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THE RESEARCH RESULTS
AT A GLANCE

If you haven't time to read all this "Review," you may like to know some results of immediate interest.

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
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<tbody>
<tr>
<td>1.</td>
<td>You can improve the standard of your flock by weighing the fleeces from the young sheep and culling the low producers. This is more trouble than culling by eye, but the Australians found it to be really worthwhile (Hansen; p. 3).</td>
</tr>
<tr>
<td>2.</td>
<td>You can increase your lambing percentage by reducing the number of barren ewes. You can do this by feeding your young sheep well so that they have a high bodyweight when they start to breed (Coop; p. 7).</td>
</tr>
<tr>
<td>3.</td>
<td>Tordon is the best chemical yet for killing sweet brier. But before spending a lot of money, you should consider if the value of the brier-infested land is really worth the cost of clearing it (Moffat; p. 11).</td>
</tr>
<tr>
<td>4.</td>
<td>The Americans found that feeding beef cattle too well in winter can reduce calving. They also found that cows poorly fed in winter but well fed in summer gave better lifetime production (Barton; p. 20).</td>
</tr>
<tr>
<td>5.</td>
<td>Snow tussock, contrary to what has been thought before, is well adapted to its environment. But it is easily killed by repeated heavy grazing after fire (Mark; p. 28).</td>
</tr>
</tbody>
</table>

If you are not clear about these or any other points in the "Review," please don't hesitate to contact the Institute (Box 56, Lincoln College; phone Christchurch 62-839).
NO CONFLICT OF INTEREST

It is often stated that the need for soil conservation in the high country conflicts with the need for pastoral production. Runholders frequently jib at the idea of destocking vast tracts of country for soil conservation purposes. They consider that much valuable grazing land would be lost to the nation, and that New Zealand’s balance of payments would be made even worse than it is.

We cannot agree. The old system of extensive grazing on unimproved native pasture is neither highly productive nor does it conserve the soil. Under it, stock numbers on much of the high country are now about half what they were in 1900; a dismal record of productivity. Again, the system has been associated with perhaps the worst case of accelerated soil erosion in the western world. It would be quite wrong to blame burning and sheep grazing for all the mess we see today. But, to be at our most tactful, it is difficult to believe that sheep are doing this highly erodable country much good.

The grazing of unimproved pastures was, of course, the only system possible in the old days. But now the development of aerial oversowing and topdressing has at last given a chance to break away from the old ways of low production and soil erosion. It is beyond doubt that much more wool and meat could be produced in the high country if runholders forgot about their Class VII and VIII lands and concentrated upon developing their lower areas which at present lie more or less idle. Many of the more progressive runholders are already showing how this can be done. For example, wool production on a large Southland run has rocketed from 135,000lb to 200,000lb within four years of starting development. Yet 17,000 acres of higher country did not see a head of stock this summer and, due to the increased feed on the oversown and topdressed country, only 9,000 sheep were available to graze a further 40,000 acres. Again, a smaller North Canterbury run has replaced large tracts of Class VIII land with 600 acres of developed ram paddock.

The high country is now at the end of an era. The old system of extensive grazing of unimproved native pasture is slowly dying. Let us not bemoan its passing, for it has not served New Zealand well. Instead, let us look forward to better years ahead; years in which pastoral production will be higher and in which a start can be made on the repair of the ravished hillsides. We must be quite clear that soil conservation and increased pastoral production go hand in hand. There is no conflict of interest.

S.N.A.
SELECTING SHEEP FOR BETTER WOOL
By W. J. Hansen
Department of Agriculture, Dunedin.

Runholders can increase their sheep and wool production in several ways. The greatest gains can be made by using over-sowing, topdressing and subdivision to grow more feed and thus to raise stock numbers. However, selection of sheep can also be very beneficial.

The success of a breeding programme for increased production will largely depend on:

(a) The accuracy of selection of the high-producing sheep.
(b) The degree to which the superiority of high-producing sheep is passed on to the progeny.
(c) The culling rate.

(a) Accuracy of selection

Many of us like to believe that we can select the high-wool cutters by eye. This is easy and quick, but unfortunately not very accurate. Many experiments have shown that fleece weighing is a better method of selection.

For example, a professional sheep classer in Australia graded 430 two-tooth ewes by eye. 105 of the worst he culled altogether. Of the remaining 325, he put 74 into the top, 125 into the intermediate and 119 into the lowest grade. The ewes were shorn approximately three months later and the fleeces weighed. The sheep could therefore be classed by measurement.

<table>
<thead>
<tr>
<th>TABLE 1</th>
<th>The Efficiency of Selection Methods in Judging Fleece Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>very best ewes</td>
</tr>
<tr>
<td>Professional classer (by eye)</td>
<td>15.8</td>
</tr>
<tr>
<td>Measurement (by weighing the fleece)</td>
<td>14.9</td>
</tr>
</tbody>
</table>

* 110 sheep only because 9 were culled at shearing.

Table 1 shows that eye appraisal gave a difference of approximately ½ lb per head between each of the three groups. This looks reasonably good, but not nearly so good as the difference of approximately 1¼ lb per head obtained by weighing the fleeces. This proves that measurement is much more efficient than judging by eye for selecting the higher producing sheep. This result is typical of many such checks on the accuracy of eye appraisal.
TRANGIE REGISTERED MERINO STUD

TOP STUD FLOCK
Top stud flock clipped 1 lb more wool than second stud flock.

SECOND STUD FLOCK

NORMAL STUD FLOCK
Rams bought from major stud for 400g. each. Selection by eye.

CONTROL FLOCK
No selection practised.

SPECIAL SELECTION FLOCK
Fleece weight selection by weighing. Conformation and wool fault selection by eye appraisal. Ewe fertility selection by actual lambs weaned to ewes. Rams selected on clean fleece-weight and are semen tested. All replacements bred in group but no inbreeding.
(b) Degree of superiority of progeny

The heritability factor for fleece weights in Merinos and Romneys is high enough for direct selection to be effective. There is no reliable figure for Corriedales.

Work at the Trangie experimental farm in New South Wales has shown the value of selecting Merinos. The flock on this farm was divided as on opposite page.

Table 2 shows the performance of these flocks. The figures are from the unculled maiden ewes averaged over the last three-year period of the trial.

<table>
<thead>
<tr>
<th>TABLE 2</th>
<th>Performance of Unculled Maiden Ewes in Selection Trial</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flock</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Greasy fleece wt (lb)</td>
</tr>
<tr>
<td>A</td>
<td>12.9</td>
</tr>
<tr>
<td>B (selection)</td>
<td>12.8</td>
</tr>
<tr>
<td>B (control)</td>
<td>11.4</td>
</tr>
</tbody>
</table>

Selection by measurement has improved flock performance remarkably. The selected flock is not only superior to the control flock but has also overtaken the A flock which was superior at the beginning and which was serviced with expensive rams.

To carry out such a scheme, the young sheep must be tagged and the fleeces weighed at shearing. The results show that this is really worthwhile.

(c) Culling rate

Culling rate is very important. It cannot affect the accuracy of selection or the degree of heritability, but it does alter the standard of the sheep retained for the flock. The higher the culling rate, the quicker the gain. The culling rate depends upon

(a) lambing percentage

(b) death rate

(c) the number of matings in an animal's lifetime

(d) whether the flock numbers are rising or falling.

In Australian experiments, the identification of multiple birth and culling of dry ewes has increased the lambing percentage. I have seen Merino flocks over there marking and, sometimes, weaning over 130 per cent of lambs based on ewes put to the ram. Such high lambing percentages permit a high culling rate and a consequent rapid increase of wool production. Multiple births would not be desirable on much of our run country,
however, but lambing percentage can be raised by culling dry ewes.

Flushing and higher body weights will do a lot to lift fertility and both these factors are related to the feeding of the ewe. Fertility on several Merino properties in Otago has increased markedly following oversowing and topdressing. This practice has given:

(a) higher body weights
(b) extra feed for ewe flushing
(c) bigger fleece weights
(d) better hoggets
(e) less deaths.

For any breeding programme to be successful, there must be a reasonable culling level. No real gain can be made where lambing percentages are around the 70 mark. First things must come first, and it is sometimes necessary to temporarily forget wool improvement, except in ram selection, and concentrate on increasing the lambing percentage so that culling may be successfully carried out.

THE AILMENTS OF HORSES

Our horsey readers may often have felt the need to diagnose their horses' ailments at a glance. To help them, we have pleasure in presenting—perhaps for the first time this century—this series of vivid illustrations throughout this Review.
SOME VITAL STATISTICS OF HIGH COUNTRY SHEEP FLOCKS

By I. E. Coop
Professor of Animal Science, Lincoln College.

Little is known about factors affecting the wool production and reproduction of high-country sheep. Four high-country flocks were therefore studied to gain some information. The flocks examined were at Castle Hill in the Waimakariri, Barrosa in the Ashburton, and Glenfallock in the Rakaia and Irishman Creek in the Mackenzie Country. The first two flocks are half-breds mated first as two-tooths and the second two are Merinos mated first as four-tooths.

METHODS

About 500 maiden ewes at each run were tagged and weighed just before mating in May or June. The fleeces from the tagged ewes were weighed and graded at pre-lamb shearing. At tailing in December, barren ewes were identified by examining the udder.

Only young sheep were studied. Maiden ewes were measured in 1962 and the observations repeated in 1963 with the new intake of maiden ewes. Also in 1963, further observations were made on the 1962 ewes of which the halfbreds were then 4-tooths and the Merinos 6-tooths. In 1965 the Castle Hill ewes and a sample of the Irishman Creek ewes were again weighed and samples of ewes of all ages at Haldon Station were weighed.

RESULTS

The full results are being published in the scientific press and reprints can be obtained on request. This article shows only the results which may be of immediate interest to runholders.

(1) The Effect of Liveweight on Barrenness

Fig. 1 shows that, on average, the larger ewes are less likely

![Diagram showing percentage of barren ewes at different weight categories]

**FIGURE 1**
Weight of Ewes Before Mating and Percentage of Barren Ewes
Average Results for Two Years at Four Stations
to be barren. Each flock gave the same picture. At the same liveweight, there was no obvious difference in barrenness between two, four, or six tooths or between Merinos and half-breds. It thus seems that liveweight before mating is one of the more important factors affecting barrenness.

(2) Growth of the Ewes

Ewes weighed in May 1962 were again weighed in May 1963. Table 1 shows the liveweight gains of both the wet and dry ewes. It is clear that wet ewes did not gain weight. In the three years from 1962 to 1965 the ewes at Castle Hill gained only 2lb while those at Irishman Creek lost 4lb. Even at Haldon Station there was no increase in liveweight after entering into the breeding flock. This picture is very different from that found on the lowlands. Plains' sheep are not only much larger than high-country sheep of the same age, but also they continue to gain weight until five years old.

(3) Quantity and Quality of Wool

Table 2 shows that, on all stations, the bigger sheep produce the most wool. On average, each 10lb increase in liveweight is associated with two-thirds of a pound increase in fleece weight. The heavier fleeces from the larger sheep were higher in grade in all flocks in all years. The grade improvement is rather small and not of much commercial significance.

<table>
<thead>
<tr>
<th>Station</th>
<th>Ewes Wet in 1962</th>
<th>Ewes Dry in 1962</th>
</tr>
</thead>
<tbody>
<tr>
<td>Castle Hill</td>
<td>-</td>
<td>up 5lb</td>
</tr>
<tr>
<td>Barroso</td>
<td>-</td>
<td>down 1lb</td>
</tr>
<tr>
<td>Glenfalloch</td>
<td>-</td>
<td>down 4½lb</td>
</tr>
<tr>
<td>Irishman Creek</td>
<td>-</td>
<td>down 5lb</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Station</th>
<th>Ewe Weight (lbs)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Under 70</td>
</tr>
<tr>
<td>Castle Hill</td>
<td>4.7</td>
</tr>
<tr>
<td>Barroso</td>
<td>4.5</td>
</tr>
<tr>
<td>Glenfalloch</td>
<td></td>
</tr>
<tr>
<td>Irishman Creek</td>
<td></td>
</tr>
</tbody>
</table>
The effect of liveweight on count differed between the two breeds. An increase of 30 lb liveweight decreased the halfbred wool count from 58.0 to 57.7, but increased the Merino wool count from 66.0 to 67.7. For the Merino, this increase could be commercially significant. It was also found that larger ewes continued their fleece weight advantage in subsequent years, showing that early selection for this could remain true in later life.

As would be expected, barren ewes produced more and better wool in the following season than did wet ewes—but only half to one pound more. It was confirmed that the larger sheep is no less efficient than the smaller sheep at turning feed into wool and a sheep of 10 per cent higher liveweight needs about 7 per cent more feed.

(4) Lamb Mortality

Lamb mortality could not be measured directly in such difficult terrain. However, the difference between the percentage barren ewes and the paddock tailing percentage measures those ewes which had lost lambs if no twins were present. The mean difference at Castle Hill, Barroa and Irishman Creek was 6 per cent. Thus, if no twins were present, 6 per cent of ewes had lost their lambs and if, say, 10 per cent had twins, then 16 per cent of ewes had lost their lambs. Since it is unlikely that more than 10 per cent of ewes had twins, lamb mortality therefore probably lies between 6 and 16 per cent. This is remarkably low, and comparable with lowland flocks. If this deduction is correct, the problem of raising lambing percentage is not so much reduction of lamb losses as reduction of barren ewes and increasing twin-bearing ewes.

CONCLUSIONS

The experiments showed clearly that there is everything to be said for larger sheep in the high country. The larger ewes produced more wool of a slightly higher grade and, with Merinos, the wool from the larger sheep was also finer. The larger ewes were less likely to be barren. As lamb mortality was relatively low, increased lambing percentage depends upon reducing the proportion of barren ewes and increasing twins. Moreover, one would imagine that larger sheep would have a lower mortality in the severe high-country climate.

The work also showed that wet ewes do not gain weight once they have entered the breeding flock. To increase the average liveweight of the flock, the maiden ewes must therefore be better grown. One way to achieve this would be not to mate
half-breds until they were four-tooths, or Merinos until they were six-tooths. This may not be as stupid as it sounds if the length of the life of the ewe is thereby increased. However, it is essentially a negative approach.

A more positive solution is to increase the growth rate from birth to the two-tooth stage. This can be done by providing more feed of better quality for the young sheep and it could be that other management techniques could be evolved. If the amount of improved feed is limited, the runholder is faced with the choice of feeding his young sheep better or of giving the ewes better nutrition to increase their liveweight as they grow older. I firmly believe that priority should be given to the young sheep to lay the foundation of better flocks in the future.

AILMENTS OF HORSES—Continued.

HORSE SUFFERING FROM ACUTE GASTRITIS.

THIRD STAGE OF SPASMODIC COLIC.
SWEET BRIER AND ITS CONTROL
By R. W. Moffat

Sweet brier is widely distributed throughout New Zealand. It is well known and despised by run HOLDERS of tussock country of the South Island. It is mainly confined to lower altitudes and in the South Island is found from sea level up to 4,000ft. The upper limits of its distribution vary according to latitude and local aspect.

Sweet brier is not a great problem in sown pastures. It thrives on disturbed ground or where the vegetation is open and lightly grazed. Hence the reduction of the rabbit population in the post-war years greatly assisted the increase of sweet brier. On the more fertile areas where pasture competition is greater the rapid increase of sweet brier has been checked, but its mere presence still provides a source of infestation should conditions become favourable for its dispersal.

Over the years many methods of control, including hand-grubbing, burning, cutting, mechanical clearing and the use of chemical weedkillers have been used with varying results. In recent years emphasis has been given to control with herbicides, and many materials old and new have been tested by the Department of Agriculture and commercial interests. It was soon recognised that many herbicides were available which could "brown off" the foliage, but the resulting basal regrowth brought many disappointments. Until recently the most common and reliable method in use was basal spraying with 2,4,5-T in diesel oil. The disadvantage of this is that complete coverage of all stems is essential for satisfactory control. This method is time consuming and difficult to carry out adequately, particularly on larger bushes which often require retreatment. The activity of 2,4,5-T seems to persist in the plant only for a few months and there is no suppressive effect of the herbicide after this.

A major break-through to the solution of many of our obstinate perennial and woody weed problems was provided by the introduction of TORDON*, a new systemic herbicide discovered by The Dow Chemical Company. TORDON (also known by the common chemical name picloram) has been under observation in New Zealand for nearly three years and it is now obvious that sweet brier is an extremely susceptible species. Tordon is very persistent in the plant tissue. This is of real value when controlling weeds such as sweet brier which exhibits

*Trade mark of The Dow Chemical Company.
strong basal regrowth characteristics. Tordon also has a com-
paratively long residual activity in the soil and shows outstanding
movement within the plant. It is not toxic to stock.

Two products containing Tordon are now on the New
Zealand market for the control of sweet brier. Tordon 75-T
is a liquid formulation containing 2,4,5-T and Tordon which
is applied as a foliage spray. The 2,4,5-T component gives the
initial knockdown of the foliage and allows the tordon to control
the resprouts. Tordon 2G is a granular formulation of Tordon
which is applied by hand around the base of the plants.

With a difficult-to-kill perennial weed such as sweet brier
at least 18 months are required before a final assessment can be
made of trials, and because of this a number are still in the
interim stages. The following recommendations have given
completely satisfactory results to date both on a plot trial and a
farm scale basis.

TORDON 75-T at 1 in 200 applied to full coverage of the
foliage from commencement of spring growth until the green
hip stage has given outstanding results. Applications outside
this period have given good control, but results may be more
variable and less effective, especially autumn treatments. The
use of motorised knapsacks for the treatment of scattered sweet
brier is growing in popularity and TORDON 75-T can be
applied in this manner by using a 5-10 times concentration
depending on the nozzle output and speed of coverage when
misting.

TORDON 2G, the granular formulation of Tordon, is
preferable where bushes are scattered over a wide area, where
there is a water shortage, or where it is difficult to obtain access
with conventional spray gear. To use TORDON 2G effectively,
it is necessary to have a clear understanding of how the chemical
works. The Tordon is released from the granules and is taken
up by the plant through its feeding roots. The granules should be
spread evenly around the bush from the base out to the drip-line
—generally the area covered by the foliage. The leaves tend to
channel moisture to this vital root feeding zone, thus assisting
in the release and uptake of the Tordon. Except for small
plants, applications close to the base of the plant are likely to be
less effective than those around the drip-line, particularly with
large multi-stemmed bushes. On steep slopes most of the
Tordon 2G granules should be spread uphill of the bush, then
the downward leaching will spread the chemical towards the
root zone.
Both overseas and New Zealand trials have indicated that for maximum uptake Tordon 2G should be applied in the late winter to early spring, that is the August-October period. At this time of the year the rainfall is normally sufficient to leach the chemical down into the root zone. Sweet brier root growth starts some time before bud movement, so active root absorption takes place soon after granule application. In the subse-

(Ivon Watkins-Dow photo.)

Treating brier with Tordon pellets.

13
quent summer, dry warm conditions concentrate the active TORDON in the soil solution and the transpiration stress means that a more lethal dose of chemical is in the plant to destroy the cells and tissue. Recent trials where granules have been applied outside this period have given satisfactory results, but further work is required to substantiate this. Granules should not be applied before the winter in areas that experience very cold conditions and snow.

As large bushes require a higher quantity of Tordon 2G than smaller ones some measure of the amount of plant tissue present is required to assist in estimating the amount to be applied. The basic unit used to date has been the basal diameter of the bush, the granules being applied at a rate of so many ounces per six-inch basal diameter.

As Tordon is particularly toxic on clovers the area treated should be kept within the drip-line of the plant and not used as a broadcast application. Some temporary damage may occur to certain less vigorous grasses, but the grass sward is re-established by the following season.

There has been insufficient time to fully evaluate the residual effect of Tordon in the soil, so no definite recommendations about the withholding period prior to oversowing treated areas with clovers can be made.

The suggested rate of application for Tordon 2G granules on sweet brier is two to four ounces per six-inch basal diameter. A clenched handful of granules weighs approximately two ounces, but this should be checked before application. Where it is difficult to assess the basal size of the bush a rate of one to two ounces per square yard of ground cover would be suitable.

Many farmers treated sweet brier with both TORDON 75-T and TORDON 2G last season to gain experience prior to expanding its use in a full control programme.

Further investigations are under way to obtain longer term more precise data, but undoubtedly Tordon is the most active weed-killing chemical yet used for the control of sweet brier.

**COMMENT ON TORDON AND SWEET BRIER**

By S. N. Adams

I agree that Tordon is the best chemical yet for killing sweet brier. Once again the commercial chemists have developed a product of great potential benefit to farming. The trouble is that, as the granules at present cost 7/- per pound and the spray formulation £11/10/- per gallon, control is expensive. More recent trial work with the granule indicates,
however, that the rate of application can be reduced on the present recommendations. Before embarking on a large control programme, runholders should therefore ask themselves to what extent is brier really limiting or threatening their production. I doubt if sweet brier is worth bothering with on some of the scruffy sites at present infected by it—especially if the land would only be stocked at the rate of one sheep to about five acres if the brier were removed. On the other hand, if brier is taking over a block which is an important one in the economy of the run, or if the infestation on a block is at a very early stage, it may be worth clearing. Runholders could gain valuable experience of the value of Tordon under their conditions by approaching the problem in this way.

Further development work with Tordon is continuing and cheaper methods of application may be devised in the future. I should not like to see runholders spend large sums of money on brier control at present. Oversowing and topdressing would be a better investment, especially as brier does not spread in improved, well stocked country.

AILMENTS OF HORSES—Continued.

INFLAMMATION OF THE BRAIN,

Sample of the antics of a horse during the delirium of brain fever.
In Canterbury, access to unoccupied State lands is often possible only by permissive access through leasehold or freehold lands. This has at times caused friction between hunters wanting access to State lands and runholders who fear—or who have suffered from—stock disturbance or losses. Runholders have given magnificent support to government-controlled hunting, but tend to view with suspicion any attempt by the Forest Service to organise private hunters as a control force.

At present high densities of red deer are not known in Canterbury and competition with domestic stock is negligible. Similarly chamois have been controlled in most if not all areas. Thar alone may increase should control efforts not be maintained or increased.

The situation differs from what it was two, five, 10 or more years ago; for government control operations have greatly changed the wild animal populations. The Forest Service is convinced that red deer are now largely under control, and that private hunters and commercial meat hunters can now play a larger part in maintaining control. Much thought has been given to this problem.
In 1963 the House of Representatives ordered, on the recommendation of the Prime Minister, that the Lands and Agriculture Committee consider, among other matters, “The development of private hunting in the control of deer and other animals covered by the Noxious Animals Act.”

In September, 1965, this Committee reported that, in regard to private hunter promotion, it recommended:

“(1) That provision be inserted in the Noxious Animals Act to prohibit the sale or letting of noxious animal shooting rights or charging for access through occupied property to hunt on unoccupied lands owned by the Crown.

“(2) That Forest Service activities in the provision of huts, tracks, river crossings, airstrips and information services for the use of private hunters be continued and further intensified.

“(3) That Forest Service step up its cooperation with recreational hunters in providing training for young private hunters and in organising large-scale private hunting expeditions.

“(4) That access to unoccupied land be improved to assist private hunters.

“(5) That a study be made overseas of the organisation of private hunting.”

For many years the Forest Service has helped private hunters. Huts have been built, access jeep tracks formed, river crossings established, and some evaluation attempted of the controlling effects commercial and recreational hunters may exert on noxious animal populations in specified areas.

The Forest Service has increased its promotion of private hunting as we envisage government control teams eventually being replaced in some degree by private hunters. As a preliminary move, manpower employed on the North Canterbury deer blocks has been reduced by a third where deer have been reduced so that competition with domestic stock is negligible. This has been accompanied by a drive to obtain an equal, or greater, increase in private hunting. A New Zealand Deerstalkers’ Association group has been provided with 4 x 4 vehicular transport, accommodation, and on the spot information and advice to gain their cooperation in sponsoring further parties of experienced hunters in North Canterbury.

Another New Zealand Deerstalkers’ Association group in South Canterbury has been helped to obtain excellent thar hunting. This group erects huts supplied by the Forest Service and works to a plan to try to reduce the thar population. At their
request a specialist officer has trained selected personnel in firearms safety. The Forest Service does not force people to hunt only in specific areas, nor is the non-N.Z.D.S.A. hunter excluded. On the contrary, if any organised group wishes to cooperate we can provide access, transport, accommodation, free ammunition and information so that they may confidently enter good hunting areas. We aim to get genuine recreational hunters on to the animals as quickly as possible.

Generally, runholders agree that noxious animals should be controlled at the least possible cost to the taxpayer but do not support any scheme which could weaken their authority to prohibit entry on to their land. Some feel that should hunters—even groups trained and vouched for by the Forest Service—be regularly given permissive access, sooner or later control will break down and stock losses or other damage will occur. Others fear that station roads, often put in on a cost sharing basis with the Forest Service, may be damaged by increased traffic. Yet again there are fears of stock disturbance, unauthorised shooting on private lands, and the possibilities of shooting, river crossing or climbing accidents increasing. Consequently runholders are reluctant to permit access.

Some runholders also think that private hunters are unlikely to control noxious animals; and that meat hunters should be given preference to operate the best blocks, thus earning overseas funds. The Forest Service does not envisage private hunting alone being efficient or intensive enough to control noxious animals. Forest Rangers will continue to inspect all unoccupied land, and to organise such government and private hunting as seems necessary to achieve and maintain control. As for preference being given to commercial interests, this situation will hardly arise. Any area receiving high recreational hunting pressure will rarely be suitable for the commercial hunter. However, commercial interests are now tending to seek permits to install freezers in State forest blocks rather than to operate the hunting blocks with their own hunters. Thus more recreational hunters may become part-time meat hunters. The future pattern is for portable meat freezing depots to be established in all major catchments, and for many recreational hunters to indulge in part-time meat hunting. Hence a greater proportion of our venison and wild pork will go overseas.

Within a decade the whole pattern of noxious animal control work in North and South Canterbury could change as the promotion of private hunting gains momentum. The Forest Service is confident that this is both desirable, and in line with
government and public opinion. However, without the full support of runholders no scheme of private hunter promotion can succeed. The provision of access is the key. Should runholders permit access to private hunters they will still control the scale, timing and type of traffic that crosses their land. This would follow the recommendations of the Parliamentary Select Committee . . . “that access to unoccupied land be improved to assist private hunters.”

AILMENTS OF HORSES—Continued.

SHOWING HOW FAR AN ANIMAL WITH TETANUS IS CAPABLE OF MOTION.

A HORSE WITH TOOTHACHE.

A HORSE QUIDDING.
THE WINTER FEEDING OF BEEF COWS

By R. A. Barton
Senior Lecturer in Sheep Husbandry, Massey University, Palmerston North.

Three main factors determine financial returns from a breeding herd and each is markedly affected by nutrition. The first factor is calving percentage; the second, the weaning weight (or the size) of the calves; the third, the cost of production of the calf including interest on capital invested in the herd, feed costs, labour and veterinary expenses and the like.

The key to success is a high calving and weaning percentage. A few extra calves from every 100 cows really make the profit. As calving percentage is greatly affected by nutrition and management it is desirable to examine the main nutritional aspects of it.

American scientists have studied the winter nutrition of breeding cows and their results will be used here as examples. A number of these studies were made at Oklahoma State University where the lifetime performance of beef cows wintered on different levels of nutrition was investigated. Winters in Oklahoma are more severe than in New Zealand so the results should at least apply to cows in the South Island high country and the central plateau of the North Island.

The results of four American experiments are summarised below.

1. Life-time Performance of Hereford Cows Wintered on Three Different Planes of Nutrition

In one long-term experiment in Oklahoma one group of Hereford cows was given a supplement each winter of 1.0 lb cottonseed meal per head daily (low plane). Another group received 2.5 lb cottonseed meal per head daily (medium plane), while the females in the high plane group were fed 2.5 lb cottonseed meal plus 3.0 lb oats per head daily. The low plane ration was considered to supply two-thirds of the digestible protein requirement of range beef cows and the high plane ration supplied the cows with ample protein and energy. The animals were in their respective feeding groups from 1 November to mid-April, i.e. the Northern Hemisphere winter. The cows were rotated among winter pastures to minimize pasture differences, but were grazed together during the summer. The pasture species were native grasses mainly bluestems (Poa species) and the carrying capacity was six acres per cow.

Although cottonseed meal is not available in New Zealand,
the results of the experiment apply to our conditions because beef cows may be fed to gain weight in the winter or they may be allowed to lose weight even when receiving hay, silage or crop. It is obviously important to know whether the subsequent production of a cow is affected by the way she is wintered. If pregnant cows which lose weight in the winter can produce almost as well as well-wintered cows, farmers may be encouraged to carry more breeding cows.

Table 1 shows the 12-year results of this study. Each of the three supplementary winter feeding groups contained 30 females when the experiment started in October, 1948. By July, 1960, however, the group of cows fed on a high plane each winter was reduced to 14, the moderate group to 18, while the low plane group stood at 27. Many cows in the high and moderately fed groups were culled because of failure to breed in two consecutive seasons, because of eye cancer or for other reasons. During the experiment the low plane group weaned 47 more calves than the high plane group. The low plane group weaned 95 per cent of their calves compared with only about 87 per cent for the two other groups. The cost of winter feeding when based on each 100 lb of calf weaned was clearly in favour of the low plane cows. The investigators believed that the low plane females were better rustlers and more active grazers than the well fed cows.

**TABLE 1**

Long-term effects of different amounts of supplemental winter feed on the performance of spring calving Hereford beef cows (Data by courtesy of Dr L. S. Pope, Oklahoma State University, U.S.A.)

<table>
<thead>
<tr>
<th></th>
<th>Low</th>
<th>Moderate</th>
<th>High</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. cows starting test, Oct., 1948</td>
<td>30</td>
<td>30</td>
<td>30</td>
</tr>
<tr>
<td>No. cows remaining, July, 1960</td>
<td>27</td>
<td>18</td>
<td>14</td>
</tr>
<tr>
<td>Av. weight change each winter in lb:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>First winter as calves (gain)</td>
<td>22</td>
<td>59</td>
<td>88</td>
</tr>
<tr>
<td>Second to fifth winters (loss)</td>
<td>-153</td>
<td>-119</td>
<td>-92</td>
</tr>
<tr>
<td>Sixth to ninth or tenth crops</td>
<td>-130</td>
<td>-131</td>
<td>-109</td>
</tr>
<tr>
<td>Liveweight, Oct., 1959</td>
<td>1092</td>
<td>1147</td>
<td>1120</td>
</tr>
<tr>
<td>Total No. calves weaned</td>
<td>252</td>
<td>219</td>
<td>205</td>
</tr>
<tr>
<td>Per cent calf crop weaned</td>
<td>94.6</td>
<td>86.7</td>
<td>87.3</td>
</tr>
<tr>
<td>A. calving date:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>First calf crop</td>
<td>14 March</td>
<td>7 March</td>
<td>8 March</td>
</tr>
<tr>
<td>Second to fifth crops</td>
<td>12 March</td>
<td>5 March</td>
<td>3 March</td>
</tr>
<tr>
<td>Sixth to ninth or tenth crops</td>
<td>15 March</td>
<td>14 March</td>
<td>12 March</td>
</tr>
<tr>
<td>Av. calf weight in lb:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>At birth (corrected for sex)</td>
<td>77.8</td>
<td>77.2</td>
<td>78.6</td>
</tr>
<tr>
<td>At weaning (corrected for age and sex)</td>
<td>488</td>
<td>477</td>
<td>479</td>
</tr>
<tr>
<td>Cow cost per 100 lb of calf weaned:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dollars</td>
<td>7.22</td>
<td>10.59</td>
<td>13.92</td>
</tr>
<tr>
<td>N.Z. currency</td>
<td>£2/11/2</td>
<td>£3/15/-</td>
<td>£4/18/10</td>
</tr>
</tbody>
</table>
2. Life-time Performance of Hereford Cows. One Group of which Calved First as Two-year-olds versus those Calved First as Three-year-olds.

In the above experiment, half the heifers were bred to calve first as two-year-olds and the others to calve first as three-year-olds. Despite more difficulty at first calving for females which calved as two-year-olds, these cows were subsequently more regular producers. At 11½ years of age, cows calving first as two-year-olds weaned on the average, 9.1 calves, whereas those calving first as three-year-olds weaned 7.9 calves. The average weaning weight of the calves out of the two-year-olds was lower than the calves from the three-year-olds as would be expected.

This experiment showed conclusively that cows calving first as two-year-olds were more profitable than those calving first as three-year-olds. Thus, under average to good conditions, heifers should be bred as yearlings.

3. The Effects of Excessive Fatness on the Performance of Beef Heifers.

Another Oklahoma experiment, in which twin females were raised under controlled or yard-feeding conditions, provided further evidence that high feeding leads to excessive fatness and poor performance of heifers. In this investigation one heifer of each twin pair was fed a ration which permitted it to grow at the rate of one-half to two-thirds of a pound a day (low plane). The second heifer of each set received a similar ration plus maize (high plane). The heifers were fed on these levels from weaning until calving at about 30 months of age and thereafter both lots were fed identically with an adequate ration for maximum milk production.

Preliminary results have shown that the high plane heifers weighed 320 lb more at first mating (999 lb versus 679 lb) and 570 lb more at first calving (1334 lb versus 827 lb) than the low plane heifers. The high plane group had more calving difficulty and greater calf and cow losses than the low plane group. All but one of the low plane heifers calved normally without assistance. Six of the eleven high plane heifers needed help at calving and two of these required Caesarean sections. Two others calved by malpresentation.

The low plane cows produced an average of 35 per cent more milk (9.2 lb versus 6.8 lb per cow daily) than the high plane cows during the first 112 days of their lactation. The average weight of the calves from the low plane cows at 210 days of age was 374 lb versus 338 lb for the calves reared by the high plane cows.
Four of the original eleven twin cows had been lost from the high plane group by the second and third lactations and one cow failed to rebreed. All the low plane cows have remained on experiment and are apparently in normal health.

4. The Effects of Excessive Fatness on the Performance of Mature Beef Cows.

To see whether mature cows (eight-year-olds), when excessively fat, were affected like the heifers in the previous experiment, a group of cows was fed at a high level from late summer through to calving, and then given the same ration as the low plane cows. The high plane cows were 323 lb heavier at calving (1445 lb versus 1122 lb). This large difference almost disappeared during the suckling period so that the high plane cows were only 42 lb heavier at weaning time (1119 lb versus 1077 lb).

No differences in breeding efficiency or in calving difficulty between the two groups were noted. Calves from the high plane cows averaged 5 lb heavier at birth and 17 lb heavier at both 112 and 210 days of age than calves from the low plane cows. These results agree with those of a previous year and suggest that the production of the mature cow is not easily affected by excessive fatness. The relatively small advantage in milk production shown by the high plane cows, as indicated by the weaning and earlier weights of the calves, also suggests that the beef cow makes very inefficient use of body fat reserves during the suckling period.

Summary

The Oklahoma and other American experiments show that:

1. While maturity is delayed in poorly fed heifers, skeletal size is little affected and such effects as do occur are largely recovered by 3½ years of age. For optimum skeletal development, a medium level of feeding appears ample.

2. Birth weights of calves out of young females poorly wintered will be adversely affected but the effect on the birth weights of calves out of poorly wintered mature cows is very slight indeed.

3. If, because of poor feeding, a weaned heifer calf gained no weight in its first winter and lost weight in the next two winters while pregnant, both the calving percentage and weaning weight will be low. The heifer will also be slow to mature and conceive.
4. Mature size of beef cows is only slightly affected by poor winter feed levels, if recovery is possible on adequate summer and autumn pasture.

5. Cows receiving the least amount of winter supplementary feed (that is, 1.0 lb cottonseed meal per head daily from November 1 to mid-April each year) produced the most calves. These cows gave a 95 per cent crop weaned versus 87 per cent for cows fed in the winter at moderate and high levels.

6. Useful productive life in the herd is shortened by liberal winter feeding. Thus, after 12 years, the 30 original cows in each group have been reduced to 14 for the high plane group, to 18 in the medium group and to 27 in the low plane group.

7. It is much cheaper to winter the cows in the low plane group.

8. Cows which calve first as two-year-olds out-produce cows calving first as three-year-olds. During their life, cows calving as two-year-olds produced, on average, slightly more than one extra calf than did cows calving first as three-year-olds.

The cow has considerable ability to regain losses in weight without adversely affecting her ability to produce calves and to feed them well. Indeed, overfeeding cattle can reduce their reproductive ability, shorten their life and lower profits.

The principles of winter feeding demonstrated by these experiments should provide the key to management of cows in New Zealand.

You should:

1. Make intelligent use of the cow’s ability to gain weight in favourable periods of the year in order to allow some loss of weight during winter.

2. Give only a small amount of supplementary feed in the winter.

3. Remember that suckling a calf strains a cow much more severely than does pregnancy.

Thus in-calf cows can be wintered satisfactorily on a minimum of supplementary feed where pasture is scarce. Indeed, where pasture is adequate and the condition of the cows is satisfactory, supplementary feeding may be both unnecessary and harmful.
In conclusion, in the nutrition of the beef cow, cattlemen must operate between two danger areas. One danger is to give too much feed which causes a smaller calving percentage, shorter life in the herd, reduced milk production and a high feeding cost. The other danger is to give too little food which can delay maturity, lead to late calving, light weaning weights and less profit. The distance between these two danger areas is quite appreciable so there is scope for satisfactory and profitable herd management under widely varying conditions of feed supply.

**OVERDRILLED CEREALS AND GRASSES MAY BE THE ANSWER TO YOUR WINTER GREENFEED PROBLEM**

P. T. P. Clifford and E. W. Vartha
Grasslands Division
Department of Scientific and Industrial Research, Lincoln.

Topdressing and oversowing tussock grassland has given spectacular increases in herbage production, but the marked disparity between the peak of production in spring and the trough in winter intensifies the winter feed problem.

Recent work by Grasslands Division in the Mackenzie country confirms the experience of many runholders that the herbage grown, particularly in the clover dominant stage of development, must be controlled. This may necessitate some changes in grazing management. As the fertility builds up, the growing season may lengthen and will supplement feed supplies in the early winter, but the gap in subsequent months still has to be considered.

The practice of overdrilling cereals and cereal-grass mixtures for winter greenfeed could be one answer, particularly because the tendency to lamb earlier as development proceeds creates a demand for an assured supply of greenfeed in the late winter and early spring.

This practice avoids cultivation and the runholder would have adequate time to assess his winter feed supplies from sources such as hay, and then be able to overdrill accordingly.

In 1965 Grasslands Division carried out a trial at Lake Pukaki to determine the suitability of some plant species for overdrilled greenfeed. The trial was on a low fertility stony
morainal outwash and, under the hard winter conditions of 1965, we obtained a severe test of plant performance.

C.R.D. ryecorn, a Mackenzie country selection from C.R.D. ryecorn, Algerian oats, and a new unnamed C.R.D. greenfeed oat were overdrilled alone and with Italian ryegrass in the first week of February with a disc-seeder. Both cereals were sown at two bushels per acre. The seeding rates were reduced where these were sown with 10lb per acre of Italian ryegrass. This grass was also drilled alone at 25lb per acre.

All the seed was drilled with 3cwt per acre of superphosphate and 3cwt per acre of nitrolime was broadcast. Three additional dressings of 3cwt of nitrolime per acre were applied up to early August. We emphasise that this was a test of plant performance only and no consideration was given to the economics of the nitrogen applications.

The establishment and early growth of the cereals was good, but Italian ryegrass was slow. Yields were determined by cutting strips from the drill rows on several occasions, but the entire drill strips were not harvested. Figure 1 shows continued yields from the time of emergence.

![Figure 1](image)

The oat varieties were low producing throughout and were severely frosted. Ryecorn yields were outstanding. This cereal showed no evidence of frosting and stood well under several falls of snow. Neither variety ran to head until late spring. The herbage produced by ryecorn over a nine-week period from early July to early September would have carried 5 ewe equiva-
lents per acre. Production would undoubtedly have been higher under grazing.

Italian ryegrass contributed little to the herbage yields of the mixture until September, when over a five-week period 450lb dry matter per acre (4 ewe equivalents) were produced. The pure sowings of Italian ryegrass produced 800lb dry matter over the same period. No earlier determination of the ryegrass yield from the pure sowings was possible because these were closely grazed by Paradise ducks all winter! Italian ryegrass grew well right through to December with no further dressing of nitrogenous fertiliser after the August application.

The results suggest that a combination of ryecorn and Italian ryegrass could be suitable for winter greenfeed and for spring grass production.

Conclusion

Under severe climatic conditions, outstanding production was obtained from ryecorn. Because this cereal thrives under hard grazing, is frost hardy and does stock well, it could play an important role in providing winter greenfeed. In subsequent work, the feasibility of overdrilling ryecorn into improved tussock grassland, using minimal fertiliser application, and its utilisation under grazing will be studied. Further trials will also be carried out with ryecorn-Italian ryegrass mixtures.

We acknowledge the cooperation of Messrs I. H. Wardell of Dusky Station and J. Cameron of Ben Ohau Station.
Narrow-leaved snow tussock (*Chionochla rigida* Zotov) dominates large areas of run country east of the main divide in the South Island, where it is important for grazing and for soil and water conservation.

Despite the importance of snow tussock grassland, the obvious deterioration which has occurred in many areas and the general reluctance of other plants to substitute for snow tussock, little research has been done on it. Kevin O'Connor, in the September, 1962 Review, dealt with management of snow tussock grassland in Canterbury.

Since 1960 I have studied several aspects of snow tussocks—their environments, growth rates, flowering, seeding, germination, seedling establishment and in particular the effects of management—over much of their range in Otago. A technical account of this work was published in four papers in the New Zealand Journal of Botany in 1965, and only the findings of some general interest are given here. Table 1 shows the location and climate of the eight sites where most of the observations were made.

**SNOW TUSSOCK ENVIRONMENT**

Precipitation varies from 32 inches at the lowest site in Eastern Otago (Maungatua) to about 56 inches at the highest...
site in Central Otago (Old Man Range). It is well spread throughout the year, but above 3,500 ft much falls as snow during winter. The annual loss of water by evaporation is everywhere less than the precipitation so there is a surplus of water, sometimes more than three-quarters of the annual precipitation, for stream flow. Snow tussocks can tolerate a very wide range of temperature. At the coldest sites the average annual air temperature is near freezing point. Frosts occur at all times during every month and at the higher sites they occur frequently during all months and may continue unbroken for over a month.

**TABLE 1**

Estimated average climatic values for eight sites in narrow-leaved snow tussock grassland in Otago.

<table>
<thead>
<tr>
<th>Location</th>
<th>Altitude (feet)</th>
<th>Air Temp. (°F)</th>
<th>Water Balance</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Annual</td>
<td>Warmest Month (Dec-Feb)</td>
</tr>
<tr>
<td>Maungatua</td>
<td>1500</td>
<td>44</td>
<td>52</td>
</tr>
<tr>
<td></td>
<td>2850</td>
<td>42</td>
<td>48</td>
</tr>
<tr>
<td>Old Man Range</td>
<td>3000</td>
<td>42</td>
<td>49</td>
</tr>
<tr>
<td></td>
<td>4000</td>
<td>40</td>
<td>47</td>
</tr>
<tr>
<td>Coronet Peak</td>
<td>5200</td>
<td>32</td>
<td>41</td>
</tr>
<tr>
<td></td>
<td>2650</td>
<td>43</td>
<td>51</td>
</tr>
<tr>
<td>Coronet Peak</td>
<td>3900</td>
<td>38</td>
<td>46</td>
</tr>
<tr>
<td>Coronet Peak</td>
<td>5350</td>
<td>33</td>
<td>43</td>
</tr>
</tbody>
</table>

**GROWTH OF SNOW TUSSOCKS**

To assess the effects of various management practices on the growth and flowering of snow tussocks, sites were selected where the appearance of the vegetation suggested that grazing had not been unduly heavy.

Growth rates of tussocks were measured in several ways but only three methods—leaf growth, new leaf production and new shoot production—were satisfactory. Leaf regrowth after clipping could not be used since clipping altered the pattern of growth. When whole tussocks were severely clipped once each season they produced about two-thirds of their original leaf length and two-fifths of their leaf weight during the first year. With annual reclipping, however, an increasing number of shoots failed to recover and by the end of the third season most of them had died and the tussocks were seriously and probably permanently weakened. This indicates that snow tussocks cannot tolerate severe clipping (or grazing) for long.

Leaf growth was measured for three years in ten tussocks
at each site. During winter (May-August) the tussocks are
dormant, but in spring there is a period of rapid growth begin-
ing early in September at low altitudes and almost two months
later at the highest sites. Leaf growth declines after January and
ceases in late April at low altitudes or in late March at high
altitudes. The growing season, then, varies from about eight
months to five months depending on altitude. The total season's
leaf growth is usually much less at high than at low altitudes.
My results show that the height of a tussock is closely related to
its rate of leaf growth as the rates at which leaves die back from
the tips do not vary from site to site.

The number of new leaves, but not the number of new
shoots, produced each season, decreases with increasing altitude.

Transplanting Experiment

A number of tussocks were transplanted to see whether the
differences in growth at different altitudes are due entirely to
the environment or to inherent differences in the tussocks.
Twenty tussocks from four different sites—Maungatua 2,850ft
and Old Man Range 3,000 ft, 4,000 ft and 5,200 ft—were
lifted in December, 1960, and each tussock was split into five
pieces. One piece was planted at each of the four sites while the
extra piece was planted at Dunedin in the University garden.
Thus the growth, flowering and seeding of the 80 tussocks could
be compared in five different situations from sea level to 5,200ft.
Differences in behaviour of pieces of a single tussock between
the five gardens would be due to differences in environment,
whereas differences between tussocks of different origin growing
in the same place are due to inherent differences between
tussocks.

The growth, flowering and seeding of these tussocks over
several seasons revealed much useful information. Firstly, it
was found that any snow tussock can survive and grow in all
parts of the altitudinal range of the species. All grew most
rapidly at Dunedin under milder conditions than they ever
experience naturally. The larger low-altitude plants outgrew
all others at all gardens, while the small high-altitude plants
always grew the least. In addition, the total growing period at
all gardens was longer for low-altitude than for high-altitude
plants. This effect was very marked at Dunedin where all tus-
socks grew continuously except the high-altitude plants which
stopped growing for two to three months each winter. These
differences indicate that the tussocks at each site are inherently
different from those at other sites in ways that make them par-
particularly suited to their own site. This same tendency is repeated in the flowering behaviour to be discussed below.

**Effects of Burning and Grazing on Tussock Growth**

I have followed, with the help of the runholder Mr. J. J. McCambridge, the after-effects of spring burning of snow tussock for six seasons at a 4,000ft site on the Old Man Range. Extensive spring fires occurred here in 1959 and 1961 on separate areas while a small area which has not been burnt for at least fourteen years was saved for comparison. The growth of ten tussocks from each of the three areas at 4,000ft has been followed from the 1960-61 season. Small areas from both burns were reburnt in spring of 1964, representing intervals of three and five years between burning, and ten tussocks from each of these areas are also being measured. Burning increased leaf growth by 35 per cent and 20 per cent in the first and second seasons after burning respectively (Fig. 1). During the next four seasons, however, the burnt tussocks grew less than the unburnt ones. The effects of fire on production of both new leaves and new shoots (Table 2) show a similar temporary increase followed by a sustained decline. O'Connor (1962) also reported an increased production of new shoots during the first two seasons after fire. Reburning after five years accelerated growth during the first season but not as much as did the initial
TABLE 2

Effect of fire on production of new leaves and new stems in narrow-leaved snow tussock at 4,000ft Old Man Range. The number of new leaves and new stems produced each season by recently burnt tussocks is given as a percentage of those in unburnt plants for the same season. Values are based on counts from 30 stems.

A. NEW LEAVES

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Season after Fire</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1st</td>
</tr>
<tr>
<td>Burnt spring 1959</td>
<td>—</td>
</tr>
<tr>
<td>Burnt spring 1961</td>
<td>92</td>
</tr>
</tbody>
</table>

B. NEW STEMS

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Season after Fire</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1st</td>
</tr>
<tr>
<td>Burnt spring 1959</td>
<td>—</td>
</tr>
<tr>
<td>Burnt spring 1961</td>
<td>151</td>
</tr>
</tbody>
</table>

fire, while with only a three-year interval between fires the stimulation was slight (Fig. 1). The study has shown that burning accelerates the growth of tussocks at first, but later causes years of weakened growth.

I added ash from burnt tussock to both cut and undamaged tussocks to find out whether the stimulation caused by burning was due to the ash alone or to some other factor. The results showed that cutting, like burning, increased both leaf growth and production of new shoots but not to the extent that burning did, even when the cut tussock was fertilised with ash. These results differ from those of O'Connor (1962) who reported that burning and a single cutting had similar effects on the growth of snow tussock. I found that the addition of ash alone did not affect growth. Acceleration of growth after fire then, is not due to the ash and only partly due to the defoliation. The blackening of the tussock crowns, which would allow more heat to be absorbed from the sun is probably the most important factor. This certainly seems to be the reason for the heavy flowering as will be explained later.

This experiment also showed that neither burning nor cutting in the spring caused any noticeable loss of shoots which indicates, as O'Connor also reported (1963), that snow tussocks probably suffer no permanent damage from a single defoliation at this time. The tussocks may however require several years to regain the size and growth rates of normal plants. By contrast, plants defoliated in the autumn, or those grazed during the recovery period, usually suffer a great loss of shoots and therefore may be seriously and permanently weakened.

Flowering, Seeding and Seedling Establishment

Narrow-leaved snow tussocks do not flower annually, but
have flowering years when the majority of plants everywhere will be in flower. Many grasses can reproduce vegetatively but the snow tussock reproduces only by seed. Hence some knowledge of seed production and germination is basic to an understanding of this species. In ungrazed grassland the snow tussock is obviously very long-lived. Although we cannot measure the age of a tussock directly, it seems probable from their size and known rates of growth that snow tussocks rival our forest trees in longevity. Although flowering stems do not persist, they usually produce one or two new shoots from the base before dying. Non-flowering stems also produce new ones so that the total number of stems or tillers in a tussock probably increases throughout the tussock’s life.

The great age which tussocks presumably reach means that the number of seedlings required to maintain the status quo must be quite small. In many disturbed grasslands where the snow tussock cover has been seriously reduced, the establishment of tussock seedlings could be a vital factor in improvement. The rarity of tussock seedlings was stressed in the report of the Tussock Grasslands Research Committee (1954) and was one reason for their suggestion that snow tussock was a declining or relic species, out of equilibrium with the present environment.

*What Makes a Flowering Year?*

Several experiments both in the field and at Dunedin have together explained the irregular flowering of narrow-leaved snow tussock.

The combined influence of temperature and the length of day is involved in making a tussock flower. The snow tussock is a long-day plant and makes the physiological change from vegetative growth to flowering only during that part of the year when days are longer than about fourteen hours. Hence whether or not a plant will flower depends on what happens between mid-November and mid-February. During this period however flowering is induced only if temperatures are relatively high for part or all of the time. The effect of high temperature on flowering seems to be cumulative, that is, the longer the period of high temperature during these three months, the more abundant is the flowering. Now, even though the plant has made the physiological change towards flowering during mid-summer the first signs of flowers, visible only with a hand lens after careful dissection of the stems, do not appear until autumn and the flowers do not actually emerge from the sheathing leaves until December of the next summer. Thus the warmth of the sum-

The transplanting experiment described earlier showed that the critical temperature for flowering is not constant for all areas of snow tussock, but is related to the normal temperatures for the altitude at which the tussocks are growing. The critical temperature is lower for tussocks growing at high altitudes than for those at low altitudes. The pattern of flowering in these transplanted tussocks which showed this effect of altitude will be described briefly. The tussocks were shifted during early December 1960. During the first summer after shifting (1961-1962) which was a non-flowering one, only those tussock pieces which had been moved to warmer sites flowered; those replanted or shifted to colder sites did not. The next season however, was a flowering one and this time the tussock pieces moved to warmer sites again flowered and so did those replanted at their home sites; but those shifted to colder sites still did not. This showed that tussocks could be made to flower in a non-flowering season by giving them temperatures higher than they normally receive, and further, that tussocks could be prevented from flowering in a flowering season by giving them temperatures lower than they normally receive. These differences which the species has developed between one site and another explain why snow tussocks synchronise their flowering years over their wide altitudinal range. Not only do the high-altitude tussocks flower with relatively low summer temperatures, but they develop their flower heads and ripen their seeds much faster than do low-altitude plants when the two are grown side by side. This quicker development is an adaptation to the more severe environment at high altitudes.

These results suggest that the tussocks growing at a particular altitude on a mountain are especially suited to the temperatures at that altitude. Moreover, the results do not support the belief that snow tussock is declining because it is a relic species out of harmony with the present environment (Tussock Grassland Research Committee, 1954).

Counting the number of flower heads produced by fifty permanently numbered tussocks at each of the eight sites during the two most recent flowering years showed that the number of heads produced varies considerably both from plant to plant during one season and within the same plant from one flowering year to the next. A plant that flowered heavily one season may flower lightly when the next flowering season comes—or it may flower heavily once more. No reason for this variation has yet been found.
Effect of Burning on Flowering

Burning causes prolific flowering of snow tussocks about fifteen months after a spring fire. Barker (1953) observed this in a non-flowering season, while O’Connor and Powell (1963) reported a five-fold increase in the number of flower heads during a flowering year. The reason for the 15-month delay in the flowering response to burning, which is quite unusual in natural grasslands, and for the extremely prolific flowering, can be explained by the factors which control flowering in snow tussock. Flowering for one season is induced during the long days of mid-summer in the previous season, but only when high temperatures are combined with the long days. The blackened crowns of recently burnt tussocks will absorb more heat from the sun than do unburnt plants. During the long days of summer immediately following spring burning, a high proportion of tillers thus makes the physiological change towards flowering, but the flowers do not actually emerge until the next summer. Autumn burning, which was done experimentally and which damaged the tussocks considerably, caused an even longer delay between burning and flowering, as the winter intervened before the blackened tussocks could react to a summer’s heat.

The pattern of flowering in relation to burning at 4,000ft on the Old Man Range over five seasons (Table 3) shows three important points. Firstly, the fire in 1959 which occurred during the early part of a flowering season substantially reduced both number of flowering tussocks and the number of flower heads in each tussock. Secondly, on both burnt areas, flowering was abundant in the season following the fire, but was more abundant during a normal flowering year (1962-63) than during a non-flowering year (1961-62). Lastly, tussocks in their third season after fire were virtually unable to flower in a normal season.

**TABLE 3**

Effect of burning on percentage of tussocks which flowered (%Fl) and the average number of flowering stems per flowering tussock (No. Fl. Heads) at 4,000ft, Old Man Range. 50 tussocks were counted in each treatment.

<table>
<thead>
<tr>
<th>SEASON</th>
<th>UNBURNT</th>
<th>BURNT SPRING 1959</th>
<th>BURNT SPRING 1961</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>% Fl.</td>
<td>No. Fl. Heads</td>
<td>% Fl. Heads</td>
</tr>
<tr>
<td>1959-60</td>
<td>90</td>
<td>21</td>
<td>8</td>
</tr>
<tr>
<td>1960-61</td>
<td>2</td>
<td>1</td>
<td>94</td>
</tr>
<tr>
<td>1961-62</td>
<td>0</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>1962-63</td>
<td>90</td>
<td>28</td>
<td>24</td>
</tr>
<tr>
<td>1963-64</td>
<td>8</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>1964-65</td>
<td>12</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>35</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
flowering year (1962-63). This may have been due to the declining vigour of these plants (Fig. 1 and Table 2), a decline which began after their heavy flowering and which probably was due largely to a depletion of food reserves which the prolific flowering causes.

**Effect of Clipping on Flowering**

Tussocks which had been clipped, both with and without the addition of tussock ash, flowered more than unclipped plants but less than burnt tussocks. Clipping the foliage, by reducing insulation, would allow the crowns to heat up more than in unclipped plants, but in the absence of blackening, less than in burnt tussocks. The addition of tussock ash to normal plants did not promote flowering.

**Seeding of Snow Tussock**

The seed set at each site was measured for both flowering seasons by counting the number of full seed in 200 florets collected at random. The percentage of seed set varied from 0 to 61 per cent and showed no consistency either with altitude or from year to year at the same site (Table 4). Even values for individual tussocks were quite variable from one flowering year to the next. At all eight sites, seed set exceeded 10 per cent during one or other of the two flowering years, indicating that throughout their range snow tussocks produce a large number of full seeds. The weight of the individual seeds decreases strikingly with increasing altitude (Table 4). On both Old Man Range and Coronet Peak, for example, there is a decrease to one-third or one-fifth the seed weight at the lowest sites in passing to the highest altitudes. This may be largely due to less favourable environment at higher altitudes, but the transplant study showed that high-altitude plants continue to produce

<table>
<thead>
<tr>
<th>Site</th>
<th>% Seed Set</th>
<th>Avge Wt of Single Seeds (mgm)</th>
<th>% Germination</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1959-60</td>
<td>1962-63</td>
<td>1959-60</td>
</tr>
<tr>
<td>Maungatua 1500ft</td>
<td>0.5</td>
<td>30.5</td>
<td>1.30</td>
</tr>
<tr>
<td>&quot; 2850ft</td>
<td>61.0</td>
<td>61.5</td>
<td>1.11</td>
</tr>
<tr>
<td>Old Man Range 3000ft</td>
<td>21.5</td>
<td>26.5</td>
<td>1.56</td>
</tr>
<tr>
<td>&quot; 4000ft</td>
<td>6.5</td>
<td>27.0</td>
<td>1.02</td>
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<tr>
<td>&quot; 5200ft</td>
<td>13.5</td>
<td>0.0</td>
<td>0.44</td>
</tr>
<tr>
<td>Coronet Peak 2650ft</td>
<td>11.5</td>
<td>1.5</td>
<td>1.45</td>
</tr>
<tr>
<td>&quot; 3900ft</td>
<td>21.5</td>
<td>18.0</td>
<td>0.97</td>
</tr>
<tr>
<td>&quot; 3350ft</td>
<td>10.5</td>
<td>0.0</td>
<td>0.25</td>
</tr>
</tbody>
</table>

**TABLE 4** Percentage seed set, average weight of individual seeds and their viability in random collections of 200 snow tussock florets from eight sites. Two flowering seasons, 1959-60 and 1962-63.
lighter seed than low-altitude plants even when they are grown together. High-altitude plants have an inherent tendency to produce relatively light seed.

The seed set associated with the prolific flowering which follows burning is usually better than in adjacent unburnt plants, but the weight of individual seeds may be only four-fifths of that produced by the unburnt tussocks. The lighter seed is probably a result of the very much greater seed production in the burnt plants.

**Seed Germination**

Germination was tested in batches of 200 seeds kept moist and at 70°F in an incubator. Germination varies considerably between tussocks at a site, between sites and from year to year, with a total range of 0 to 94 per cent. There was no obvious relation between seed weight and viability except that most of the very small grains produced above 5,000 ft were inviable. On the other hand, between 50 and 70 per cent of the seeds collected below 4,500 ft during 1962-63 germinated. The pattern of germination was interesting. There was an initial flush followed by intermittent germination over a very long period, exceeding four years. The only treatment which substantially altered this pattern was the exposing of moist seed to a period of high temperature, such as would occur in a tussock fire. This produced immediate germination though it killed some seed. The 1961 fire on Old Man Range seems to have had the same effect. Soon after the fire a mass germination of snow tussock seeds occurred, presumably from seeds accumulated over several flowering seasons and lying dormant in the litter on the ground.

Germination of the lighter seeds produced by recently burnt tussocks was considerably less than of the seeds produced by nearby unburnt plants (50 per cent v. 75 per cent in 1962-63 at 4,000 ft). However, if we consider total seed production, many more viable seeds are produced by burnt tussocks in the season following burning, than by unburnt plants.

**Establishment and Survival of Snow Tussock Seedlings**

No seeds were sown in the field but the fate of 200 seedlings which resulted from the 1961 fire on the Old Man Range has been followed for three seasons. Two groups of 100 seedlings, one fenced from stock, were marked in April 1962. Figure 2 shows that seedling numbers have been halved on both areas after three years. Most deaths occurred with desiccation during late summer and autumn in seedlings which had been previously lifted by frost. There was some grazing damage to the unfenced
seedlings especially as they grew larger, but few seedlings were killed by grazing. It is obvious from the size of these plants—after three and a half years they are one to two inches high—that seedlings require many years to develop into mature tussocks.

CONCLUSIONS

Although this study of narrow-leaved snow tussock was confined to Otago, many of the findings reported here should apply throughout much of the range of this widespread species. Confirmation from areas further north, however, would be most desirable.

The environment is in general severe, for growing season temperatures are relatively low with many freeze-thaw cycles. This frequent freezing, together with adequate soil moisture, means that soil frost is intense and frost heaving, especially on depleted sites, is a major factor retarding establishment of seedlings.

Despite the severe environment, snow tussocks grow actively for five to eight months each year. As the growing season and usually also the growth rates decrease with altitude, productivity of snow tussock grassland is much reduced at high altitudes.

There is no indication that narrow-leaved snow tussock is out of equilibrium with its present environment. Rather, the snow tussock has become differentiated throughout its wide range to adapt its growth, flowering and seeding to the particular conditions of its home site. Despite these adaptations, the very slow growth and severe environments at high altitudes make the grazing of snow tussock grassland there of extremely doubtful value, especially as it is important to maintain an intact plant cover for soil and water conservation.
The irregular flowering of snow tussock may be an adaptation to conserve the plants' food reserves since forced annual flowering reduces the vigour of plants. Moreover the seeds are sufficiently long-lived to bridge the gap between successive flowering years.

Much controversy has centred around the effects of burning on snow tussock grassland and only recently has it been shown that burning as such does not permanently damage the tussocks (O'Connor 1962). My study has also shown that narrow-leaved snow tussocks can tolerate spring burning without permanent damage. In fact snow tussocks show in some ways a definite adaptation to fire. Burning triggers a marked but temporary increase in growth which culminates in prolific flowering and the production of abundant viable seed during the second season after fire. Moreover, under certain conditions fire will trigger germination of the long-lived seed lying dormant in the leaf litter and many of these seedlings may become established provided that frost lifting is not severe.

The important aspect to stress from the point of view of management is that these apparent adaptations to fire are very seriously counteracted by grazing, especially heavy grazing during the period when the tussocks are recovering from fire. Even healthy unburnt plants are vulnerable to heavy grazing. They can for example be virtually killed after three years of severe annual clipping, and a recently burnt plant, being much more palatable, is more vulnerable to grazing. All grazing of snow tussock grassland should be curtailed at least until the third season after burning, by which time regrowth will be considerable and abundant viable seed will have been produced.

Burning during the spring of a flowering season should be avoided if a good seed crop is desired, since it will seriously reduce flowering. Flowering seasons can be forecast prior to spring burning by carefully dissecting a number of shoots, preferably during spring but even as early as late autumn. Further work may allow prediction of flowering almost a year ahead from temperature records alone.

Reburning should be delayed sufficiently to permit a widespread fire, since the severe grazing associated with the inevitable concentration of stock on a limited area of burnt tussock usually kills or severely weakens the burnt plants. Moreover, growth after reburning increases with the interval between fires.

Establishment of snow tussock seedlings at high altitudes is much more difficult than at low altitudes because reduced seed production, reduced viability and the extremely severe environ-
ment all reduce the chances of seedling establishment. However, it has been found that establishment at high altitudes of whole tussocks or even portions of tussocks shifted from lower altitudes is not difficult, at least when the sites are stable. These plants continue to grow faster than those of the high-altitude strain and provide an effective cover. Although such plants probably would never flower here, this need not be serious since plants are very long-lived. Plantings of individual tussocks on deteriorated or unstable sites in areas which supported snow tussock grassland at the time of European settlement might also be successful. Even single open-planted tussocks modify the environment in their vicinity considerably and may allow the natural establishment of other species which otherwise would fail. This may prove to be the best way of rehabilitating severely depleted land at high altitudes.

As Dr Lucy Moore stated ten years ago, tussock grassland has more of the characteristics of a forest than of a short rotation pasture, being the product of a long, slow development. Like a forest it is much easier to destroy than to rebuild.

REFERENCES

MR M. M. CHISHOLM, M.B.E.
High-country men everywhere will be delighted with the award of an M.B.E. to Bill Chisholm in the Queen's New Year Honours' List. He is to be congratulated on a well deserved award.

Bill Chisholm has done a first class job in the high country. The condition of Molesworth must have daunted the stoutest-hearted of men when he took over. By an intelligent appreciation of the needs of his country and by sheer hard work he has overcome many of his most formidable problems. The rabbits have gone, thousands of acres of bare hillsides have been reclothed and meat production is on its way up. All this has been achieved without costing the taxpayer a penny.

As opposed to the O.B.E., which is the "Other B——’s Effort," the M.B.E. is popularly supposed to stand for "My B—— Effort." In Bill Chisholm's case, how true this is.

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Postal Address:
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Lincoln College,
Christchurch.

Telephone:
62-839 Christchurch

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