spare ground, it is worthwhile to put in a block of trees for timber. This will probably take up to 30 years to come to maturity. These, to my way of thinking, should be planted each variety in separate blocks as some trees grow faster than others and, if they are mixed, one variety will overgrow and spoil another. *Pinus insignis* should definitely be planted by itself. Trees for farm timber to my way of thinking would be: *Pinus insignis*, macrocarpa, gum and Douglas fir. These, I should say, would be the most useful. I would suggest planting them at six or eight feet apart with the idea of thinning them out later on.

Any farm looks well if it has some nice trees round the home­stead and nothing looks nicer than the deciduous ones such as oaks, elms, ashes and chestnuts; but these trees require shelter from the strong winds to do best. Also the heavier the ground the better they do. One great advantage with them is that they can be planted much nearer the house and, in winter when the leaves have fallen, they do not shut out the sun the same as the conifers. Also the leaves can be raked up and make very good compost.

Finally, any tree lover who has a well-sheltered corner should put in a block of native trees. If young trees are got from the bush they should be put in the garden for a year to let them put on good fibrous roots before finally planting out.

THE FARM WOODLOT

W. H. Joliffe, New Zealand Forest Service

The previous speakers have told you of shelter belts—my remarks will refer to farm woodlots; that is, any area of farm land bearing trees as a crop or whose purpose is more than the provision of shelter only.

We can summarise the ways in which a woodlot benefits the farmer in the following list:

1. The provision of timber, fencing material, firewood and other forest produce required on the farm.

2. The raising of a profitable crop on what may be otherwise un­farmable land.

3. Increased production from stock and crops as an effect of shelter.

4. A preventative or a cure for erosion.

5. Greater aesthetic effect—a well wooded farm being more satisfying than a bare one.

Planning

Having become convinced that trees might be a good idea then there are several things to consider.

1. The extent and location of the area which can or should be devoted to the growing of trees. On first class farm land, the area will likely be restricted to a minimum and include steepish sidings; areas of gorse, broom, etc., frequently on outcrops of poorer soil; and odd areas of irregular shape including the corners where three or
four adjacent paddocks meet. On marginal lands the allocation of land for trees will likely be on a more generous basis—in some cases trees may be the best crop for the site.

2. The purpose of the planting—whether for timber, or fencing materials, or firewood or to prevent or combat erosion, etc. The choice of species will be influenced by these reasons.

3. The site factors such as altitude, topography and aspect, soil, climate and vegetative cover already present. All these peculiarities will affect the choice of species.

4. The source of tree stocks—whether by purchase or by home growing, and

5. Whether or not proper silvicultural treatment can be given to the stand once it is planted. This point will concern the espacement of the trees which will govern the number required per acre.

All these things require consideration before a start is made and you will find a wealth of helpful detail in the publication “Farm Trees and Hedges” by J. S. Yeates. If you are still in doubt, consult your local Agricultural Instructor or the nearest Forest Officer.

Preparing the Site

Clean country requires no special preparation, although on ploughable slopes, one or two furrows along each planting line will be time well spent. But where there is much fern or scrub it is a different story. The simplest way is to fell all the scrub in the summer and burn it in the autumn, leaving a more or less clean face on which to plant—but this method leaves no shelter. In exposed situations or where a not-so-hardy species is being planted, it is best to cut lines through the scrub which may later be fired or not. If it is fired then there is not so much immediate shelter as in the unfired case, but in the latter it is almost certain that lines will have to be opened up in the first and perhaps the second year after planting to avoid smothering the young plants. The degree of initial shelter required will usually decide which method to adopt.

Protection

In all cases the area should be fenced—where there are rabbits or hares then with netting as well. As regards fire, the best protection is clean, well-farmed land adjoining the woodlot. Where this is not possible, then a ploughed or chipped break combined with a few rows of non-inflammable species such as Douglas fir, larch, poplars or oaks is a good fire insurance. Large areas should be subdivided by firebreaks of this nature.

Protection from insect pests and fungus diseases is attained more by choosing the right species for the site and by allowing full development by thinning when needed. However, I will mention one or two what-not-to-do’s: don’t plant pines within three years after the felling of a previous crop of pines for fear of the bark beetle (*Hylastes ater*); don’t plant Lawson’s cypress and macrocarpa in districts where “gummosis disease” is prevalent; and don’t plant tall growing trees in peat with a high water table.

Raising the Stock

Apart altogether from the greater satisfaction in doing it there are several real advantages in raising your own tree stocks; they are fresh on the job when you and the weather are ready, they are acclimatised to the locality, and they cost little more than the necessary time and energy. These advantages increase greatly the further you are away from a commercial nurseryman.
Young trees can be raised on any garden soil as easily as vegetables, but do not use either lime or fertilisers. Having prepared the ground as you would for vegetables, the seed is commonly sown in bands about six inches wide, made by pressure on a board of that width. Sowing is arranged to give one seedling per one inch square if they are to be lifted as one year olds and one per two inch square if they are to stay in the bed for two years. The seed is covered with sifted soil or sand and firmed.

Better results are obtained if the beds are protected by frames made of eight-inch boards and wire netting on which is spread open-weave scrim, brush or slats. After the young plants have produced real leaves (distinct from cotyledons) the frames are lifted on one side a little longer each day to harden off the plants prior to complete removal of the frames.

Weeding must be regularly attended to—weeds can soon suppress a crop of young trees. Long tap roots are a nuisance to the tree planter and so they have to be pruned in the process known as “wrenching.” This is done with a sharp spade and is easier if two men with spades are available for the job. The spade is plunged in at an angle so as to cut the roots between four and five inches below the surface and is done after rain about four to six weeks before planting time.

On lifting, the soil is shaken from a clump of trees, the individuals are carefully disentangled from one another, the stunted and misshapen ones are discarded, the selected ones are bundled into convenient sized bundles which are tied with flax, and the roots of the bundles are dipped in a mud bath (known as a “puddle”) about the consistency of gruel. The “puddled” bundles are then heeled-in, in readiness for transport to the scene of the planting.

Planting

The main points in planting are: 1. to see that the roots are directed downwards and not bent unnaturally; 2. to insert the plant to the same level as it was in the nursery; 3. to firmly fix the plants in the ground and see that the roots are not hanging in an air pocket; and 4. to keep the roots of the young trees moist at all times while out of the ground.

The best general tool for planting is the grubber and time spent on clearing a space about the young tree and in pulverising the soil to the full depth of the grubber head is time well spent. Planting 500 trees a day properly is far better than 750 a day which may require “blanking-up” next year.

Nature does not plant in lines but we do because it is then easier to get the spacing fairly even and simplifies the business of finding the trees if they have to be released from overtopping fern, etc., later.

Spacing of plants may vary from 6ft. x 6ft. (i.e. 1210 per acre) to 12ft x 12ft. (i.e. 300 per acre). Generally speaking, closer spacings are preferable because a continuous leafy canopy is formed at an earlier age, resulting in a quicker suppression of weed growth, the early suppression of side branches which are thus kept small, and the incentive to increased height growth. But close planting must be followed by early thinnings to avoid stagnation. Therefore if you are not likely to be able to thin, then plant your trees wider apart, say 10ft. to 12ft.

Care after Planting

In the first place it will probably be necessary to save your trees from being suppressed by cutting back the surrounding weed growth.
This job is best done with a one-hand tool like a billhook—a two-handed implement often results in a lot of the trees being cut too. This operation may have to be repeated.

As soon as the young trees are level with the competing weed growth no further care, apart from protection against fire and animals, should be necessary until between 10 and 15 years, depending on the species and the closeness of planting. By that time a low pruning will be needed and perhaps also a thinning. Low pruning (usually to 7 feet from the ground) serves several purposes—firstly, it reduces the fire risk in a plantation, secondly, it enables the trees to put on knot free wood and thirdly, it allows the owner to get about among the trees. In doing the job, don't leave “coat-hangers” and don't wound the bark unduly.

Thinning usually aims at the improvement of the final stand by the removal of the poorer type trees. However, a farmer may require certain large material before the stand is mature, in which case he may follow the opposite technique by removing some of the better-type trees. Thinning may have to be repeated before the stand is fully mature.

If high quality timber is the aim, then some years after the low pruning, high pruning will be desirable. This operation can be done using a curved pruning saw mounted on a twelve-foot pole; it cuts on the full stroke. It is a slow job and is usually restricted to those trees which will form the final crop.

Utilisation

Of prime importance is the supplying of the farmer's own requirements of forest produce. Thinnings will yield strainers, posts, and firewood, and with the aid of a sawbench, gate timber and the like could also be obtained.

For outside use, non-durable timbers will have to be treated either by immersion in creosote, pure or diluted with old engine oil, or the double-diffusion method which uses solutions of bluestone and sodium chromate. Both these simple methods are lengthy but they can be going on while a farmer is attending to his normal work.

Where the woodlot is of some size, final utilisation is really a job for a sawmiller. In some districts, there are itinerant sawmillers with portable gear, who will come and saw the logs on your own property. It is my opinion that there is ample room for more of these outfits. However, in most cases you will have to deal with an established sawmill and it is wise to know the approximate quantity you have to sell and what is a reasonable royalty for your locality. I have known sawmillers playing one woodlot owner against another in an endeavour to beat the royalty down. Where there are many farmers with woodlots in any district it is wise to form a co-operative association to protect and regulate the marketing of the produce. Incidentally, such an association can be of value in other ways, especially in providing a centre for discussion of forestry problems generally.

Taxation

This short story would not be complete without some reference to the incidence of taxation on a woodlot. We will very briefly consider the five taxes: Land, Income and Social Security Taxes, Local Body Rates and Death Duty.

1. Land Tax: Land Tax is payable on the unimproved value of land bearing trees in just the same way as it is payable on other classes of land. Please note that the value of the trees does not enter
into the valuation for tax purposes—trees, both natural and planted, were specifically exempted by legislation in 1927.

2. Income Tax: Nett returns from the sale of trees are taxable but in the case of intermittent sales it is permissible, on application to the Commissioner of Taxes, to spread the nett proceeds over a period of five years and so reduce the effects of the graduated scale of taxation. In arriving at the nett return, all reasonable costs may be claimed as deductions, including the value at the time of purchase, if the property was bought with the trees already standing on it.

Further, the costs of planting trees for farm purposes, and maintaining and protecting them, can be claimed as deductions against the farm income for the year in which they were incurred.

3. Social Security Tax: The position is the same as for Income Tax.

4. Local Body Rates: The position is the same as for Land Tax. Where rates are levied on the capital value, the Local Body must be careful to exclude the value of trees.

5. Death Duties: Trees are valued for death duties in the same way as any other crop on the property. However, the Valuation Department states that its policy is to value farm trees conservatively for this purpose.

The Forest Service is still pressing for further improvement in forest taxation.

In conclusion, let me assure you that the Forest Service is interested in Farm Forestry and will advise you in your problems. Take them to your nearest Forest Officer.

DISCUSSION ON PAPERS

Chairman: In Canterbury where we put in shelter belts for the sou-westers or the nor-westers, the ground on the lee side is shaded and stock don't like shaded grass.

Mr Wendleken: If you run your belt due north and south you will get a fairly high degree of shelter from both easterly and westerly winds, and a minimum amount of shaded grass.

A speaker: Those wide belts of trees take up far too much land from the average farmers' point of view; particularly in windy areas we want shelter for each paddock. If we are going to have wide belts of trees we're going to have half our farm in timber. We want something which will break the force of the wind for short distances.

Mr Wendleken. Type A can be put into a strip of land half a chain wide. If it grows to 60 feet high you will get about 400 yards of protection. Half a chain on the windward edge of a field 400 yards wide is a small percentage of that field, far less a percentage of land area than the increased production you will get. Perhaps in New Zealand we may some day be able to have some controlled experiments regarding these matters. Type A shelter belt has so many advantages over others that I think it is well worth considering.

Mr Alderton: I would like to make some comments about tree planting in Otago and Southland where the conditions are different from those in Canterbury. We have a great dearth of trees on our farm land. We took off the natural cover provided by the tussock and exposed the land to cold winds. Although we have increased production tremendously with lime and fertilisers, we are losing heavily on further production because we have made our land cold. I believe we could increase production more by the use of
shelter belts than we could in eradicating foot-rot. It is obvious
in Otago and Southland that the great bulk of the trees are all
around homesteads. Apparently the farmers think that while they
need shelter the stock doesn't. Why are our plantings so restricted?
I think it is because the wrong type of tree has been used. I am
antagonistic to the use of Pinus radiata and macrocarpa as shelter
trees. They suit the impatient farmer in that they grow quickly
but after they are about 10 years old you saddle yourself and your
family with a lot of hard work and trouble. If you have to put a
knife on a tree you have the wrong type for the particular place.

I have planted 2000 trees in shelter belts. It doesn't sound a
lot if you are planting a forest but in a shelter belt of three rows
you cover a lot of territory. I have used Lawsonianas on the out­
sides and Oregons on the insides. One plantation which has been in
seven years gave me a great thrill when in the snow-storm during
lambing the ewes voluntarily went up to that plantation and lambed
there. I was well rewarded for all the work and money I had spent.

I would stress the question of proper fencing. The majority of
trees are jammed up against the fence when they are planted and
have another fence jammed up against the tree trunks. As a result,
the stock chew the branches off, the winds blow underneath and the
sheep get pneumonia. By proper fencing, the grass will grow up
to the bottom branches and you have no dead ground. I am sure
that farmers, as the speakers have said, could make a wonderful
contribution to the wealth and beauty of the country if they would
plant the right type of shelter tree and look after it adequately but
also plant deciduous trees in various parts of the farm. These will
not only give beauty but shade, which I am convinced is almost as
necessary to stock as shelter.

Mr Deans: I am trying to eliminate the wide belt but in Can­
terbury Lawsoniana is too slow. It does not like our dry ground.

Mr Chapman: Has the State Forest Service done anything with
selection of types within a species? We notice tremendous variation
within one plantation. Some trees are of the timber type, others are
of infinitely better shelter types. Selection is not a job for an indi­
vidual. It is obviously a job for the Forest Service.

Mr Jolliffe: Through our Forest Research Institute at Rotorua
we are doing considerable work on the genetics of trees. It will be a
long time, though, before you as planters will get any benefit from
that work. In the meantime you will be at the mercy of your
nurseryman. Several that I know personally are paying considerable
attention to selection and the only hope you have at present of
getting just what suits your purposes is to deal with reputable
nurserymen.

Mr Cooney. I was interested in the way the farmers sat up and
took notice when Mr Jolliffe talked about taxation. I would like to
expand on the returns that a farmer can expect from his trees.
Farmers would be well advised if they have trees to sell to get
advice from the local Forest Officer. In 1925 six acres of land were
planted in Douglas fir as a second crop. In 1953 those trees
were thinned and we received £80 an acre for the thinnings. I am hoping
those trees will go on for another sixty or eighty years. I am
quite sure my successor will get a net income from these six acres
of £8 an acre a year and his successor should receive from the final
crop about £800 an acre. From Pinus radiata and some other types
you cannot expect such results, but here in Canterbury a farmer
should get a return from his shelter belts of at least £5 an acre
a year over a rotation of 40 years. At Burnham when adjoining
land was producing from wool and white clover £15 an acre we purchased identical land at £3/15/- an acre. We expect to get, in 40 years, £400 or £10 an acre a year. Farmers can grow trees at a profit, get shelter from them and get increased productivity as far as meat and wool are concerned.

A speaker: What is the best tool to use on stony ground?
Mr Deans: I like an old grubber or possibly, if very stony, a grubber and a pick. You have to be careful in putting your soil back that you don't get a stone packed on the roots, otherwise when you firm it you are going to squash those roots. Always put fine soil back in contact with the roots.

Mr Jolliffe: We found that an old crow-bar, flattened at the business end into what we call a planting spear, is as good as anything for really stony ground. By working it backwards and forwards you can get whatever sized holes you need.

Mr Ireland: I planted about 50,000 trees at an altitude of 2,000 feet. I first bought an expensive spade with a narrow point but, after trial, my men decided that the pick would be better. They just jammed the pick into the ground, wriggled it a bit, and put the tree in. The replacements were very low. I planted in rows a mile or two long. At first I planted six rows but I am now thinning out two because they are getting smothered. They have no side branches and no hold as far as the wind is concerned.

Chairman: We have had a lot of trees blown down both in the 1945 gale and last year too. I cannot remember seeing any tree blown over that was standing on its own unless the ground was very wet. The trees that blew down were in the middle of five-row belts. I decided I would never plant a five-row belt again. I now plant a belt in a single or double row and fence very wide. I then get every tree strong and it will grow high without blowing over. I am prepared to let them open up a bit underneath provided I get general shelter over the paddock.

Mr Wendelken: You are speaking entirely about *Pinus radiata* I take it. As you go round Canterbury you will see remnants of shelter belts where *Pinus radiata* grew and has blown over. The trees which have stood are such species as Douglas fir, *P. laricio*, silver birch and larch which are all much more wind-firm. This business of spacing is a very important matter as far as stability of trees is concerned. They must have room for their roots and in Canterbury we have such shallow soil that the room for the roots must be horizontal rather than in depth. Different species have different rooting habits and different types of top growth. They offer varying degrees of resistance to wind and behave in different ways to it. Where we want to use a valuable tree like *P. radiata* we can possibly help it by planting wind-firm trees like Douglas fir or oak. We thus go back to our three, four or five-row shelter belt which gives us shelter, stability against wind and also produces timber.

Mr Buchan: Many farmers are worried about the fouling that takes place under evergreen shade trees and consequently they like to fence them. This reduces the shade available to stock. I would suggest that the planting of well-spaced Lombardy poplars on the northern boundary of paddocks. The sheep have to follow the shade around, no part of the ground becomes fouled, and the grass continues to grow everywhere.

Mr Polhill: Near the foothills I think any tree will blow down if the conditions are too tough. I have tried a single row of *P. radiata*
and trimmed it to make a hedge. Inside I have planted Douglas fir and macrocarpa. The hedge breaks the wind so that the other trees have a chance to get well rooted.

Mr Deans: I think that's a good idea, but don't let the *P. radiata* grow too high, otherwise they will blow over and take the others with them. Cut out your pines later and leave your Douglas fir and macrocarpa to make the shelter belt.

Mr Joliffe: I would like to thank Mr Cooney for drawing attention to the great assistance farmers can render the state in growing timber where we cannot get big plantations established. This applies especially in areas which are mainly high-class land, but I must warn you against accepting his figures too literally. I don't doubt for one moment they are what he is obtaining, but his areas are largely shelter-belt areas, fairly narrow, with the roots of the trees spread out well beyond the limits of his fences. Obviously then his areas not not quite the areas of the land on which those trees are grown. I just want you to realise that in a woodlot you cannot expect quite the returns he gets from his plantations.
INCREASING PRODUCTION ON MARGINAL LANDS

THE MARGINAL LANDS ACT

D. M. Greig, Director-General of Lands

It is probably well that I should open my address by attempting to clarify what is meant by marginal land. The Oxford Dictionary defines the adjective “marginal” as meaning “close to the limit” and while this could give a very clear picture when applied to certain subjects it becomes somewhat troublesome when applied to land.

With perhaps minor reservations, however, it is basically a matter of economics and when applied to a particular piece of land amounts to whether a farmer with the will to work and equipped with all the available knowledge of how to successfully farm such land, can then afford to farm it.

There is little need to widen the meaning of the words “can afford” though they must of necessity embrace such things as the availability and cost of capital and the individual’s assessment of the standard of living he expects for himself and his family.

Whether land remains in this marginal class or not depends on many things and here perhaps I could assess, what to me are the main dependent factors as I see them though in doing so I want to confine myself to the major conception of New Zealand farming, viz., grass lands and animal production.

To me the main dependent factors are:

1. That our knowledge of the soil type both scientific and by practice is such that we know that grass can be grown and stock can be raised thereon in a thrifty and healthy condition.

2. That the essential capital required to bring the land to such a condition is available.

3. That the prices received for the produce from such land hold at such a level that the standard of living of those who farm it remains sufficiently high so as to encourage the continued and successful occupation of such land.

One can, of course, add many other factors but if you ponder those that will readily come to your minds I think you will find, as I do, that each one is simply complementary to those I have mentioned.

There is one, however, that I have not specifically drawn attention to and that is the human factor—perhaps the frailest, while yet the most important in any undertaking whatsoever its character.

Anyone who has wandered up and down New Zealand throughout the years must have been seized with the fact that our marginal land has made for marginal farmers and in saying that I do not wish to detract in any way from the fine human qualities of those people, many of whom I have been privileged to call my friends.

I draw attention to the fact, however, because it has caused, and continues to cause, a lack of confidence amounting almost to a bias, in the minds of financial institutions to lend money on this type of land and it is money that is required to exploit in the first instance.
the latent possibilities of thousands on thousands of acres of such land in this country.

The Royal Commission established to enquire into and report upon the Sheep-farming Industry of New Zealand in 1947 saw this and in its Report of 1949 recommended the establishment of a Marginal Lands Board charged with a responsibility to provide finance for the development and improvement of this class of land.

In their report the Royal Commission recommended a system of advances by the Board as follows:

1. Such advances to be based on a complete plan for the economic establishment of the farm in question.
2. These advances should be for productive development as we have defined it under the definition of marginal land.
3. To be free of interest or repayment for a period of up to five years at the discretion of the Board or for longer periods if the Board thinks fit.
4. Power for the Board to write off all or any portion of any advance if it considers such a course desirable having regard for our recommendations that the state should pay the difference between total cost and economic cost to the individual.
5. The Board should be able either to make an advance or to have the work done, if it considers it more economical for the Board itself to do so, either directly, or through the Ministry of Works, or through any other agency which may be convenient.

Late in 1950 Parliament enacted legislation to give effect to the Commission’s recommendation and in that year the Marginal Lands Act 1950 became law.

The title to the Act is important, if not significant, "An Act to make Provision for Increasing the Production of Farm Lands that are not Fully Productive."

Section 2 of the Act defines Marginal Land as “any land that in the opinion of the Board is used, or is capable of being used, for agricultural or pastoral production, but which in the opinion of the Board, is not developed to its full productive capacity or is declining or tending or likely to decline in productivity or has suffered or is liable to suffer soil erosion or has suffered or is liable to suffer damage or loss of productivity from floods or similar disasters, and which in the opinion of the Board, is worth developing, maintaining or protecting.”

I make mention of these two definitions because:

1. They give reason for the Board’s policy which I will explain later on, and
2. They clarify a misconception, that existed in some quarters, that the intention of the legislation was to provide financial assistance to improve certain classes of sheep country that accorded, economically, with the definition “close to the limit,” to the exclusion of swamp drainage, irrigation and so on.

The Act provided for a Board and for local Committees to administer the legislation—the Committees were charged with fact finding and the making of recommendations to the Board while the Board was charged with the responsibility of lending monies, provided annually by Parliament, for the purposes of the legislation.

A perusal of the Act will show that the charter given to the Board was extraordinarily wide, as to its powers of discretion, both as to the subject matters upon which monies could be advanced and as to the terms and conditions of such advances.
Apart from restricting certain actions by Board and Committee members the only restriction, of the Board's discretionary powers affecting borrowers, is in respect of the interest rates to be charged on advances. These are fixed by the Minister of Finance and at the moment are 5 per cent. on a first mortgage and 5\(\frac{1}{2}\) per cent. on any subsequent mortgage securing current account advances by the Board. If and when these current account advances are amortised and secured by a table mortgage the interest rate is reduced to 4\(\frac{3}{4}\) per cent with a concession to 4\(\frac{1}{4}\) per cent. for prompt payment on first mortgage and 5\(\frac{1}{2}\) per cent with a concession to 5 per cent. on any subsequent mortgage.

Some complaints have been made that these interest rates are too high, but if you examine the ruling rates of the State Advances Corporation and other lending institutions in respect of first class securities you will find that this is not so.

It will be seen however, that because it has almost unlimited discretionary powers and because it is charged with a particular function by the very Title to the Act itself, the Marginal Lands Board is confronted with a task that would make the normal board of directors of a lending institution shudder.

At the inaugural meeting of the Board, and after seeking the advice of the members of all the Committees throughout New Zealand, certain policy decisions were made with a clear understanding that these would be subject to changes and additions thereto in the light of circumstances as our activities developed.

These basic decisions were:

1. That the Board was not a financing institution established to lend money to credit worthy borrowers for the purposes of making profits and because of this, and the fact that the community was already adequately and efficiently served by such institutions, we would not compete with such institutions. It was therefore determined that an applicant for Marginal Lands finance must first satisfy the Board that he was unable to secure assistance through the normal lending channels.

2. That advances would not be made for the development of properties which, even when fully developed, would still be uneconomic because of their size.

3. That a plan of full development to an economic stage would be required from any applicant. This would not necessarily embrace the development of the whole property but the Board was opposed to lending money for partial development which would not bring the property to an economic stage.

4. That advances would be made only to those applicants whom the Committees recommend as persons of trust and worthiness and who had the qualities essential to successfully carry out the development programme.

5. That, subject to the foregoing, advances would be made for the development of any type of farm land the production of which could be increased.

It was also decided at this meeting that the Board would not attempt through its Administrative Department to establish an organisation to map marginal lands on a district basis. This decision was made not because of any lack of appreciation of the value of such surveys but simply because similar information was already being collated by the Meat and Wool Boards and by the Department of Agriculture. These organisations readily and willingly agreed to
make available to us any information we required and the Board was most grateful for this evidence of co-operation.

Certain other policy decisions of a machinery nature, dealing with the functions of Committees and so on, were also made, but I do not propose touching on them here as they are really irrelevant to the purpose of this address.

Members of the Board realised at the outset that these initial policy decisions could not be other than a mere frame-work, upon which to build and that we would never escape from the details of examination of each case on its own merits.

In the first year of active operation by the Board, Parliament voted a sum of £250,000 for the Board's purposes. It must be remembered, however, that by the time applications were lodged and examined by the Committees a substantial part of the year had slipped away. The total advances approved by the Board in that first financial year of 1952-53 amounted to £281,060 but, of course, some of these related to programmes spreading over three to five years.

These facts, however, established a guide as to where we were going and how thickly or thinly we should spread the monies made available to us. Here I would like to say that having regard for the buoyant condition of the farming industry, since the passing of this legislation, no one could responsibly say that Government had been ungenerous in the amount of monies made available.

We found, however, that desirable though it was to have complete control and particularly complete control of the stock, if development programmes were to be prosecuted speedily and effectively, that the expenditure of our monies to liquidate mortgages, bills of sale and bank overdrafts grew not one single extra blade of grass which, in the ultimate, was what we were charged to bring about.

Obviously no government or other human agency could make all the unproductive lands of New Zealand productive over night, or provide sufficient finance for such a purpose and it was at this stage that the Board found it necessary to consider priorities and, at the same time, in individual cases, to approach mortgagees, stock and station agencies and banks to ascertain whether they would knit with us by agreeing to provide stock, restrain from unnecessary demands for reductions in their accounts and so on, and so by a joint effort make a success of the particular cases.

Priorities are not easily established without a feeling of hurt and frustration by those who are not preferred and the Board had this added difficulty that its main job was to increase production without necessarily determining by whom. It will readily be seen that a few large propositions could make heavy inroads into the funds available and, while perhaps achieving the objective of increased production, many worthwhile people, crying out for assistance, would go lamenting.

We therefore decided that our most worthwhile objective would be to concentrate, in the main, on those farms which were capable of being made fully economic units but which today, even with high prices, were barely economic.

Apart altogether from any consideration Board members may have felt as being due to good people who were just unable to provide sufficient security to the normal lending institutions for further advances for improvements, we felt that to lift such farms to a definite economic level would provide a buttress in the event of a recession in prices, so that production from them would continue, whereas, if left at their present low production even that would be lost to the country if any substantial drop in prices occurred.
These further policy decisions were then made:

1. That the Board, though still willing to advance monies on second and third mortgages, was not prepared to take over existing mortgages, except in exceptional cases. Where control or change of stocking was of first hand importance to a programme of development we expected that existing mortgagees should play their part if an advance was to be forthcoming from the Board.

2. That within the bounds of the monies available to us, but without necessarily denying consideration of any proposition, we would endeavour first of all to bring to an economic level existing low producing farms capable of improvement.

In pursuing this policy we have lent monies for every conceivable purpose associated with land development—housing, farm buildings, fencing, plant, tractors, grass seed, fertiliser, contract cultivation, draining, scrub clearing, etc., etc.

Here now is a summary as at 31 March 1954 of the applications that have been considered, the number declined for various reasons, the amount of money advanced, and an estimate by our Committees of what a successful outcome of the various development programmes means in increasing productivity.

**SUMMARY OF APPROVALS AND ADVANCES TO 31 MARCH, 1954**

| Individual farmers who applied for assistance | 352 |
| Cases deferred | 2 |
| **Finalised** | **350** |
| Approved by the Board | 182 |
| Declined by the Board | 134 |
| Approved but not proceeded with by applicants | 34 |
| **Total** | **350** |

| Amount approved and accepted | £597,246 |
| Monies actually expended 1952-53 | £54,843 |
| Monies actually expended 1953-54 | £189,726 |
| **Total** | **£244,569** |

**Estimate by Committees of results from expenditure:**

- Unimproved land grassed | 10,010 acres
- Run out pasture renewed | 6,900 acres
- Inferior pasture improved | 4,500 acres

**Estimate by Committees of additional stock that will be carried:**

- Dairy cows | 2,300
- Sheep | 49,000
- Run cattle | 3,700

Now I would like to conclude my address by giving a few impressions that I have gained since the Board commenced operations under the Marginal Lands Act.

My first thought is one of appreciation of the work that has been done by the Marginal Lands Committees in giving to the Board the
benefits of their knowledge, their fearless appraisals of the personal element and their sound judgment on the projects they have had to examine.

The combination of officials from the Lands Department and the Department of Agriculture with their farmer colleagues is paying a good dividend. Here, too, I may be forgiven for selecting my own officers for a word of praise for the immense amount of preparatory data they have produced for the local Committees and for the enthusiasm with which they view this particular aspect of their work.

My second thought is that there is a need for a better understanding and appreciation of what each organisation, in the field of rural finance, is doing as a contributor to our national well being.

I am glad to say that many local managers, both of banks and of stock firms, are becoming most helpful in marginal lands cases in rendering additional financial support to our undertakings and here is a typical case which came before the Marginal Lands Board recently.

A father and son, owning a property capable of development and viewed by the local Committee as men of ability and repute, sought from a firm additional finance for development. They already owed this firm something in the vicinity of £2,000 so they may not have been surprised when they received a reply which contained these words: “Your account is above the working limit set for it, and I would be pleased to see you effecting some reductions in it rather than increasing it by advances for further development.”

At this stage the Board came into the picture with the result that, following discussions, the Commissioner of Crown Lands received a letter from the manager of the firm stating: “I would be very pleased indeed to facilitate the development of this block of country by these two good types of farmers by any reasonable means. I am prepared to keep pace with your development, should you decide to go ahead with it, by providing all the extra stock and plant... and to suspend our present arrangements regarding reductions in this account.”

In my opinion, however, there is a place, at top level, for an exchange of views so that the problems of each will be better understood and our efforts not dissipated by pulling one against the other.

My final thought is that, despite the general affluence of the farming community today, the number and nature of the applications received points to the need for the legislation introduced in 1950 and while the greatest factor in the further early development of New Zealand fundamentally rests on a continuation of buoyant prices for our farm produce, many worthy people have had opened up to them a changed outlook on life because of the Marginal Lands Act.

Mr Hurst: During the last few years, four things occurred that in my opinion will alter the face of the South Island entirely; in fact, will be of greater benefit even than the discovery of gold. The first has been the destruction of rabbits; the second, aerial topdressing and the aerial distribution of clover seed; the third, the pick-up baler which allows hay to be made easily by a large number of farmers on the low country for feeding sheep in the back country, and the fourth the discovery of the value of molybdenum. But it is no good topdressing clover and grass unless the extra feed is eateri by stock. There is very little benefit to the land until it has passed through the grazing animal. Extra stock requires finance, and it requires fencing. As a deductible item for income tax you may be
allowed to topdress up to two or three thousand pounds, but you are legally allowed only £200 for fencing. In the years gone by, £200 was something. Obviously more sheep and cattle will require a tremendous lot of finance and where are we going to get that finance? Also, we have to overcome the complacency of people who are satisfied with things as they are. In the radio session we are given a choice: you can have the money or the bag. I can assure you that if we handle this problem right we can have both the money and the bag.

Mr Ireland: This Marginal Lands Act interests me very much. For 30 years I have been developing a piece of land behind Omarama. Today I am not appealing for myself but for settlers in that district. Many of them have been rabbiters who managed to save a bit of money and get a piece of land. I cannot see anything in what Mr Greig has told us to help them. They are hard-working men, but it needs inspiration in that district to help them along. You cannot develop that back-country tussock land the same as you can the Rotorua areas which I think the Marginal Lands Board has been doing. What would I like to know is how can these men be helped? If they could be induced to form a committee, could that committee work through the Marginal Lands Board?

Mr Greig: All that the Marginal Lands Board does is to put out an opportunity that people can grasp. There is nothing to stop these people coming to the Board. It is up to the farming community to provide the inspiration. Neither as an official nor as an individual would I ever want to see officialdom inspire people to do things. That should be done by the guiding hand of the older people in the community. I do not think assistance has been denied to the people in the Omarama district.

I would like to correct a possible wrong impression about the Rotorua district. There is not much marginal lands finance going there. That is land-settlement development by the Crown. Most of our money is being spent in North Auckland on very tough land, with a lot of unknown factors in it. The people who set out to develop it using our funds—small, struggling people—were inspired by a group of the Federated Farmers up there. I was there a short time ago and it was an inspiration to see what they are doing in the way of developing their asset. The money is spent on general development including the building of cowsheds and we believe that farmers now struggling to produce 6000lb. of butterfat will eventually be producing up to 14,000lb. With production like that we are certain they could stand up to any possible recession of prices. These funds have been used on ironstone land and sticky gum land clays—country which is frowned on by the normal financial institutions.

Mr Grigg, Longbeach: I agree that we should not expect officials to take action. I would suggest to Mr Ireland that the Federated Farmers in Omarama should take action, form a voluntary production council, investigate the problem thoroughly, and then apply to the Marginal Lands Board for assistance.

A speaker: In my district some farmers appear to be reluctant to go to the local Commissioner of Crown Lands for advice and assistance. Those who have done so have been enthusiastic about the help they have received.

Mr Chaytor: Does the Marginal Lands Board allow a young farmer to start on marginal land?

Mr Greig: An applicant for unimproved land must be able to show the Land Settlement Committee that he is capable of putting
half the farmable area into grass. At that stage he is entitled to get State finance. We treat marginal land the same way. He must be able to demonstrate that he can do something for himself before he comes to the Marginal Lands Board for help.

Professor Flay: The energy of youth is a wonderful thing. Could I ask Mr Greig if he knows whether those 182 people who have taken advantage of the Marginal Lands Act are relatively young or relatively old?

Mr Greig: I would say that the bulk of the applicants come from the 30-40 age group.

Mr Laidlaw: Might I suggest one reason for inertia, particularly towards the end of a lease, is the system we seem to have of penalising those people who improve their leases up to the point where their unimproved value is considerably bumped up.

Mr Greig: Crown leases today with one exception, pastoral leases, can be freeholded. With pastoral country the rents have been reduced despite the fact that tenants are getting a better lease entitling them to perpetual renewal, and also despite the fact that prices are high. Normally one would expect the rents to have gone up, but we aim at giving a permanent benefit to the land. As a matter of fact, the rents of the pastoral country in the South Island have gone down.

Mr Bayley, Fernside: It does not matter where the money comes from, it has to be secured somehow. Anybody taking on a job of improvement needs a lot of courage and faith. In many cases there is the fear of what will happen to the individual in a slump.

Mr Greig: I think your answer lies in the history of the democratic government in New Zealand. The policy of the Board, whether it is a risky case or not, is to lend money on current account. When the development programme is finished the Committee will look at it and say, “We will bring this on to a table mortgage. The question is, how much?” We may have to write off the money. What we want to see at the end of the development programme is a farmer with his capital debt limited to such an extent that he can live in reasonable comfort. I don't think you can write the treatment of individual cases into legislation. If you try to do that you write back subsidies into legislation.

Mr Harrington: It appears that the Marginal Lands Board is doing more to help people on Crown Lands than people on land that is privately owned.

Mr Greig: I just have to accept your statement that it is so. It is not planned that way at all. The ultimate ownership of the land does not concern us one bit.

Mr Preston: Speaking as Commissioner for Canterbury I can assure you that the applications granted to freeholders have been three times the number granted to leaseholders.

Mr Cooke, Lincoln College: Mr Greig mentioned that it is not the policy of the Marginal Lands Board to take over existing mortgages. I gather they do take second mortgages. If they don't take over existing mortgages, how is the finance arranged?

Mr Greig: Most of our loans are on second or third mortgages. We want to see that the money is used for development. We do not want to dissipate the money available by paying off existing mortgages.
A speaker: Have you any safeguards to discount the land speculator? Does your debt have to be liquidated before the land can be sold?

Mr Greig: When we have reached the stage of complete development we will look at each case. We have the right to protect the taxpayers' money and would certainly use it if we think a man is a speculator. We can postpone the payment of interest and may even write it off in certain cases but we would not do it to the speculator. We hold the whole advances on the land as a debt, not as a subsidy.

SOME ASPECTS OF TUSSOCK COUNTRY MANAGEMENT

L. P. Chapman, Mount Somers

In agreeing to give this paper I am very conscious of the difficulty of generalising on the management of tussock country.

As has been stated here previously, the high country sets its own conditions of climate and cover, and the farmer up till now has had little opportunity of altering the environment to suit his stock. The physical factors of size, accessibility and the lie of the country also largely dictate what can be done.

I propose however to discuss some aspects of management and to illustrate them where possible from my own property.

This property, totalling about 9000 acres, comprises a pastoral lease taken up in 1931, and an adjoining block acquired later which provided a homestead site with some 300 acres of paddocks.

The leasehold was heavily overstocked at the time and also carried a "blister" in the shape of an exhorbitant rent. The stock were quickly reduced, but the "blister" proved much more stubborn and took some 20 years to reach normal proportions.

I am glad to say that under the present policy of the Lands Department, rents of pastoral leases are being assessed on the inherent capacity of the country and not on the tenant's farming ability or capacity to pay.

The property has a rainfall average of about 36 to 40 inches, lies in the sou-west snow belt and has a typical gorge climate. The altitude is 1,500 feet at the homestead running up to 4,500 feet, with much of the country lying between 2,000 and 3,500 feet.

The cover is fescue tussock and snow tussock, with the snow tussock dominant to low levels in many places. The carrying capacity of the tussock country approximates one sheep to three acres unless the young sheep are wintered off the property.

The stock are Romney half-bred sheep and Aberdeen Angus cattle. The Romney half-bred does much better under the conditions than the Leicester half-bred previously used. It is not difficult with this cross to obtain the 56/58 type of wool which appears essential in order to keep out weather and sand from the fleece.

The Aberdeen Angus cattle thrive and range well over the hill country. They will climb out voluntarily and winter at 3,000 feet on some blocks.

I turn first to the question of cover, because it is fundamental to all hill farming.

The aim of all real farmers must be to leave their land in a condition as good as, or better than they found it, and there can be no satisfaction in farming a wasting asset.
The question of hill-country deterioration is by no means simple, as change is so gradual and there are so many factors involved. Feed may deteriorate either in amount or in quality or in both. Improvement of cover may mean reduction of sheep feed and vice versa. Stock numbers alone are not a reliable guide. The sheep population of the back country reached a peak about the turn of the century and have since declined greatly, even in the absence of the rabbit. At the same time the yield per sheep has mostly increased. It appears that in the early years, pastoralists, with little experience to guide them, over-grazed the annual production of their country and were living on capital in the form of palatable species—to the extent that some species, aniseed for example, were eaten right out. Of later years introduced grasses, such as sweet vernal, fog and browntop and clovers have come in and to some extent restored the balance. Speaking of Canterbury conditions it is remarkable how much of the tussock country below 3,000 feet is now dominantly in introduced rather than native species.

This invasion by introduced grasses may be the explanation of a problem which occurs widely, that is, the increasing difficulty of getting sheep through the latter half of the winter. These grasses fade out completely under severe frost, unlike the finer and harder native grasses which retain some attractiveness to sheep in a resemblance to hay.

In my case it is noticeable that though the standard of the hill sheep has gradually improved over the years, the seasonal loss of condition in the late winter appears to be greater.

Being early convinced of the necessity of burning on rank growing country, and that much of the bad effects of burning were due to uncontrolled stocking after burning, and being convinced also of the value of spelling, I evolved a scheme of rotational burning.

The aim was to attempt to burn a complete block at a time, so that after-management could be controlled and the bad effects of patch burning avoided. The extent of subdivision lent itself to this, though, as there are no natural firebreaks, it meant hard work and willing assistance to keep a fire in bounds. The subsequent management was to close the block up until the autumn, allowing a regrowth of tussock and a reseeding of grasses. The essential point about no grazing, as compared with even light stocking is that the palatable species have an equal chance with the unpalatable to re-seed.

A point with regard to spelling. This can be done following a burn, but spelling alone on country where fog and browntop are present may result in a smothering mat of vegetation which is no good either to tussock or stock.

The results of this system are not easy to assess—particularly in the absence of reliable observation by a disinterested party. The cover appears good, but in common with most of our hill country the run-off of rainfall is excessive, causing scouring of creeks and bank erosion of rivers, even where no shingle is carried off the hills. One definite result has been an increase in snowgrass to low levels, where previously patch burning and consequent over-grazing had resulted in its near elimination.

My observation has been that, after burning, fescue tussock will stand almost unlimited abuse from sheep, but that snowgrass can easily be eliminated. On the other hand cattle, if allowed to, will eliminate the fescue tussock without unduly punishing the snowgrass. Silver tussock, of course, is a great deal more resistant to grazing damage.

With regard to stock, the sheep numbers have remained pretty
constant, and wool weights also—though against this there has been a rise in fineness of four counts, equivalent to one pound of wool according to Lincoln College authorities.

Cattle have risen from nil to approximately one hundred head for six months of the year.

In the absence of conclusive evidence, and after discussion with a neighbour who practises a somewhat similar system, I would claim only that a greater stability in cover and stock-carrying capacity has been achieved than would otherwise have been the case.

Cattle have been the subject of growing interest in Canterbury lately—both on the farms and on the hill country. Like most innovations they have their enthusiasts and their opponents.

It is unfortunate that cattle in the back country have suffered in the past from being handled—or should I say mishandled in most cases—by conservative sheepmen who have forgotten more about sheep than they ever learnt about cattle.

The result has been the all-too-common picture on a Canterbury station of derelict cattle yards, smashed fences, a few scrubby beasts in the nearest swamp and a herd of wild cattle somewhere on the country. This provides a lot of fun for the younger men on the place, but is not farming. Willingness to give the necessary time to their handling, and a certain amount of secure fencing are essential. As in sheepfarming, home breeding is much preferable to buying.

On this property the cattle are kept on the homestead paddocks from calving until after marking, and then when the summer flush of feed in the paddocks is dealt with they are turned out to a hill block. This coincides with the time that the feed is getting away from the sheep, and the cows and calves do reasonably well till weaning. After weaning in May the cows are again put out on the hill till about mid-winter. I used to leave them all winter, but found that they did considerable damage through pulling of the fescue tussock and also to the hill fences through rubbing to get rid of their old coats.

For two years I have brought them into the paddocks in July and fed them second-grade hay on which they have wintered very well.

By this system the calves are reared and educated on good fences, see plenty of movement, and with a week's handling at weaning with a steady dog are never any more trouble, and have a reasonable respect for hill fences.

This method makes the most of the homestead paddocks, and renders them more fit for the hill sheep—particularly if they are cultivated and successfully growing “cow feed” or “modern high-producing pasture” as most people call it. There is also a valuable build-up of the paddocks under the concentrated winter feeding.

On the tussock country a careful balance has to be held between the sheep and cattle feed and also between the interests of controlling the roughage and conserving the protective cover of tussock. Contrary to what is often thought, cattle are just as keen as sheep on the short sweet bite, and on the high country cannot be forced on to rough feed in the text-book manner.

The most revolutionary development in tussock country farming is the advent of aerial topdressing. Revolutionary because for the first time, it offers an opportunity of reversing the trend of the last 100 years—in which we have been so busy skimming the cream off the back country—by putting something back into it.

For some time it was thought that, though silver tussock country might show results, fescue tussock country was hopeless, but
pioneers have shown that remarkable clover growth is obtainable, even up to 3,000 feet.

With the economics of topdressing unproven, especially over a long period, there has always been concern over the possible results of its discontinuance. The official view has been rather that there was a danger in altering the balance of native country by topdressing, with a possible reversion to a poorer pasture than the original on the cessation of manuring. Having observed a number of results I do not subscribe to this argument. On country with sufficient rainfall to show results from topdressing the native grasses are usually in a minority already. The result of giving up topdressing appears to be a decline in the boosted growth about the third or fourth year, but the effect of improved ground cover and the establishment of long-lived vigorous clovers should cause a much more prolonged decline before, if ever, reaching the initial low level of productivity.

A more real danger to farmers, as a result of discontinuing topdressing through force of circumstances, might be the necessity for a number to reduce and sell stock at the same time.

The high-country farmer of course is fundamentally interested chiefly in securing a return greater than his costs, and, like his fellow on the plains confronted with irrigation, is not going to rush into increased production for its own sake, without considering the disadvantages. He has, over the years, evolved and perfected a system of raising and handling sheep under the existing difficult conditions with a minimum of expense or of alteration to the environment. However he is very interested in any way of doing his sheep better and latterly of improving his country.

A very encouraging feature of the manuring and oversowing of tussock country is the marked strengthening effect on the tussock itself, which in turn should increase its protective effect and also enable it to withstand heavier stocking with cattle.

I venture here to suggest that the conservation authorities might give more attention to studying the effects of topdressing of tussock country in relation to cover and run off, and, if results are favourable, to the active encouragement of the practice.

On the question of whether the winter feed position will be improved or otherwise by topdressing it is difficult to say. On the one hand the tendency may be to encourage softer grasses and to depress the finer and harder grasses—with a consequent vulnerability to hard winter conditions. On the other hand there is an undoubted shortening of the dormant season and an improvement in the thrift of stock which may see them through the difficult period. The position does not parallel that of a grass farm, since it is never likely that the whole of a back-country property would be topdressed.

It would appear that the development of topdressing on tussock country will be towards special-purpose blocks, such as hogget blocks, holding paddocks, early spring feed, etc., with increased cattle stocking to control the summer surplus rather than increased sheep numbers.

I cannot speak with much certainty of results on my own property as I have only twelve months' experience to go on.

A hill holding paddock of 150 acres, altitude 1,600 to 2,000 feet, which was oversown in winter with clovers and only one hundredweight of super has given results varying from nil to an excellent thick mat of clovers. Noticeable is the good strike and growth of Montgomery clover as well as pedigree white, and that best results are on the warm sunny facings, i.e., the winter facings.
On harder tussock country further back the Department of Agriculture has established two comprehensive plot trials. A portion of this area is scanty tussock with bare ground between the tussocks—bare to my knowledge for 20 years, and probably increasingly so as frost, wind and stocking play their part on a plant association with its original balance disturbed.

Significant results are:

a. Again the best results from the sweeter country.
b. Reverted super has given better results than the same rate of super plus one ton of lime—though both are much ahead of other treatments.
c. Montgomery clover, alsike and certified white clover have all established under very intensive continuous grazing outside the enclosure, even on the bare ground referred to above.

Taking into account the three subjects which we have been considering—controlled stocking following burning where that is necessary, aerial sowing of seed and manure, and the use of cattle—all common practices on good hill country—I think that there is scope for their application on country which has hitherto been regarded as outside their field. On selected blocks where they can be applied there should result:

a. A reduction in the need for burning.
b. An improvement in cover together with the arresting of any deterioration.
c. An increase in the production per sheep and in numbers of cattle.
d. Followed after, and only after the other effects have proved themselves, by an increase in sheep.

The economics of the practices referred to here are difficult to arrive at, as back country farming does not lend itself to accurate costing. Perhaps the only test is that of a reasonable return over a long period from country maintained in good condition.

An interesting subject which should provide a field for research is the relative effect on tussock country of seasonal grazing: whether the check to the palatable species is greatest from the severe grazing of winter with a spell during the growing season, or from defoliation during the summer growing season only, with complete freedom from grazing in the winter, as occurs on much high country. In practice winter country has usually to serve as lambing country, too—so that it is subjected to heavy grazing at both seasons.

On my own country the block which appears to have made the greatest recovery is the wether block, which is normally set-stocked the year round, and so gets lenient summer grazing. However, the question is complicated in that case by the further issue of the effect of grazing by wet or dry stock.

Turning now to the problem confronting the owner of a run with a proportion of ploughable land, who has to integrate this with his hill management.

I do not include here the man who has sufficient farm land to winter his whole flock—he usually concentrates on the farm and tends to neglect his hill country. Nor do I include the fortunate few who have sufficient safe tussock country to winter their whole flock comfortably. But the owner of a few acres of worthwhile land has a whole series of factors to balance one against the other.

Is it worthwhile buying a tractor and the whole range of implements to grow say 30 acres of turnips? Shall he add the whole hay-
making apparatus to his outfit? Will his available labour do, without neglecting the routine work and the hill country, or will he need another man and perhaps a house?

Having decided to cultivate, how best can he make use of the feed grown? He can winter part of his hill flock, or retain his cast ewes for a year (supposing he has any) or merely look after his rams better and grow some feed for the horses.

As against all this he can tip the old tractor into the nearest gully, saddle up his hack and drive his sheep out to turnips. My own solution is a compromise. I retain the older ewes on the paddocks for a year, send them and the hoggets out to turnips, and use the tractor as a hack.

However, keeping the older ewes has a number of advantages. They become quieter and they also grow out and become acclimatised to the stronger feed before going down country. You can breed a saleable lamb by a longwool ram, or, in the event of snow losses, a replacement for the hill flock. Also you can wean early before sale time as a result of earlier lambing. Late-shorn ewes or undesirable types from the hill flock can be absorbed into the paddock sheep.

Although full-scale cultivation is probably inevitable eventually, I have compromised, while fencing and draining are in progress, on a system of improvement by surface means. The method used is the old one of heavy concentration of cattle in one paddock with feeding of bought hay. Later, harrow and oversow Montgomery and white clover and cocksfoot with superphosphate. Results on poor run-out paddocks have been very encouraging. The animal fertility, being supplied in the dormant season, and the superphosphate, appear to be complementary and combine to give the clover a good start. There is no danger of the paddock being blown away and the only implement required is a set of harrows. It is to be noted, of course, that the balance of seasonal feed on the paddocks, since turnips are not being grown, is made up through the buying of turnip grazing and hay.

As may be realised from the tenor of this paper, my chief concern is for the farming of the tussock hill country on a continuing basis. There is a tendency to regard the cultivation of the ploughable back country as the solution of our problems. To my mind this largely dodges the issue. The fact that high altitude country can be successfully cultivated has long been established. But the large scale adoption of this policy brings as many problems as it solves. Also it must be remembered that there are some properties which can never have the area of flat land required.

The Lands Department has a policy which will eventually provide the conditions that will encourage all tenants to farm their country to the best of their ability—security of tenure, reasonable rentals, the regrouping of unbalanced runs and the safeguarding of improvements.

We look to the research worker and experimentalist to supply us with the knowledge to restore and improve the hill country itself.

I have a friend who farms near the coast. His farming is recognised as being most efficient, and he can grow feed to further orders but I sometimes feel that his sheep management leaves something to be desired. On the other hand, though he occasionally wants to buy some sheep or a dog off me, I know that he is secretly horrified at my farming efforts. Unfortunately, I think we are both right.

And so, even as I have listened interestingly over the last two days, I hope this paper may be of some interest to a predominantly down-country audience.
Management of tussock country and management of a farm have, I think, this in common. Success in the art of farming, by which I mean more than financial profit, goes to the careful weighing up of many factors and the achievement of a harmonious balance in their application.

Mr Samson: What time of the year were those plots put down? We found that at 1,800 feet if we sowed in the autumn we got a frost lift of as much as six inches. If we sowed in the spring we did not get enough root development before the summer drought set in.

Mr Chapman: The plots were sown in August and had a very favourable season. On the 150 acres, where the results were good, the sowing was done in the winter which I think is the best time where you get severe frosts. Seeds sown about June just didn't germinate, but on bare ground the severe frost-lift provided the seed bed and the seed germinated when the conditions suited.

Professor Calder. I think we will all agree that Mr Chapman has given us a masterly account of problems associated with the high country. One of our great problems today is to know what to sow. He has given us his sowing of clover but he also mentioned that his ground at 1,500 to 3,000 feet is occupied by introduced grasses, browntop, sweet vernal and fog, which have limits we know. We are at the stage when we should sow better grasses than those. Knowing that we are going to be able to topdress and bring the fertility up to a level where the better-type grasses will grow, would Mr Chapman give us his views on what we should try? My thoughts are directed towards the sowing of cocksfoot. From what I have seen over the last 20 years, cocksfoot is probably the best grass one can have on tussock country provided it is given an opportunity to establish and is subsequently well managed. What does Mr Chapman do after burning? He suggested he spells his land. Here is another opportunity of introducing these better grasses and clovers. Whatever we do, we have to fill the bare land with good species before it is filled with browntop.

Mr Chapman: The obvious time to sow if you have to burn is to sow following the burn. As far as cocksfoot is concerned I think it is ideal, especially if you think your improvement will lead to the greater use of cattle; but cocksfoot is not easy to establish. If you have a tight cover I don't think it is worth sowing cocksfoot, but I have seen it established on bare hard ground on a nor-west face. At present we are just trying a hit-and-run business. More work should have been done on this problem. Should we wait until the clovers have established, and improve the country and then try cocksfoot, or should we sow it now while we are sure of a strike and risk losing it later?

Mr Samson: At 1,800 feet we had success with cocksfoot, but for two years we could not put sheep on. It is so palatable that sheep will eat it right out. We could of course use cattle at this stage. After that you cannot graze your cocksfoot block indiscriminately. You must be able to spell cocksfoot to get the best results from it.

Mr Scaife, Wanaka: I would like to quote my own experiences of experiments on tussock country. Seven years ago we sowed 150 acres with a mixture of grasses and clovers but without topdressing. The results were negligible. Only in the damper gullies was there any sign of establishment of cocksfoot and dogstail. After seeing
Mr Ireland's work we decided to recommence the job with clovers and superphosphate. We have had amazing results. The blocks are unfenced (the oldest is four years old) and they have been grazed heavily both winter and summer by sheep and cattle. The white clover particularly is quite a sight in the middle of summer. As a result of the increasing fertility a few plants of cocksfoot, dogstail, and even ryegrass are showing. We firmly believe that the establishment of clovers on tussock country in our area is essential to the establishment of the grasses.

WEED CONTROL OF SOUTH ISLAND HILL COUNTRY

A. R. Dingwall, Asst.-Fields Superintendent, Department of Agriculture, Christchurch

In this paper I've based my remarks mainly on weeds as they occur in the foothills and high country of Canterbury. I doubt whether this restriction will overlook many weeds of importance elsewhere in the south. Though, naturally, the extent and relative importance of the various weeds and the feasibility of applying one or another of several control measures may vary from place to place.

Weeds of Hill Country

On the hills and high country of Canterbury there are, at least, 40-odd species of plants to be found growing in places where they are not wanted and, as such, to be classified as weeds. Some are natives; many are introduced species. Some occur extensively and are wide spread; others, as yet, occur sparsely and only in a few localities.

Doubtless those of greatest concern would include gorse, broom, sweet brier, Nassella tussock, St. John's wort, blackberry, Spanish heath, ragwort and the native species, matagouri, manuka, tutu, tauhinu, bracken fern and bidibidi.

Others, perhaps of lesser importance are hemlock, foxtail, burdock, dyers weed, tutsan, Himalayan honey-suckle (spiderwort), "Spaniards," lawyer, Maori onion, and various members of the thistle family—Californian, variegated, winged and nodding thistles.

Some of you may care to include in your weed collection the natives; scab weed, needle-leafed heaths, and cotton plant, and the exotic flannel leaf (mulein); though these often predominate on severely depleted or actively eroding country where they serve some useful purpose as soil stabilisers.

When cultivating hill or high country—and many runs do cultivate, if only to a limited extent—then you may have to include some of the more obnoxious weeds of arable land such as sorrel, spurrey (yarr), fat-hen, docks, oxeye daisy, rushes, and the twitches—creeping fog, brown top, old man twitch and even yarrow.

Where, as on some arid, sparsely covered tussock lands, such species as sorrel, yarrow, dyers weed, winged and even Californian thistles, afford some grazing, you may not choose to classify these plants as weeds. Or if you're a soil conservator or forester you may rate manuka a useful soil stabiliser or excellent "nurse" plant for forest regeneration.

Yet I've never known farmers to get enthusiastic over a "blight" until the so-called manuka "blight" appeared.

Obviously, "circumstances alter cases." Nevertheless, I think you'll find, somewhere in the hill country, most of the species mentioned, occupying ground that could be put to better purpose by more
useful, productive plants. For some, like gorse, manuka, broom and variegated thistle tend to dominate ground cover to the exclusion of all else. Others such as matagouri, and “Spaniards” (or spear grass) may hamper mustering operations; an arduous task on hill and high country without these added hindrances.

Species like hemlock, tutu, ragwort and dyers weed are poisonous and stock losses also arise when snowblind or weak animals become entangled in sweet briar, lawyer and matagouri.

The hooked burrs of bidibidi, sheep's burr and burdock, adversely affect wool quality whilst the presence of sorrel, spurrey, fat-hen, Californian thistle, and twitchy grasses make cultivation and cropping more difficult.

The unusual parasitic plant, dodder, not previously mentioned, affects the growth and persistence of clovers in certain hill-country areas and may be added to our collection.

All these and, no doubt many more, will be found growing somewhere on South Island hill and high country under circumstances which warrant their classification as weeds and the adoption of control measures.

**Weed Control: General Principles**

But, before discussing control measures, let’s briefly review the general principles of weed control.

First principle is to know your weeds and realise the consequences of their establishment and spread.

Secondly, to possess a working knowledge of and guard against the many natural and man-made agencies responsible for the dispersal of weeds and their introduction to new areas. Agencies such as the movement of animals—farm livestock, wild animals and birds—the impurities in sown seed mixtures; weed seeds in purchased fodder and packing materials or conveyed on transport vehicles, and farm machinery; or by the natural agencies of wind and running water. All are likely sources of weed introduction and as “prevention is better than cure” it pays to know and wherever possible, guard against, all avenues of weed introduction.

Thirdly, if new weeds do appear, it’s advisable to “nip invasion in the bud.” You’ll save yourself a lot of future heartburnings if you do; and, certainly a great deal of unproductive expense.

Fourthly—and you’ll all be aware of this one—a dense, vigorous ground cover of useful species is the best counter to weed invasion. Hence the answer to weed invasion of grass lands is the establishment of a dense, vigorous sward of grasses and clovers maintained by top-dressing and liming under controlled grazing.

This principle applies both to the initial prevention of invasion by new weeds, and to the re-infestation of areas from which weeds have been removed by control measures. Some areas affected by manuka blight are now reverting to gorse. Coastal sand country cleared of lupins has been known to give rise to a flourishing stand of hemlock; and gorse-cleared areas to variegated thistles in profusion. Plough up certain brown top-dominant swards in the high country and you get a weed—creeping fog—just as bad. Suppress the creeping fog by chemical means and the result—sorrel and spurrey to perfection. Eliminate rabbits and you may get—as they have done in parts of Central Otago and the McKenzie country—sweet briar.

“Out of the frying pan into the fire.”

And last, but by no means least, as a general principle of weed control, is the very necessary precaution of guarding against man-
agement practices that encourage the ingress of weeds. Such practices as indiscriminate and too-frequent burning off of existing ground cover; over-grazing—whether intentional or unintentional; by farm stock or by vermin—and ill-advised crop and pasture husbandry practices generally.

When it comes to hill and high country, it's by no means easy to apply all these general principles.

For here, climate, topography, soils types and fertility status favour the natural, open canopy of our tussock grasslands as distinct from the dense, vigorous grassland sward; and favour too the ingress of alien plants of cosmopolitan habitats, as most weeds are.

Moreover the position has been aggravated in some areas, by over-burning or over-grazing—whether by intent or mischance.

The vastness of high country runs and many hill country properties and the relative inaccessibility of much of the country renders difficult the early detection of invading weeds and the application of control measures.

Quite naturally, too, the combination of circumstances which renders hill, and especially high country, less productive, deters the adoption of weed control measures which are, in the main, costly per unit area of land cleared of weeds. If the adoption of weed control measures depended solely upon the comparison of land values and production, on the one hand, and the cost of clearing weeds, on the other, then much of our weed infested hill and high country would remain weed infested and the total area so affected will eventually become correspondingly greater.

The danger of weeds lies in their ability to spread and to do so at the expense of productive species.

If they’re not halted, no matter what the cost, the time must come when weeds will assume complete command.

Perhaps it’s just as well we have a number of control measures to call to our aid.

Control Measures

For there are numerous ways and means of going about the job of controlling and eradicating established weeds.

1. Burning. Of the methods at our disposal, burning is probably one of the oldest. It’s also one of the cheapest—providing it’s not fraught with serious consequences. Burning is still used extensively on hill country for clearing scrub and fern-infested areas to be followed up by immediate over-sowing and top-dressing; or where feasible, by cultivation, and eventually sowing down to pasture—sometime after an intervening crop. Gorse, manuka, broom, blackberry and bracken fern and any of the scrub weeds, can often be handled this way; especially in high rainfall areas where climatic and soil conditions favour establishment from over-sowing or where topography permits subsequent cultivations from the cropping and sowing down.

On the lower rainfall, high, tussock grasslands where the sparse cover regenerates slowly after a burn and where it’s difficult to confine the fire to any desired area, burning is often fraught with serious consequences. Especially if the burning is indiscriminate and frequently repeated, and the country is steep; of sunny or exposed aspect—and where the natural cover is dominantly fescue tussock or snowgrass.

The need to control matagouri is often advanced as the main reason for burning off tussock land. Unfortunately, periodical burning appears to be the only practical method of controlling this widespread weed.
If it's essential to burn tussock grasslands endeavour, wherever possible, to:

a. Avoid burning steep, sunny faces.
b. Burn only in spring or early summer—never in late summer or autumn.
c. Avoid burning the same area more often than once in every five to seven years.
d. Oversow and topdress following the burn.
e. Spell the burnt area for at least six months if silver tussock country, or twelve to eighteen months if hard (fescue) tussock.

Burning in high rainfall districts with more favourable grassland soils and climates, is best done in spring or early autumn—according to the locally favoured season for over-sowing (or for cultivating prior to cropping or over-sowing). Here, over-sowing and top-dressing should follow immediately the ash has cooled.

Whether or not the burning-off will be preceded by some preliminary clearing, such as cutting or bulldozing, will depend on the type and growth stage of the weed concerned; the extent and nature of the infestation and—in the case of bulldozing or mechanical cutting—the feasibility of employing machinery on the area.

2. Manual Methods: Manual methods of weed control such as cutting, grubbing and hand pulling are arduous, time and labour consuming and, hence, costly ways of getting rid of weeds. Cutting before burning is still applied on manuka areas. Cutting and/or grubbing was standard practice as the initial step in gorse eradication on hill country, but has been largely superseded by mechanical and/or chemical methods. Hard pullings and grubbing was used for ragwort, foxglove, and scattered manuka seedlings, but, in the case of ragwort, sodium chlorate and more recently, the hormone weed-killers have been employed to greater advantage. Grubbing is still employed against Nassella tussock, though trials with the new chemical, T.C.A., promise greatly facilitated control. (The manually operated knapsack sprayer or the flame burner is useful on scattered plants or small areas of weeds.)

For obvious reasons, manual methods are employed today only in dire necessity and mainly for the removing of scattered weeds either making their first appearance, or those recovering after the main infestation has been treated by other means.

3. Mechanical Aids: I've mentioned that some of the previous methods may be preceded by mechanical clearing. This preliminary work is generally done either by bulldozing—in which case the weeds are uprooted and often heaped or windrowed and burnt—or by crushing with a heavy roller or scrub bar prior to burning off.

Weeds like sweet briar can be expeditiously handled by a tractor and drag chain provided the infested area is small. The "topping" of weeds to prevent seeding and the mowing of rushes prior to treating with "hormones" are further instances of mechanical aids to weed control.

4. Cultivation and Fallowing: The plough or giant discs, together with cultivating implements and the fallowing of land, still provide the best and surest methods for controlling weeds. Their application is naturally limited on hill country—due often to the slope of the land and the soil type—but both the plough and more especially the giant discs, are used extensively on hills of easy contour where such implements can be handled safely. Heavily infested areas of relatively tall, but light, scrub and rushes can be
handled by ploughing or discing. Tall, heavy scrub will require some prior treatment such as cutting and burning or crushing. Very extensive areas of gorse, manuka and other scrub lands are being rapidly developed by these methods.

The best practical method of controlling many annual weeds of arable land like spurrey and fat-hen and such creeping perennial ones as sorrel, creeping fog and "old man" twitch, is by fallowing accompanied by repeated surface cultivations.

Mechanical grubbing of lucerne stands during their dormant season checks invading brown top and other grassy weeds, but here—and also in the control of "twitch" grasses on arable country—the aid of chemicals T.C.A. or I.P.C. may be used to advantage to supplement the effects of fallowing and surface cultivations.

5. Over-sowing, Top-dressing and Grazing Management: The commendable practice of over-sowing and top-dressing hill and high country is another obvious way of keeping weeds in check and, in some instances, of eradicating established weeds. The increased ground cover and competition afforded by over-sown species—and the more concentrated grazings that can be applied to these more vigorously productive areas—are most useful adjuncts to any policy of weed control. In fact, top-dressing, preferably accompanied by over-sowing and combined with a period of spelling followed by heavy cattle grazing, seems to offer the only practical solution to the control of bidibidi on heavily infested, unploughable, hill country. The ingress of Maori onion on mixed fescue-silver tussock country can be checked by the smothering growth of over-sown red clover and cocksfoot.

A method akin to that of over-sowing involves the planting of fast-growing trees to smother out weeds, particularly scrub weeds like gorse and broom, on areas of low productive potential. This method has not proved very satisfactory against Nassella.

Controlled grazing, with alternate spelling and grazings, and occasional spelling of hill country during the flowering and seeding periods for useful species, is a recognised practice for maintaining relatively weed-free, grassland swards. Conversely, over-grazing, whether by farm livestock or vermin, has the opposite effect, and the position is aggravated if repeated burning accompanies over-stocking.

To be most effective, controlled grazing entails relatively-close subdivision; a feature not so readily achieved on hill country and particularly on large high country runs.

Where adequate subdivision can be achieved—and the electric fence can prove useful for this purpose—stock can be manipulated to crush out weeds.

This method, employing cattle, is successful with bracken fern, and sheep can sometimes be concentrated to advantage to graze off re-establishing gorse seedlings on burnt-off and over-sown areas. One successful way of handling gorse on workable hill country is to burn-off, giant disc and cultivate—sow swedes and subsequently surface cultivate and sow down to pasture. The feeding off of the swedes plus the subsequent cultivation destroys most of the gorse seedlings that appear after the initial clearing.

6. Biological Control: One other avenue of attack on weeds lies in the field of biological control. Here, beneficial insects or, occasionally, plant diseases, are employed as the destroying agents. Owing to necessary safeguards, and the need for discovery and long term tests of suitable insects and diseases, biological control has limited application, though some spectacular results have been achieved. In New Zealand the Chrysomela beetle has proved suc-
cessful in controlling St. John's wort and more recently the combined effects of an Eriococcus scale insect and fungus, has resulted in the so-called manuka "blight." At one time it was hoped the Cinnabar moth caterpillar—the woolly bear—would wipe out ragwort but it appears to be more effective against cinerarias.

Some plant parasites work more unobtrusively and generally do not effect actual destruction of the weed plants. Two widespread instances of this are the blackberry mite (Aceria essigi) which prevents the ripening of the fruits of blackberry, and the gorse seed weevil (Aption ulici) which destroys the seeds of gorse. The introduction of the bidibidi saw fly was another attempt at biological control though I doubt whether this insect has become established in areas of bidibidi except in one, or possibly two, localities.

7. Chemical Methods: Today, interest is largely centred round chemical methods of weed control. Non-selective, inorganic, chemicals like sodium chlorate, the arsenicals and sulphuric acid have been widely employed for many years. These "contact" weed killers have proved reasonably successful but possess several disadvantages in that they tend to destroy only those portions of the plant in which they come in contact; they are non-selective in action and kill useful plants associated with weeds; and many are harmful to operators and livestock.

The use of chemical has been greatly stimulated by the discovery of several effective organic compounds including the hormones (plant growth regulating substances); growth inhibitors like maliec hydrazide (M.H.30), and the "grassy" weed killers, T.C.A. and I.P.C.

8. Hormone Weedkillers: Hormone weedkillers like most organics, become most effective only after being absorbed into plant tissues and transported in the sap system. They come in several different formulae and under a host of trade names. Yet all forms are based on three parent materials, designated by the terms, M.C.P. (3 methyl, 4 chloropbenoxy acetic acid); 2.4-D (2.4-dichlorophenooxy acetic acid), and 2.4.5-T (trichlorophenoxy acetic acid).

M.C.P. and 2.4-D compounds are useful on soft, herbaceous plants whilst 2.4.5-T is used against the more difficult to kill herbaceous perennials and woody shrubs.

Hormones possess decided advantages in being selective in action, relatively non-corrosive and non-injurious to man and animals. Points to note in connection with their use are:

a. They are most effective when applied to actively growing plants and during fine, warm weather.

b. Established seedlings and young growth, especially of difficult-to-kill weeds, are more susceptible to hormones than flowering plants or mature growth.

c. Complete coverage of top growth is important especially when treating woody plants—unsprayed foliage and stems of sweet briar when treating with 2.4.5-T, will remain unaffected and the plant revives.

d. The amount of water used to cover a given area of weeds and the strength of the spray solution will depend upon the amount of water required to achieve complete spray coverage over plants on the area concerned. Consequently, to avoid excessive or expensive use of hormone weedkiller, or unsatisfactory results, the dilutions of spray solutions have to be adjusted according to requirements.
Other Organic Weed Killers

Of the other organic weedicides, of interest in controlling weeds on hill country, probably the most promising is the grassy weedkiller, T.C.A. (trichloro acetic acid). This material at 25 to 50lb. per acre is useful in controlling brown top, creeping fog and "old man" twitch in arable country.

Its efficiency is increased by soil cultivation both prior to and following application of the chemical, as T.C.A. has to be absorbed through the root system. For this reason, too, rain following application is advantageous as it leads to quicker absorption. T.C.A. remains effective in the soil for approximately six weeks under normal conditions—for longer periods if the season is dry.

T.C.A. can also be used at rates of 15 to 20lb. per acre and accompanied by surface cultivations, to control grassy weeds in dormant lucerne stands. One of the most interesting outcomes of trial work with T.C.A. has been its effect on Nassella tussock. Though repeat applications are necessary—at least two treatments totalling 150-200lb. per acre—the effects are quite promising. The cost is naturally high but no higher and certainly much more convenient than manual methods of eradicating this very troublesome weed on unploughable areas.

Two more recent chemicals, C.M.V.—a "kill-all" type—and a boron-chlorate compound are under trial and may prove of some assistance in controlling hill country weeds.

Aerial Application

There are many types of spray equipment available for applying chemical treatments to weeds. These range from the ordinary knapsack sprayer to the engine-functioned, low and high volume, outfits.

However, the spectacular advance in aerial top-dressing and over-sowing—a practice pioneered on the hill country of New Zealand—naturally suggests that this form of applying weedicides might prove a practical one on hill and high country. A successful start was made when variegated thistle—a plant very susceptible to "hormones"—was treated from the air on North Island hill country.

Quite recently some aerial spraying of gorse, using low volume and a fine-spray pattern, has been done in Canterbury. Good coverage was obtained by two applications, given at approximately six months' interval.

Observations next spring should indicate the possibilities of this method which, if successful, will greatly facilitate the control of scrub weeds on hill and high country.

Chemical Treatments

Many of the more serious weeds are amenable to chemical treatment. Of the woody scrubs and semi-woody plants, gorse, broom, blackberry, tutu and lawyer are all reasonably susceptible to 2,4,5-T. Spanish heath and sweet briar are moderately susceptible: the former, Spanish heath, being apparently more susceptible to mixtures of the esters of 2,4-D and 2,4,5-T than to 2,4,5-T alone.

Mature plants of sweet briar require at least two coverage sprays to obtain reasonable results, and trials indicate that regrowth from cut stumps can be killed by one spraying with sodium chlorate or 2,4,5-T solutions providing stock have access and browse the treated shoots.

Tutsan and St. John's wort are moderately susceptible to 2,4-D in the young stage. Biological control is best for St. John's wort where it is strongly established.
The native species, matagouri, manuka, tauhinu and bracken fern are all highly resistant to 'hormones' and, to date, chemical control methods offer no solution to the problem of these weeds. They can be tackled only by such other methods as burning, cutting and burning, crushing or by the use of the plough or giant discs where the country lends itself to such treatment.

Of the herbaceous weeds, those most susceptible to M.C.P. and 2,4-D include the annual thistles—variegated, Scotch, nodding and winged thistles, and the perennial, Californian—and such species as fat-hen, burdock, ragwort and the common variety of rushes (*Juncus effusus*).

Of the other rush species, *J. pauciflorus* and *J. vaginatus* are moderately susceptible whilst *J. polyanthemus* and *J. pallidus* are resistant.

Other plants moderately susceptible to 2,4-D include hemlock, sorrel, yarrow, foxglove and spurrey, though in the case of sorrel, spurrey and yarrow which are likely to give trouble on arable ground, cultivation and fallowing is the best method to adopt in their eradication.

Similarly the twitchy grasses are best handled in the same way though T.C.A. can be used to supplement this treatment.

Docks are resistant to "hormone" preparations though the recently developed polyethylene glycol ester of 2,4-D shows some promise, as does malie hydrizide (M.H.30). Bidibidi is moderately susceptible to 2,4-D but owing to the nature of its infestation is not likely to be treated chemically except in cases in conjunction with some other more susceptible weeds.

The only chemical treatment of promise on Nassella tussock is the use of T.C.A.

As far as I am aware no work has been done to determine the possibilities of chemical control on such species as "Spaniards," Maori onion, cotton plant (*Celmisia*) the needle-leafed heaths (*Dracophyllum*) or Himalayan honeysuckle.

**Conclusion**

I've dealt with the question of weed control in the hill and high country only in general terms. There are so many weeds, that the detailing of possible control measures would take considerably longer than the time at my disposal.

I can only hope that the deficiencies of this paper, will, at least, be partially rectified in any discussions which follow.


APPENDIX

Botanical Names of Some High Country Weeds

Bidibidi - - - - Acaena spp.
*Blackberry - - - - Rubus fruticosus
Bracken Fern - - - - Pteridium esculentum
*Broom - - - - Cytisus scoparius
*Browntop - - - - Agrostis tenuis
*Burdock - - - - Arctium lappa
*Californian Thistle - - - - Cirsium arvense
Cotton Plant (Celmisia) - - - - C. spectabilis
*Creeping Fog - - - - Holcus mollis
*Dock - - - - Rumex obtusifolius
*Dodder - - - - Cuscuta epithymum
*Dyers Weed (Giant Mignonette) - - - - Reseda luteola
*Fat-hen - - - - Chenopodium album
*Flannel Leaf (Mullien) - - - - Verbasum thapsus
*Foxglove - - - - Digitalis purpurea
*Gorse - - - - Ulex europaeus
*Hemlock - - - - Conium maculatum
*Himalayan Honeysuckle - - - - Leycesteria formosa
Lawyer - - - - Rubus spp.
Manuka - - - - Leptospermum scoparium
Maori Onion - - - - Bulbinella hookeri
Matagouri - - - - Discaria toumatou
*Nassella Tussock - - - - Nassella trichotoma
Needle-Leafed Heath - - - - Dracophyllum spp.
*Nodding Thistle - - - - Carduus nutans
*Old Man Twitch - - - - Agropyron repens
*Oxeye Daisy - - - - Chrysanthemum leucanthemum
*Ragwort - - - - Senecio jacobaea
Rushes - - - - Juncus spp.
*St. John’s Wort - - - - Hypericum perforatum
Scabweed - - - - Raoulia lutescens
*Sheeps Burr - - - - Acaena ovina
*Sheeps Sorrel - - - - Rumex acetosella
*Spanish Heath - - - - Erica lusitanica
Speargrass (Spaniard) - - - - Aciphylla spp.
*Spurrey (Yarr) - - - - Senecio jacobaea
*Sweet Briar - - - - Rosa rubiginosa
Tauhinu - - - - Cassinia spp.
*Tutsan - - - - Hypericum androsaemum
Tutu - - - - Coriaria spp.
*Variegated Thistle - - - - Silybum marianum
*Winger Thistle - - - - Carduus tenuiflorus
*Yarrow - - - - Achillea millefolium

* Introduced species.
Mr Scott, Timaru: Can you give us any information on the use of hormones on Californian thistle in pasture?

Mr Dingwall: Generally speaking you get best results if you don't get too quick a top kill in the first instance. The best way is to let the thistle get a fair bit of growth and spray it before it gets to the flower stalk stage. You won't get it all with one application. You may have to spray any regrowth the following autumn or possibly the spring.

Mr Hurst: We notice that the stock eat thistles after spraying. Will that affect the animal?

Mr Dingwall: Stock take to sprayed plants very rapidly, but if they eat them too soon after spraying, the hormones don't get down to the roots and the kill may be affected. A certain amount of risk is involved in spraying hemlock as when it is sprayed it becomes palatable to stock and you may run into hemlock poisoning.

Mr Grigg: What is the best way to eradicate sweet briar in the back country? Since the elimination of the rabbit the briar is inclined to get away.

Mr Dingwall: Sweet briar is moderately susceptible to 2,4,5-T. Mature plants require at least two applications, but young plants normally only one. According to trials in the Waikariri Basin the best time to spray seems to be late spring or early summer, when it is in full leaf. Some advocate spraying when the hips are formed. Most of my autumn spraying has resulted in the plants recovering the following season.

Mr Turton: Have you any complete kill for docks?

Mr Dingwall: Docks have always been difficult, particularly if they occur in crops because most of the crops are susceptible to hormone. There is a new type of water-based ester of 2,4-D which has shown some promise in controlling docks in lucerne and red clover stands, both of which are susceptible to hormone. We have also got surprising results with M.H.30 which has given 90 per cent control in red clover without seriously affecting the stand.

Mr Gray: Mr Dingwall mentioned control of manuka by burning. I have never seen it eliminated by burning and I think it's a good way of spreading it. At the present time in my district the blight has a good control of manuka but it may disappear and we may have to face the problem again. Are there any hormone sprays which will control manuka?

Mr Dingwall: I must admit that my reference to control of manuka by burning largely applied to the North Island. To control manuka by burning you have to put something in its place. As regards the effect of sprays, you can, I think, kill manuka with 2,4,5-T, but it is extremely difficult to kill because it is hard to get complete coverage. We have an idea that aerial spraying might be easier than we first thought as it seems that it is the fineness of the spray rather than the volume of water which is the important thing. With aerial spraying we may be able to get down to 10 gallons to the acre.

Chairman: Would you spray gorse from the air? You could not otherwise spray old-man gorse from the top. You have to get in underneath.

Mr Dingwall: Aerial spraying does permit easier application of spray to old-man gorse, but we think it is better, if possible, to cut and burn and then later spray the regrowth.
WEATHER FORECASTING AS IT AFFECTS FARMERS

I. S. Kerr, N.Z. Meteorological Service

On the farm, the day's work or the programme for a month or a whole season is favoured or hindered, or even completely nullified by the weather. Climate, fundamentally, is even more important for it determines the type of farming and the crops likely to be most profitable or even whether farming is possible at all. The way in which the pattern of farming in such a small area as New Zealand is determined to a large extent by comparatively minor climatic variations is obvious.

Since the success of almost every crop is so dependent on climate and weather, it is desirable, if the best possible use is to be made of the land, to have available as much climatic data as possible and details, for every crop, of the limits between which weather conditions must lie for the success of the crop.

In some parts of the world trial-and-error methods in the introduction of crops into new areas result in more failures than are necessary. Co-operation between research workers in agriculture and the meteorologist could reduce losses of this sort. For example, the New Zealand Meteorological Service has been asked to assist in the search for new areas suitable for raspberry growing. We have also been asked recently if there is anywhere in New Zealand where peppermint could be grown successfully as a commercial crop.

Climate

The climate of a place is described concisely by the meteorologist, if he has a sufficiently long period of records, in terms of means of temperature, rainfall, amount of sunshine, etc., and of measures of the variability of these quantities. The insufficiency of mean values alone is shown by a comparison of maximum temperatures at Christchurch and at Kansas City, U.S.A. The mean daily maximum temperatures for these two cities are 61°F. and 64°F. respectively. Kansas City is evidently appreciably warmer but the difference is not very striking. The difference between the ranges of maximum temperature is much more impressive. The highest and lowest recorded at Kansas City, are respectively, 113°F. and —6°F., and at Christchurch 96°F. and 34°F., respectively.

The variability of monthly or seasonal means at a place is of considerable importance. If the growing season mean (of temperature or rainfall) varies sufficiently from year to year it is likely that some crops will fail in the "poor" years. Hence, one of the greatest services meteorologists could perform for farmers would be to perfect seasonal forecasting methods. No successful technique exists or is in sight. A great many people have tried to find one, most effort being spent on cycles. Although there is probably some connection between the sun-spot cycle and variations of earth's weather, the connection is likely to be too indirect and complex to be of much use when it comes to forecasting for small areas. Supposing it were possible to predict that summer rainfall over New Zealand as a whole is going to be below normal next year, the forecast would be of little value since it could vary in several ways. For instance, rainfall might be
above normal in the east but very much below normal on the west coast giving the required net below normal rainfall.

Although seasonal forecasts are not possible, the meteorologist can help to decide whether a certain crop can be grown profitably if he knows the crop's limiting weather factors and has sufficient climatic data. Given this information it is possible to determine the frequency of crop failure that is to be expected and, even if the climatic record is long enough, how often failures in two or more successive years are likely.

**Modification of Climate**

In addition to the possibility of forecasting the year to year fluctuations of climate, the possibility of modifying climate presents itself. Irrigation to alleviate the effects of insufficient rainfall is probably the most important undertaking in this field. The study of problems in connection with irrigation and with the siting of shelter belts to modify the effects of wind is the concern of the Winchmore Research Station. The meteorologists' part in such projects is to supply data, instruments and advice, as required.

In particular the use made of irrigation water will be most efficient if the water requirements of the crop can be determined. The determination of the requirement involves measurement of evaporation from the soil and transpiration from the foliage. Much work has been done on the problem of measuring or estimating these quantities, particularly in the United States. This is one of the problems which, I believe, is engaging the attention of the Winchmore scientists.

The converse problem of excessive rain in short periods is primarily an engineering problem of drainage and flood control. Again in the solution of the problems meteorological data are usually required.

**Weather**

Having discussed briefly the intimate connections between climate and agriculture let us see how the day to day weather affects farming.

Sudden changes in the weather, spells of dry weather or unusually cold weather, as well as the climate have an effect on germination, growth and ripening. These effects have been widely studied and meteorologists should know of them.

Among the many farming operations that are seriously affected by the weather are haymaking, lambing, stock on high country pastures, shearing, harvesting, aerial top dressing. Each of these operations could be carried out with a minimum of loss if weather forecasts were sufficiently detailed, covered a long enough period of time and were always accurate.

**Long and Medium Range Forecasts**

For planning purposes, if seasonal forecasts are unobtainable, forecasts for a month ahead would be of immense value. Detailed forecasts for such a period are no more possible than are seasonal forecasts but forecasts of rainfall and temperature anomalies for a month ahead have been issued on a routine basis for some time in the United States. These forecasts are of very limited value, partly because of the necessarily vague terms in which they are couched and partly because success is not high. Slightly more detailed forecasts for five days to a week are also prepared by the United States Weather Bureau. The technique used involves analysis of the atmospheric circulation patterns over the whole hemisphere. Useful but not spectacular results have been achieved. It is clear that such methods are quite out of the question at present in this hemisphere.
Current methods of forecasting in general use are not likely to be capable of giving reliable forecasts for periods of more than forty-eight hours. In fact, the value of the forecasts for the second day is very doubtful and forecasts for the first day, even, are too often wrong. However, there are occasions when the meteorological situation can be recognised as an almost stationary one or as changing so slowly that important changes in the weather are unlikely to occur for several days. In these circumstances a forecast that there will be little change in the weather for three or four days may be issued with some confidence. The Meteorological Service encourages farmers, therefore, to lodge requests just before the hay is ready for cutting, for instance that advice be sent whenever three or four days' fine weather is expected. This type of request leaves the forecaster free, within limits, to choose the time of issue of the forecast. Requests are also received for forecasts for specific periods of up to a week, leaving the forecaster no choice but to issue as good a forecast as he can immediately before the period stated. If the forecast requested is for as long as a week it is often quite impossible to give any indication for the second half of the week. In such cases the first reply is usually followed up two or three days later by a forecast for the later part of the period. Special enquiries of this nature can be made by letter, telegrams or telephone. If by telegram, it is preferred that ordinary telegrams be used and replies will be sent "Collect."

In all cases the enquirer can help the forecaster by giving all of the following information:

(a) The type of weather with which he is concerned, such as fair weather, strong winds, rain, snow or cold changes. The nature of the job being undertaken, for example, shearing, haymaking, is also useful information.

(b) The actual dates for which the forecast is required or between which the operation must be carried out.

(c) The time the forecast is required. In the case of requests for a forecast for a specific day or period this may be "as soon as possible" or it may be by a certain time, but it should be as near as possible to the beginning of the period for which the forecast is required.

(d) If the Telegraph Office of origin does not give an adequate idea of the situation of the place for which the forecast is required, a brief description of the location should be given. This is clearly important if the place is near mountain ranges or is at a considerable altitude above sea level.

Short Range Forecasts

Next on the scale are the routine daily forecasts for a period of 24 to 36 hours ahead. These forecasts are intended to be as useful as possible to all sections of the community. To the farmer they should be of considerable value whenever any of the operations listed above are in train or about to be started. Particularly should we aim to provide warnings of cold changes during lambing and shearing times, and of snow when there may still be stock on high country pastures and so on. At other times the forecasts should serve as a guide when there is a choice of tasks.

Weather Control

Methods of modifying the effects of climate were discussed previously. The next step which has long been dreamed of and is now
being studied seriously is control of the weather. Frost prevention methods and devices come under this heading and some success has been achieved but more may yet be done. More in the public eye are reports of experiments on the artificial inducement of precipitation or "rain-making" as it is popularly called.

Apart from methods based on superstition, scientific rain-making experiments have been carried out from time to time over the last sixty years or more. Among the earliest experiments were those which used artillery to fire an explosive charge into cloud masses. These were based on the belief that it nearly always rained after battles and the theory was that the noise vibrations caused the cloud droplets to coalesce. Mr Clement Wragge, remembered for his whimsical custom of naming storms, conducted an experiment at Charleston in 1902 using six guns (each had a name). The experiment was not successful, owing, it was said, to the failure of the assistants to follow the instructions faithfully. Two of the guns burst. Nearer home, explosives were used in attempts to produce rain at Oamaru in 1907. Rain did occur after one of the attempts but it was widespread and could not have been caused by the explosions.

Another experiment, using a "gas made from certain chemicals," conducted in Victoria in 1902 is worth noting because of the following newspaper comment it evoked.

"... experiment carried out at Serpentine, Inglewood district, Victoria, where, ... it is said, an inch of rain fell after the gas had attacked the heavens for 15 hours. ... We have looked up the records in the files of Melbourne papers and find that rain certainly fell in the district mentioned on April 24. Rain also fell over the greater part of the State on the same date, and it would appear that while the latest rain-maker was producing a good fall by means of gas near Inglewood, it was raining all round the country without the assistance of gas. It was evidently most fortunate for Serpentine that Dr --'s experiment was carried out on that particular day, otherwise the district might have remained dry while a general rain fell all through the rest of the State."

That this exposure is relevant to present-day experiments is shown by one of the statements made in 1953 by a special committee of the American Meteorological Society:

"Cloud seeding acts only to trigger the release of precipitation from existing clouds. The release of substantial amounts of precipitation by either natural or artificial means requires the pre-existence of an extensive moisture supply in the form of moist air currents and of active cloud-forming processes. For this reason the meteorological conditions most favourable for the artificial release of precipitation are very much the same as those which usually lead to the natural release of precipitation. This makes the evaluation of the effects of seeding difficult and often inconclusive."

One of the conclusions of a report issued this year by the Technical Division of the World Meteorological Organisation Secretariat reads:

"Present day techniques ... have very little value, if any, in augmenting the precipitation in areas of very low rainfall or during dry periods in regions of normally medium rainfall."

In spite of these findings, the W.M.O. report recommends that "new scientifically designed and rigorously checked experiments be undertaken in all regions where there is a possibility of success."

The United States Congress has caused to be set up an Advisory
Committee on Weather Control and given it the job of finding out whether the U.S. Government should "experiment with, engage in or regulate activities designed to control weather conditions."

The Background of the Weather Forecast

As there is no immediate prospect of our being able to control the weather, forecasting must continue to be an important job. To be of maximum value forecasts need to be accurate always. Regrettably, even the forecasts for only one day ahead are too often wrong.

To appreciate some of the difficulties it is necessary to understand something of the methods used in weather forecasting.

There are four stages in the production of a weather forecast:

(a) Simultaneous observations of weather conditions at a large number of places and gathering these into the forecasting office.
(b) Analysis of these observations in terms of air masses, fronts, anticyclones, depressions, etc.
(c) Prognosis or projection of the analysis into the future.
(d) Forecast or interpretation of the prognosis in terms of wind, weather and temperature.

Collection of Weather Observations

Weather observations for immediate transmission to Wellington are made regularly at about 100 places in New Zealand. Only a few of the observers are employed by the Meteorological Service; some are lighthouse-keepers and others are Post Office officials or local body employees.

The main observation times are, by international agreement, 6 a.m., noon, 6 p.m. and midnight. Additional observations are made at 3 a.m., 9 a.m., 3 p.m. and 9 p.m., and at some aerodromes at hourly intervals. The largest number of reports is received at 9 a.m. and the fewest, naturally, during the night.

The most important of the details of the weather recorded are the kind of weather (rain, showers, drizzle or snow) and its intensity (whether slight, moderate or heavy), the occurrence of such special phenomena as fog, squalls, hail and thunderstorms, the direction and strength of the wind, atmospheric pressure, air temperature and types and amounts of clouds. For easy and rapid transmission by telephone, teletype or radio the observations are translated into a numerical code message of five-figure groups. So efficient is the communications system (for most of which the Post and Telegraph Department is responsible) that the 90-odd reports prepared at 9 a.m. on weekdays are available usually in less than one hour, not only in the General Forecasting Office in Wellington, but also in five branch offices.

At the four main hours weather reports are received also from ships at sea, the islands Macquarie, Campbell, Chatham, Raoul, Norfolk and Lord Howe and from many of the tropical islands of the South Pacific and from Australia. The tropical reports collected in Nandi, Fiji, and the Australian reports are sent to New Zealand by modern high speed radio-teletype transmission.

In return a selection of the New Zealand observations is transmitted to Fiji and Australia by the same rapid means and is also broadcast in morse for others interested.

In addition to the large number of observations of the weather details previously mentioned, members of the Meteorological Services at key points observe winds, temperatures and humidities in the atmosphere to heights of sixty to eighty thousand feet. Temperatures
and humidities are continuously measured in a small instrument called a radiosonde which is carried upwards by a large hydrogen-filled balloon. The measurements are automatically radioed back to the observer on the ground. Winds are measured by observing the track of a hydrogen-filled balloon either visually with the aid of a theodolite or by radar.

Before the mass of information received in Wellington at each of the main observing hours can be analysed it has to be translated from the figure code in which it is transmitted into a set of symbols and entered on a large map of Australia, New Zealand and much of the South Pacific Ocean. The symbols and figures clustered round a spot on the map show at a glance the details of the weather at that spot. A new map is prepared at each observation time, in fact, a series of maps, for separate maps are used to represent temperatures, pressures and winds at 10,000, 20,000, 30,000 and 40,000 feet.

Analysis

On these "plotted" maps the forecaster first draws isobars, which are lines joining places with the same barometric pressure. When these lines are drawn it is found that they form definite patterns which are usually relatively simple and are few in number. These facts are very important for two reasons. In this part of the world the areas from which observations are obtainable are limited, but fortunately they are large enough to make it possible to determine which of the patterns the portions of the isobars that can be drawn directly to fit the observations belong. It is possible, therefore, to infer with some confidence the courses of the isobars over much of the ocean area from which few or no observations are available. The second reason, of direct importance for forecasting, lies in the fact that each pattern is usually accompanied by its characteristic type of weather. The most important of the pattern are the anticyclone, depression, trough of low pressure and ridge of high pressure.

Anticyclone. An anticyclone is a region of high barometric pressure surrounded by closed isobars usually of roughly oval or elliptical shape. In the Southern Hemisphere winds blow anti-clockwise around an anticyclone. Hence there are southerly winds when the anticyclone centre lies to the west and northerlies when it has passed to the east. In anticyclones there are usually no strong winds and little rain. The nearer the centre is the better conditions are likely to be, but some anticyclones are cloudy with drizzle or fog, especially in the mornings.

Depression. Where roughly circular isobars enclose an area of low pressure, a depression or "low" exists. If the central pressure is very low the system may be called a cyclone but this term is used nowadays almost entirely with reference to tropical cyclones. Winds are usually strong and blow clockwise around the centre of low pressure. Most of the rain of temperate latitudes is associated with depressions but the weather conditions vary widely. When pressure is falling at the centre of the depression it is said to be "deepening" and, when rising, "filling up."

Trough of Low Pressure. When one anticyclone has moved off the country to the east and another lies to the west the relatively low pressure over the country between the two anticyclones is called a "trough of low pressure." It is usually the northward extension of a deep depression centred far to the south of New Zealand. The weather is often unsettled with troughs which are regions favourable for the development of new depressions. Sometimes an extensive anticyclone somewhat elongated in the east-west direction lies almost stationary across the north Tasman Sea and to the northeast of the Dominion. Depressions usually continue to move eastward far to
the south and as each passes an associated trough crosses New Zealand giving a temporary change from northwest to southwest winds. These troughs often pass over at intervals of 24 to 36 hours for several days to a week or more. These conditions are briefly described as “westerly conditions” or a “series of westerly depressions.”

Ridge of High Pressure. This name is sometimes applied to extensions of anticyclones or it may refer to a comparatively small region of high pressure between two depressions. The weather in ridges is usually fine but the latter type of ridge is so fast-moving as a rule that the fine weather is transient.

While the isobaric analysis is being made the forecaster is also noting other details given in the observations, such as temperatures, cloud types, the presence of showers or rain and so on. In particular, he is on the watch for fronts, the fairly sharp boundaries between warm and cold air masses. When a front is moving over a place in such a way that cold air replaces warm air it is called a “cold front.” Normally, a cold front is associated with a trough of low pressure. The passage of a vigorous cold front is accompanied by a drop in temperature already mentioned, heavy rain, and an abrupt backing of the wind, from northwest to south, for example. On the west coast, especially, rain may set in before the front arrives. Behind the front, showery weather prevails, but conditions clear gradually. Some fronts, however, may become so weak that neither rain nor showers develop.

A warm front marks the forward boundary of warm air which is advancing and uprising over colder air. It is characterised by an extensive cloud sheet and by rain of increasing intensity, but when the front passes, the heavy rain ceases, to be replaced, sometimes, in the warmer air, by drizzle.

As has been stated already, the analysis over areas from which no observations are available has to be inferred from what is going on in the areas that are covered by observations. The fact that weather maps for the whole area are analysed every six hours helps considerably. For instance, a depression which has moved from South Australia over Victoria can usually be placed later in the South Tasman Sea with fair accuracy. Unfortunately, however, the pressure systems and fronts are constantly changing their characteristics and intensity. The extent to which such changes are occurring in the “blank” areas is seldom completely known and so the analysis may rarely be regarded as completely accurate in all parts of the area.

Prognosis

The next stage is to project the analysis into the future, usually 24 hours.

The pressure systems are observed to move most of the time in a general eastward direction. If the centre of an anticyclone has moved in 24 hours 500 miles on an east-north-east track, a first estimate of its position at the end of the next 24 hours will be 500 miles to the east-north-east of its present position. Similar estimates are made for all the pressure systems on the map and also for the fronts. Cold fronts move on the average at about 30 m.p.h., but their speed varies widely. The estimate for each system must then be adjusted to allow for any speeding up or slowing down or change of direction that is evident or appears from the behaviour of neighbouring systems, likely to occur. In addition, the forecaster has to decide whether the systems are intensifying or becoming weaker, whether
fronts are becoming sharper and more active or are becoming weak and whether there are any signs of new systems, particularly depressions, developing.

The solution of these problems has been aided considerably in recent years by the analysis of the wind, pressure and temperature fields at levels well above the earth's surface made possible by the radiosonde and wind measurements by radar.

These analyses reveal that the isobaric patterns at, say, 20,000 feet are seldom, if ever, identical with those at sea level. For instance, at 20,000 feet immediately over the area occupied at sea level by a depression, the isobars may be straight, running from north-east to south-east. This usually means that the depression is moving fairly rapidly and roughly in the direction of the upper level isobars, i.e., towards the south-east. It is not likely to be very active. On the other hand, if the isobars at 20,000 to 30,000 feet above a sea level depression are circular and enclose an area of low pressure, indicating the existence of the cyclonic circulation at these high levels, the depression is likely to be slow or erratic in its movement and active in the production of rainfall. Unfortunately, the network of upper air observation points is even more open than the surface network and, moreover, the cost of radiosondes and their operation does not permit Australia and New Zealand to take more than one set of radiosonde observations per day.

Forecasts

The final stage consists of the interpretation of the prognosis back into terms of weather. The forecasts have to apply not only to the time to which the prognosis refers but to the whole period between the present and the time of the prognosis, so the weather in the intervening period has to be inferred. Allowances have to be made for changes in intensity of pressure systems and fronts. For example, a front which has given half an inch of rain at Invercargill may produce only the lightest of showers or nothing at all in Auckland. The extremely important part played by the mountains has to be taken into account. As is well known, a cold front approaching from the west is quite capable of causing several inches of rain in Westland and none whatever on the Canterbury Plains.

The following notes on the wording of forecasts may be helpful. The usual steps of wind-strength are: light, moderate, fresh, strong, gale, strong gale, whole gale, and storm. Increasing temperatures range; cold, cool, moderate, mild, warm and hot, where moderate is about the average for the time of the year. There appear to be various interpretations in popular speech to such words as fine, fair, cloudy and so on, but meteorologists are careful to use them only with fairly definite meanings. Thus, for example, "fine" is for the most favourable weather with seldom more than a quarter of the sky being covered by cloud. "Fair" still denotes favourable weather without rain but implies a greater amount of cloud. "Cloudy" is used when about three-quarters or more of the sky is covered, and "overcast" when there is, in the main, no blue sky visible at all. "Dull" indicates the sky is overcast with a dark threatening appearance. "Showers," as distinct from "rain" are characterised by clear, or at least appreciably brighter, intervals. In contrast, the sky remains cloudy, overcast or dull between spells of "occasional" or "intermittent" rain.

In a district forecast, the difference between scattered and occasional showers is that "scattered showers" indicates that some parts of the district will receive, and others escape showers, whereas "occa-
sional showers” means that showers are liable to be encountered at times in all parts of the district.

Most forecasts issued by the Meteorological Office relate to specified districts and not to individual towns.

There are often marked variations in weather conditions experienced in different parts of quite small districts and it is not feasible to attempt to cover in detail every local variation. For this reason, many people find that a combination of the newspaper or radio forecasts for general trends together with their own local knowledge for local details works out well. If the forecast is “scattered showers” the weather-wise will often be able to judge rightly whether or not his particular part of the district will escape.

Conclusion

Most types of farming would undoubtedly benefit very considerably if the range and accuracy of weather forecasts could be greatly increased. The large expanse of ocean in our area from which no observations can be obtained is often blamed for our incorrect forecasts. This deficiency does account for some of the failures but not all. All the Meteorological Services of the world have their failures and so the weather forecaster provides a good stand-by for the world’s cartoonists and quipsters. The unpleasant, but challenging, fact that our knowledge of the extremely complex processes of the atmosphere is still inadequate. However, slow but steady progress is being made and our understanding is gradually growing.

Mr Hurst: Weather forecasts generally start off at Auckland and go right through the North Island and down to Canterbury and Otago. As one of my friends said, by the time it gets to Southland he’s wondering into which paddock he will put the sheep and he has forgotten what is coming. I think that must be pretty general. I would like to suggest that stations 3YA and 4YA, instead of giving us what the weather is at Wanganui and the Chatham Islands, should give us the general situation, and a pin-pointed forecast at 7.30 and at 12 noon.

Mr Kerr: The sort of district forecast you suggest is already done to some extent. For instance, the Canterbury forecasts for Banks Peninsula, Christchurch City and the Plains are issued from 3YA at two minutes to eight and again at 1.30 p.m. Perhaps North Otago is not catered for in that way. We arrange such forecasts in response to requests. If there is a general demand for increased coverage from any district you can put it through Federated Farmers.

A speaker: Is there any substance in the theory that when we get a prolonged drought everything seems to be set for rain but the heat of the ground prevents precipitation which would otherwise occur?

Mr Kerr: I doubt it. New Zealand is a fairly small spot in the ocean. It is just a case of the whole area being dry.

Mr Butcher: I have from time to time got weather reports through the local Post Office and found them fairly reliable in connection with hay-making and harvesting. Last year I had a lot of oats and hay to stack. I got a three-day weather forecast which told us that the weather would be fine for two days and rain for the third. Within two hours we were soaked to the skin. What is the position regarding local thunderstorms?
Mr Kerr: I am afraid that is just one of those things that happen. Fairly often we can give probability of thunderstorms but we cannot pin-point them.

Mr Chapman: Has any provision been made for profiting by your mistakes? For instance, in the case of heavy snow storms, so far as I can remember, none of the severe storms have been prophesied.

Mr Kerr: When we predict snow it is usually because there is a very cold sou-west current spreading over the province. That usually carries only snow showers. The other snow storms are usually associated with intense depressions which have a very rapid development, and so far we have not got on to any warning signs. We do try to profit from our mistakes. We have a research section in the office but we are a little handicapped by the lack of staff, whose time is taken up with so many specific problems from all over the country.

Mr Samson: I have a lot of sympathy for the weather man. With us, it will rain like blazes and we might have one and a half inches. Three miles up the road it is quite dry. Heaven help the weather man who is asked to prophesy that.

Chairman: Do you take much notice of local weather signs? Most people who live in one place for any length of time know them, such as a certain cloud formation appearing over a particular range.

Mr Kerr: We by no means scoff at local signs. After all, people have lived close to the land for centuries and there is a great deal of wisdom accumulated in the observations of various signs of the kind you mention. Many of them are quite sound and there is a scientific explanation for them. As regards instances of birds and animals giving weather signs, there does not seem to be any scientific proof that they can be relied on.

CLOSING REMARKS

Chairman: Only a limited number of farmers have been able to come to this Conference. I feel those of you who have had the privilege of attending should, when you get back, talk to your neighbours and friends and give them the benefit of the information you have obtained. I know everybody interested can obtain the Proceedings for 7/6, but reading them is not the same thing as being there yourself. The next best thing to being present is hearing a verbal report as well as reading the book.

Professor Calder: I think we can all agree we have had three splendid days. So far as the first day’s discussions are concerned I think we will go home with the objective of complete control of foot-rot in New Zealand. How long it will take, I cannot say, but it is a challenge you will have to meet. The account of the present state of trace elements in New Zealand and the testing for them has given us a good appreciation of their importance and how we can set about tackling our own particular problems. The paper on the Marginal Lands Act gave us vital information as far as many districts in this country are concerned, and the papers on farm shelter and weather forecasting should be of help to everyone.

I think we ought to express our thanks to the speakers who have prepared and delivered the papers, and I think we ought also to thank the audience for their contributions to the stimulating discussions.

As regards the suggestion that the Conference should transfer to Christchurch and be held in a larger hall, I doubt whether that will
satisfy most people. I think the College is a place that does lend itself to agricultural discussions of national importance. We might be able to meet the problem of handling a greater attendance. We will certainly do everything we can to help.

Finally I would like to thank the Committee for their work and co-operation in planning and carrying out the programme. Those who lived in, and there were 40 of them, I am sure have enjoyed themselves. The discussions in the evening round the fire, with everyone relaxed in lounge chairs, with pipes going, and members of the staff making occasional provocative statements, will long be remembered. We hope that more members will live in at future conferences.

Then I must thank you all for your generosity and the expressions of confidence that you have in the College in the donation of £60 that you have made to us for the purchase of a sheep-handling machine. It will be most useful for the instruction of students and others in the care of the feet of sheep. The thought that was behind your action in collecting these funds will be deeply appreciated by the College authorities.

Mr John Hunt expressed the gratitude of the Conference to the Board of Governors, the Director and staff of Lincoln College for all their help.

Mr Scaife, Wanaka, on behalf of the body of members expressed their thanks to Lincoln College for placing facilities at the disposal of the Conference and to the organising committee for their work. The Radio and Press had been most co-operative in reporting proceedings to the public. He felt that the Conference displayed to other members of the farming community and to the city community as well, that farmers are endeavouring to be progressive and to increase production from our farm lands.

The following suggestions were made for discussion at the next conference:

(a) Wool and its production in the South Island.
(b) Lucerne in South Island farming.
(c) Rooks as a farm pest.
(d) The management of high-producing farms.

Any farmer is invited to send in further suggestions to the secretary.

At a meeting of the Committee, Mr John Hunt was appointed chairman in place of Mr D. S. Studholme, and Mr L. P. Chapman was appointed to the Committee in place of Mr P. P. L. Dillon.