HIGH-COUNTRY FARMING
MANAGEMENT FACTORS AND POTENTIAL


The term "high country" is in general use and in New Zealand it has acquired a special meaning, being applied to the mountainous country of the South Island of New Zealand on which stock—principally sheep—graze under range conditions. It carries about two and a half million sheep of which over 50 per cent would be Merino and the remainder Halfbred and Corriedale. The main income, and in fact the only income on over 50 per cent of the runs, is from wool.

These high country runs have features which combine to make high country attractive to some people and very unattractive to others: long distances, difficult roads, bad access, in some cases communication is by radio telephone only and in many cases children are taught by correspondence. Most runs are subject to the normal high country hazards for stock which can result in heavy losses.

This high country, as well as making its contribution to the national income through production of wool and stock, is also a considerable and growing tourist attraction. It is familiar territory to many who are not high-country farmers—trampers, ski clubs, fishermen, wild life enthusiasts, botanists and geologists, and consequently it is very much in the public eye and many are the pronouncements upon high-country management—past, present and future—depending upon the viewpoint and interests of the person making the statement.

It is a very large area of country—some ten million acres—and it must be cared for, because in addition to its pastoral production—present and potential—its mountains and valleys are catchment areas and maintenance of cover and stability of land here is of great importance to the land lower down. Opinions on the causes and effects of erosion and suitable land cover and whether erosion is proceeding at a normal or excessive rate are frequently given or refuted. Many think that intelligent occupation by high-country farmers who would care for the land and at the same time make a contribution to the national income, is the best answer while others think that large areas of the country should be closed up and not used for grazing, and others again favour a compromise between the two.

We tend to lump all high-country runs into one category but in fact, as in other types of farming, they do vary considerably although in general terms we can describe them as carrying out the same type of farming, i.e., extensive grazing under range conditions and a high dependence upon wool as a source of income. The extent of this dependence upon wool can be seen from the following table.

Wool prices are notorious for the way they fluctuate from season to
<table>
<thead>
<tr>
<th>Year</th>
<th>Net return per Head Sheep Shorn (s. d.)</th>
<th>60/64s and up per lb (pence)</th>
<th>56/58s to 58/60s per lb (pence)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1949-50</td>
<td>23/8</td>
<td>59.83</td>
<td>105.27</td>
</tr>
<tr>
<td>1950-51</td>
<td>45/2</td>
<td>99.0</td>
<td>48.38</td>
</tr>
<tr>
<td>1951-52</td>
<td>15/1</td>
<td>49.89</td>
<td>55.18</td>
</tr>
<tr>
<td>1952-53</td>
<td>19/8</td>
<td>63.79</td>
<td>61.27</td>
</tr>
<tr>
<td>1953-54</td>
<td>24/10</td>
<td>62.57</td>
<td>55.29</td>
</tr>
<tr>
<td>1954-55</td>
<td>18/1</td>
<td>52.53</td>
<td>47.73</td>
</tr>
<tr>
<td>1955-56</td>
<td>12/9</td>
<td>45.64</td>
<td>60.93</td>
</tr>
<tr>
<td>1956-57</td>
<td>23/6</td>
<td>60.57</td>
<td>49.77</td>
</tr>
<tr>
<td>1957-58</td>
<td>15/5</td>
<td>45.89</td>
<td>40.03</td>
</tr>
<tr>
<td>1958-59</td>
<td>8/8</td>
<td>41.27</td>
<td>45.37</td>
</tr>
<tr>
<td>1959-60</td>
<td>12/8</td>
<td>47.55</td>
<td>41.36</td>
</tr>
<tr>
<td>1960-61</td>
<td>11/6</td>
<td>41.54</td>
<td>42.33</td>
</tr>
<tr>
<td>1961-62</td>
<td>12/2</td>
<td>43.62</td>
<td>45.42</td>
</tr>
<tr>
<td>1962-63</td>
<td>N.A.</td>
<td>48.31</td>
<td></td>
</tr>
</tbody>
</table>

season and sale to sale, and when the economy of a farm is based on wool the farming net return will also fluctuate sharply. Note the very close resemblance between pattern of wool price per pound and total net return per head of sheep shorn, which is a very good indication of the dependence upon wool as a source of income.

If wool then is such an important factor any management trend or policy that tends to affect wool production should be studied very carefully before it is put into operation. Policy changes are long term matters in high-country flocks.

The runs can vary from the most difficult in terrain down to those on comparatively easy country and those on difficult country will be handled in a different way from those on the easier country, and on the latter there may be a considerable output of sale stock. The main difference between these properties is that caused by terrain and we find a higher proportion of wethers in the flocks on the most difficult country and on the easier runs we may find an all-ewe flock. The extremes would be from a flock where "wethers only" are carried and replacements bought, to an all-ewe flock where there is a high output of sale stock.

In general, high-country farming can be summarised as follows:

1. **High Country:** Properties situated at high altitudes with extensive grazing and subject to severe weather hazards such as risk of snow loss.

2. **The Stock:** Fine-wool breeds used and over half the sheep would be Merino.

3. **Extensive Grazing:** Average about five acres to the sheep and range is about three to 12 acres per sheep.

4. **Sources of Income:** Predominantly wool (approximately 80 per cent of income).

5. **Stock Management:** In its simplest terms consists of movement of stock to and from winter and summer grazing at the appropriate time of the year but calls for a high degree of skill in flock management to get good results.
Management of High-country Runs

The class of stock and the method of handling them will be very largely dictated by the topography and climate, but good management will be a very dominant factor in the handling of the property since so much depends upon stock "know-how" of the owner or manager.

High country, like any other branch of farming, has the aim of being a profit-making venture and it is usually a case of determining the way in which the best use can be made of the country. Limitations will be imposed by the terrain and climate, and scope of breeding country, and the factors that need to be taken into account in establishing a management policy are very complex.

Farming in New Zealand varies according to location, climate, and terrain and there are fat lamb farms, mixed cropping farms, store sheep farms and high-country farms. In each one of these groups there will be sub groups such as fat lamb farms breeding replacements, and non-breeding plus cropping, or no cropping. In high country, too, there will be dry sheep runs, balanced ewe and wether flock runs, and runs carrying ewes only plus replacements. One type will merge into another according to the conditions in the area.

Dry-sheep Runs (see Appendix I (a))

There are not many dry-sheep runs, but they are characterised by a lack of breeding and winter country and are therefore unable to carry ewes. The wethers are bought in each autumn as 2-tooths (or in some cases hoggets) and this is reasonably satisfactory if the run is in an area where supplies of suitable replacements are available. The breed may be Merino but this depends upon source of supply of replacements.

On average there is a loss on stock returns, and wool is the only source of income. This loss is due to the fact that stock sold each year will be less in number than those bought, due to the normal mortality and also to the fact that the stock sold will be culls only.

Balanced Flock—Ewes and Wethers (see Appendix I (b))

These properties carry a fairly large wether flock and are those usually on the more difficult country with limited breeding winter country. Sufficient breeding ewes are carried to maintain a balanced flock of ewes and wethers (approximately 30 per cent of breeding ewes in a flock required for this purpose). There is no great reliance upon sales of stock and probably little culling other than on an age basis. The breed is usually Merino. There is a good income from wool as there is a large wether flock. Returns from stock are low because the output is not great and consists of cull Merino stock.

Mainly Ewe Flock (see Appendix I (c))

These properties, carrying mainly ewes, are generally on the easier and front country and have more favourable winters and better breeding country and probably facilities for growing some supplementary feed. There is usually a high output of sale stock with regular drafts of lambs and cast ewes.

It is to be expected that an increase in breeding ewe numbers will lead to a greater output of sheep and lambs, but it is pertinent to point out that a breeding ewe does not produce as much wool as a wether and that to get a large output of sale stock some production of wool is sacrificed. Careful consideration should be given to this point when deciding whether the bias is to be toward stock or wool production.
Variation in Management Practice

The aim of most farmers is to increase production wherever possible so long as it can be done efficiently, and high-country men are no exception as we have seen from the greatly increased production coming from the runs in recent years in terms of wool and stock. These increases have been due to a number of reasons, and the improvement in wool and stock prices with better returns enabling development to proceed, with a reduction of the rabbit menace, have been prime factors.

Current wool prices are encouraging but during a few seasons in the past the economic situation has not been so good with falling prices and a fairly rigid cost structure, and this has caused many runholders to appraise critically their runs and management to see if any improvement can be effected. But a change in management on a high-country property is not always an easy matter. Such changes may be the result of a favourable sequence of events following on development where top-dressing and oversowing, subdivision and the growing of supplementary feed have all played a part. Or they may have been forced on a runholder through economic necessity or changes in his leasehold arrangements.

The changes which take place as a result of development are relatively easy to make since they come gradually, and both stock and owner have time to become adjusted to changing conditions. If, however, a change has to be made fairly quickly as a result of economic necessity or changes in land tenure, then the matter has to be considered very carefully indeed.

If, for example, there is a change in area of land held, then the balance within the flock may be affected and a run may find itself entirely dependent upon a relatively small ewe flock. If this ewe flock is to be an economic unit then it must be highly productive. It will have to step up lambing percentages, stock output and wool weight, and to do this a fairly intensive development programme would be necessary. This cannot be done overnight and therefore if a change of tenure is looming up it is imperative that development should be under way as soon as possible.

If a change is rendered necessary through economic conditions a careful study is required to ascertain the best course of action.

It may be that the maintenance of an all-ewe flock is too difficult or leading to high mortality, poor stock output and low wool weights, and that a higher proportion of dry sheep could be the answer. It may be a question of heavy mortality in hoggets necessitating special attention to the hogget country. Five per cent of hoggets saved could pay for quite a lot of topdressing and oversowing and thriving young stock are a good investment for a high-country flock.

One of the most efficient ways of improving production on a high-country flock is to build up the wool weights. It costs no more to shear, muster or maintain a sheep with 10lb of wool than one with 8lb.

It is not possible to cover all the factors to be considered in run management since each place will have its own problem or problems; but it should always be remembered that wool is a very important source of revenue to a high-country farmer and an improvement in wool production and quality should be a constant aim to be achieved very largely through the better treatment of young stock.
Dry Sheep on the High Country

The policy of carrying more dry sheep on the high country is worthy of careful study. With maximum ewe numbers there will be less wool and more sale stock. But broadly speaking a wool bias is preferable, for where, owing to difficult conditions, lambing percentages are low and losses high, there is little point in keeping a lot of ewes which produce lambs and wool inefficiently. It is far better to use more dry sheep and benefit from an increased wool clip and lower costs. (A ten per cent increase in the proportion of ewes in a flock could cause an overall drop in wool clip from the whole flock of up to 1lb per head. See F. L. Ward, N.Z. Meat and Wool Boards’ Economic Service Bulletin No. 8, 1960.)

Cattle

Cattle numbers have been trebled on the high country in recent years but there is still considerable room for increase. The runs in the higher rainfall areas and those with extensive swampy valley floors could carry a lot more cattle with benefit to the country. They could also be another factor in maintaining lower operating costs since when a property is geared to the carrying of a considerable number of sheep, an increase in cattle numbers does not greatly affect the management and labour situation.

Production Increases

Marked production increases have occurred in the high country, wool weights have increased considerably and lambing percentages have gone up. Lamb sales have doubled and cattle numbers trebled.

Limitation of Stock Numbers

A lot of this has been accomplished in a different way from the usual production increase pattern on downland farms in that sheep numbers have not increased greatly, but unit or per head production has gone up considerably.

This practice of stock limitation is in part the result of stock limitation clauses written into leases, but also due to awareness on the part of runholders of the ill effects of overgrazing.

Dependence Upon Wool

The dependence upon wool as a source of income is regarded by some as a weak point in the economy of the high country, but it can also be a strong point if the proper relationships are maintained. Basically the management of high country is on a low cost economy. In times of high prices this tends to be forgotten and management commitments made which are difficult to maintain.

Wool is an international commodity and as such is subject to overseas’ market fluctuations and therefore an economy based on wool must leave itself room to manoeuvre. For example, on a fat lamb farm with a meat production of 100lb and wool of 30lb per acre the application of a hundredweight or more of fertiliser, overall, is regarded as sound farming practice. On the foothill country, too, the overall application of fertiliser is worthwhile but on the high-country run with meat production at 2.3lb and wool 1.9lb per acre it is a very different situation—in the latter case the topdressing done will be of a strategic nature designed to achieve some particular object. For example, losses in hoggets may be high and hogget country in need of improvement; lambing percentage too low and ewe country or some part thereof in need of attention.
Management Changes

On most runs there is usually a weak link or links in the production chain and it is of great importance to be able to recognise that weakness so that appropriate counter measures may be taken.

This may merit a big change in management and a large-scale development plan involving the taking of calculated risks. But very often it can be handled by some variation in management at little or no cost. Perhaps a judicious use of topdressing and oversowing and some subdivision may meet the case with careful consideration of the importance of the main product of high country which is wool.

In the case of certain favoured and suitable runs there will be scope for large, costly and no doubt successful schemes. But overall future development policy may lie more in the field of limited development out of revenue with appropriate management practices.

APPENDIX I

High-Country Sheep Farms, South Island
Percentage Pattern of Revenue 1961-62 Season

<table>
<thead>
<tr>
<th></th>
<th>Dry-Sheep Run</th>
<th>Balance Flock Ewes &amp; Wethers</th>
<th>Mainly Ewes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wool Account</td>
<td>103%</td>
<td>86%</td>
<td>57%</td>
</tr>
<tr>
<td>Sheep and Lambs Account</td>
<td>-3%</td>
<td>10%</td>
<td>30%</td>
</tr>
<tr>
<td>Cattle Account</td>
<td>-</td>
<td>4%</td>
<td>13%</td>
</tr>
<tr>
<td>Other Account</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

100 100 100

(a) Dry-Sheep Runs

- Wool weight per head of sheep shorn - - - - 10.1lb
- Stock output - - - - -10.5%
- Stock loss - - - - -10.5%
- Gross profit per head from wool - - - - 31/3
- Gross profit per head from sheep and lambs - - - - -11d
- Gross profit per head from other - - - - -

Total gross profit per head - - - - 30/4
Total expenditure - - - - 14/9

(b) Balanced Flock—Ewes and Wethers

- Wool weight per head of sheep shorn - - - - 10.2lb
- Percentage of breeding ewes in flock - - - - 26%
- Sheep and lambs output percentage - - - - 19%
- Lambing percentage - - - - 87%
- Lamb input percentage to flock - - - - 22%
- Sheep and lamb loss - - - - 3%

The pattern of Return and Expenditure per head of sheep shorn:
- Gross profit from wool per head - - - - 35/4
- Gross profit from sheep and lambs - - - - 4/3
- Gross profit from cattle - - - - 1/6

Total gross profit per head - - - - 41/1
Total expenditure - - - - 18/3
(c) **Mainly Ewe Flock**

<table>
<thead>
<tr>
<th>Description</th>
<th>Weight</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wool weight per head of sheep shorn</td>
<td>6.5 lb</td>
<td></td>
</tr>
<tr>
<td>Percentage breeding ewes in flock</td>
<td>69%</td>
<td></td>
</tr>
<tr>
<td>Lambing percentage</td>
<td>81%</td>
<td></td>
</tr>
<tr>
<td>Sheep and lamb output percentage</td>
<td>49%</td>
<td></td>
</tr>
<tr>
<td>Lamb input percentage</td>
<td>55%</td>
<td></td>
</tr>
<tr>
<td>Sheep and lamb loss</td>
<td>6%</td>
<td></td>
</tr>
</tbody>
</table>

The pattern of Return and Expenditure per head of sheep shorn:

- **Gross profit from wool per head**: 22/8
- **Gross profit from sheep and lambs**: 12/-
- **Gross profit from cattle**: 5/6
- **Gross profit from other**: 

| Total gross profit per head | 40/2 |
| Total expenditure           | 26/8 |

**APPENDIX II**

High-country Sheep Farms, South Island

Pattern of Farm Income 1961-62 Season

<table>
<thead>
<tr>
<th>Gross Farm Income:</th>
<th>Per Sheep</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Wool Account</td>
<td>29/-</td>
<td>77.2</td>
</tr>
<tr>
<td>2. Sheep and Lambs</td>
<td>6/1</td>
<td>16.1</td>
</tr>
<tr>
<td>3. Cattle Account</td>
<td>2/2</td>
<td>5.7</td>
</tr>
<tr>
<td>4. Other</td>
<td>5d</td>
<td>1.0</td>
</tr>
<tr>
<td><strong>£1/17/8</strong></td>
<td>100.0</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Working Expenses:</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Wages and Rations</td>
<td>6/7</td>
</tr>
<tr>
<td>2. Farm Requisites</td>
<td>1/4</td>
</tr>
<tr>
<td>3. Shearing expenses</td>
<td>2/10</td>
</tr>
<tr>
<td>4. Fertiliser, Lime and Seeds</td>
<td>1/1</td>
</tr>
<tr>
<td>5. Vehicles, Fuel and Power</td>
<td>2/1</td>
</tr>
<tr>
<td>6. Feed and Grazing</td>
<td>8d</td>
</tr>
<tr>
<td>7. Contract work</td>
<td>9d</td>
</tr>
<tr>
<td>8. Repairs and Maintenance</td>
<td>2/2</td>
</tr>
<tr>
<td>9. Railage and Cartage</td>
<td>10d</td>
</tr>
<tr>
<td>10. General expenses</td>
<td>9d</td>
</tr>
<tr>
<td>11. Sub-total—Working expenses</td>
<td>19/1</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Standing Charges:</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>12. Insurance</td>
<td>4d</td>
</tr>
<tr>
<td>13. Rates and Land Tax</td>
<td>1/8</td>
</tr>
<tr>
<td>14. Managerial Salaries</td>
<td>4d</td>
</tr>
<tr>
<td>15. Interest</td>
<td>1/2</td>
</tr>
<tr>
<td>16. Rent</td>
<td>1/-</td>
</tr>
<tr>
<td>17. Sub-total—Standing Charges</td>
<td>4/6</td>
</tr>
<tr>
<td>18. Total Cash Expenditure</td>
<td>£1/3/7</td>
</tr>
<tr>
<td>19. Depreciation</td>
<td>1/11</td>
</tr>
<tr>
<td>20. Total Cash—Expenditure and Depreciation</td>
<td>£1/5/6</td>
</tr>
</tbody>
</table>

| No. runs in sample | 35 |
| Average No. sheep shorn | 6,286 |
| Average No. cattle wintered | 103 |
| Average area of runs | 29,663 acres |
ASPECTS OF HIGH-COUNTRY CROWN LANDS ADMINISTRATION

N.S. Coad, Commissioner of Crown Lands, Christchurch.

(This article by Mr Coad is based on a talk given to Federated Farmers' High-Country Conference at Timaru, 22 June, 1964.—Ed.)

When I meet a group of high-country people I feel very much aware that the special problems of the high-country runholder are still relatively new to me. That is of course something which only time will correct, but in the meantime it may even be of some advantage for me to be able to view these very complex affairs from a more detached standpoint, and to look at our mutual problems almost, as it were, from the outside.

Our mutual problems—I use these words deliberately. The Department of Lands and Survey tries always to act in a reasonable, helpful and commonsense way towards all its lessees, whether they be high or down country, urban or rural. We regard many problems as joint ones, to be solved together, and this policy applies nowhere more actively than in our administration of the high country of the South Island. We believe that the Department and the runholders are together joint trustees of the high country and that it is our shared duty to ensure that the mountain lands remain a permanent investment asset for all time, returning a continuing dividend both to the runholder and to the nation. We know that we must work together to preserve the high country, for if we do not work together and if we ignore the lessons learned so painfully in the past, nothing will prevent the mountain lands from becoming a useless liability to the runholder and a downright threat to vast areas of lower country.

There are people who are so concerned at the difficulties of this task that they see little future for high-country runs, but I am not one of them. Although no one could fail to be impressed with what has already been done in the way of improvement, perhaps the most compelling impression I have gained so far is of the real, positive, and expanding role our high country has yet to play. We have in the run country one of the few extensive, largely undeveloped areas remaining in New Zealand. We have the basic techniques of development already established, and further progress is constantly being made. We know beyond doubt that results can be achieved.

While all this is true, it is also true that development of run country is not as simple as it may appear at first glance. It is known that development sometimes brings new problems in its train. It is also a fact that some runholders are not yet convinced that the economics of development are proven. Above all, only those connected with the high country can understand what a critical decision it is to depart so radically from a trusted farming pattern evolved laboriously and painfully over 100 years, and now developed on most runs into a regular system which works well, year in and year out.

All these are difficulties in the path of the improvement and development of run country, and they will undoubtedly affect the rate of progress, but they will be overcome. They will be overcome because the most formidable obstacle—the only one which could completely halt progress—has already been surmounted. That major obstacle was the
generally accepted opinion that run country could not successfully be
developed.

The big breakthrough occurred when the idea that development of
run country is both possible and desirable became widely accepted.
Other problems exist and the Department readily recognises this, but
no other problem will now be insuperable. We want to find the answer,
and history has shown that when man genuinely wants to conquer a
problem, he always manages to find a solution.

The biggest victory has therefore been won, but many more battles
have still to be fought in the farming revolution into which the high
country is steadily moving, and the Department will play its part in
assisting runholders to find solutions to the problems they meet in the
improvement of their runs. Pastoral Lands Officers cover large areas of
country and visit many runs. They are always ready to help with advice
from their own experience, or from their knowledge of other people’s
experience with the same problems. If they cannot provide the answer
they may know where advice may be obtained. They will do all in
their power to assist.

If finance is limiting development and cannot be obtained elsewhere,
the Department may be able to help in obtaining a Marginal Lands
Board loan. Perhaps it is not as widely known as it could be amongst
runholders that the Marginal Lands Board can help them, but whatever
the reason very few applications for loans to develop run country have
been received. The Board does in fact lend for run country improve-
ment, and, moreover, is a flexible and understanding lender. If a proposi-
tion is sound and has good prospects of success the Board will lend—
even on security which no other major lending institution would consider.

Loans are normally made on current account during the develop-
ment period, so that interest only is payable during this period, and no
repayment of principal is required until it is apparent that the property
is on a sound footing and can stand the charges. When this stage is
reached the loan is placed on a table mortgage, repayable over a long
term.

Day to day administration of Marginal Lands loans is carried out
by the Department of Lands and Survey which itself has a vital interest
in the high country, and has therefore acquired a very full understanding
of, and consideration for, the special problems of runholders. A develop-
ment proposition held up for lack of finance could well be worth a full
discussion with the Department.

A discussion of finance should not be ended without mentioning
that many of us in the Department are concerned about the extent of
mortgage commitments being undertaken by recent purchasers of some
runs. To understand our concern, consider the situation which led up
to the passing of the Land Act 1948, the charter under which runholders
and Department both work. The Act provided a new deal for run-
holders, and indeed its passing marked a turning point in the history of
run country. It brought to an end the era of high rents and uncertain
 tenure, which it replaced with a system of reasonable rentals based on
the safe carrying capacity of the country, and it gave permanent tenure
and perpetual rights of renewal.

A former runholder has said that only because of the confidence
created by the security of tenure given under the 1948 Act were run-
holders prepared to tackle the rabbit problem so wholeheartedly and effectively, and it is only since the rabbit has been controlled that the development of run country has been a practical proposition. It is due at least in part, therefore, to the enlightened provisions of this Act that extensive development of run country is under way today.

One of the essential principles of the Land Act is that rentals of runs are to be reasonable, and are to be calculated on the estimated carrying capacity of the run. This is necessarily accompanied by a stock limitation defining the type and maximum number of stock which can be carried on the run. This figure is the basis for the rental calculation, but the stock limitation may later be increased without rental increase if development of the run makes it possible.

The whole purpose of the stock limitation is to ensure that overstocking does not threaten the stability of the land, which not only provides the runholder with his living, but is also of such vital importance to people down country. Rentals based on these stock limitations have been fixed at very reasonable or even low figures, so that the runholder would not need to push the country very hard in order to pay his way.

However, a lessee who buys a run and involves himself in high mortgage commitments will become involved in a high level of annual outgoings to service his mortgages, and our concern in the Department is that the whole purpose and value of the reasonable rental may well be submerged, and the run may once again be subjected to an undesirable level of grazing pressure. Certainly, the stock limitation system will prevent gross overstocking and a reversion to the worst practices of the past, but it is equally true that it is more difficult for a runholder to adjust his run management to the best soil conservation practices when faced with a large annual mortgage interest bill. The level of mortgage commitments is something which all interested in the well-being of the high country will watch with great interest and we in the Department, with some concern.

The value of stock limitations in preventing overstocking to the detriment of the vegetative cover is fairly well accepted and understood by runholders, but there is apparently a certain amount of confusion about the precise meaning and effect of such a limitation. Most pastoral runs are now held under pastoral leases subject to the Land Act 1948, and contain a clause stating that the lessee must not carry more than a specified number of sheep and cattle, including a specified number of breeding ewes or breeding cows. The figures quoted in the lease refer to winter stocking, for obviously during the summer the numbers will fluctuate with the birth and death rates, but on no account may the property carry into winter more than the stock numbers specified in the limitation.

However the high country, like any other farming proposition, rarely remains static. With pasture improvement, fencing, and other development, many runs become capable of carrying, without detriment to the land, more stock than specified in the limitation. The Act provides for the limitation to be increased in such cases, but the first consideration will always be the maintenance of an adequate vegetative cover, and the stability of the country.

Stock limitations cover all stock, both sheep and cattle. This is not always realised by runholders, particularly so far as cattle are concerned. There is an increasing use of cattle on pastoral runs and generally this is a desirable trend which will almost certainly increase, but cattle may
not be carried, nor their numbers increased, unless the stock limitation is first adjusted to provide for them.

Another provision in the pastoral lease which sometimes puzzles lessees is the prohibition of cultivation without the consent of the Commissioner of Crown Lands. This requirement is in fact a soil conservation one and serves a very definite purpose on run country which is so subject to windblow and other forms of erosion. It is treated very seriously by the Department. Each application is investigated carefully, and although approval is not withheld unreasonably, neither is it granted as a matter of form. The requirement for consent to cultivation is yet another example of the way in which the administration of pastoral leases is designed to protect the high country for all time, and not to allow short term considerations to obscure the long term future of the critically important South Island high country.

There is another threat to the future of the high country of which we must also be aware, and that is the problem of noxious weeds, especially Nassella tussock. The infestations of this plant in North Canterbury and Marlborough demonstrate clearly the seriousness of the problems faced and the costs which have to be met by those whose land the weed has invaded. Many of the existing areas of infestation are on high-producing country which can carry the cost of fighting the weed, but the position would be grave if it were to become established extensively in our lower-producing run country. It is absolutely essential therefore that any new infestation should be discovered and brought under control before it has spread seed over a wide area. I strongly urge everyone who lives in or visits the high country to find out what this weed looks like, and be able to identify it. County Noxious Weeds inspectors, Department of Agriculture officers or Pastoral Lands officers will be able to assist in identification, and are anxious to hear of any new colonies of the plant. We cannot allow this weed to entrench itself in our high country for once established it knows no boundaries.

Nassella tussock can be controlled only with the cooperation of all runholders in seeking it out, but I have no reason to doubt that this cooperation will be offered for it is rarely that the Department has not been given full and enlightened support by runholders as a whole in our administration of pastoral runs. We appreciate that support, and for our part will continue to administer the Act reasonably, humanely, and with a genuine regard both for the future of the high country and for those who live in it.

OUR COVER

Whether a tussock fire is accidental or part of a management plan, the stocking system after the fire is generally recognised to be of vital importance.

In this case, an accidental fire in October, driven by a strong, hot, norwester burned several hundred acres including snow tussocks. The photograph was taken three weeks afterwards and indicates the ability of snowgrass to recover if the crown has not been burned into the ground. These new leaves are extremely palatable; grazing at this stage may result in the early death of the tussock.
CLIMATE AND STOCK ON HIGH COUNTRY AND EFFECT OF CLIMATE ON HIGH-COUNTRY PRODUCTION

P. C. Ensor

(The Economic Service of the N.Z. Meat and Wool Boards will shortly publish another of its bulletins dealing with the high country. It is a ten-year summary of production from twenty-six runs under survey and indicates that there has been a remarkable increase in production over the period. The Service sent the text to Mr Ensor of Double Hill, chairman of the High-country Committee of Federated Farmers, for his comments. These, with Mr Ensor’s permission, have been made available by the Service for publication in the Review. We wish to thank Mr Ensor for permitting us to print them.—Editor.)

The next bulletin to be issued by the Economic Service discloses a very satisfactory and interesting story of increases in production from high-country runs. That these increases are coming through the medium of increase per animal unit rather than through an increase in stock numbers must be a point of satisfaction to all those interested in the better care and management of our South Island high country.

The supply of more and better quality feed is a fundamental and proved requirement for the raising of animal-unit production and this is obviously being achieved. It is not within the scope of this brief comment to elaborate on how this is being achieved; sufficient to say that it is being done. However, there is one question that will probably come to the mind of most who know the high country and that is: To what extent have these figures and results been influenced by the weather during the seasons under review, and could or would a series of bad seasons upset or throw doubt on these figures?

This is a pertinent question when we come to discuss high-country affairs and one that has played a major role in the fortunes or otherwise of those who have chosen to make their life there, and any answer to this question must always be open to doubt. There are, however, a number of factors which would suggest that the weather is unlikely to upset seriously the trend or validity of the figures produced.

It is a fact that people will often say the winters are getting warmer and that we do not get the snows that we used to see; but there is very little factual information to support this contention when one is considering a specific term of years such as the period under review. The only scientific information available is that over a period of 100 years or more there has been an overall temperature rise of one or two degrees and that the major glaciers are receding. This is a long-term trend and as such will exert little influence on the comparison of short-term periods.

The survey by the Economic Service covers country from Marlborough to Southland and as such it would require adverse conditions over the whole island to materially affect the findings of the survey.

Snow can be notoriously local in its effect so that impressions gained or expressed by one individual have a local character, and also the conditions under which the seasons are remembered exert a strong influence on opinions. For the last ten to fifteen years, living and working conditions in the high country have improved immeasurably—houses are better built and heated, we travel in comfortable cars supplied with heaters,
and trucks and landrovers equipped with heaters have largely supplanted the station hack as a means of conveyance about a station, being warmer and reducing the time one is exposed to adverse conditions.

In order to attempt to assess the facts as to whether or not the weather during the period under review has been sufficiently favourable to affect the result, diaries over a period of twenty-five years kept on one property have been examined. With the exception of the year 1945 it is difficult to detect any great differences in the weather pattern, good winters being interspersed with bad ones, and there appears little difference in the depth of snow falling or the number of days on which it falls. Further, these records would suggest that the period under review reflects a fair and average ten-year period; indeed, there have been seasons, or parts of seasons, with very severe conditions during the period of this survey. Both 1951 and 1952 record heavy autumn snows, eighteen inches of snow being recorded on 26 May 1952 with snows continuing into late October and November. In 1959 one of the worst recorded early snows started on 7 May affecting a very large area of high country; in the same year the coldest day since 1902 was recorded. Turning to more recent times, but outside the period of this survey, on 20 April 1963 a snow of exceptional severity caught many runs without their autumn muster completed or even started. In spite of this there have been few or no reports of heavy stock losses whereas in earlier years there is no doubt that this snow would have been a disaster to many runs.

On balance it appears reasonable to assume that the results of a future survey taken over a period of years would not be seriously affected of seasonal conditions, with perhaps the exception of a snow or storm (which history suggests may occur once or twice in fifty years) affecting the South Island from Blenheim to Invercargill.

If there has been no very marked alteration in seasonal weather conditions, it is pertinent to ask the reasons why heavy stock losses are not so frequently reported from the high country, marked by the declining death-rate figures as shown in the survey. Basically they are the same as those leading to higher animal-unit production. More and better feed resulting in stronger animals, more capable of withstanding adverse conditions; much more provision made for winter feeding of stock; better management of hoggets reducing the death rate. Over the last twenty years high-country runs have tended to become more manageable in size, very large ones being reduced and some small and uneconomic ones amalgamated or increased in size. Much old fencing has been rebuilt and new fences erected, both making for more efficient and economic working. Finally mechanisation by way of bulldozers, tractors, trucks, landrovers and aircraft all play their part in reducing waste time and speeding up operations.

Security of tenure has undoubtedly encouraged the leaseholder to invest capital and to increase working expenses on his run, thus enabling him to take advantage of the aids to increased production now at his disposal.

There is no doubt that considerable progress has been made in the care and occupation of the high country. Many of the problems of the occupation of the high country are being overcome. Grazing pressure on the higher or more vulnerable areas of country is being reduced, both by domestic as well as noxious animals, while at the same time production is increasing and we are farming more efficient animals.
MAN AND THE MOUNTAIN LANDS

J. T. Holloway

(Officer in Charge of the Forest and Range Experiment Station, New Zealand Forest Service, Rangiora)

(In February, 1964, Mr Holloway delivered the Banks Lecture at the Annual Conference of the Royal New Zealand Institute of Horticulture held in Dunedin. The lecture was printed in Plants and Gardens, the journal of the Institute, Vol. V, No. VI, 1964, and we wish to express our thanks for permission to reprint in this Review.—Editor.)

Introduction

In response to the rush and bustle of modern life, a deplorable custom has grown up. Great masterpieces of literature are presented, for our hurried consumption, in condensed and emasculated forms, as if the style and subtleties of the original works could survive this treatment. It is a custom I abhor. Nevertheless, tonight, I myself propose attempting such a precis, not of a single literary work but of a century of scientific effort. In doing so, in attempting to summarise for your our present knowledge of the New Zealand mountain country, I take many conscious risks; but I do feel that the occasion, for two distinct reasons, is an opportune one.

In the first place, the threads of the story I have to tell, however imperfectly I tell it, are drawn from many contributory natural sciences. I believe, therefore, that it is a story that would have been of absorbing interest to the great naturalists of the late 18th century, foremost amongst whom stood Sir Joseph Banks, whose name is commemorated in these lectures given at your Annual Conferences. The attempt may appropriately be made in his memory.

In the second place, I believe that we now stand at the threshold of an era of awakening national interest in our mountain lands. Interest to date has been sporadic, or sectional, with long periods of neglect or disinterest. On the whole, we have followed a comfortable lowland way of life inherited from, and patterned on, that appropriate to the subdued mature landscapes of the old country. On the whole, we have been forgetful of the fact that our small fragments of lowland are, almost everywhere, backed by larger areas of high and difficult mountain country. We have chosen not to consider the essential inter-dependence of lowland and highland.

These attitudes of mind cannot long continue. Step by step as lowland resources are developed and our population grows, pressures on the mountain lands must also grow. There must inevitably be demands for increased pastoral production, for the further realisation of hydro-electric potentials, for more water for cities and farms, for better flood control, and for additional mountain-land sport and recreation. And because these various demands, each legitimate in itself, will not everywhere be mutually compatible, there must inevitably be recurrent controversies. I venture the forecast that, from this date on there will rarely be a time when an acrimonious battle is not being fought, some-
where in New Zealand, on some mountain-land issue. We have had more than one taste of this in recent years.

It seems to me, therefore, that there is a need for the development of a substantial body of well-informed public opinion on mountain-land matters. Otherwise, conflicts, as they occur, are most likely to be resolved piecemeal, in favour of vociferous minorities irrespective of the real strength of their claims. If I can make a small contribution, tonight, toward the development of this desired body of public opinion, I will be satisfied. I would ask you to remember, however, that, in the time I have available, I can only present a condensed and emasculated account. The justification offered for condensed books is that they serve to stimulate an appetite for the originals. I hope that this brief account of the mountain-lands will also prove to be an appetiser.

The Geological Background

To begin with, it is necessary to know something about the origins and structure of the mountains. I will not dwell long on this. Superb summary of this part of the story has recently been published by Dr Charles Fleming(1). I draw his account to your attention and apologise to him, in advance, for any errors I may make in the abstraction and interpretation of those details that appear to me to be of present significance.

The oldest rocks of which our mountains are composed were laid down in Ordovician, Cambrian and pre-Cambrian times, 400-1000 million years ago; but these ancient rocks are not of wide distribution. The real story of the mountains begins approximately 300 million years ago when a deep oceanic trough or geosyncline developed over that portion of the earth’s crust now occupied by the land we call New Zealand. This trough, over the course of 150 million years, slowly filled with sediments derived from lands lying, at various times, to the east and to the west.

The oldest sediments were deeply buried and were subsequently converted into gneiss and other hard metamorphic rocks by heat and pressure. Locally, they were massively invaded by igneous rocks which solidified to form granites and diorites or, where they poured out upon the surface, basalts and andesites. Sediments of younger age, not subjected to such great heat and pressure, were converted into schists of varying degrees of metamorphism. The youngest geosynclinal sediments, mainly deep-water sandstones and inter-bedded mudstones, underwent little alteration and survive as greywackes and argillites.

Later, during the Cretaceous Period (80-130 million years ago), the floor of the trough rose and its contained sediments were thrust up to form mountains which, however, by the end of the Cretaceous, had already been worn down again to form a land of low relief subject to flooding by the sea. There followed a long period during which shallow waters sediments, mudstones, limestones and the like, accumulated.

Throughout this period, the Tertiary Age, New Zealand was probably an archipelago of islands, sometimes volcanic, that were uplifted or resubmerged as the local buckling of the earth's crust continued. Not all of the land was under the sea at any one time but, over the greater part of it, marine sediments were laid down at one time or another.

The pace of events now accelerated. Beginning slowly, at first in the far south perhaps 10 million years ago, but not reaching a climax until one to two million years ago, massive mountain building movements took place. The land rose rapidly but unequally, sometimes as great tilted blocks, sometimes in complex, faulted folds; and, as the land rose, the soft Tertiary sediments were stripped from the higher ground, once more exposing the metamorphic and sedimentary rocks, the gneisses, schists, greywackes, etc., of geosynclinal origin. The maximum height of uplift has been calculated to have been as much as 40-50,000 ft, though the mountains, of course, never reached this height. They were worn down almost as fast as they were uplifted. Uplift continues though apparently at a substantially reduced rate.

Simultaneously, over the latter part of this period, in response to world-wide climatic changes, the South Island mountains were subjected to intense ice action. The ice advanced and retreated many times, the last major advance of the ice not terminating until approximately 15,000 years ago. Since then we have passed through a period of warmth and the climate has again cooled. A minor advance of the alpine glaciers culminated as recently as the mid-19th century.

During each advance, the valleys were cut deeper and immense quantities of glacial detritus were spewed out on to the plains, and following each retreat, the valley walls, greatly oversteepened, were left, podocarp forests spread widely across the present grassland regions of rock, talus, and other glacial debris. Where the mountains escaped direct ice action, as in parts of eastern South Island and in the south of the North Island, they were subjected to and moulded by the freeze and thaw of periglacial climates. Northern ranges of the North Island, which escaped both glaciation and the effects of periglacial climate, were, very late in the period, repeatedly and lavishly coated with loose pumice sands and volcanic ash derived from centres of volcanic activity extending from Mt. Egmont to the Bay of Plenty.

In brief, this is the story of the mountains themselves, or, more accurately, that part of it essential to an understanding of the vegetation and to an understanding of mountain-land management problems. The key points are the extreme youth of the mountains and their complex recent history. I would pause only to note the very wide extent of the greywacke and schist mountains, particularly the former, in comparison with those built from harder and more erosion resistant materials. These latter, the oldest and most strongly altered geosynclinal metamorphics, their associated intrusives, and the more ancient pre-Cambrian to Ordovician rocks, are largely confined to the geological provinces of Fiordland and north-west Nelson. It is the greywacke country that is the hard-core problem country.
The Story of the Vegetation

Dr Fleming, in the paper already mentioned, has also summarised existing information concerning the origins of the New Zealand flora. Briefly, it is unlikely that any substantial mountain-land element that may have been contained within the flora during early Cretaceous times when the land stood high, survived the later periods of reduction and general submergence of the land surface. In other words, our present mountain-land flora is probably derived from that of Tertiary oceanic islands, by speciation, since mountain building began. Some new species or genera may have arrived, subsequently, from overseas but these would most likely be casual accidental introductions. In the absence of land connections, no strong reinforcement of the mountain-land flora from overseas was at all probable. The story of the vegetation proper, as we know it, may be taken up at this point.

As the mountains rose, a host of new plant habitats were created, to be filled by the most readily adaptable of the species that had survived the long period of mild oceanic island climate, by new species arising through mutation or hybridisation, or by casual immigrant species. And out of this almost random collection of old island species, evolving species, and casual immigrants, a new mountain-land vegetation made up of new combinations of species to form new plant associations had to be forged.

There is room here for endless fascinating speculation. The detailed stages through which the vegetation passed in the course of its rapid evolution will, however, never be known. Following the onset of the first ice age, probably before any new state of vegetation stability had been achieved, almost all traces of the mountain-land vegetation were destroyed, the ice reaching the sea on the west coast of the South Island, south of the Grey River, extending out on to the inland margins of the Canterbury Plains and into the intermontane basins of Otago and Southland. Most mountain-land species and possibly many mountain-land plant associations survived, however, in lowland refugia and on northern mountains that escaped glaciation.

Following the retreat of the ice, therefore, though the mountains had everywhere to be recolonised by plants, there was now a strong mountain-land element in the flora, an element probably strengthened by continued speciation during the glacial period. The recolonisation of the mountain country is therefore likely to have been rapid, the mild climates of the subsequent long interglacial almost certainly permitting the development of a closed cover of vegetation at altitudes much greater than at present.

But again we will never know the full details. The mountain forests, scrublands and grasslands of the first interglacial were, in their turn, destroyed when the ice advanced again. The whole process was repeated. It was to be repeated at least four times at irregular but shortening intervals, the position of the ice front, on each occasion, falling short of that reached on the previous occasion. All advances, probably, were multiple in character, the last certainly being marked, in
its diminuendo phase, by many secondary advances and retreats. And
with each swing of the ice pendulum there was, of course, a corresponding
movement of plant species and associations from the mountains to the
plains and back again, leading to a confusion of vegetation patterns, to
the probable development of new plant associations, and to continued
speciation because of the abundant new habitats provided and the
abundant opportunities offered for hybridisation.

All of these processes have continued into very recent times and
still, in fact, continue. Thus it has already been noted that the last,
irregular, retreat of the ice did not commence until, approximately,
15,000 years ago. The climate then warmed rapidly, reaching a peak
of warmth, the so-called climatic optimum, 3-5000 years ago when con-
ditions were much warmer than they are at present. Even the rate of
cooling since the climate optimum has been irregular with many minor
reversals in trend. The most recent of these, indeed, falls well within
our own experience as shown by the present rapid retreat of alpine
glaciers throughout the Southern Alps, glaciers which, themselves, may
not be more than a few hundred years old. There are some grounds for
the belief that they did not start to form before the cold years of the
16th-17th centuries. At the time of the climatic optimum, and for some
time thereafter, there may have been little ice left in the New Zealand
high country.

The period of the climatic optimum was, in fact, a period when
podocarp forests spread widely across the present grassland regions of
eastern South Island and far into the now semi-arid intermonts of Otago
and South Canterbury, replacing the grasslands of the late glacial period
and the grasslands and beech forests of the immediate post-glacial.
Much information concerning these forests is accumulating though the
interpretation of this information is difficult for reasons that will become
apparent later. Little is yet known, however, concerning the distribution
and composition of other types of vegetation as they were during the
period of the climatic optimum, though it is becoming increasingly
obvious that many broad present-day vegetation patterns were set at this
time or even earlier. They thus reflect more the events of the past
than the conditions of the present.

I have time for only one example. As is well known, there are no
beech forests in Westland between the Taramakau and Paringa rivers
though the forests to the north and south of these rivers are predomin-
antly beech forests. The explanation appears to be that, between these
rivers, all forests were completely destroyed during the last advance of
the ice. On the retreat of the glaciers, the area was colonised by the
podocarps and their associated broad-leaved species, not by the beech
species as would normally have been expected, simply because of the
pronounced differences that exist in dispersal rates between these two
groups of species. The podocarps and their associated species could
enter rapidly by wind and bird dispersal of seed, the beech species
migrating slowly by gravity fall or water carriage of seed. The replace-
ment of podocarp forest by beech forest, since then, has been slow
because of intense competition in the lowland zone through which the beech species has to pass, and because, during the period of the climatic optimum, regional climates more strongly favoured the podocarp forests. At this time, the advancing beech forests may even have been forced into a temporary retreat. The result of all these things is that, today, in the upland valleys of central Westland, the forests are kamahi-rata forests (with a diminishing podocarp element) even though present day conditions would appear to be most suitable for beech forests.

Many other examples could be given, particularly from the forests that lie along the eastern flanks of the Southern Alps. The main point to note is that vegetation patterns, as we know them, or rather as they were before the arrival of man, were not always attuned to present environmental conditions, because these conditions had themselves undergone such frequent and rapid alteration. Vegetation adjustments and re-adjustments had inevitably lagged behind, the type of vegetation occurring in any one place depending as much upon such factors as the accidental survival of seed sources, the time available for the migration of species and plant associations, and methods of migration, as upon the intrinsic nature of the site.

In other words, the very common assumption that the native vegetation, as it was before man interfered with it, was a stable vegetation existing in a state of harmonious balance with the physical factors and forces of the environment, is palpably erroneous. Even in some of its broadest features, as indicated, the vegetation was climatically out of phase to a greater or lesser extent. In detail, many changes were in progress in response not only to the major climatic events of the past but also in response to the minor climatic fluctuations of more recent times. Present trends in forest composition consequent on the minor climatic variations of the past thousand years have been described elsewhere (2) and I will make no attempt to recapitulate details. I would add, only, that in addition to climatic changes, major and minor, abnormal catastrophes have also played a significant part in the evolution of present-day vegetation patterns, the most notable, of course, being the volcanic catastrophes experienced over much of the North Island, though abnormal storms and earth movements have locally been significant factors elsewhere.

The Influence of Man on the Vegetation

It is against this background of natural environmental and vegetational instability that the impact of man on the vegetation must be assessed. There can no longer be any doubt but that Polynesian man, from the time of his first arrival in the country, was responsible for the destruction of very large areas of forests by fire. In eastern South Island, however, we can rarely be sure to what extent the replacement of forest by grassland, in Maori times, was entirely due to fire. Over much of the area affected, particularly in the case of the old inland and upland

matai and totara forests of Canterbury and Otago, the clearance of the forest was so complete, there is so little evidence of any trend towards forest regeneration, and there are such strong indications that present climates lie beyond the tolerable range of the destroyed forests, that we must suspect the operation of predisposing climatic factors. In other words, a trend toward replacement of these forests by grassland, or perhaps by forest of a more xerophytic type (beech forest) already existed. It is only in a few places of above average rainfall, where local temperature regimes are also favourable, that there is any indication that forest of the old type could redevelop.

Where beech forests were destroyed in pre-European times, regeneration was usually rapid and complete wherever seed sources survived the fires. This is clearly shown in the case of the extensive pole beech forests, with subsoil charcoals, of many North Canterbury mountain valleys. Seed sources, however, did not always survive and, over wide areas, the beech forests were also replaced by grassland. With respect to the grasslands, we do not know how widely or frequently these were burnt. We can only assume that, wherever forest was destroyed by fire, very great areas of the more readily inflammable tussock grassland were also burnt.

The exact amount of South Island mountain country affected by fire in pre-European times is likewise not known but the limits of the area affected were more or less those of the occupied high country of today. This means only that all fires, accidental or intentional, usually stopped short at about the same point no matter by whom they were set, by Polynesian man or by Europeans. The single major exception to this general rule, covering the case of the pole beech forests already mentioned, is only an apparent exception because most of these forests lie within the limits of the occupied high country or border it. In parenthesis, it may be said here that, contrary to popular opinion, the extent of mountain-land forest destroyed in European times, in comparison with that destroyed at an earlier date, was not very great. Much of it was, moreover, pole beech forest or scrub forest, itself of fire origin.

Beyond the limits of the South Island occupied high country, traces of ancient fires can rarely be picked up, and in almost every known instance it is clear that the area affected was very small. There may have been larger conflagrations but, if so, these were so long ago that all consequent fire patterns in the vegetation have been eliminated. In the North Island mountain forests, on the other hand, sign of fire is much more frequent and extensive though it is generally difficult, if not impossible, to distinguish between fires of early human origin and those of natural (volcanic) origin. Fire patterns definitely ascribable to human agency are, however, locally traceable in many places, e.g. in the Urewera county, about the Inland Patea, and in the forests of the northern Tararua range. The very extensive manuka and kanuka scrublands of the mountain country to the east of the Inland Patea, as elsewhere in central North Island, are probably of mixed origin, both Maori fires and volcanic catastrophes being involved.
There were probably other ways by which man modified or disturbed the mountain-land vegetation in pre-European times. Thus both the introduction of the native rat and the extermination of many species of birds undoubtedly had some effect, but these must remain matters for pure speculation. We will never know the facts. All that we can do is to keep such possibilities in mind. Fire must, however, always have been the principal factor on the modification of vegetation patterns and, concerning fire, the most important points have already been noted, namely, that the old patterns destroyed or modified by fire were themselves unlikely to have been stable patterns, and that the effects of fire were felt most drastically over that extent of country now known as the occupied high country.

The story of European times is too well known to need recapitulation. Summarising, we may note the rapidity of occupation of the eastern South Island mountain country from about the year 1855 onwards. This was necessarily accompanied by a prodigal use of fire in the clearance of rank growth, a great part of the country, judging from early descriptions of the height and density of the plant cover, not having been touched by fire for centuries, parts of it possibly having escaped pre-European fires altogether. The use of fire then became traditional and this traditional frequent use of fire in pastoral land management continued for more than fifty years, this also being the period over which sheep numbers climbed to a maximum because of a lack of suitable outlets for surplus stock. Depletion of the grasslands was consequently severe and this led, in turn, to the invasion of most of the high country by rabbits and therefore to continuing depletion despite a steady reduction in both stock numbers and in the use of fire. And, finally, this was also the period of the introduction and spread of many species of game animals, deer, chamois, thar and the like, other introduced animals such as goats, opossums, hares and pigs also contributing, widely or locally, towards the general rapid modification of the vegetation.

It was, in fact, a period of such profound and rapid change, consequent upon the operation of so many new factors at such varied levels of intensity and in so many permutations and combinations, that all details, both of the vegetation as it was and of the stages of modification through which it has passed, must forever remain obscure. And now, today, consequent upon the strict control of fire, control of rabbits, the partial replacement of sheep by cattle, and oversowing and topdressing, a fresh series of changes leading to the development of still new patterns of mountain-land vegetation, has begun, the further modification of the vegetation beyond the limits of the occupied high country, by introduced wild animals, continuing apace.

Conclusion

In effect, the situation can be summed up in one word. It is a word that has, perhaps, been used too frequently already but it is the only appropriate word. The situation is complex. It is complex in broad outline and it is just as complex in detail, for when we come to the study
Block-faulted, tilted, schist uplands in central Otago. Rainfall less than 20in in valleys, rising to 50in plus at higher altitudes. Once forested at least in part but these forests were destroyed long before the arrival of Europeans. The grasslands severely depleted by fire, and past overgrazing by sheep and rabbits but now responding favourably to rabbit and fire control and improved stock management. Primary object of management—pastoral production.

Solid rock highlands in western Nelson. Rainfall 150-200in. Moderate to slight erosion risk. Red, silver and mountain beech forests and extensive alpine grasslands largely of unpalatable species. Moderate past grazing by sheep and, in the valley, by cattle but no current pastoral occupation. Primary object of management—control of water yield for hydro-electric generation.
Recently uplifted alpine schist highlands in central Westland, the schists merging into greywacke towards the main divide. Rainfall 100in plus along the foothills, rising to above 300in per annum in the river headwaters. Kamahi-rata forest, with some podocarps at low altitudes, in early stages of modification by red deer and opossum. Recently-killed rata are conspicuous on the mid-slopes. Depletion of the sub-alpine scrubland and alpine grasslands by deer, chamois, and increasingly, thar. Primary object of management—river control.

Greywacke country in Canterbury. Rainfall 50-80in with heavy winter snow, severe frost action and severe wind exposure. The greywacke is intensely faulted and shattered and is overlain with deep unconsolidated deposits of erosional detritus. Soils wind-deposited and unstable without a protective mantle of vegetation. Forests, mountain beech, burnt in Maori times and again in European times. Grazed by sheep and rabbits for 60 years and today by deer, chamois and hares. Primary object of management—watershed repair.

(PHOTOS: J. Johns, N.Z. Forest Service.)

It has been just as easy to have chosen 400, each illustration a distinct complex of watershed problems.
of individual land management units, be they river, catchments or high-country sheep stations, we soon discover an infinite number of variations on the themes I have already outlined.

There are, in fact, no two mountain-land management units that present precisely the same set of management problems. As soon, therefore, as we begin to discuss management, or future management possibilities, which we are compelled to do because of increasing pressure on the mountain lands, we must avoid all generalisations. If we are to make any progress at all, each case must be considered entirely on its own merits, with a full appreciation of all factors involved—the geological character of the country to the extent that this dictates actual and potential rates of erosion; climatic and soil factors to the extent that these affect both rates and hazards of erosion and the capacity of the vegetation to respond to various management practices; the vegetation and the history of the vegetation with particular reference to points of weakness and to trends in condition and composition: the animals present, their requirements and probable future trends in population levels: and, finally, man and his requirements, long-term and short-term, compatible and incompatible.

The complexity of mountain-land issues, the steady growth of conflicting pressures on the mountain lands, and the need to avoid all generalisations, these are the thoughts I would leave to you. If these points are not widely appreciated, decisions can go, as already remarked to the most vociferous irrespective of the rights or wrongs of their case. The immediate requirement in mountain-land management, in New Zealand, is extreme caution. We can no longer afford to proceed by trial and error. Mistakes in mountain-land management can rarely be rectified.

RESULTS OF RESEARCH PROJECTS

It is the policy of the Committee of Management of the Institute to sponsor and to assist financially projects connected with the understanding and improvement of tussock grasslands and mountain lands which might not otherwise be carried out. Up to the present twenty-three grants have been made to thirteen individuals or institutions and a total of £6,450 has been allocated in the past four years. Six of the projects have been completed and full reports made to the Institute. In each issue of the Review we propose to include accounts of some of these completed reports.

MANUKA (Leptospermum scoparium) AND KANUKA (L. ericoides) IN OTAGO

(For a description of the two species see Review No. 5, September, 1963.)

Miss Juliet Burrell, who travelled 5,000 miles in making her studies, set out to map the present distribution of both species, the factors most likely to be controlling their occurrence and the relationship between the manuka and kanuka communities and the other vegetation types of
the Otago area. The results of the survey and conclusions arrived at by Miss Burrell are given in summary form.

The youngest ages of flowering recorded were four years for manuka and seven years for kanuka. Both species are pollinated by a variety of insects and are self-fertile. This means that, potentially, a new area can be colonised by one plant. Kanuka sheds its seeds annually in April-May. Although some manuka seed from the current season’s flowering is ripe as early as March, it does not normally shed its seed annually. The seed remains in the capsules on the tree for a number of years and can survive the passage of fire through a stand. The capsules open after environmental shocks such as severe frost, fire and an attack of “blight.”

Seed of both species is dispersed by wind and water, and it is also readily transported by man and animals. In both plants, seed germinates within two or three weeks of being shed and rarely gives more than 20 per cent germination.

In general, where the rainfall is over 30 inches a year, undisturbed manuka and kanuka are displaced by forest if seed of forest species is available, but where the rainfall is under 25 inches they will persist as a stable climax association. Where the rainfall is less than 20 inches, both species may be found but only where there is a reasonable ground water supply.

Either species may occur in a particular locality. Where both are present, kanuka succeeds manuka by overtopping it and suppressing it.

At the time of settlement in Otago the pattern of distribution of both species appears to have been incomplete. This is attributed to slow migration by seed dispersed by wind and water following the pre-European destruction of forest and shrubland, and their failure, in the absence of grazing and browsing animals, to compete with tussock grasses after fire. Though both species have spread considerably since settlement, the pattern of distribution still seems incomplete. Whereas burning in the early period of settlement favoured the tussock grasses, today it favours manuka and kanuka, especially the former. This is because grazing after burning keeps the tussock canopy open for sufficient time to allow the shade-intolerant manuka seedlings to establish. Repeated burning and heavy grazing pressure resulted in considerable spread.

The factors which restrict distribution today are:

a. Frost. Manuka may be killed by severe frost.
b. Altitude. Both species have a common altitudinal limit of about 3,250 feet but in most areas it is several hundred feet less than this. When approaching the limit, plants are confined to northerly faces.
c. Rainfall. With less than 20 inches per annum, plants occur only in sites where water is readily available such as crevices where rocks concentrate the water.
d. Excessive soil water. Kanuka will not tolerate this but manuka does.
e. Burning. In most parts of Otago, burning on tussock country is permitted only in July, August and September. This means that manuka seed is immediately available in the burnt area from the scorch-resistant capsules while kanuka does not become available until the following autumn and then has to blow into the burnt area. Repeated burning thus reduces kanuka in favour of manuka.
f. Blight. This scale insect is present in nearly all localities and except near the altitudinal limit is reducing manuka. Kanuka is resistant.
and this fact tends to hasten the replacement of manuka by kanuka.
(At present the fungus attacking the scale insect does not seem to be present in Otago.)

g. Competition with tussock. Except where burning is practised, neither species appears to be able to compete successfully with tussock grasses and in particular with red tussock. Competition with rescue tussock may be partly responsible for the finding of both species only on sunny faces when near the altitudinal limit.

INSECTS OF TUSSOCK GRASSLANDS

Mr Graham White spent over 18 months making a survey and investigation of the insect fauna associated with some tussock grasslands. Included in the study were areas at Dunback, the Mackenzie Country and Porter's Pass, but most of the work was done in the Cass district which was considered representative of tussock grasslands generally and also potentially. It is in a medium rainfall zone; it affords continuous grassland cover over a range from 1,900 feet to 4,500 feet; both tall-tussock and low-tussock associations are present and include four of the five commonest species of tussock; the low-tussock association exists as both improved and unimproved grassland and parts of the latter are in various stages of deterioration.

To make the survey comprehensive, diverse trapping procedures were used designed to account for aerial populations as well as insects inhabiting foliage, litter and the soil. The traps used were grease cylinders, a grease-table, wind nets, a hand net, pitfalls and damp sacks. Additional collecting procedures were sieving of soil samples, hand searching of plants and soil, collecting of tussock samples for insect emergence and rearing of immature insects.

Animals persisted in interfering with the research designed partly for their benefit. Cattle broke light traps, rubbed the grease off grease-cylinders, uprooted damp sacks, uncovered pitfalls and ate the nylon of a wind net.

The total number of insects collected and identified was about 100,000 consisting of over one thousand species. The results indicate that the insect fauna associated with tussock grasslands is both diverse and extensive.

Although some of the species have only an indirect association with the grasslands, the majority are, in effect, directly associated either as plant and carrion feeders or as parasites and predators. Although the range of species may differ from one grassland to another, it is likely that the same orders and families (and even certain genera) which are a feature of the Cass fauna also characterise the fauna belonging to other areas.

Since little is known about the precise habits of many of the insect species occurring in the tussock, their likely economic importance is difficult to estimate. As the major purpose of the investigation was survey, little time was available for study of detailed life histories and habits. However, much was learned about the relative abundance of many and by taking account of previous information relating to habits and distribution, Mr White has attempted to evaluate the economic significance of some of the more important species. In his report he provides lists of these under the headings of leaf and stem feeders, seed feeders, and root feeders. His insect collection has been deposited at
Lincoln College along with his full report which will be available to anyone doing further research in this field.

The Institute hopes that other students will follow up this work with detailed studies of the species of economic importance with a view to finding methods of control.

INFLTRATION IN MOUNTAIN SOILS

Mr A. G. Gillingham made a study of the infiltration properties of a steepland yellow-brown earth under diverse conditions of vegetation near Porter's Pass, Canterbury, at an altitude of nearly 3,000 feet. He worked on three adjacent areas of contrasting vegetation types which had resulted from different grazing treatments of what was originally an almost pure stand of broad-leaved snowgrass (Chionochloa flavescens) in an endeavour to assess the potential hazard of each area to erosion by surface run-off. The slope is about 25 degrees and the rainfall about 50 inches.

On one side of a fence is tall snowgrass which has had very little grazing and approaches virgin condition; on the other side the area has been grazed regularly for the best part of a century. Consequently, the tussocks have diminished and have been replaced by various introduced and native plants of which the commonest are browntop and matagouri. In the grazed area a portion, one square chain in area, was in 1948 fenced by the North Canterbury Catchment Board against grazing by sheep. Natural regeneration has proceeded unchecked (except by hares) since that time with the result that speargrass (Aciphylla colensoi), Draco-phylllum acerosum, and snowgrass have become abundant. Detailed botanical surveys of each site were made.

Using a North Fork infiltrometer specially constructed by the Ministry of Works, Christchurch, water was applied to three sites on each area as simulated rainfall at a uniform constant rate in excess of the soil infiltration capacity. The surface run-off was collected in a tank in which the depth was read to one-hundredth of an inch. Applications of water were made on the existing vegetation and also after the vegetation had been clipped to a height of two to three inches and removed. (Clippings were dried and weighed.)

As the relative infiltration rates of water into different soils is associated with their physical characteristics the following soil physical properties were assessed: primary particle size and aggregate size distribution, aggregate stability, porosity, bulk density, and antecedent moisture content. Of special interest here was the difference in aggregate size distribution between the grazed and regenerated areas indicating that the period of retirement from grazing has had a beneficial influence on the soil aggregation. Comparison of the grazed and snowgrass areas indicated that grazing, with its accompanying reduction in vegetative cover and removal of litter, appears to have brought about a decrease in the number of large aggregates and a corresponding increase in the proportion of fine material, especially in the top-soil.

The report on the project provides a mass of figures of interest to research workers and helpful suggestions for anyone undertaking similar work. The results indicate that retirement from grazing for fifteen years and allowing the vegetation to regenerate, have improved the soil infiltration properties as compared with those of a continuously grazed area, but not yet to the extent that they are in as favourable condition as in the adjacent ungrazed area of snowgrass.
FURTHER NOTES ON ELECTRIC FENCING

L. H. Weston
(Farm Advisory Officer (Farm Machinery) Department of Agriculture, Dunedin)

Since the writing of the Institute's special publication No. 3 “Electric Fencing,” some new techniques and equipment have been developed. Continuing experience has brought changes and improvements to those used in the past.

The following comments are a summary of present recommendations.

(1) Types of Fence

(a) For sheep only. Six wires, all of 12½ gauge high tensile wire, spaced from the ground surface 5in, 5in, 5in, 6in, 7in, 8in. Total height 3 feet. Use 5ft 6in (where possible) waratah-pattern standards or light posts. Have alternate wires earthed and live with bottom wire earthed, top live.

(b) For sheep and cattle. Seven wires—bottom six wires of 12½ gauge high tensile wire, top wire of 12 or 14 gauge barbed wire. Wires spaced from the ground surface 5in, 5in, 5in, 6in, 6in, 7in, 8in. Total height 3ft 6in. Use 6ft (where possible) waratah-pattern standards or light posts. Alternate wires earthed or live with bottom and top (barbed) both earthed.

Six or seven wires, instead of the once popular five, make a better physical barrier of a fence which is still cheap. A strong, substantial fence saves a lot of maintenance.

Barbed wire is more easily seen than plain wire by cattle.

(2) Individual Insulators or Bracket and Chain

(a) Individual polythene insulators (“Beattie,” “Williams,” “Stafix” brands or short lengths of polythene pipe) are cheaper than porcelain and are more reliable in severe frosts. If crossing ground with shallow soil over rock, standards can be shortened by cutting off the bottom to bring the bottom wire to a correct height above ground surface. Side stays may be necessary for short standards.

(b) Bracket-and-chain assemblies are adjustable for height. They are suitable for less-permanent fences. They are more expensive than individual insulator fences.

RECOMMENDED TYPES OF ELECTRIC FENCE

28
(c) Cost comparison.

<table>
<thead>
<tr>
<th>Bracket brand</th>
<th>Total cost of standard and assembly</th>
<th>Insulator brand</th>
<th>Total cost of standard and three insulators</th>
</tr>
</thead>
<tbody>
<tr>
<td>Allways</td>
<td>13/8</td>
<td>Beattie (1/7 ea.)</td>
<td>10/1</td>
</tr>
<tr>
<td>Arcrite</td>
<td>12/7</td>
<td>Stafix (1/7 ea.)</td>
<td>10/1</td>
</tr>
<tr>
<td>Barrier</td>
<td>13/10</td>
<td>Williams (c. 8½d ea.)</td>
<td>7/5½</td>
</tr>
<tr>
<td>(standard)</td>
<td></td>
<td>Homemade from split 4in lengths of</td>
<td></td>
</tr>
<tr>
<td>(alternate earth)</td>
<td></td>
<td>½in high density polythene pipe using</td>
<td></td>
</tr>
<tr>
<td>Speedrite</td>
<td>11/10</td>
<td>12g soft wire to tie-on.</td>
<td>6/-</td>
</tr>
<tr>
<td>(standard)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(two phase)</td>
<td>c. 13/-</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

If 5ft 6in “waratahs” are used instead of 6ft, subtract 3d. per assembly.

(3) Controllers and Electrical Source

An electric fence system needs:

A source of power (mains electricity; wind-driven generation, or daylight cell).

A storage device (wet or dry batteries—none required with mains electricity).

A controller, to give a periodic shock.

(a) A mains unit is effective, reliable and strongly recommended for use whenever possible. There is no need to erect feeder power lines (at a possible cost of £800 per mile) to the fence if remote from a power source. A 14-gauge lead-in wire can be carried on insulators fixed to existing fenceposts for several miles from the present source to the new fence. This lead-in could be used to serve several other fences.

(b) Other types of controllers and chargers currently available:

(i) 6- or 12-volt wet battery and ordinary semi-mechanical controller.

(ii) 12-volt wet battery and low impedance transistor controller (very satisfactory). Two separate shock sources allow some wires to earth without affecting others, when live wires are on separate insulators.

(iii) 9-volt dry battery (6 telephone cells) and controller. Eight months’ continuous service is possible. Satisfactory where insulation good (fence well made; no touching vegetation).

(iv) Solar cell (daylight activated) charger with batteries lasting many years (little maintenance needed).

(v) Wind-powered generator (two makes available) each coupled to a wet battery and semi-mechanical or transistorised controller. Batteries require occasional attention.

(vi) Phillips’ type. This unit of which the mains electricity operated unit will shortly be placed on the market has some novel features. A diagram of its principle is shown.
PRINCIPLE OF THE PHILLIPS ELECTRIC FENCE

There are no working parts and the valve life is expected to be many years. The size of the mains units is about 7½in x 5in x 3½in.

A number of spectacular demonstrations of an experimental model seemed to show no need for insulation of the “live” wire at all and even substantial shocking power without direct contact. This effect was due to the very high voltage output of the model (some three times that of a normal electric fence) being greater than the ability of a weak earth contact (vegetation; wire lying on, or even in, soil) to transfer the charge instantaneously to earth and thus neutralise it. This system is effective without insulators for fence lengths up to about half a mile but, of course, with an insulated fence of greater length gives an outstandingly severe (but non-fatal) shock. The power drain is higher than for a conventional unit but the lack of insulation needed for short lengths of fence and the strength of its shock make it economical. A battery-operated unit is being developed.

CORRECT THREADING OF GALVANISED WIRE
(4) Notes on Fence Construction

(a) Five miles of fence seems to be the practical limit one electric fence unit can be expected to live effectively.

(b) It is very important to have a well-grounded earth wire the full length of the fence. It is preferable to tie earth wires, particularly the bottom one, to standards with 12- or 14-gauge wire for good earthing but if threading wire, pull it, if possible, through the smooth side of the holes in standards and Beattie insulators to reduce the stripping of galvanising from the wire.

(c) Chain and insulator tie-downs are valuable for gullies and dips in hill country but where a number of such tie-downs are necessary, every third one should be a “waratah,” tied down, to give rigidity.

(d) Permanent toothed reel strainers should be used on all wires to keep them tight. If sheep can get their heads through easily, they feel no shock through their wool.

(e) Strainers and corners must be of very good quality to keep tension in the wires.

(f) Ample cut-out fuses should be used to make trouble-finding easier. This is very important where older-type battery units are used.

(g) At gateways, use insulated wire of 1/0.44 TPS grade (1 wire 44 thousandths of an inch thick with tough plastic sheath) buried one foot below ground surface for connecting the electric fence on either side. Preferably use stainless steel wire for earthing.

(h) Since a half-hundredweight coil of 12½-gauge wire is about 33 chains in length, half this or 16 chains is a convenient length for a strain.

(5) Costs of Fences

<table>
<thead>
<tr>
<th>Materials only, per mile</th>
<th>Flat and easy Country</th>
<th>Hill Country</th>
</tr>
</thead>
<tbody>
<tr>
<td>(a) Homemade polythene insulators on 6ft “waratahs” seven wires, top barbed</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>£162</td>
<td>£184</td>
</tr>
<tr>
<td>(b) “Speedrite” standard bracket assemblies on 6ft “waratahs,” seven wires, top barbed</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>£230</td>
<td>£267</td>
</tr>
</tbody>
</table>

(less £15 for sheep only—no barbed wire)

(6) Specification for one mile of fence

(i) “Flat and easy country”: 6 strainer posts, 4 corner posts, 283 “waratahs,” 5 whole-standard tie-downs, 10 half-standard tie-downs, 6 yard standard spacings.

(ii) For “hill country”: 6 strainer posts, 8 corner posts, 208 “waratahs,” 10 heavy tie-downs of “waratah” and chain, 10 tie-downs of half “waratah” to “waratah” standard, 30 tie-downs of half “waratah” to chain.

Average transport costs for farms 50 miles from main centre would be about £20 per mile of fence.

Average erection cost by contract fencer about £80 per mile.
PLANT INTRODUCTION AND TESTING FOR THE TUSSOCK GRASSLANDS AND MOUNTAIN LANDS

In Review No. 7, September 1964, we reported on a seminar called by the Institute to discuss the introduction and establishment of grasses into tussock grassland. The seminar requested the Institute to call a further meeting to go into the details of a research programme of plant introduction and testing for the tussock grasslands. The meeting was held in August 1964 and after a day's discussion by representatives of the Departments of Scientific and Industrial Research and of Agriculture, the New Zealand Forest Service and Lincoln College, set up a committee of six to continue investigations and to produce a report for submission to interested organisations.

The report which follows has the general approval of the participants but does not necessarily commit the organisations concerned.

A. (1) OBJECTIVES

Since 1910, many hundreds of species and strains of grasses and legumes and some other herbs have been introduced and tested in some way as to their suitability for use in tussock grasslands. Work was concentrated largely on the depleted areas in the semi-arid region.

With the passing of the Soil Conservation and Rivers Control Act in 1941 and the subsequent establishment of Catchment Authorities from 1944 onwards emphasis has been placed on the need for revegetating depleted and eroded tussock country. Out of the vast amount of uncoordinated and often uncompleted testing work has come little published material which would point the way to action on the more difficult sites. Failure to achieve conclusive results in most cases was due to such factors as the presence of rabbits, lack of efficient sod-seeding machinery, lack of knowledge of nutrient deficiencies, and inability to control grazing so as to permit establishment and reseeding. The provenances of many of the species and strains used were unknown and detailed records of performances and final assessments are rarely available. In nearly all trials inadequate provision was made for supervision and recording, and time was not allotted specifically for writing up coordinated accounts of the results. Support was forthcoming for initiating but rarely for completing projects.

In spite of the many difficulties, certain species can be recommended for use now on the more favourable sites and methods of establishment and fertiliser requirements are reasonably well known. Some at least of the species have possibilities for use at higher altitudes and on unfavourable sites (e.g. cocksfoot, Dactylis worsenowii, improved strains of tall oat-grass and of tall fescue, species of Agropyron and white and alsike clovers).

It is highly desirable that a comprehensive, coordinated research plan be implemented to explore the possibilities of species already available in the country and of promising introductions not previously available or not satisfactorily tested. Any scheme of plant introduction
must take cognizance of the dangers of indiscriminate introduction and make provision for conscientious screening of species before release for trial in the field.

Two needs must be kept in mind, first that there is a demand for increased production from the tussock country and this stresses the need for considering grazing values, and second, there are areas where the need is solely for protection for soil and water conservation.

(2) PRESENT ACTIVITIES

(a) Forest and Range Experiment Station, New Zealand Forest Service.
   (i) Woody plants. Selection and testing of the most promising species and provenances of exotic woody plants previously tested in a preliminary way at high altitudes followed by large-scale trials of a limited number of species shown to have high potential.
   (Under this latter head come *Alnus viridis*, European larch, *Pinus sylvestris*, *P. contorta*, *Picea engelmannii*, *P. glauca*, *P. montana*.)

(b) Grassland Division, D.S.I.R.
   (i) Plant introduction. The system at present operating provides for the introduction of species of grasses and legumes for the use of the plant breeder who requires plant material from specific overseas localities and of the worker assembling a range of material on which to base a selection programme, and material for workers at substations where such is required for use in their own particular projects.
   (ii) Testing. Introductions are subject to study at Palmerston North or at appropriate substations, e.g. paspalum at Kaikohe and alsike in the tussock country. Promising material is available to the Lincoln substation for testing in the tussock grasslands.

(c) Crop Research Division, D.S.I.R.
   Testing of existing varieties of lucerne in the field in an attempt to find their altitudinal limits.

(d) Physiology Division, D.S.I.R., have introduced about 80 species of North American alpine plants for testing in New Zealand high country.

(e) Department of Agriculture
   Farm Advisory Division—testing of several strains of cocksfoot in the Waitaki and Waimakariri Valleys. Soil Conservation Service—introduction and testing of willow species.

(3) RESEARCH PLAN

(a) Introduction
   It is highly desirable that further introductions be made to enable the incorporation into existing grasses and clovers with potential for use in tussock grasslands, of genes for such factors as hardiness, winter
growth, ability to forage for phosphate, ability to establish and grow at low pH.

To enable the maximum benefit to be obtained from future introductions it is essential that New Zealand should send collecting expeditions overseas. In addition to selecting plants of species already used here, if they have the characters mentioned above, they should search for species of grasses, legumes, other herbs and edible shrubs which might have a place in the New Zealand programme. In the case of plants already tried here, expeditions should remember that available provenances today may perform here very differently from those previously tried.

(b) Re-assessment of previous introductions

(i) The records of past introductions should be assembled and analysed and species which show high potential should be further tested, using modern techniques. If they fail to establish and persist the reasons for failure should be fully documented. Early inspections should be made of trial areas sown since 1910 and material collected of species still persisting.

(ii) A very few selected species from previous introductions, e.g. *Agropyron* spp., *Bromus inermis*, *B. carinatus*, should be tried on ploughable land on runs under conditions of high fertility and in conjunction with legumes in several climatic zones. It is possible that there may be strains which can give a wider spread of production than the grasses now used. Immediate action should be taken to obtain or produce seed in sufficient quantity for such trials.

(c) Methods of sowing and establishment

Old material being re-assessed and new introductions should be given every chance to establish (whether by sod-seeding or oversowing) by using the best techniques of inoculation and pelleting. To ascertain these we need a comprehensive programme involving testing of techniques of pelleting with lime and with fertiliser of both grasses and clovers. Testing of grasses at the field scale should be done in conjunction with legumes.

Rhizobia for use in tussock grasslands are faced almost universally with low pH. Work should be aimed at locating and selecting strains of rhizobia which can tolerate low pH and other adverse conditions.

On badly depleted areas testing should include the use of annuals, including annual clovers, as a base for the establishment of perennials.

(c) Introduction procedure

Overseas material consisting of grasses and legumes should be imported through the Plant Introduction Section of Grasslands Division, D.S.I.R. which has excellent storage facilities for small quantities of valuable material. Preliminary screening should be given at Grasslands, Palmerston North or at Lincoln or Gore. Any testing on a field scale of plants passing the screening tests should be carried out on sites in the tussock grasslands, e.g. Pukaki out-station (D.S.I.R.); Tara Hills Research Station; or selected runs. Plants surviving the tests would be made available to the plant breeders for further work.
(e) Testing of indigenous species

It is considered that there should be a programme of testing known strains of indigenous species such as *Chionochloa* spp., *Agrocyran scabrum*, *Deyeuxia avenoides*, *D. forsteri*, *Dichelachne crinita*, *Festuca matthewsii*. The work should aim at assessing their suitability for both occupied and unoccupied land. (Species which might not prove suitable under grazing may have high conservation value.)

(i) Study of the ecology and phenology of the species selected (work has already been done on a few species) to discover site preferences, to determine flowering and seeding behaviour and to ascertain management methods best suited to increase seeding and establishment at the higher altitudes.

(ii) Establishment of a small base nursery at Lincoln for the further comparative study of species and to provide a source of seed for field testing.

(iii) Investigation of seed treatments (e.g. the use of the hammer mill to remove awns) to enable easier handling and sowing. Trials should be made with a very few promising species to investigate the costs of producing seed commercially and the problems of storage.

(4) PARTICIPANTS IN THE SUGGESTED PROGRAMME

The following are already involved and are interested in continuing in research in the field of plant introduction and testing for the tussock grasslands and mountain lands:

Botany Division, Grasslands Division, Plant Physiology Division, D.S.I.R.

Forest and Range Experiment Station, N.Z. Forest Service.

Lincoln College—Departments of Microbiology; Soil Science; Plant Science.

Research Division, Department of Agriculture.

Tussock Grasslands and Mountain Lands Institute.

Organisations likely to be interested in the programme largely because they are concerned with application of research results are:

Soil Conservators of Catchment Authorities.

Farm Advisory Division, Department of Agriculture.

High-Country Committee, Federated Farmers.

Pastoral Lands Officers, Department of Lands and Survey.

(5) PRIORITIES

The committee thought it unwise to divide the proposals into separate projects and attempt to suggest priorities. It felt that only the necessary elements of a coordinated programme had been listed and that they should go forward simultaneously on a broad front.

(6) PROCEDURE

In all discussions preceding the production of this statement it was assumed that projects will be carried out on a basis of full cooperation between interested organisations.
For instance, the Departments of Microbiology, Soil Science and Plant Science at Lincoln College have agreed to pool their resources for work on the particular field of introduction and establishment of legumes into occupied tussock grasslands. The facilities they have for collection and testing of rhizobia and for testing the quality of such things as pelleted seeds will be available to workers in the D.S.I.R. and Department of Agriculture.

The New Zealand Agricultural Engineering Institute will give a high priority to the development of improved sod-seeding equipment so that seeding trials may be carried out under the best possible conditions.

The Tussock Grasslands and Mountain Lands Institute will assist with personnel, transport and contacts with runholders. Together with the Forest and Range Experiment Station it will take a particular interest in the unoccupied land.

Cooperation at the stage of individual projects could be assured by the formation of sub-committees which could be serviced where necessary by the Tussock Grasslands and Mountain Lands Institute. Any part of a research plan for introduction and testing for the tussock grasslands should be embarked on only after assessing the total agronomic and other requirements until the completion of the project. The history of plant introduction for tussock grasslands is full of promising beginnings but even the comparatively well-supported experiments at Tara Hills seem to have failed to reach the desirable endpoint of firm recommendations, positive or negative.

B. A RECORDING SYSTEM

It would appear to be hopeless to attempt again to have established a central Plant Introduction Service for the introduction of plants of all kinds. Nor does there seem to be much interest in the establishment of a Central Register of Plant Introduction even though this could be shown to be highly desirable.

For research workers it is essential that a register be kept of all grasses, legumes, other herbs and woody plants introduced for testing in the tussock grasslands and mountain lands.

It is recommended:

(i) That the present organisations concerned with these introductions continue in their fields: Grasslands Division—grasses and legumes; Forest Research Institute—woody plants, and that some organisation take responsibility for herbs (other than grasses and legumes) and edible shrubs.

(ii) That these organisations should supply the requisite information to Botany Division, D.S.I.R., Lincoln, to enable it to keep a register of introductions, records of performance, advice as to seed available. All notifications of introductions should be accompanied by voucher specimens.

(iii) That evaluation of species in preliminary screening should take note of such factors as:
b. The nature of reproduction (e.g. sexually by seed, or asexually by rhizomes, stolons, corms, bulbs, suckers; ability to produce adventitious roots on broken stems).
c. The nature of the fruits and their means of dispersal. (Whether likely to depreciate wool, cause mechanical injury to stock or humans).
d. Whether there are any characteristics which could be of negative economic importance.
e. Palatability.
f. Botanical relationship with known weeds in New Zealand or overseas.
g. Whether, while a suitable plant for a particular habitat, e.g. tussock grassland, a plant might have undesirable features should it spread to other habitats, e.g., fertile flats.

(iv) That the Tussock Grasslands and Mountain Lands Institute produce a regular Newsletter summarising activities and preliminary results of plants being tested. This Newsletter should be distributed to interested research workers in cooperating organisations, e.g. Grasslands, Botany and Plant Physiology Divisions and Soil Bureau, D.S.I.R.; Forest and Range Experiment Station, N.Z. Forest Service; Research Division, Dept. of Agriculture; Lincoln College; Massey, Canterbury and Otago Universities. It should also go to interested soil conservators in Catchment Authorities and the Department of Agriculture; farm advisory officers, Department of Agriculture working with runholders; pastoral lands officers, Department of Lands and Survey. Such a Newsletter should contain full details of field trials of new introductions.

HISTORICAL SUMMARY OF INTRODUCTIONS TO THE TUSSOCK GRASSLANDS

1910

In January 1910, A. Macpherson, Fields Instructor, Department of Agriculture, was sent by the Minister to investigate depletion of tussock in the Mackenzie(1). He selected areas on which to conduct experiments with the growing of grasses and fodder plants “for revegetating the depleted country” and rabbit-fenced eight acres on Sawdon (Burnett), ten acres on Haldon (Preston) and one acre on Simons Pass (Matheson). Twenty-seven species of grasses and fodder plants selected by A. H. Cockayne were sown in plots in October 1910.

On Earnscleugh, Central Otago, an area was fenced and sown in November, 1910. Seeds sown in plots were:

1. Cocksfoot
2. *Poa pratensis*
3. Chewings fescue
4. *Festuca duriuscula*
5. *F. ovina*
6. *F. rubra*
7. *Danthonia pilosa*
8. Prairie
9. *Lotus corniculatus*
10. Red top
11. White clover
12. Dogstail
13. Chicory
14. Yarrow
15. *Bromus inermis*
16. Sheep’s burnet and sainfoin
17. *Melilotus alba*
18. *Anthyllis vulneraria*
19. *Tricholoma rosea*
20. Tall oat-grass

(21 was omitted at Haldon and Earnscleugh and 27 at Simons Pass and Sawdon.)

Seeds sown in drills were: *Chloris virgata*, *Festuca dumatorum*, *Phalaris canariensis*, *P. commutata*, *Buffalo grass*, *Choetochloa caudata*, *Panicum plenum*, *P. bulbosum*, *Boutiloua cantipendula*, *B. oligostachya*, *Sporobolus wrightii*, *S. cryptandrus*, *Leptochloa dubia*.

Mixtures were also sown, three plots at each site.

Reports were made by field officers a year later and by Macpherson in 1912 when he mentioned that in October, 1911, the following had also been sown: *Agropyron scabrum*, *A. pectinatum*, and *Triodia nuda*.

In October, 1913, Macpherson(2) reported that there were 408 plots of grasses, clovers and deep-rooted plants in the Mackenzie and Central Otago, that five sowings had been made at Sawdon, Haldon and Earnscleugh and two sowings were made at Whalesback. He said that spring sowings were better in the Mackenzie and autumn sowings in Central Otago. Surface sowing was a “waste of money,” cultivation was not much better if the seed were broadcast, but good results followed cultivation and drilling.

Promising species were: Tall oat, *Bromus inermis*, cocksfoot, prairie, white clover, lucerne, burnet, chicory, sainfoin, yarrow, *Phalaris commutata*, *Festuca dumatorum*, ribgrass, Bokhara clover, *Agropyron repens*.

1911

In 1911, A. H. Cockayne(3) drew attention to the widespread occurrence of Australian spiked blue-grass (*Agropyron pectinatum*) and suggested sowing it on dry depleted faces.

1920


Cockayne reported on the trials in 1922(4) as did R. B. Tennent in 1935(5) but it is unfortunate that no subsequent reports have been published.

1921

In 1921, F. E. Ward, Department of Agriculture, in cooperation with Canterbury College made sowings on unenclosed areas at Haldon (1200ft) and at Mt. Possession (2000ft). In 1923 he reported(6) that success was obtained on shady faces sown on frost-cracked soil in Septem-
ber, the most encouraging species being: Fog, cocksfoot and yarrow; with white clover, burnet and Poa pratensis in second place; followed by lucerne and tall oat-grass. He planned to sow in spring of 1923:

South African spp.: Ischaemum glauchatichium, Panicum maximum, P. laevifolium, Pennisetum cinnoides.

Queensland spp.: Eriochloa annulata, Panicum (2 spp.), Setaria glauca.

1924

In 1929, R. McGillivray reported (7) that the areas at Haldon and Whalesback were still under the control of the Department of Agriculture. At Haldon on the shady face sown in 1921 in spite of grazing all year round, cocksfoot, yarrow, Poa pratensis and some perennial ryegrass were in good healthy condition. At Whalesback, white clover sown in 1911 covered several acres and in places with Poa pratensis and with yarrow was making "a splendid sward." Zig-zag clover transplanted there in 1924 was prolific and good growth had been made by cocksfoot, tall oat-grass, burnet, fescues, browntop, red top and yarrow.

1938

In 1944, G. G. Calder published an interim report (8) on the Pisa Flat Experimental Area of 30 acres taken over by the Fields Division, Department of Agriculture. Part was rabbit-fenced and used for a variety of sowings with subsequent grazing treatments. By 1944, 195 strains and species from all parts of the world had been sown. In 1944 Calder considered lucerne, cocksfoot, tall oat-grass, Agropyron scabrum, Poa pratensis, browntop, Danthonia pilosa, sub. clover, yarrow, Chewings fescue, and crested wheat grass to be giving best results.

Work at Pisa Flat was carried on by J. M. Hercus and discontinued in 1951. Altogether 350 species and strains had been tested for their suitability for semi-arid areas, but no final report has been published.

1938

In 1940, S. H. Saxby reported (8) on trials on the establishment of clovers on depleted land at Mowhiti, Central Otago. Seeds of white, Mont. red, Lotus spp., alsike, strawberry, suckling, striated, clustered, haresfoot and subterranean (Mt. Barker, Tallarook, Dwalganup) were surface sown and lime and superphosphate were used in various quantities. Two years later he concluded that annual clovers were not easy to maintain and perennial clovers needed superphosphate and lime.

1944

In 1934, the Botany Division, D.S.I.R., undertook "a long-term project of observation and experiment on the Molesworth and Tarndale blocks of high country in inland Marlborough." One of the objectives was "to select species of grasses and legumes useful in renovating the grasslands, to propagate them and to make trials in different localities."

Trials began in 1944 near the Molesworth homestead at 2900 feet and sowings were made annually from 1944 to 1953. In 1961 a detailed report was published (10) on the performance in nursery rows of 40 species of exotic grasses up to 1954. The more attractive grasses in order were:
Agropyron cristatum, A. elongatum, A. intermedium, Bromus inermis, Dactylis woronowii. In 1954 the area was mown and opened intermittently to grazing until 1960 when it was ploughed and sown to lucerne. The paper comments on the success of surface-sowing of cocksfoot on the run, higher rainfalls 1953-7, and decrease in rabbits as resulting in a "waning interest in the unfamiliar and, on the whole, less well-adapted grasses" used in the trials.

1948

In 1948, T. G Sewell commenced trials at Craigieburn, Canterbury. Seeds were spring-sown in single rows on cultivated land without fertiliser.

In 1952 Sewell(11) reported that Agropyron intermedium and A. dasystachium were the most promising species followed by Bromus carinatus, cocksfoot, burnet and alsike. Some strains of Agropyron scabrum, supplied by H. E. Connor, did particularly well, growing as vigorously as any of the introduced grasses. The promising species were sown out in plots on cultivated ground in grass-legume mixtures and topdressed with lime and superphosphate. Broadcast sowings on the grassland failed to establish.

Sewell's work was continued in the Waimakariri Catchment by A. R. Dingwall and L. C. Bascomb in 1951 and 1952.

1948

In 1956, H. M. Sievwright reported on work at Holbrook at 2200 feet, from 1948-1956(12). Basing his work on the persistence of certain species sown at Holbrook in 1910 he used broadcasting and drilling with the Blackmore grassland tips and applied two hundredweight of equal parts of lime and superphosphate. In one trial he sowed plots of Agropyron cristatum with lucerne, Lotus spp., subterranean, white, strawberry and sweet clover, sainfoin, burnet and chicory. In another he used a basic mixture of dogstail, lucerne, sub. and sweet clover to which was added in turn Agropyron intermedium, Ehrhata calycina, Bromus carinatus, Phalaris tuberosa, Chewings fescue, tall oat, browntop and cocksfoot.

In October 1951 he sowed 8½ acres for a grazing trial with cocksfoot, tall oat, tall fescue, Danthonia pilosa, white clover, alsike, Mont. red., Tallarook sub., suckling. To one acre he added lucerne and to another sweet clover. Establishment of white, alsike and red clovers was good and cocksfoot, tall oat and tall fescue were the best of the grasses. From May to August 1953 the area grazed two and a quarter sheep per acre. The grazing trial created such interest that between 1953 and 1956, 1200 acres of tussock were drilled with grassland tips in South Canterbury.

After seven seasons at Holbrook recommendations were for sub-surface drilling where possible of seed and fertiliser, the use of white, alsike and red clovers, with cocksfoot and tall oat, the spelling of sown areas for four months, control of clover by grazing it and subsequent topdressing to maintain the sward.
1948

In August 1948, G. A. Dunbar entered into residence at Tara Hills and commenced work on plant introduction and testing. Off and on he was closely associated with this work until December 1955 when it was carried on by I. A. McNeur (who went to Tara in June 1953) until the late 'fifties. (A list of 180 strains and species tested by Dunbar and McNeur up to 1956, with ratings, is available, but no reports have been published.)

The most promising grass and legume species in the trial plots, after being subjected to severe grazing trials, were established on seed-increase areas. In 1956 and 1957 the annual reports of the Soil Conservation and Rivers Control Council mentioned the most promising species as being: smooth brome, intermediate wheat grass, weeping love grass, creeping-rooted lucernes, tall oat-grass var. Tualatin, Bromus popovii, Dactylis woronowii, Phalaris tuberosa, tall fescue and sheep's burnet. Reference was also made to the sowing separately in replicated blocks of several clovers and lucernes at four altitudes from 1600ft to 4000ft.

1949

A large-scale trial was sown by J. M. Hercus in March 1949 on 80 acres of depleted land on the property of D. J. Kane near Hawea Flat. In 1954 he reported (113) "On bare exposed slopes with little or no soil cover no exotic species have been found which can establish and thrive after oversowing."

1953 Ophir.

Plant introduction trials were laid down at Ophir, Central Otago, on depleted Dunstan stony loam from 26 February to 30 March 1953. One hundred and fifty-three species and strains were sown on plots which had no previous lime or fertiliser and which was double rotary hoed before sowing and after sowing.

(A list of sowings is available.)

Reports on establishment were made in November 1953, June 1954 and December 1954.

1954

Nursery rows of 70 species and strains were sown 20 September 1955. These were also grown at the base nursery at Tara Hills.

(A list of sowings is available.)

1956

Ten more species were sown May 1956.

A note in July 1956 stated that there was good establishment of all grass species and all legumes established well especially the lucerne varieties which were outstanding.

1956

In September 1956 a further 179 nursery rows were sown. (Rows 11-17, 28-34, 45-51, 62-68 were treated with two hundredweight nitro-lime at sowing across half of each row. Rows 79-84 were treated by inoculating half of each row.)
A report on five years' work indicated that "it is possible to revegetate this severely depleted country."

"Preliminary observations at the plant testing nursery have shown the striking superiority of lucerne as a legume. Few grass species showed superiority to cocksfoot at any one time of the year and none over the whole year. Also although on the half-acre grazing blocks cocksfoot was not the best in the number of sheep grazing days it supported, it recovered more rapidly than most other blocks."

Observations on both nursery and trial sowings showed the following factors to be important in ensuring successful establishment:
1. Early spring sowing.
2. Drilling seed, especially legumes, into the ground.
3. Using artificial nitrogen enables species better to withstand the rigours of the climate, gives increased establishment, and earlier seed-set. Use of superphosphate at sowing is desirable (it may be the sulphur which produces the response).
4. Inoculation of all legumes, if not essential is nevertheless very advantageous.
5. On this low-fertility, dry country plants must be allowed to mature before defoliation. This may be more than one season. It is essential that such sowings be fenced.
6. The prime factor in rehabilitation is control of the rabbit.

At the conclusion of the report a recommendation was made that 100 acres be sod-seeded in the spring of 1957 with Marlborough lucerne and cocksfoot in alternate rows; the cocksfoot to have half a pound Tallarook subterranean clover added.

A request was made for the detailed observations on the nursery to be statistically analysed.

The area was opened to grazing and weeds were controlled by cultivation. No further sowings had been made.

No reports are available since 1959.

The nursery area was on a river terrace of fescue tussock on the Motatapu Road on the property of Mr A. Scaife. Sowings were made on 6 October 1955 of some 108 single rows of species and strains also grown at the base nursery at Tara Hills. A list of sowings is available.

A report on 2 April 1957 stressed the importance of inoculating legumes in nursery sowings. Inoculation gave increased rates and numbers of initial establishment. There was "no question of the high-producing clover strains over the low-producing clovers and medicks for this high-rainfall tussock country."
1957

At a meeting in December 1957 it was decided that no more detailed recordings of plant performances in nurseries would be taken in the meantime.

1958

24 October. The area was oversown with clovers between the rows to eliminate the necessity for weed control. This clover had established well by April 1959 and the area was opened to grazing.

1955

At Fruitlands, Central Otago, in September-October 1955, 57 species and strains were sown in single rows (list available). All were growing in the base nursery at Tara Hills and it was proposed to make observations and attempt to correlate with data at the base nursery. (No report is available.)

1962

In a Directory of Research prepared by the Tussock Grasslands and Mountain Lands Institute the following trials were reported:

(a) Dr B. Hercus: Testing of survival of 10 overseas strains of cocksfoot and comparison of performance with New Zealand strains at six sites (2800ft-3400ft) near Porter’s Pass and in the Waitaki Catchment. The trials were laid down in 1960. The 1963 Annual Report on Field Research Work of the N.Z. Department of Agriculture says that “one striking feature has been the superior tillering and growth of all strains on the more fertile schist soils of Otago compared with the production on the greywacke soils of the Waimakarir. As regards differences between strains of cocksfoot, there have been variations between sites but in all cases both C23 and Grasslands strains have been as vigorous and productive as any of the introduced material.”

(b) J. W. Kinder: At Tara Hills, a variety trial with sub. clover, nine varieties compared with Mt. Barker and Tallarook and with white clover on depleted fescue tussock.

Anyone reading this sketchy account must have been struck by the number of times the same plants keep cropping up. The following case histories recorded by Botany Division should point a moral for all would-be introducers.

_Bromus inermis_

Examples of trials:

1910 Clyde, Central Otago
  Simon’s Pass, Sawdon,
  Haldon, Mackenzie Country,
  Earnscleugh, Central Otago.

1911 Earnscleugh.

1944 Waiwhetu Nursery.
  Molesworth Nursery.
  Te Akatarawa Station.

1945 Pisa Experimental Area

1948 Molesworth, broadcast.
  Cockayne plots, Dunstan.

1951 Craigieburn.
  Tara Hills.
  Wither Hills.
  Winchmore and Ophir.
  Earnscleugh.
  C. E. Kerr, Orton, Geraldine.
  G. Murray, Glenmore.

1952 G. Barnes, Craigieburn.
Agropyron cristatum

Examples of trials:

1935 G. Keliher, Springvale, Central Otago.
1936 McElroy, Bannockburn.
1938 A. Scott, Gibbstown, Otago.
1944 Te Akatarawa Station.
   Mt. Edwards plot.
1946 Pisa Flat.
1947 A. Young, Tarras.
1948 Waiwhetu Nursery.
   Molesworth Nursery.
   Molesworth, broadcast.
   Craigieburn.
   Holbrook Station, Fairlie.
   Cockayne plots, Cromwell.
   G. Barnes, Craigieburn.
1949 Tara Hills.
   Earnscleugh.
   Wither Hills.
1944 J. C. Saunders, Central Otago.
1947 O. J. Kane, Hawea Flat.
1948 Blue Cliffs, South Canterbury.
1949 Kaka plot, near Lake Coleridge.
   S. Hunt, Otago.
1950 Ophir Experimental Plots.

REFERENCES

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