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This charming little fellow, originally imported in hopes of developing a thriving fur trade, has since become a major pest as related by Jerry Aspinall (pp. 47-50). The drawing of this Australian arboreal denizen was done by Australian artistically delightful Miss Pat Prendergast.

W. G. KREGER
Editor

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Designing fencing for grazing management

J. G. Hughes and K. F. O'Connor

Influential factors

1. Size of flock

Flock size may affect grazing behaviour with consequential demands on the fencing design.

It has been suggested that sheep in a flock position themselves when grazing so that two other sheep or fixed objects are within the limits of their vision. Without this "security" they do not settle. Also, very small flocks are likely to stay near fences separating them from larger flocks in adjacent paddocks. However, in general, research has found no significant difference between the liveweight changes and wool production of flocks of different sizes at similar grazing pressure on pasture.

It has been pointed out, though, that the availability of shelter and water, and the distances between shelter, water and the limits of the block, could influence the performance of large flocks on pasture of low carrying capacity. In other words, sheep may spend time travelling from sparse forage and water or shelter that they could better spend grazing. Also, vegetation near these points may be overgrazed and animal production fall accordingly.

2. Grazing Pressure

Grazing pressure to be applied in different situations will determine the intended stocking rate.

In general, there is more risk than benefit from periodic high grazing pressure on both unimproved or improved grasslands in semi-arid zones. Where soil moisture is less than plant demand, particularly at levels approaching wilting point, plants are especially vulnerable to too-frequent defoliation.

But on improved grasslands in sub-humid and particularly in humid zones, periodic high-intensity stocking for herbage control and active nutrient cycling is essential.

In the short term, as grazing pressure increases:

(i) There may be less exclusive grazing of preferred plants; previously unacceptable plants will be more likely to be eaten, and their opportunity to dominate the sward reduced.

(ii) The sward will be opened up letting in light and reducing the amount of leaf death by shading. Total herbage yield will tend to increase towards climatic, nutritional and soil moisture limits.

(iii) There will be more tillering in grasses.

(iv) There will be less rainfall interception, perhaps more surface compaction by raindrops, less infiltration and ground
water storage and more runoff—a trend gradually reversed if soil organic matter has the opportunity to increase.

(v) There will be increased recycling and redistribution of nutrients by animal defaecation and urination.

(vi) The nutritional value of the animals' intake will decline and eventually, at high grazing pressure, the intake of each animal also. However, animal production per acre will increase.

(vii) There will be increased treading damage of plants by animals, soil compression and perhaps displacement. Plant density and/or basal area may decrease.

Thus, as grazing pressure increases, total animal production tends to increase but the risk of soil erosion increases also—unless sward density is kept high by nutrient supplementation in conditions of adequate soil moisture for vigorous plant growth.

### 3. Stocking rates determine size of paddock

In rotational grazing systems*, for herbage control, stocking rates of at least 45 per hectare and even, in humid grasslands with a scrub problem, 250 or more per hectare must be used. Paddock size must be suited to the number of stock of one class available as a mob. Thus, 2000 ewes need 44ha paddocks for 45 per hectare, or 22ha paddocks for 90 per hectare. At lower stocking rates, the grazing pressure will likely be so low that you will be unable to cope with the seasonal flush of herbage induced by top-dressing. You will lose the opportunity to graze off new growth on scrub. Shading, death and decay of foliage will waste your investment in growing it and light-demanding plants such as white clover may succumb. In addition, such an environment is ideal for the proliferation of pasture-eating pests. Remember, flock size determines block size! The same applies to cattle.

On large properties with large numbers of stock in one class—say, more than 5000 ewes—some managers break the flock to mobs able to be vaccinated, drenched, dipped or otherwise handled in one day by a unit of shepherds. But the mobs—perhaps two in this case—will still be big enough to apply high grazing pressure when needed on improved country.

At some point you must compromise between gain and losses in sward quality and gains and losses in animal performance due to continuing grazing. The point you select depends on what your objectives are—high animal growth rate, roughage control, some use with minimum soil loss?

Obviously, the more animals you put into a paddock of a given size, the faster will the consequences of their presence occur.

If you put in too few, some might never occur at all—the unacceptable plants may never be eaten, changes in soil moisture might not take place, animal performance may not decline. If herbage control takes too long, the regrowth of preferred plants will be too frequently eaten and their position in the sward weakened, especially if the plant is short of moisture.

Clearly, the size of the mob turned on to a given pasture is all important.

In the interests of reduced capital expenditure early in a development plan, you should consider constructing two types of fence. First, a framework of strong permanent fences along obviously permanent fencelines. Second, to get high stocking rates with initially small mobs, build temporary netting and electric fences to subdivide the large blocks enclosed by the framework. These fences can later be strengthened or removed, depending on their usefulness.

### 4. Paddock shape and orientation

(a) Area and fence length:

The perfect shape for economical fencing

---

The precise meanings of various terms used in this article (e.g., grazing pressure, seasonal set stocking, stocking density, stocking load, etc.) are defined in N.Z. Range Management Guidelines No. 1, "Objectives, Concepts and Principles in Grazing Management," by J. G. Hughes and K. F. O'Connor, Tussock Grasslands and Mountain Lands Institute Review 32: pp5-15.
of a single paddock would be, of course, a circle. A circular perimeter would enclose the largest area of land within the shortest boundary.

For practical subdivision the shape with the nearest approach to a circle's economy is the square.

For instance, to enclose 50 hectares in:

(i) a circular paddock: total fence needed is 2500m.

(ii) a square: total fence needed is 2840m.

(iii) a rectangle with two sides each 1000m long, and two sides each 500m long: total fence needed is 3000m.

On the near flat inland plains of Australia, some properties are subdivided almost entirely into square paddocks. This is rarely possible in New Zealand because of our broken topography.

However, on plains, terraces and downs you should always fence to make paddocks as near square as possible.

Note: On cropping farms without stock or fences, long narrow paddocks are more economical for cultivation since tractors then waste less time turning on headlands.

(b) Animal factors:

Grazing behaviour: In square-type or "fat" paddocks, animals can spread out better and disturb each other less by their movement.

Water: Some recent Australian studies have shown that dry sheep in some climate zones can survive and grow wool quite well without water. However, other classes of stock need water and you must either plan your subdivision to enclose part of a permanent stream, or pipe in water, bore wells, tap springs or excavate ponds. Preferably water supply points should be so distributed in a block that they spread grazing into otherwise unfavoured areas such as higher up slopes and in the heads of intermittent streams. You may be able to plan for the corners of several paddocks to meet at an important water point.

Climate: Animals tend to graze into light winds but run before strong winds. Therefore, trees for stock shelter are best planted along the downwind boundary of a paddock. Even more effective is to plant them a hundred or so metres away from the boundary and let sheep shelter behind them. Thus, consider good sites for shelter-belts when planning subdivision.

In the back country, trees are rarely grown for stock shelter. Here you should make as much use of hills and gullies lying across the storm winds as possible. If you are fencing on a terrace or flat-topped hill, remember to give sheep a downwind run-off over the edge so they can shelter from driving rain. If the face is scrubby, so much the better. Seed it for feed.

Animals used to snow often climb out to high ground before it gets deep. Try not to block sheep moving out of potentially dangerous gullies, especially if they have few access tracks across rough country. Again, remember where you may need to reach a safe face when snowraking. On the other hand, you may often have to site fences to stop sheep getting into high snow risk areas, particularly in late autumn or early winter.

5. Flock Management Requirements

Rams, of course, must be able to be kept separate from ewes and bulls from cows but it is rare now to find a hill country property which does not also fence and keep young stock from old, wethers from ewes and steers from cows to allow differential feeding.

If possible, any fence should aid and not hamper mustering by avoiding the obstruction of obvious contour tracks, leads through bluffs, safe stream crossings and driving paths down spurs. Sheep follow certain drains, tracks and saddles when being mustered. Try not to disrupt their movement.

Lanes greatly simplify stock management. The cost of double fencing may be frightening but those few sheepmen who
have built them consider lanes to be well worth the investment: To simplify stock movement, not only between blocks but also to and especially from the shearing shed or yards. The saving in labour is quite significant. You do not need musters to shift sheep along lanes. Lanes from shearing sheds and sheltered, well-grassed paddocks are particularly valuable in bad weather.

Where a lane would help but cannot be afforded now, site a fence to one side of a leading spur or other obvious route where possible to complement a parallel fence later.

6. Soil Conservation Factors

Fencing for soil conservation purposes is erected either:

(a) To act as an exclosure to stock, e.g., from trees, a pond, a waterway, a seriously eroded area or a crop, or

(b) To act as enclosures to allow different grazing pressures on different areas of land. This may be:

(i) To spell plants for seeding and/or to permit seedling establishment.

(ii) To suit different levels of erosion risk.

Other fences may need to be considered in a plan; for instance, fences designed principally to aid sheep-class separation or high-intensity stocking for herbage control.

Exclosure fence placement is controlled by location of the structure or vegetation to be protected.

Enclosure fences should basically follow land-capability-class boundaries, wherever topography permits – dividing the shady face from the sunny, the steep slope from the gentle, and the high-risk land from the low. In other words, areas of similar slope and quality or type of vegetation should be fenced and managed from other dissimilar areas. Obviously, while land capability boundaries should guide the line of the fence, the size of the area enclosed has to depend on the proposed grazing system and grazing pressure as already discussed. Where single classes of land are too large for sufficient grazing pressure to be reached, the unit may need to be further subdivided along boundaries of convenience.

Soil conservation fences could be called protection fences. These latter are clearly production fences.

7. Design Practice

(a) Siting the line:

(i) Fence lines straight up and down a slope suffer least from snow, boulders and slips.

(ii) Where slopes must be crossed, look for natural glacial ridges, for old terraces, for changes of slope, for anything which will break or divert the slide of snow or the avalanche of rock or mud. Strangely enough, fences crossing shingle scree frequently suffer less than those in dense snow tussock. Perhaps this is due to snow sliding on shingle when it is less deep than when it is held by snow tussock until a critical amount builds up.

(iii) A fence right on a ridgetop can often be seen by musterers on adjacent ridges and the area thus checked for sheep. Where the fence lies just out of sight over the ridge or disappears from view in places to leave blind pockets, much time can be wasted if the conscientious musterer has to move across to the fence ridge itself to check.

(iv) Unfortunately, a fence on an exposed ridgetop lying across the prevailing snow wind is just where a fence will suffer most from driven snow. In the lee of the ridge (but sited free from cornices), the fence may be protected if routed through basins with deep but non-sliding snow in winter.

(v) A ridgetop fence is usually much easier to traverse for maintenance, inspection and repair than a fence across a face.
(vi) A ridgetop can often be fenced with fewer undulations and hence fewer tiedowns than a slope. Apparently smooth slopes are often deceptive. The fewer the tiedowns, the less the maintenance.

(vii) A fence line that can be bulldozed may halve the transport and maintenance costs but beware of easily-eroded clearings on steep hill faces.

(viii) The shortest fence line is not necessarily the best fence line if it means crossing a face.

(ix) Cross streams at gorges or narrow confined points, not where they can meander or where the banks can easily erode.

(b) Siting the gate

(i) Siting of gates for mustered sheep is a ready art to those who have moved sheep down from higher blocks through series of paddocks without lanes.

(ii) Siting of gates for use in rotational grazing practice must now depend on observation of grazing behaviour of settled sheep rather than driven sheep, so that movement of stock can be achieved readily and quickly.

(iii) Siting of gates to have them more readily usable is an essential step towards rotational grazing. It probably demands considerable observation or intuition to arrive at a system of low-cost hill country gates which make it possible to move sheep or cattle freely and with little disturbance at low cost of labour.

(iv) There has been considerable research in fencing practice and material. There has been little, if any, research in gates. Either we learn to design and use gates or we will have to find some way to do without fences.
The return of the natives

G. A. Dunbar, E. J. Costello, I. R. Fryer

In recent years there has been much emphasis on revegetation of high altitude eroded surfaces, especially in work conducted by the Forest and Range Experiment Station of the New Zealand Forest Service and by the Tussock Grasslands and Mountain Lands Institute. A summary account of work in the Institute was contained in an article published in Review 20 (Dunbar 1970a) and more detailed accounts have been published subsequently (Dunbar 1970b, 1971, 1974a, 1974b, 1974c; Dunbar and Adams 1972).

Amongst the work described in Review 20 were the investigations begun in 1966 at 10 high altitude trial sites from Marlborough to Southland. To recap, the results were, briefly, that best growth of a grass-clover mixture would be obtained in such locations by using a fertiliser containing nitrogen, phosphorus, magnesium and potassium, while sulphur also would be beneficial on most situations. Little or no growth of grass or clover could be expected in the absence of phosphorus, and nitrogen also was usually necessary for satisfactory grass growth.

It was recognised in this work that the establishment of a grass/legume cover was not necessarily the final step in a revegetation process. Instead, it was felt that it should be the primary step in achieving a stable soil surface and that this in turn should encourage the further establishment and growth of a wide range of native species, well adapted to the environment. By 1970 the original objectives of the trials had been reached and in the spring of that year each enclosure of about 400m² was surface sown with a mixture of Yorkshire fog, browntop, Chewings fescue, ryegrass and white clover. A uniform fertiliser mixture, which supplied nitrogen, phosphorus, sulphur, magnesium, potassium, calcium and molybdenum was also used on all plots. Two maintenance fertiliser dressings, mainly superphosphate, have been applied since 1970. Records have been kept of the results of this resowing and the changes over the years, using as units the 64 sub-plots laid

Table 1: Description of trial sites

<table>
<thead>
<tr>
<th>Location</th>
<th>Altitude (metres)</th>
<th>Slope (degrees)</th>
<th>Aspect</th>
<th>Percentage Erosion Surface Estimate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Black Birch, Marlborough</td>
<td>1,430</td>
<td>7</td>
<td>N</td>
<td>95</td>
</tr>
<tr>
<td>Dog's Range, Canterbury</td>
<td>1,430</td>
<td>6</td>
<td>SSW</td>
<td>100</td>
</tr>
<tr>
<td>Island Pass, Marlborough</td>
<td>1,370</td>
<td>10</td>
<td>W</td>
<td>100</td>
</tr>
<tr>
<td>Mid-Dome, Southland</td>
<td>1,420</td>
<td>13</td>
<td>WSW</td>
<td>95</td>
</tr>
<tr>
<td>Carrick, Otago</td>
<td>1,220</td>
<td>28</td>
<td>E</td>
<td>90</td>
</tr>
<tr>
<td>Dunstan, Otago</td>
<td>1,160</td>
<td>27</td>
<td>SSW</td>
<td>95</td>
</tr>
</tbody>
</table>
out at each site in 1966. For various reasons, the methods of recording, and the years in which recordings were made, have not been consistent for all sites. While this complicates the presentation of this account, it does not invalidate the records.

Re-establishment

In the autumn of 1976 all sites, except two, were visited and the records confirmed earlier observations that at most plots there was a significant re-establishment of the native species. However, six sites only have been chosen for this account of the major changes in vegetative cover which have taken place. The six examples give a good representation of the altitude, aspect, soil and vegetation types covered by the whole series. Apologies are given for the lack of positive species identification at this stage for plants of some native genera which have established in the plots. Species may indeed be very important in the interpretation of successional changes, and the necessary identification will be completed before this is attempted.

In the account which follows, the sites are listed not so much in strict geographical order, as in three sets of contrasting pairs. Thus, as shown in Table 1, Black Birch and Dog’s Range represent sunny and shady
aspects respectively of gently sloping, high-altitude surfaces with fine-grained surface materials. Island Pass and Mid-Dome represent a sunny, dry and a colder, wet aspect respectively of moderately steep surfaces of greywacke material, while Carrick and Dunstan represent sunny and shady aspects on strongly to steeply sloping surfaces of schistose material.

Black Birch

The enclosure on the Black Birch Range in Marlborough was established on an extremely eroded surface, with just a few scattered remnant clumps of Notodanthonia setifolia (mountain danthonia), Festuca matthewsii (Matthew's fescue) and Celmsia spectabilis (cotton plant). Direct exposure to north-westerly winds appears to have been largely responsible for the degradation from what was once probably a community dominated by Chionochloa pallens, with N. setifolia far less prominent than at present. A potential seed source of native vegetation exists about 20 metres from the plot.

Table 2 gives the figures obtained from sampling the vegetation with a point frame on three occasions between 1969 and 1976. Each of the 64 original subplots was sampled separately and the figures given are the means for these. The 1969 figures illustrate the rundown in vegetation cover at the end of the initial experimental phase. The 1973 figures show the improvement in cover three years after the general resowing and the 1976 figures show a subsequent rundown in living vegetation cover, especially in introduced species. What the latest figures also show, however, is a marked increase in the amount of the native cover.

In 1973 seven native species were recorded on twenty of the subplots. N. setifolia and C. spectabilis occurred most frequently and together provided about 80 percent of all “hits” on native species. On the other hand, in 1976, twelve native species were recorded on fifty subplots, and the presence of another four species was noted, giving sixteen species altogether.

Although the actual frequency of Notodanthonia and Celmsia had together increased by about 25 percent, Epilobium had increased much more to become the second most commonly hit species, next to Notodanthonia. Other, perhaps less ephemeral
natives present in 1976 were *Raoulia subsericea*, *Poa colensoi*, *Gaultheria depressa* and *Festuca matthewsii*, along with species of *Luzula*, *Myosotis*, *Scleranthus*, *Acaena*, *Drapearis*, *Lachnagrostis*, *Gentiana* and lichen and moss.

While the general trend of native re-invasion may be obtained from the combined

<table>
<thead>
<tr>
<th></th>
<th>1969</th>
<th>1973</th>
<th>1976</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total vegetative cover</td>
<td>13.8</td>
<td>40.2</td>
<td>30.1</td>
</tr>
<tr>
<td>Living vegetation</td>
<td>9.2</td>
<td>28.5</td>
<td>25.1</td>
</tr>
<tr>
<td>Introduced living</td>
<td>6.4</td>
<td>25.1</td>
<td>18.6</td>
</tr>
<tr>
<td>Native living</td>
<td>3.8</td>
<td>3.4</td>
<td>6.5</td>
</tr>
</tbody>
</table>
The enclosure on Black Birch Range in 1973 with residual mountain danthonia clumps prominent amongst darker coloured introduced vegetation.

records of 50 or so point samples from each subplot of 3m² area, the detail may only be seen from closer study. The sketch of one subplot from Black Birch (Figure 1) shows a greater number of native plants than would be expected from a sampling of 50 points which gave just one hit on *N. setifolia* and one hit on *Poa colensoi*.

Dog's Range

The Dog's Range site, with a slight southern aspect, provides an interesting comparison with the slight northerly aspect of the Black Birch situation. Other factors of slope, altitude and degree of erosion are similar. The major species in the discontinuous vegetation surrounding the plot are *Chionochloa macra*, *Poa colensoi*, *Dracontophyllum prostratum* and *Celmisia walkerii*.

There were very marked differences in establishment amongst plots in the initial experiments at this site. At the end of the early experimental phase in 1970 the mean estimated cover for the 64 subplots was a low 17 percent. Five plots had no vegetation at all and a further 31 plots had no more than 10 percent cover remaining from experimental treatment. Point sampling of the best 15 plots showed that the introduced living vegetation seldom exceeded 15 percent of surface plot area. No native plants were recorded.

Three years after the general resowing, that is, in 1973, the mean figure for estimated cover was a moderate 28 percent, but this still gave a high degree of surface stability. Seedling *Poa colensoi* were noted on five plots, while one seedling each of *Chionochloa macra* and *Festuca matthewsii* were on two other subplots.

The latest 1976 point sample gave figures of 44.6 percent total vegetative cover, and 33.3 percent for living vegetation, comprising 31.5 percent for introduced living, and 1.8 percent for native species. The 1.8 percent native vegetation was provided by 9 species found on 31 plots from point records, but a further 9 species were noted as present to give 18 natives all told. The
Bulk of point records on natives were given by the *Epilobium* and moss; other species occurring sparsely were *Koeleria novozelandica*, *Poa colensoi*, *Chionochloa macra*, *Notedanthonia thomsoni* (?), *Festuca matthewsii*, *Poa lindsayi*, *Celmisia spectabilis*, *C. lyallii*, *C. walkerii*, *Raoulia grandiflora*, *Dracophyllum prostratum*, *Scleranthus biflorus* and *Wahlenbergia*, *Anisotome*, *Luzula* and *Myosotis*.

Sketch detail of native species present on one subplot is shown in Figure 2. A 50 point sample of this plot did not actually hit any natives, despite the presence of 5 *Chionochloa macra* plants and other species.

Although the number of natives on this site is still quite low, it is quite significant that a start has been made by the snowgrass species, *C. macra*.

Looking east to the Taylor Range from the Dog's Range site. Chewings fescue is the main plant species inside the fence in 1976.
Island Pass

The westerly facing slope of the site at Island Pass represents some of the most difficult situations for revegetation. Apart from the high altitude and severe exposure to sun and wind, there is little material at ground level that would qualify to be classed as subsoil. The substrate available for plant growth is mainly angular stones ranging from 15cm in diameter down to fine gravel and this is underlain by parent rock at about 20cm. Perhaps it was not surprising then that the original experimental treatments in 1966 failed to introduce exotic grasses and clovers to the hillside.

The success of the 1970 sowing (right) at Island Pass produced a marked contrast with the bare site in 1968.

The enclosure remained barren of vegetation until the spring of 1970 when, with the others of the series, it was treated with the standard seeds and fertiliser mixture. The result this time was most encouraging — there was a very good establishment of Yorkshire fog, Chewings fescue, browntop and white clover.

Point sampling results on three occasions in subsequent years are shown in Table 3.

This site is unlike the others in the series in that despite six seasons with the introduced plant cover, establishment of volunteer native species has been negligible. No

<table>
<thead>
<tr>
<th></th>
<th>February, 1973</th>
<th>May, 1975</th>
<th>April, 1976</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total cover</td>
<td>43.5</td>
<td>56.5</td>
<td>53.6</td>
</tr>
<tr>
<td>Living cover</td>
<td>34.4</td>
<td>51.7</td>
<td>40.5</td>
</tr>
<tr>
<td>Introduced grasses</td>
<td>11.5</td>
<td>14.9</td>
<td>22.8</td>
</tr>
<tr>
<td>Clover</td>
<td>18.7</td>
<td>33.3</td>
<td>16.9</td>
</tr>
</tbody>
</table>
With a good establishment of grasses and clover, the resowing of the Mid-Dome site in 1970 meant that there was about 50 percent cover of the ground surface two years later.

natives were recorded in the 1976 point sampling, but a closer ground search showed that there were in fact a few *Epilobium* plants present. It is true that some of the other sites showed few natives after six years with introduced cover, but the process of re-establishment may still be slower on this westerly exposure. Competition for moisture and nutrients from the established exotic species must be very high and there has not been much build-up of mulch. The wind-swept exposure and comparative isolation of the plot in a large bare area probably militate against re-invasion of the natives. Nonetheless, it is hoped that the few *Epilobium* may mark the beginning of a slow return.

**Mid-Dome**

The summit of Mid-Dome in Southland is completely exposed to strong southerly

<table>
<thead>
<tr>
<th>Table 4: Vegetation as a percentage of total point records, Mid-Dome</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>April, 1973</strong></td>
</tr>
<tr>
<td>Total vegetative cover</td>
</tr>
<tr>
<td>Living cover</td>
</tr>
<tr>
<td>Introduced living cover</td>
</tr>
<tr>
<td>Native living cover</td>
</tr>
</tbody>
</table>
Establishment of grasses and clover from the original experimental sowings was poor. By the end of the third season there were few clover plants remaining and the mean estimated frequency of remaining grasses was less than four small plants per square metre.

There was, however, a very good establishment from the general resowing in 1970 and at the end of the first season the estimate of plant cover for the whole plot was 35 percent.

The 64 subplots were point sampled in 1973 and 1976 and results in broad terms are given in Table 4.

In 1973, five native species were recorded on fifteen subplots, *Neopaxia australasica* being the most frequently occurring species. In 1976 there were 12 species recorded from 48 plots and a further 6 species were noted, giving 18 all told. The native figure for total hits is, however, much inflated by records for moss, which in fact comprise more than half of the total. Despite this, there was clearly a large increase in the number of species, between 1973 and 1976. Apart from moss, species present in 1976 were an *Acaena, Agrostis subulata, Chionochloa* and westerly winds. The tall tussock *Chionochloa macra* is dominant close to the plot site but in 1966 the plot was bare of vegetation and topsoil.
macra, Drapetes dieffenbachii, Epilobium, Festuca novae-zelandiae, a Gentiana sp., Helichrysum bellidioides, Hebe epacridae, Luzula, lichen, Notodanthonia setifolia, Poa colensoi, Raoulia subsericea, R. grandiflora, and Scleranthus.

The blue tussock, *Poa colensoi*, is one of the most obvious invaders, although plants are still small. Figure 3 gives the details of natives in one subplot (55) from Mid-Dome. The point record gave 9 percent hits on the native species shown.

**Carrick**

The Carrick site, between Bannockburn and the Nevis Valley, is on a sunny slope of schistose material. Although at high altitude, low rainfall during the short growing season appears to be a major factor limiting re-establishment of vegetation. Although the surrounding vegetation may once have been dominantly snow tussock, these are now mainly near the drainage channels and a short tussock association of *Poa colensoi* and *Festuca novae-zelandiae* predominates elsewhere.

Data from point sampling the Carrick site on three occasions between 1967 and 1976 are given in Table 5. As for other sites, these are means for 64 subplots.

The 1967 figures show that even in the first year of the experimental treatments, establishment of sown vegetation was poor. The adventive species *Rumex acetosella* (sheep's sorrel) has been present throughout and has responded to fertiliser at each application. The figures in parenthesis for introduced vegetation are totals when sorrel is included. Thus, in 1967 sorrel was as common as the sown grass and clover. Resowing in 1970 did not give large increases in grasses and clovers but the increased sorrel was still very much in evidence in 1973. By 1976 the sorrel/other vegetation ratio had fallen again. The 1976 sampling results have to be treated with some reservation because rabbits had gained access to the plot during the summer, even at this altitude of 1220m and very severe grazing of all species had occurred. It was especially severe on white clover in the plot, frequently extending to the complete removal of stolons. The low figure of 17.7
percent for living vegetation is a reflection of the severe grazing on introduced species. Despite the grazing, natives showed a slight increase. In 1973, there were 7 native species recorded on 28 of the 64 subplots. Notodanthonia buchanani, Poa co/ensoi and Festuca novae-zelandiae occurred most frequently and provided about two-thirds of the total records of native species. In 1976 there were 9 native species recorded on 44 subplots, while another 3 species were noted, for a total of 12. The only two species to show an increase in frequency of occurrence at the 1976 sampling were F. novae-zelandiae and Raoulia subsericea. The latter species would certainly be least affected by the grazing. Other natives present on this plot were Blechnum penna-

The mobile schist scree (left) seen in the 1966 photograph on the Dunstan Range has been well stabilised, as is seen in the detail of Plot 12. Here several blue tussocks have established in the sown grasses.


Table 5: Vegetation as a percentage of total point records, Carrick site

<table>
<thead>
<tr>
<th></th>
<th>1967</th>
<th>1973</th>
<th>1976</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total vegetative cover</td>
<td>16.5</td>
<td>41.1</td>
<td>32.8</td>
</tr>
<tr>
<td>Living vegetation</td>
<td>16.5</td>
<td>37.9</td>
<td>17.7</td>
</tr>
<tr>
<td>Introduced living</td>
<td>8.6 (15.2)</td>
<td>10.0 (34.6)</td>
<td>7.1 (14.1)</td>
</tr>
<tr>
<td>Native living</td>
<td>1.3</td>
<td>3.3</td>
<td>3.6</td>
</tr>
</tbody>
</table>

Dunstan

This site on the eastern flank of the Dunstan Range north of Alexandra, Otago, is on a steep schist scree with a cold southerly
aspect. At 1160 metres, it has the lowest altitude of the sites discussed here. Vegetation surrounding the scree is pre-

dominantly a blue tussock/Matthews fescue association, but tall tussock (*Chionochloa macra*) and speargrass are occasionally locally dominant.

At the end of the first experimental phase in 1970, vegetative cover on the individual subplots varied from complete absence to about 30 percent of area, but the mean overall was estimated to be at the low figure of 7.3 percent. The resowing in the spring of 1970 gave a good establishment of introduced grasses and white clover. By the autumn of 1973 the mean for estimated cover on subplots was 50.6 percent of area, with a dominant Chewings fescue content. Seven native species were recorded as having become noticeable within the plots at this time, the major species being *Stellaria gracilenta*, *Poa colensoi* and *Festuca matthewsi*.

A feature of this plot, especially in the last three years, has been the very large number of lichens which has established. Although not contributing much volume to the above-ground vegetative cover, the high content of lichens has at least been confirming evidence of considerable stability in the scree materials. As an indication of the extent of the stability in 1976, 8.2 percent of all point samples fell on lichens, a further 2.5 percent on moss—a total of 10.7 percent of all points. Lichens and mosses rightly should be regarded as part of the revegetation process but because of their high proportion in the total sample in this case they have been excluded from the 1976 vegetation cover summary. Thus, the figures show: total vegetative cover 48.3 percent; living cover 38.0 percent; introduced living 36.2 percent; and native (other than lichens and mosses) 1.8 percent. This 1.8 percent of living natives came from 9 species found on 32 plots from point records, but a further 5 were noted as present on the plots, giving 14 species altogether. The major species in order of occurrence in 1976 were *Stellaria gracilenta*, *Festuca matthewsi*, *Poa colensoi* and *Aciphylla aurea* (?). Species of *Cotula*, *Epilobium*, *Wahlenbergia*, *Helichrysum* and
### Table 6: Native species occurrence by number of subplots

<table>
<thead>
<tr>
<th>Species</th>
<th>Black Birch</th>
<th>Dog’s Range</th>
<th>Mid-Dome</th>
<th>Carrick</th>
<th>Dunstan</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Epilobium sp.</strong></td>
<td>39</td>
<td>23</td>
<td>19</td>
<td>7</td>
<td>3</td>
</tr>
<tr>
<td><strong>Poa colensoi</strong></td>
<td>2</td>
<td>2</td>
<td>6</td>
<td>11</td>
<td>11</td>
</tr>
<tr>
<td><strong>Mosses</strong></td>
<td>11</td>
<td>16</td>
<td>44</td>
<td>-</td>
<td>35</td>
</tr>
<tr>
<td><strong>Lichens</strong></td>
<td>3</td>
<td>-</td>
<td>5</td>
<td>1</td>
<td>60</td>
</tr>
<tr>
<td><strong>Luzula sp.</strong></td>
<td>1</td>
<td>-</td>
<td>1</td>
<td>-</td>
<td>1</td>
</tr>
</tbody>
</table>

**Two or three sites**

<table>
<thead>
<tr>
<th>Species</th>
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<th>Mid-Dome</th>
<th>Carrick</th>
<th>Dunstan</th>
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<tbody>
<tr>
<td><strong>Acaena sp.</strong></td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td><strong>Aciphylla sp.</strong></td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
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<tr>
<td><strong>Agrostis subulata</strong></td>
<td>-</td>
<td>-</td>
<td>3</td>
<td>-</td>
<td>x</td>
</tr>
<tr>
<td><strong>Celmisia spectabilis</strong></td>
<td>15</td>
<td>1</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td><strong>Chionochloa macra</strong></td>
<td>-</td>
<td>1</td>
<td>1</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td><strong>Drapetes dieffenbachii</strong></td>
<td>x</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td><strong>Festuca matthewsi</strong></td>
<td>1</td>
<td>x</td>
<td>-</td>
<td>-</td>
<td>9</td>
</tr>
<tr>
<td><strong>Festuca nova-zelandiae</strong></td>
<td>-</td>
<td>-</td>
<td>x</td>
<td>22</td>
<td>-</td>
</tr>
<tr>
<td><strong>Gentiana sp.</strong></td>
<td>x</td>
<td>-</td>
<td>2</td>
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<td>-</td>
</tr>
<tr>
<td><strong>Helichrysum bellidioides</strong></td>
<td>-</td>
<td>-</td>
<td>x</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td><strong>Koeleria novo-zelandica</strong></td>
<td>-</td>
<td>3</td>
<td>-</td>
<td>-</td>
<td>1</td>
</tr>
<tr>
<td><strong>Myosotis sp.</strong></td>
<td>1</td>
<td>x</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td><strong>Notodanthonia (buchanani)?</strong></td>
<td>-</td>
<td>x</td>
<td>-</td>
<td>11</td>
<td>x</td>
</tr>
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<td><strong>Notodanthonia setifolia</strong></td>
<td>22</td>
<td>-</td>
<td>1</td>
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<td>-</td>
</tr>
<tr>
<td><strong>Poa lindsayi</strong></td>
<td>-</td>
<td>x</td>
<td>-</td>
<td>x</td>
<td>-</td>
</tr>
<tr>
<td><strong>Raoulia australis</strong></td>
<td>-</td>
<td>-</td>
<td>1</td>
<td>1</td>
<td>-</td>
</tr>
<tr>
<td><strong>R. grandiflora</strong></td>
<td>-</td>
<td>x</td>
<td>x</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td><strong>R. subsericea</strong></td>
<td>4</td>
<td>-</td>
<td>1</td>
<td>24</td>
<td>-</td>
</tr>
<tr>
<td><strong>Scleranthus biflorus</strong></td>
<td>1</td>
<td>1</td>
<td>x</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td><strong>Wahlenbergia albomarginata</strong></td>
<td>-</td>
<td>-</td>
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**One site only**

<table>
<thead>
<tr>
<th>Species</th>
<th>Black Birch</th>
<th>Dog’s Range</th>
<th>Mid-Dome</th>
<th>Carrick</th>
<th>Dunstan</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Anisotome sp.</strong></td>
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<tr>
<td><strong>Blechnum penna-marina</strong></td>
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<td>-</td>
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<tr>
<td><strong>Celmisia lyallii</strong></td>
<td>-</td>
<td>x</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td><strong>Celmisia walkeri</strong></td>
<td>-</td>
<td>x</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td><strong>Catula sp.</strong></td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>3</td>
<td>-</td>
</tr>
<tr>
<td><strong>Deyeuxiaavenoides</strong></td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>x</td>
<td>-</td>
</tr>
<tr>
<td><strong>Dracophyllum prostratum</strong></td>
<td>-</td>
<td>x</td>
<td>-</td>
<td>-</td>
<td>-</td>
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<tr>
<td><strong>Gaultheria depressa</strong></td>
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</tr>
<tr>
<td><strong>Hebe epacrida</strong></td>
<td>-</td>
<td>-</td>
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<td>-</td>
<td>-</td>
</tr>
<tr>
<td><strong>Lachnagrostis sp.</strong></td>
<td>x</td>
<td>-</td>
<td>-</td>
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</tr>
<tr>
<td><strong>Neopaxia australasica</strong></td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>x</td>
<td>-</td>
</tr>
<tr>
<td><strong>Poa maniototo</strong></td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>3</td>
<td>-</td>
</tr>
<tr>
<td><strong>Stellaria gracilenta</strong></td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>13</td>
<td>-</td>
</tr>
</tbody>
</table>

**Note:** Figures represent numbers of subplots on which species hit by point sample (Maximum 64). Symbol x denotes plant observed in one or more subplot but not hit by point.
Koeleria were also struck in point records, while Luzula, Acaena, Notodanthonia, Agrostis and Deyeuxia were represented outside the points.

On this site, as well as on others, it was surprising to find the relatively low numbers of point records on native species compared with what appeared to be the case visually, especially perhaps with speargrass. The sketch of Plot 43 from the Dunstan site shows a high degree of colonisation by Poa colensoi, Aciphylla and Koeleria. Cotula and Stellaria, although present, have not been drawn. The sample of 50 points on this plot resulted in one hit on Poa colensoi, one on Aciphylla and three on Cotula. There were 16 hits on non-native material.

In Table 6 the varying incidence of native plants in five sites is shown. There was little in common amongst these sites 10 years ago except an absence of seedling vegetation. A common factor now is the presence in varying degree of Epilobium plants and seedling tussocks of Poa colensoi. Luzula is also a genus that has ability for early colonisation. Apart from the general nature of the blue tussock establishment, there is special encouragement in the record of Chionochloa macra seedlings at the Dog's Range site. Despite some disappointing results with tussock seeding trials in the past, the trends in these high altitude plots suggest that a direct progression from sown exotics to long-lived native species is possible. The further investigation of the cultivation and harvest of seed of native species is still required. If we are faced with the expense of a topdressed substrate of introduced vegetation as a nursery, it seems wasteful of resources to leave the future provision of native seed to unaided nature.

Acknowledgement

Many people have assisted with one aspect or another of the high-altitude revegetation trials in the 10 years since establishment. Rather than attempt to name individuals (and perhaps to forget to name some), the authors trust that a more general form of acknowledgement will be accepted; by runholders and the Department of Lands and Survey for allowing use of tracks and freedom of access to trial sites; and by staff of catchment authorities and the Water and Soil Division of the Ministry of Works and Development for assistance variously with establishment, maintenance, transport and data recording from time to time.

References*


* Revegetation work conducted by the Tussock Grasslands and Mountain Lands Institute.
Criteria for high mountain recreation development

Dr Howard R. Alden

Introduction

Concern about the impacts of traditional recreation uses of the New Zealand mountains and facilities to support these uses has been well expressed by individual citizens, organised groups such as the Federated Mountain Clubs of New Zealand Inc., and central Government departments such as Lands and Survey and the New Zealand Forest Service. These departments, organisations and individuals have also expressed their views on the necessity of planning for the wise use of mountain resources to include outdoor recreation (Conway 1970, Lucas 1974, McKelvey 1974, Mason 1974, Molloy 1974, O'Connor 1972). The various National Park boards have put forth policy plans to give direction to the management of people and resources in the high country parks consistent with the National Parks Act of 1952.

All of these concerns are timely and well articulated. They do not, however, provide the means to properly address the question of “when, where and how much use is enough in terms of providing a quality recreation experience – and minimising people impacts upon the resources?”

You may ask why that question to begin with? The response is: look at the condition of existing areas of limited access; look at areas where changing land uses have not recognised recreation values; look at the overcrowding of low cost accommodation adjacent to and in some of the national parks; look at the rate of increase in the New Zealand population. And there is the fact that memberships in the fishing “fraternity,” the New Zealand Deerstalkers’ Association, the Royal Forest and Bird Protection Society and the Federated Mountain Clubs are growing at rates up to three times that of the national population (McKelvey 1974).

Criteria for high mountain development can be looked at from a broad overview to determine if existing or projected use recommends allocation of resources to outdoor recreation. Assuming such allocation is necessary, detailed criteria can then be used to identify specific sites or areas consistent with providing a quality recreation experience with minimal environmental impact. These two viewpoints – broad overview and identification of specific sites or areas for outdoor recreation – will be the basis for the following discussion of criteria for high mountain recreation development.

The overview

The “overview” requires us to proceed with a process that puts recreation resource inventory and recreation use information into a format that is comparable to other land uses (Alden 1969, 1974a). The process is one that allows us to determine if there is a need to consider allocation resources to outdoor recreation. The implication of criteria is very clear.

Figure 1 provides a very basic flowchart
of the process for the "overview."
Prior to further discussion of the "overview," it is emphasised that the process only provides guidelines for negotiation and action in allocating resources to outdoor recreation. With this being understood, we can proceed with a brief discussion of the four elements A, B, C and D from Figure 1.

Element A, the resource inventory, requires us to properly assess the existing and potential recreation resources within the region. This includes, at a minimum, a general description of the resources by geographical location, number of hectares by a broad recreation land classification, by tenure, access, present recreational activities occurring on the land, facilities supporting these activities and the actual recreational...
opportunities provided (in an understandable unit of measure). In addition, the potential for use and development must be evaluated in reasonable yet general terms. Assuming that the resource inventory is procedural and we have completed it for "High Mountain Recreation Land, Class I" within "Region A." let us briefly look at a sample summary of the inventory (Figure 2).

Element B. of the overview, can be accomplished by three steps. These are:

- Simple car and people counts at key access points in the region - this to assess vehicle and people distribution without regard to recreation participation.
- Observation and recording of use distribution and user behavior at all key recreation areas in the region - this to assess the proportion of vehicles and people (passing key access points) using specific areas, what specific areas, what activities they participate in and how much time they spend participating in each activity (this related to high mountain recreation land classes).
- By location and land class within a region projecting to the future total use according to activities and time spent participating in these activities.

Once again, let us assume that we have completed the people surveys and projected the use data to the future for activities compatible with "High Mountain Land, Class I" within "Region A" (U.S.F.S. 1974c). A summary of the surveys is presented in Figure 3.

Element C. of the overview is the direct comparison of Elements A and B. This is shown in Figure 4.

Interpretation of Figure 4 illustrates that to meet present demands "A" hectares of
unalienated Crown lands, both existing and potential, should be made available (dedicated to outdoor recreation). Depending upon particular characteristics of these unalienated lands, action to guarantee recreation opportunities may include one or several of the following courses of action:

1. Redesignation to recreation reserve status.
2. Additional access – roads, tracks.
3. Basic facility development – huts, fire circles, pit toilets, primitive camping sites.

To meet future demands, “B” hectares are required. This might be accomplished through any one or several courses of action:

1. Intensify the people management of the supply of recreation reserves and unalienated Crown lands to increase the recreation opportunities.
2. Total acquisition of land use rights vested in alienated Crown land and freehold land at a fair market value.
3. Less than full acquisition of land use rights vested in alienated Crown land and freehold land at a fair market value (i.e., recreation or scenic easement).
4. A subsidy to compensate for the diminution of an economic unit as the result of public recreation use.
5. Legal protection to the freeholder as the result of permitting public recreation use of freehold lands.
6. Reduced tax rates to the freeholder as the result of permitting public recreation use of freehold lands.
7. More favourable insurance protection and rates for liability insurance protection.
8. Encourage the freeholder to provide outdoor recreation opportunities by leasing suitable areas of freehold land to individuals or clubs or by developing facilities and charging a fee for use of such facilities – a business operation.

Element D of the overview represents a summary of the recommendations/guidelines for action to provide outdoor recreation opportunities identified as being needed in Element C. This summary usually
includes the financial year action which is recommended, the department or departments responsible for carrying out the action, the action recommended – acquisition, access or development of “A hectares” of “High Mountain Recreation Land, Class I” in “Region A” – and how the action is to be accomplished. Table 1 represents a summary of a recommended action programme to meet outdoor recreation needs: to provide guidelines for allocating resources to outdoor recreation.

Once all elements, A through to D, have been completed, we have the justification for consideration of allocation of resources to outdoor recreation. With this justification in hand, appropriate action and responsibilities defined, and agreement to proceed, we now are in the position to assess alternative sites, areas within the region for land acquisition and/or development.

Identification of specific sites

From the preceding discussion, I am now going to identify and select the areas or sites that provide multiple recreation opportunities where there is a low cost of converting land to outdoor recreation, where environmental impact from access, facility development and use can be held at a minimum, where a quality recreation experience is possible, and where there is no to minimal impairment to an existing economic unit (Alden 1974a, 1974b). It is abundantly obvious that these interpretations require good information, as good as that required for a farm or ranch operation, a forestry operation, or any year-round tourist development.

Considering we have secured reasonable information from the “overview” about both the user and where the preferred resources are located, we are going to concentrate on the specific resource information to select the most desirable area. The selection process assumes that high quality resource inventory data is available and mapped, that aerial photographs are available and that resource managers are knowledgeable about the areas being considered.

Table 2 represents a summary of the factors (criteria) used to establish the priority for outdoor recreation land acquisition and development (Alden 1974b, U.S.F.S. 1974a, U.S.F.S. 1974b).

A brief interpretation of Table 2 is in order. The first point is that we are utilizing as full a range of factors or criteria as is available to select the best area or site. The numerical values for the various attractive features represent a low (5) to a very high

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<tbody>
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<td>Present</td>
<td>Region A</td>
<td>High mountain land, Class I</td>
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<td>Existing</td>
<td>Lands and Survey Dept</td>
<td>Change suitable Alienated Land to Recreation Reserve</td>
<td>Where appropriate to dispense</td>
<td>Where appropriate for safety, health requirements</td>
<td>Central Govt</td>
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<td>A hectares</td>
<td>Crown land</td>
<td>Existing, Potential</td>
<td>Alienated Crown land</td>
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<td>Change suitable Alienated Land to Recreation Reserve</td>
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</tbody>
</table>

TABLE 1: A SUMMARY OF RECOMMENDATIONS FOR ALLOCATING TYPES OF RESOURCES TO OUTDOOR RECREATION IN A GEOGRAPHICAL REGION
TABLE 2: A SUMMARY EVALUATION OF HIGH MOUNTAIN LAND, CLASS I, ALTERNATIVES TO ESTABLISH PRIORITIES FOR ACQUISITION AND DEVELOPMENT OF RECREATION PROCEDURE

<table>
<thead>
<tr>
<th>Factors Used to Determine Priorities for Land Acquisition and Development</th>
<th>High Mountain Land, Class I, Alternatives</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>A</td>
</tr>
<tr>
<td>MTN PEAKS</td>
<td>5</td>
</tr>
<tr>
<td>GEOLOGICAL INT. SITES</td>
<td>10</td>
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<tr>
<td>ROCK MIN. COLLECTION SITE</td>
<td>15</td>
</tr>
<tr>
<td>LAKES</td>
<td>15</td>
</tr>
<tr>
<td>RIVERS, STREAMS</td>
<td>5</td>
</tr>
<tr>
<td>B. GAME HUNT. HABITATS</td>
<td>5</td>
</tr>
<tr>
<td>S. GAME HUNT. HABITATS</td>
<td>5</td>
</tr>
<tr>
<td>WATERFOWL HUNT. HABITATS</td>
<td></td>
</tr>
<tr>
<td>U. BIRD HUNT. HABITATS</td>
<td></td>
</tr>
<tr>
<td>FISHING HABITATS</td>
<td>5</td>
</tr>
<tr>
<td>WILDLIFE OBSERV. AREAS</td>
<td>5</td>
</tr>
<tr>
<td>SP. WATER FEATURES</td>
<td></td>
</tr>
<tr>
<td>BOT. INT. SITES</td>
<td>5</td>
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<tr>
<td>FLORA GATHER. AREAS</td>
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</tr>
<tr>
<td>ARCH. INT. SITES</td>
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<tr>
<td>HIST. INT. SITE</td>
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<tr>
<td>RESERVOIRS</td>
<td>15</td>
</tr>
<tr>
<td>CAMPGROUNDS</td>
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<td>PICNIC GROUNDS</td>
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<td>SWIM. FACILITIES</td>
<td>15</td>
</tr>
<tr>
<td>BOAT. FACILITIES</td>
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<tr>
<td>WINTER SPORTS SITES</td>
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<tr>
<td>PUB. VIS. CENTRES</td>
<td>10</td>
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<tr>
<td>COM. PUB. SERV. SITES</td>
<td></td>
</tr>
<tr>
<td>ORG. SITES</td>
<td>10</td>
</tr>
<tr>
<td>TOURS S. GUIDED</td>
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</tr>
<tr>
<td>BIRD OBSERV. AREA</td>
<td>5</td>
</tr>
<tr>
<td>SUBTOTALS</td>
<td>20</td>
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<tr>
<td>ACCESSIBILITY</td>
<td></td>
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<td>REMOTENESS</td>
<td>10</td>
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<tr>
<td>VISUAL RESOURCE</td>
<td>10</td>
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<td>ENV. IMPACT</td>
<td>10</td>
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<tr>
<td>RECREATION OPPORTUNITY INDEXES</td>
<td></td>
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<tr>
<td>LAND TENURE</td>
<td>Freehold</td>
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<tr>
<td>RECREATION OPPORTUNITY CLASS - POTENTIAL (P)</td>
<td></td>
</tr>
<tr>
<td>ACQ. - DEVEL. PRIORITY</td>
<td>2</td>
</tr>
</tbody>
</table>

(50) value. The values for accessibility are from low (10) to high (30); for remoteness, close by (6) to distant (30), for visual resource, moderately diverse, high opportunity to view (26) to very complex and/or unique landscape (44); and environmental
impact, where resources can basically absorb and recover from modifications (-10) to resources which cannot absorb or easily recover from modification due to slope, elevation, lack of vegetative cover, potential for soil erosion and mass movement (-40). The recreation opportunity index is the sum of all values with the range of sums consistent with low to high potential for outdoor recreation use. Land tenure should be self-explanatory in that existing uses (other than recreation) and tenure both constitute legal and physical limitations to outdoor recreation use. The recreation opportunity class-potential merely represents an assessment of the opportunity index along with ease of conversion to outdoor recreation use.

Acquisition and development priority is the obvious statement that High Mountain Land, Class I, Alternative D, has the highest recreation opportunity index (multi-purpose recreation activity potential), accessibility could be improved, the area is reasonably close, the area's ability to absorb impacts from development and use is quite good, the visual resource is reasonably diverse and can be viewed by many users, and the area is unalienated Crown lands resulting in a lower cost—less of a problem as far as being converted to recreation use. For purposes of this example the priority for acquisition and/or development is obvious.

Summary Comments

The criteria presented in this paper, elements to justify high mountain recreation development and then factors to specifically select sites for acquisition and development consideration, are reasonable and straightforward. The difficulty in accomplishing both the "overview" and then "site selection" is in acquiring good resource inventory data properly mapped and in a usable format, recreation use distribution and user pressure information, and a full complement of professional land managers from different disciplines who can assess the more specific information to determine acquisition and development priorities.

Similar criteria and their applications have been tested and successfully applied in the high mountain states of North America. At best, the results have provided guidelines for such outdoor recreation development. The results have also aided in defining the roles of various agencies and the private sector in providing recreation opportunities in the high mountain setting. Results have also sharpened up the problem of adequate protection for the freeholder who allows public recreation use on his private or freehold land.

References


MASON, B. J. 1974: Back country boom. N.Z.
A guide to 'researchese'

Certain phrases often used in scientific research papers have varying degrees of hidden meaning. So that readers of Review will better understand the meaning of certain phrases, the following explanations are facetiously offered.

1. “It has long been known that...”
   
   Means: I haven’t bothered to look up the original reference.

2. “Of great theoretical and practical importance...”
   
   Means: Interesting to me.

3. “While it has not been possible to provide definite answers to these questions...”
   
   Means: The experiment didn’t work out, but I figured I could at least get a publication out of it.

4. “Three of the samples were chosen for detailed study...”
   
   Means: The results on the others didn’t make sense.

5. “Accidently filtered and purified...”
   
   Means: Dropped on the floor.

6. “Handled with extreme care throughout the experiment...”
   
   Means: Not dropped on the floor.

7. “Typical results are shown...”
   
   Means: The best results are shown.

8. “It is suggested that... It is believed that... It may be that...”
   
   Means: I think.

9. “It is generally believed that...”
   
   Means: A couple of other blokes think so too.

10. “It is clear that much additional work will be required before complete understanding...”
    
   Means: I don’t understand it.

11. “Unfortunately, a quantitative theory to account for these results has not been formulated...”
    
   Means: Neither does anybody else.

12. “Correct within an order of magnitude...”
    
   Means: Wrong.

13. “Thanks are due to Bill Bloggs for assistance with the experiments and to Dr Smedley for valuable assistance...”
    
   Means: Bloggs did the work and Smedley explained what it meant.
Gains from drenching

C. C. McLeod

The effect on liveweight gain and wool weights of worm and selenium drenching of high-country Merino and Halfbred ewe hoggets.

Summary

In 1969 to 1971 the production responses obtained from drenching young Merino and half-bred sheep with worm drench and selenium were examined in 11 trials covering 6 localities in the high country regions of South Canterbury.

In six trials, at four of the sites, sheep grazed extensively and little supplementary winter feed was provided. Liveweight gains between February and October in the six trials ranged from -3.3 to +3.5kg for hoggets given three to four worm drenches plus selenium in alternate months. The responses to this treatment over undrenched sheep averaged only 1.5kg liveweight (range 1.0 to 1.8kg) and 0.10kg in greasy fleece weight (range -0.01 to 0.32kg). Most of the responses were due to selenium.

In four other trials at two different sites, adequate quantities of supplementary feed were provided in paddocks. Sheep given three or four worm drenches plus selenium in alternate months made liveweight gains ranging from 8.5 to 13.2kg between February and October or March and November. Compared with untreated animals, the response to drenching averaged 2.9kg liveweight (range 1.7 to 3.8kg) and 0.30kg greasy fleece weight. In three of the trials most of the response was obtained from worm drench alone, while in the other trial only the selenium plus worm drench response was significant.

In another trial at one of the first four sites the hoggets were given daily access to adequate quantities of supplementary winter feed in paddocks and also provided with extensive grazing on a tussock hill block. These sheep made average liveweight gains of 14.6kg between February and October, but no response to either worm drench or selenium was obtained.

It is concluded that high-country hoggets become infected by worms only when they are offered supplementary winter feed and are restricted to a paddock grazing system. Under extensive tussock block grazing it is likely that few infective worm larvae are ingested. In contrast selenium responses are frequently obtained under both intensive and, in particular, extensive hogget grazing systems.

As a result it is recommended that high-country hoggets on paddock winter feed be given worm drench and selenium at weaning and every second month until late spring while those grazing extensive tussock blocks be drenched with selenium at weaning and every second month or as frequently as mustering permits.

Editor’s note: Hughes (1973)* determined that in 1971-72 ninety percent of high country runs drenched their hoggets at least once. Half the runs drenched their hoggets two to three times a year. Over one-third of the runs drenched their ewes once, but nearly one-half did not drench them at all. Sixty-five percent of the runs drenching their hoggets used selenium and 45 per cent of the drenched ewes got selenium.

Introduction

Improved hogget liveweight gains and wool growth responses to worm drench and selenium have been reported in many parts of New Zealand. In South Canterbury very consistent drenching responses have been obtained with Romney or Romney x Border Leicester hoggets regardless of locality, season, type of feed or management and drenching in January, March, May and July is recommended. There have, however, been no reports of similar trials conducted in the high country of the South Island where feed supplies are frequently inadequate and as a consequence sheep often grow very poorly during their first winter. The present study was carried out on properties with a wide variety of winter grazing conditions to determine if, as occurred with down country hoggets, all flocks require frequent drenching. On some of the trial properties sheep grazed only unimproved native pastures while on others, pastures were improved and sheep received adequate amounts of supplementary winter feed.

South Canterbury trials

Location of the trials is shown in Figure 1. Each trial contained untreated animals and those given worm drench and/or selenium. The maximum frequency of drenching adopted in each trial depended on the ease with which the mob could be mustered for drenching and weighing. Each trial flock was run with the remainder of the farmer's hoggets as one mob.

The trials can be divided arbitrarily into two categories. In group A are six trials on four sites with widely differing climatic conditions. They were mainly unimproved tussock blocks with limited supplementary winter feeding. This included hay and/or oat grain at approximately 0.1kg dry matter per head per day plus occasional soft turnip grazing (Simons Pass). As a consequence the sheep gained less than 4kg liveweight between weaning in February/March and the following spring. Group B includes four trials with well fed animals. Supplements consisted of ample hay, turnip grazing and oat grain between June and September. It is estimated that supplementary feed intake on these properties would have been about 0.5kg dry matter per head per day. In contrast to group A animals, these sheep gained up to just over 13kg liveweight between weaning in February/March and the following spring.

Results

Group A (limited supplementary winter feed). See Table 1. Although liveweight gains in these trials were generally small there were significant responses to selenium and drenching did appear to minimise the overall winter weight losses that occurred in three of the trials. In only one of the six group A trials was there a significant wool weight response and this was to selenium. In all trials some 5 to 10 percent of the untreated hoggets required drenching to prevent ill thrift, scouring and further severe weight losses. Left undrenched, these sheep probably would have died.

Group B (ample supplementary winter feed). See Table 2. At the Grampians, significant liveweight responses were obtained with thiabendazole plus selenium in both trials and to thiabendazole alone in the second.

In the second trial significant wool weight responses were also recorded. At Stew Point there were significant responses in both liveweight gain and wool weight, the addition of selenium sometimes being beneficial. At this site drenching every second month achieved 67 percent of the liveweight gain and 61 percent of the increased greasy wool production from sheep drenched at monthly intervals.

A feature of the Stew Point trials was that a number of the undrenched group hoggets became unthrifty. Approximately 15 percent from each trial required drenching to prevent further severe weight losses.

In the group B trials the addition of
Boundary of high-country tussock vegetation

FIGURE 1. Trial locations.
Table 1: Liveweight gains and wool weights of Group A trials. Tussock grazing with little supplementary winter feed.

<table>
<thead>
<tr>
<th>Locality, breed, period and treatments</th>
<th>Liveweight gains (kg)</th>
<th>Wool weights (kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Total</td>
<td>Treatment response</td>
</tr>
<tr>
<td>Mt John Half-breds</td>
<td></td>
<td></td>
</tr>
<tr>
<td>27.2.69 to 13.10.69 – Initial wt 25.0kg</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Undrenched</td>
<td>1.9</td>
<td>–</td>
</tr>
<tr>
<td>Thiab Feb, April, July, August</td>
<td>2.2</td>
<td>0.3</td>
</tr>
<tr>
<td>Thiab &amp; selenium ditto</td>
<td>3.5</td>
<td>1.6</td>
</tr>
<tr>
<td>Mt Cook Merinos</td>
<td></td>
<td></td>
</tr>
<tr>
<td>14.3.69 to 24.10.69 – Initial wt 20.4kg</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Undrenched</td>
<td>0.5</td>
<td>–</td>
</tr>
<tr>
<td>Thiab March, May, July, September</td>
<td>0.9</td>
<td>0.4</td>
</tr>
<tr>
<td>Thiab &amp; selenium ditto</td>
<td>2.3</td>
<td>1.8</td>
</tr>
<tr>
<td>Ruataniwha Merinos</td>
<td></td>
<td></td>
</tr>
<tr>
<td>20.2.70 to 19.10.70 – Initial wt 23.3kg</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Undrenched</td>
<td>–0.1</td>
<td>–</td>
</tr>
<tr>
<td>Thiab Feb, April, June, August</td>
<td>0.1</td>
<td>0.2</td>
</tr>
<tr>
<td>Selenium ditto</td>
<td>0.8</td>
<td>0.9</td>
</tr>
<tr>
<td>Thiab &amp; selenium ditto</td>
<td>0.9</td>
<td>1.0</td>
</tr>
<tr>
<td>Ruataniwha Merinos</td>
<td></td>
<td></td>
</tr>
<tr>
<td>20.2.71 to 28.9.71 – Initial wt 26.7kg</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Undrenched</td>
<td>–4.9</td>
<td>–</td>
</tr>
<tr>
<td>Thiab Feb, April, July, August</td>
<td>–3.8</td>
<td>1.1</td>
</tr>
<tr>
<td>Selenium ditto</td>
<td>–2.6</td>
<td>2.3</td>
</tr>
<tr>
<td>Thiab &amp; selenium ditto</td>
<td>–3.3</td>
<td>1.6</td>
</tr>
<tr>
<td>Simons Pass Merinos</td>
<td></td>
<td></td>
</tr>
<tr>
<td>22.2.69 to 17.10.69 – Initial wt 23.1kg</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Undrenched</td>
<td>1.9</td>
<td>–</td>
</tr>
<tr>
<td>Thiab Feb, April, June, August</td>
<td>2.8</td>
<td>0.9</td>
</tr>
<tr>
<td>Thiab plus selenium ditto</td>
<td>3.2</td>
<td>1.3</td>
</tr>
<tr>
<td>Thiab per month</td>
<td>2.5</td>
<td>0.6</td>
</tr>
<tr>
<td>Thiab &amp; selenium per month</td>
<td>3.1</td>
<td>1.2</td>
</tr>
<tr>
<td>Simons Pass Merinos</td>
<td></td>
<td></td>
</tr>
<tr>
<td>21.2.70 to 16.10.70 – Initial wt 24.7kg</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Undrenched</td>
<td>–0.2</td>
<td>–</td>
</tr>
<tr>
<td>Thiab Feb, April, July, Sept.</td>
<td>1.0</td>
<td>1.2</td>
</tr>
<tr>
<td>Thiab &amp; Selenium ditto</td>
<td>1.0</td>
<td>1.2</td>
</tr>
<tr>
<td>Thiab per month</td>
<td>0.5</td>
<td>0.7</td>
</tr>
<tr>
<td>Thiab &amp; selenium per month</td>
<td>1.5</td>
<td>1.7</td>
</tr>
</tbody>
</table>
selenium to the worm drench increased average liveweight gain by 24 percent and average wool weight by 85 percent. During the investigation one trial, intermediate between group A and group B, was conducted at Simons Pass. In it the sheep were well fed, having access to soft turnips and hay. However, instead of continuous paddock grazing they had an extensive hill block runoff. Hoggets in this trial had good liveweight gains and there were no significant responses to any of the drenching treatments (see Table 3).

The trial results indicate that there are good increases in per animal productivity and survival to be gained by administering

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**Table 2: Liveweight gains and wool weights of group B trials. Paddock grazing with ample supplementary winter feed.**

<table>
<thead>
<tr>
<th>Locality, breed period and treatments</th>
<th>Liveweight gains (kg)</th>
<th>Wool weights (kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Total treatment response</td>
<td>Total</td>
</tr>
<tr>
<td>--------------------------------------</td>
<td>-----------------------</td>
<td>------------------</td>
</tr>
<tr>
<td><strong>Grampians Half-breds</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10.2.70 to 27.10.70 – Initial wt 27.3kg</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Undrenched</td>
<td>8.5</td>
<td>3.78</td>
</tr>
<tr>
<td>Thiab Feb, April, July, Aug</td>
<td>9.2</td>
<td>3.74</td>
</tr>
<tr>
<td>Thiab &amp; selenium ditto</td>
<td>11.0</td>
<td>3.96</td>
</tr>
<tr>
<td><strong>Grampians Merinos</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10.2.70 to 27.10.70 – Initial wt 21.4kg</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Undrenched</td>
<td>11.5</td>
<td>4.20</td>
</tr>
<tr>
<td>Thiab Feb, April, July, Aug.</td>
<td>13.3</td>
<td>4.35</td>
</tr>
<tr>
<td>Thiab &amp; selenium ditto</td>
<td>13.2</td>
<td>4.52</td>
</tr>
<tr>
<td><strong>Stew Point Half-breds</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7.3.69 to 5.11.69 – Initial wt 22.3kg</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Undrenched</td>
<td>6.7</td>
<td>2.32</td>
</tr>
<tr>
<td>Thiab March, May, July</td>
<td>9.8</td>
<td>2.60</td>
</tr>
<tr>
<td>Thiab &amp; selenium ditto</td>
<td>10.2</td>
<td>2.77</td>
</tr>
<tr>
<td>Thiab per month</td>
<td>10.2</td>
<td>2.60</td>
</tr>
<tr>
<td>Thiab &amp; selenium per month</td>
<td>11.5</td>
<td>2.77</td>
</tr>
<tr>
<td><strong>Stew Point Half-breds</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>24.2.70 to 6.10.70 – Initial wt 25.8kg</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Undrenched</td>
<td>4.7</td>
<td>3.01</td>
</tr>
<tr>
<td>Thiab Feb, April, June, Aug.</td>
<td>7.5</td>
<td>3.13</td>
</tr>
<tr>
<td>Thiab &amp; selenium ditto</td>
<td>8.5</td>
<td>3.24</td>
</tr>
<tr>
<td>Thiab per month</td>
<td>10.4</td>
<td>3.42</td>
</tr>
<tr>
<td>Thiab &amp; selenium per month</td>
<td>10.3</td>
<td>3.62</td>
</tr>
</tbody>
</table>
Table 3: Liveweight gains and wool weights. Trial with ample supplementary winter feed and access to tussock hill block grazing.

<table>
<thead>
<tr>
<th>Locality, breed period and treatments</th>
<th>Liveweight gains (kg)</th>
<th>Wool weights (kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Total</td>
<td>Treatment response</td>
</tr>
<tr>
<td>Simons Pass Merinos</td>
<td></td>
<td></td>
</tr>
<tr>
<td>20.2.71 to 14.11.71 – Initial wt 23.0kg</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Undrenched</td>
<td>14.3</td>
<td>–</td>
</tr>
<tr>
<td>Thiab Feb, April, June, Aug, Oct.</td>
<td>15.2</td>
<td>0.9</td>
</tr>
<tr>
<td>Thiab &amp; selenium ditto</td>
<td>14.7</td>
<td>0.4</td>
</tr>
<tr>
<td>Thiab per month</td>
<td>14.3</td>
<td>0.0</td>
</tr>
<tr>
<td>Thiab &amp; selenium per month</td>
<td>14.7</td>
<td>0.4</td>
</tr>
</tbody>
</table>

Worm drench and selenium during the late summer, autumn and winter in South Canterbury high-country hogget flocks. It is emphasised that these responses were, in most cases, obtained from sheep which showed none of the clinical signs of worm infestation, such as scouring, at any time during the experimental period.

All trial flocks came from extensive high-country tussock summer grazing, probably with very low worm populations and hardly any acquired immunity to low valley or paddock winter grazing. During this late summer/winter period, under more intensive grazing and feeding, worm populations obviously increased although harsh environmental conditions would be expected to delay the hatching of eggs into infective larvae.

It is also possible that previous low feed availability and marginal selenium deficiency, which is widespread throughout high-country areas of the South Island, may have further inhibited the development of any natural immunity.

Trial responses varied depending on the locality, the level of winter feeding and whether the animals were held in paddocks or had access to tussock grazing. In the group A trials the hoggets were brought down from extensive tussock country summer grazing of up to 6ha per sheep to less extensive tussock winter grazing (up to 2ha per sheep). The winter grazing intensity therefore remained light and a build-up in parasite numbers was probably avoided as there was hardly any response to worm drenching.

Selenium, however, gave consistently significant but small responses in liveweight gain. The growth of these sheep was obviously restricted by a lack of reasonable quality feed on the blocks they were grazing.

In group B trials the hoggets were brought down from extensive tussock country summer grazing to paddocks for winter feeding. Here they were often confined to restricted areas under unaccustomed systems of intensive grazing and would probably suffer an accelerated build-up in parasite numbers.

Although this is not reflected in faecal egg counts (only in July 1969 at Stew Point did they reach pathological numbers) responses were obtained from worm drench alone. As in the group A trials the inclusion of selenium also gave worthwhile increases in growth rate.
In the 1971 Simons Pass trial, adequate feed favoured good liveweight gains and wool production while the access to extensive tussock block grazing apparently kept parasite numbers to a minimum and reduced the need for stock drenching. Such a feeding system, however, has the disadvantage of requiring a large daily input of labour for mustering from tussock block to the supplementary feed paddocks.

Only in one trial (Stew Point, 1970) out of five did monthly worm drenching achieve a significant improvement in liveweight gain over that obtained from three drenches at two monthly intervals.

The practical importance of the trials is to focus attention on the importance of worm drenching for the runholder who attempts to increase the productivity of his young sheep by improved feeding. While the improved feeding may have helped to increase long term resistance to worm infection, the system of grazing management usually adopted will, in the short term, also result in higher levels of infection that the sheep are unable to repulse.

Consequently, a programme of worm drenching must be adopted to take full advantage of better feed availability.

The South Canterbury investigation also highlighted widespread responses to selenium. These indicated that high-country hoggets should be treated with selenium under both intensive and extensive systems of grazing management.

The trial results indicate that Merino and half-bred hoggets grazing extensive tussock blocks should be drenched with selenium at weaning and every second month or as frequently as they are mustered, and that unthrifty tail-end animals be drafted off and given worm drench plus selenium. High-country hoggets grazing paddock winter feed would obviously benefit from worm drench and selenium given at weaning and every second month until late spring.

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In the next Review . . .

The World Wildlife Fund, which has been active internationally in the conservation of endangered animals and plants, has now established a branch in New Zealand. As will be outlined in Review 35, WWF/NZ has established goals which hopefully will stop the depletion and destruction of rare flora and fauna including the kakapo and takahe.

Over the past 75 years more than 100 species of wildlife in the world have become extinct and at least 15 of these were New Zealand species. At present we have at least 30 species of bird life alone on the endangered list.

Some of the specific projects which will be supported include protection of the Chatham Island robin, studies of high mountain habitats and research into the implications of the Waitaki hydro project on wildlife habitats and populations. The latter project will include the participation of the Tussock Grasslands and Mountain Lands Institute and will involve the survival of the black stilt.

Also in Review 35, D. J. Musgrave of the Tara Hills High Country Research Station will discuss the effects of time of sowing on the establishment of oversown pasture. Soil, sward and seed preparation are all relatively well understood for many of the more common situations and the only other major factor open to manipulation is that of when to sow. It has been found that the two weeks following sowing are the most important and that soil temperature plays a very important role in seedling establishment.

In addition there will be an article on the influence of breed and crossbreeding on high-country beef cow performance and several other features on topics of interest to hill and high country readers.
South Island high country

... a review of work by Grasslands Division DSIR

With 1976 being the 50th Anniversary of the Department of Scientific and Industrial Research, it seems appropriate to review the activities of one of its groups which is closely associated with the high country. Naturally in the circumstances, we are highlighting our own contribution but we are aware and appreciative of the past and present co-operation of runholders and agencies, in everything from germs of an idea to the sweat of practicality.

D. Scott

Introduction

In agricultural terminology, South Island high country is the area east of the Southern Alps consisting of properties at high altitude with extensive grazing which are subject to severe weather hazards such as risk of snow loss. Although the number of properties or runs, predominantly pastoral leases from the Crown is small (300-350), the total area is large (3.2 million ha), the average sized holding being about 10,000ha. The main produce of the area is fine wool, from a total sheep population of about two million, half of which are Merino and a quarter Merino x Romney half bred. Most properties run some cattle, with numbers increasing rapidly over the past decade. Total numbers are about 108,000, half of which are Hereford and a quarter Hereford x Angus. About 50,000ha are being improved each year.

Research associated with the high country has been the concern of Grasslands Division's Lincoln Regional Station for many years. Initial work started before World War II in the eastern Mackenzie Basin and expanded afterwards in the Waimakariri Basin. Since 1961, work has been centralized in the Mackenzie Basin, because of the wide range of sites available from a central base. Present Grasslands Division personnel engaged in high country research are 2-3 scientists, 3-4 technicians, and teams of plant breeders, plant nutritionists, and agronomists assisting all such regional groupings.

Because of the extensive area involved and the range of soils, sites, altitude, and
climates, much of the past work has been the immediate problems of identifying suitable legumes, together with their associated rhizobia, and grasses. Fertiliser requirements and suitable oversowing and drilling techniques for increasing both quality and quantity of the feed available for pastoral agriculture were also investigated. Increases achieved for the main growing season have highlighted the need for further development of winter feeding techniques. Although research has been directed mainly towards pastoral agriculture, the knowledge so acquired on soil/plant relationships and plant establishment is applicable to soil and water conservation.

Research and development of high country agriculture have four phases: use of the native grassland in its natural or modified form; initiation of development transition; management practices for continuing and maintaining transition; and management options and practices within the developed state. In the present decade, most of the research effort is on phases 2 and 3, though there are examples of all stages in practice. We are assuming that many problems of the undeveloped and transition stages may be peculiar to the high country, but at developed stages, principles and practices will be extensions or slight modifications of those from other parts of New Zealand.

Because current research knowledge of some of the plant/environment interactions in the high country is sufficiently in advance of that being applied by farmers or land administrators, it is felt that great emphasis can now be given to an in-depth study of particular problems. In this, Grasslands and other DSIR divisions can undertake sustained continuous research on plant/soil/climate/animal relationships, using indigenous and introduced plant material available in New Zealand.

The following review reports on recent examples of the type of research undertaken by the high country group, together with a bibliography key to all reported past and present activities.

Some current research

Vegetation, soil, and climate processes at higher altitudes

Management of existing tussock grassland, or improvement by oversowing and topdressing, requires understanding of the processes occurring in plants, climate, and soils. Ten years work on these processes in the moderate to high rainfall, alpine, and sub-alpine zone in the north-east Ben Ohau Range is nearing completion (1-5, 95, 108-110).

Soil parent materials, though from a small range of rock types, vary greatly within short distances in texture, composition, and age as a result of glacial, freeze/thaw, and related phenomena associated with climatic changes past and present.

The climate measurements showed that temperature decreased from northern to southern aspects, and with altitude (1). Surveys over several years show that snow begins to accumulate late May-early June, reaches its maximum in September, and then abates rapidly in October/November (2, 4, 109).

Soils on southern aspects are associated with a seasonal microclimate of contrasting warm and cold snow-free periods (3,4). Soils are above field capacity throughout the year with the addition of snow-melt waters at least through the summer. These snowmelt waters add nutrients and fresh sediment which may offset podsolisation in the younger soils. Older soils are usually covered with a dense vegetation conducive to progressive podsolisation.

By contrast, the altitudinal sequence of soils on the northern aspect show a microclimate without a significantly marked difference between warm and cold seasons, but because of a reduced period of seasonal snow, they are under a strong freeze/thaw regime. These aspects are associated with high insolation, strong winds, and greater evaporation (1, 4, 5).

Aligned with these differences are changes in the forms of phosphate and their
availability to plants (4). The most readily available reserve of calcium bound fraction from apatite decreases from 60 percent of total, to a trace in 1500 years, while the more slowly available and non-available forms accumulate progressively. Consequently, on northern aspects the least fertile soils occur about mid slope, with the more fertile soils on lower slopes from accumulation of leached material, and on the upper slopes from freshly weathered rock. On the more stable southern slopes, fertile soils occurred about mid slope where good moisture and vegetation lead to maximum accumulation of organic material.

The object of such investigations is not only to understand the process, but to recognize similar areas that will be expected to respond to improvement techniques.

Interpretation of soils can be complicated by occasional events like cloudburst, Polynesian fire, and avalanche debris, causing previous soils to be buried or modified (95). Influence of native vegetation on oversown seed

Success in seed establishment after oversowing with clovers and grasses was found to be dependent on both the type of ground cover in which the seed landed, and its proximity to the nearest tussock. Bare ground provided a poor seed bed because of damage by frost heave or soil structure (42, 54, 74).

Dry short tussock areas revealed a threefold increase in clover establishment near tussocks (106) because of an associated better microclimate. This effect was caused by shading and cooler temperatures in the summer, with little effect on spring germination (102). However, establishment was greater away from the tussocks in high rainfall tall tussock sites (106).

Differences between establishment in various ground covers can be traced to a number of effects. One effect was the acidity or pH influence of surface soil (79), which can vary by 0.5 pH units within a few centimetres depending on the particular species sampled beneath, being high beneath flat weeds and low beneath tussocks.

Differences in soil acidity are probably large enough to influence the establishment or rhizobia relationships of clovers. Another effect was the rediscovery that resident plants can release chemicals which either inhibit or promote germination of oversown seed (e.g. scabweeds promote germination of oversown seed), and these seemed to affect grass rather than legume species (75). Some of the more inhibitory species were resident clovers, sweet vernal, and silver tussock.

Plant introduction and cultivar testing

Initial improvement of tussock grasslands stems from the introduction of a legume, with alsike and red and white clovers currently being those most widely used. There is a greater emphasis on choice of legumes in the cultivated and overdrilled improved pasture, with lucerne being used as a hay species on the better dryland soils. Among the grasses, the main species are cocksfoot in almost all situations, timothy in hay paddocks, and perennial and short-rotation ryegrasses only on the more fertile soils under intensive management.

Additional material of species already in use, including New Zealand bred and overseas lines, coupled with a continuing search for new species from other countries, forms the basis of the plant testing programme, (see reference section) which averages about 50 lines per year. Two main conclusions derived are that there is potential for improvement in all existing lines, and that these overseas lines rarely excel those bred in New Zealand. With the increasing importance of cattle, more emphasis is being given to non-bloating legumes.

Red clover is used as an oversowing species, as a legume component in grass hay paddocks, and as a minor constituent of improved grazed pastures. Ten-year assessments show that the new tetraploid red clover “Grasslands Pawera” will give further notable improvements in yield in all roles in the high country, over the existing “Grasslands Turoa” and “Grasslands Hamua”. There is an indication that a “Hamua x Morrocan” experimental line
may give improved cool season production in drier high country regions.

White clover, an early introduction to the high country, initially exhibited little potential in many areas owing to a lack of understanding of rhizobial and trace element requirements which has been rectified. "Grasslands Huia" is still the most suitable cultivar, with no advantage in total yield or seasonal distribution having been gained from the more recent introduction "Grasslands Pitau."

With major introductions having been made since World War II, alsike clover is now one of the main clovers in the high country (8). Its value is its ability to grow in high country environments, to better winter feeding quality, and to reduce stock health problems when compared with white clover. It is a free seeding, dual purpose (oversowing and hay) species. Plant evaluation has shown that lines superior to those already imported exist, and this coupled with the present and future role of this species, has resulted in a plant breeding programme being initiated.

Once establishment problems can be overcome, trial work indicates that Lotus species may be among the main legumes in the future because of their lower phosphate maintenance requirement, compatibility with existing vegetation, and non-bloating characteristics. A new cultivar of Lotus pedunculatus, "Grasslands Maku," has been released for use in the higher rainfall zone, and has been found particularly useful in revegetation problems. Birdsfoot trefoil (L. corniculatus) shows potential in lower rainfall regions, while an experimental New Zealand bred hybrid between the two may be the best compromise.

Other legumes showing potential are, zig-zag clover (Trifolium medium) and Caucasian clover (T. ambiguum) as low nutrient requiring species capable of spreading by underground stolons, vetches (Vicia spp.) as annuals for winter and spring feed on drier hill lands, and crown vetch (Coronilla varia).

Within the grasses there is a continual testing of cultivars of cocksfoot, tall fescue, timothy, Yorkshire fog, and ryegrasses. Other grasses which show potential are Bromus spp. (B. catharticus, B. marginatus, annual B. scoparius), Poa pratensis, and Phalaris tuberosa. Non-leguminous herbs and evergreen forage shrubs are also being investigated.

Fertiliser and grazing for development

Results from a series of five grazing trials in the Mackenzie Country (43, 47, 51, 92) show that rapid development of unimproved lands depends on increasing the potential of the nitrogen cycle by oversowing with legumes, by applying fertiliser correcting any phosphate, sulphur, or molybdenum deficiencies limiting growth, nitrogen input by nitrogen fixation, and increasing turnover rates of the nitrogen particularly through the grazing animal. These trials revealed a greater long-term production with a high initial and regular maintenance fertiliser, which varied from about 100kg/ha sulphur and molybdenum fortified superphosphate initially, with 100kg/ha every second year on the yellow grey soils, through to an initial 4-600kg/ha and up to 200kg/ha annually on the high country hygrous yellow-brown soils.

All trials showed the importance of grazing, with periodic hard grazing giving substantially more forage than periodic lax grazing, the increase varying from 46 percent to 95 percent. Hard grazing fostered legume growth and increased nitrogen turnover. Results to date suggest that the subdivision and rotational mob stocking implied should be objectives in high country development.

Mineral nutrition of sheep

Both adequate minerals and digestible organic matter are needed for stock to make adequate growth on native and oversown tussock grassland. Combined investigations with Applied Biochemistry Division DSIR have shown that herbage and blood mineral levels are adequate in sodium, potassium, calcium, magnesium, phosphorus, iron, manganese, and zinc (22-24). Although copper levels tended to be low, there was no
response to direct drenching.

The expected response in growth to selenium (9 percent increase confined to the main growth period) occurred (23, 24). There was also a 4 percent increase in weight over a year from a single injection of iodine, again during the main growing season. Soil iodine values are known to reach their lowest levels in these inland basins. There was a possible beneficial cobalt by selenium effect during the winter period.

**Early winter feed**

With little or no growth for five or so months each year, lack of winter feed will always be a feature of high country farming. Hay, silage, and special crops are ways of filling this gap, though expensive in terms of labour. Another approach developed is to improve wintering blocks by oversowing and topdressing, closing this sector from February to May for feeding off in late May and June before feed quality is lost through frosting (89-92). Only 15-25 percent of a block is so developed using the more frost-resistant legumes alsike and red clovers. With this technique, it is possible to save about a third of the total hay requirements and yet maintain similar ewe body weights and lambing percentages.

**Growth potential under irrigation**

Because of greater variations between summer and winter, and diversity of topography as a result of past glaciation, inland basins of the high country were expected to show some differences in growth pattern, species and annual yields from other areas of New Zealand.

As well as the Ministry of Agriculture and Fisheries trials in Central Otago and Tara Hills, Grasslands Division undertook two recent trials in the Mackenzie Country on greywacke soils (80). These showed annual dry matter production levels ranging from 4-6 tonnes/ha on the shallow outwash soils up to 14-19 tonnes/ha on deep fertile soils. On these best soils, herbage production from irrigation has a three- to four-fold increase over equivalent dry land development and growth. Even under high fertiliser conditions growth was limited to seven months.

Highest production came from all legumes on the deeper soils and from lucerne and red clover in the drier areas. Within the grasses, timothy proved best under irrigation, followed by cocksfoot, Ariki ryegrass, and tall fescue.

**Bumble bees and seed production of tetraploid red clover**

Development of the new “Grasslands Pawera” red clover by doubling of the cell chromosomes, after selection gave plants not only superior in agronomic characters, but also in plant, leaf, and, in particular, flower size. This meant it could not be polinated by nectar-collecting honey-bees, but required three long-tongued bumble bees which had been introduced into the country last century. High populations of two of these species are known to occur in the inland basins of the Mackenzie and Central Otago (7, 9, 96).

Bumble bee queens appear in the spring, and about early December are ready to form nests. From these, the bee population increases 200 to 300-fold reaching peak densities in early February. Delayed closing of a red clover seed crop till mid to late November, after a hay cut, shortens the flowering period without altering the number of flowers produced. As the number of bees on the crop is directly related to flowers available for pollination, the only limitation in gaining a satisfactory seed set may be too large an area in crop, in relation to the local bee population. Bumble bee populations in an area may be increased by introducing queens early in December (about 10/ha), (7). For seed production, yield can be increased by using low seeding rates and wide spacings and not delaying harvest beyond early April (9).

**Mycorrhiza**

Most plants have a mycorrhiza fungi in or on their roots and show a high incidence on native species, introduced pasture grasses, and legumes in the high country (14-16, 20). Unlike rhizobial bacteria, there are only a few mycorrhizal fungi each with wide host
range. Mycorrhiza increases the effective root area and therefore increases phosphate uptake of the host plant on phosphate-deficient soils. Consequently they are likely to be more important to the coarse rooted legumes than to the finer rooted grasses.

Current research is investigating how to utilize these relationships, for it has shown that the different mycorrhiza vary in occurrence and effectiveness. Within each legume, their effect can vary from positive symbiosis to parasitism, depending on the state of the host plant and the soil or fertiliser phosphate status.

**Seed coating**

It has been established that rhizobial inoculation of legume seed, generally by coating, is an essential prerequisite for successful establishment in high country and other marginal areas. As these legumes generally require phosphorus, sulphur, and molybdenum fertiliser, direct coating of these on to the seed has developed.

Work with coating both grass and legume seed with higher rates of the usual fertilisers, has resulted in depressed germination, presumably because they are too chemically active when immediately adjacent to a germinating seedling. Preliminary results, using slow release nutrients suggest a major response in legume establishment can be achieved using a sulphur coat, especially when surface sown into existing vegetation, although suitable forms of phosphorus and molybdenum have not yet been found.

Introduction of grasses by aerial oversowing has been less successful than with clovers, with frequently less than 1 percent of the sown seed establishing. Effects of coating grass seed with various materials to double their weight, are both encouraging and confusing (77, 81, 88, 93). Best results show a five- to six-fold greater establishment for coated grass seed, but these results are highly variable between sites and season. Present indications are to expect up to double the establishment from surface sown coated seed. Little is known of coated grass seed in the drilled situation. Coating has its effect during early germination and is related to the physical presence of a coat rather than its chemical fertiliser content. Most evidence indicates that coating is effective through altering the moisture relationship on dry soils, or in seed/soil contact and method of root penetration.

Coating of grass seed has no practical significance in penetrating existing vegetation for aerial oversowing, though it may help to prevent winnowing of grass seed in cross wind situations (78).

**Future prospects**

In the 50 years before the formation of DSIR, the match and Merino reigned supreme in South Island high country, while the end of the period saw the massive invasion by rabbits and soil erosion. The political realisation that these four conflicting uses required technological investigations which were later combined with hydro-electric development, and the general growth of human populations, resulted in the present concept of multiple land use. The challenge of the next 50 years will be development of additional techniques to put these concepts into practice. Grasslands Division and other groups which have their own administrative and consequent technological requirements will have to combine their information to the mutual benefit of all.

A conservative estimate is that stock carrying capacity could be increased four-fold in the next 50 years to 8-12 million stock units. The largest increase will be in sheep, with the main breed still being Merino.

For the plant breeder, there will be a continual demand for improved legumes with their associated rhizobia which can establish among the existing vegetation of phosphate-deficient high country soils. Such improved legumes would need to withstand a fluctuating climate and be able to make an appreciable contribution to the nitrogen cycle. In view of the increasing cattle numbers, non-bloating species would be preferable. As in the rest of New Zealand, the ultimate aim must be for suitable grasses,
since these provide the key to autumn-saved pasture and winter grazing. However, there are problems of grass establishment to be overcome.

Studies on the present diet of stock in these areas indicate a need to give more consideration to deliberate farming and management of forbs and herbs, other than legumes and grasses, as stock food. Examination of native vegetation, supported by some trial work, indicates that the low rainfall sector of the high country is one place where annuals might fulfill a permanent role in a farming system.

Plant introduction from native grasslands around the world has had a long and continuing history in New Zealand high country. Though this possibility is worth pursuing it is unlikely that a "magic" plant will be found. It seems more feasible that the plant used in the high country 50 years from now will be a cultivar of material already here.

Winter-conserved feed and methods of feeding will always be the main factor limiting livestock expansion and much can still be achieved by conventional dryland hay production and early winter-saved pasture. However, the next decade will see the increasing development of irrigation to ensure winter-conserved feed. Irrigation in inland basins of the high country may differ from that of other areas, in that the availability of water supplies and topography will allow free fall systems, but the shorter growing season, topographic limitations and localisation of responsive soils to a few properties will restrict conventional border dyking.

Challenges in farm management will be to find the means of concentrating resources to initiate and continue development, and at the same time retain the long-term flexibility and economy of large scale operations offered by the present size of holdings. Collaboration must also be obtained between and within runs and localities where resources are not evenly distributed.

With the semi-continental type climate on the inland basins of the high country and its winter limitation, the question arises of whether livestock farming is in the best long-term interest of the area, when this can be more easily achieved in other areas where limitation is less severe. An alternative would be to make use of the good summer conditions. However, soil structure will probably limit conventional cropping methods and systems based on low tillage, e.g. production of legume and pasture seed, protein, cellulose, forestry, honey etc., may have to be considered.

Retirement from grazing of class VIII country, mostly above 1400m, for soil and water conservation purposes, will cause re-adjustment of present farming practices through requiring subdivision, improvement, and changing from sheep to cattle, or to cropping. However, these changes will probably be dictated as much by requirements for efficient use of labour, as soil and water considerations.

Rehabilitation of such retired areas will depend directly on the remaining high country farming areas, for the technological development of introducing plants into such areas will come as extensions of oversowing techniques of grazed tussock grassland. Present indications are that initial rehabilitation will have to be by pasture species and fertiliser, and it is only once cover is achieved using these that the slower growing, but low maintenance-requiring native and adventive species can establish.

Seed for soil rehabilitation will have to be grown in large commercial quantities, and present indications are that lines should be selected from, and grown in conditions close to those where they will ultimately be used.

Whatever the development, most of the least accessible high country will always be dominated by our native short and tall tussock grasslands, shrublands and high altitude herb fields. Therefore, there will be a continuing need to further our understanding of their natural distribution and responses, and how these might be modified by the requirement for grazing, soil and water control or nature conservation. Of equal importance will be the inter-relations
and interactions between these and adventive or improved pasture species.
— September 1976

Key to published reports

Previous and current research are listed under various headings along with the appropriate report numbers referred to in the bibliography. The same report may be listed under several headings.

High country environment
- general accounts (34, 45, 46, 108)
- climate and micro-climate (1, 3, 4, 5, 53, 64, 72, 108, 109)
- snow (2, 3, 4, 109)
- soil and soil forming factors (3, 4, 6, 34, 50, 65, 95, 108, 110)
- vegetation (1, 3, 4, 6, 56, 110)
- ecology of particular areas (1, 3, 4, 6, 59, 110)
- effect of low temperatures (49, 98, 104)
- mycorrhiza relationships (14-21, 97)
- soil/plant chemical interactions (30, 31, 50, 53, 56, 74, 79, 86, 102)

Management of native vegetation
- growth rate and other characteristics of native species (13-16, 20, 22, 23, 41, 47, 48, 49, 55, 58-60, 62, 63, 66, 68-72, 76, 83-85, 100)
- environmental factors influencing distribution of native and adventive species (1-6, 53, 58, 59, 72, 100, 106)
- sheltering effect of tussocks on other species (53, 59, 61, 74, 102, 103, 106)
- effect on tussocks and associated species of (a) fertilisers (14, 33, 48, 55-58, 114)
  (b) grazing (34-37, 41, 47)
  (c) burning (34, 40, 41, 53, 55)

Plant introduction and cultivar testing (33-37, 54, 94, 98, 99, 101, 105, 107, 113, 116, 117)

Plant establishment
- ground preparation (34, 42, 48, 56, 57, 92, 103, 114, 117)
- herbicides (42, 48, 56, 57, 114, 117)
- grass seed coating (77, 78, 81, 88, 91-93, 103)
- method of sowing (10, 48, 114)
- time of sowing (10, 48, 91, 92, 102, 114)
- establishment and survival characteristics (10, 74, 88, 92, 93, 102, 103)
- effect of resident seed on oversown seed (10, 53, 74, 75, 79, 106, 117)

Fertiliser requirements
- nitrogen (33, 35-37, 47, 48, 54, 56, 57, 87, 114, 117)
- phosphorus (10, 16, 33, 37, 42, 43, 47, 48, 50-57, 81, 86, 89, 92, 114)
- sulphur (10, 33, 48, 53, 55, 56, 57, 87, 114)
- lime (33, 42, 50, 52, 86, 114)
- initial versus maintenance requirements (47, 51, 91, 92, 114)

Pasture response and grazing management
- biology of adventive species sheep sorrel, sweet vernal, and Hieracium species (16, 25-31, 57)
- effects of fertilisers on native and adventive grasses (13, 33, 46-48, 52, 114)
- cultivation effects on nutrient release (56, 57, 87, 114)
- stocking intensity and level x frequency of fertiliser effects on different soil types (43, 47, 48, 51, 58, 91, 92)
- rate of development of ryegrass pasture from undeveloped tussock (47, 48, 92)
- nitrogen and pasture production (33, 40, 43)
- relationship between growth and climate (53, 58, 67, 72, 80, 96, 100, 102)
- comparison of grass species under grazing (91)
- species and fertiliser requirements for revegetation (42, 49, 54, 98)
- grazing management (43, 51, 89, 90)

Stock nutrition
- feed values of tussocks, native, and pasture species (13, 32, 91, 115)
- proportion of high quality feed required to utilize unimproved tussock (32, 115)
- ration required and weight change allowable during winter period (89, 90)
- species composition, herbage and blood plasma macro- and micro-element composition on developed and undeveloped tussock (13, 22, 23, 82, 90)
- mineral supplementation with selenium, iodine, cobalt and copper (24)

Winter feed
- special crops (48)
- overwintering with winter active grasses and cereals (11, 12, 89, 116, 117)
- oversowing and topdressing for early winter in-situ feeding (89, 90, 116, 117)
- feed quality of winter herbage and supplements (91, 115)
- irrigation for conserved feed (80)

Irrigation
- survey of soils for irrigation purposes (44-46)
- species x fertiliser potential of best and modal soils (80, 99)

Seed production
- use of favourable bumble bee population of Mackenzie and Central Otago for tetraploid red clover seed production (7, 9, 96)
- effect of management and environmental interaction on red clover seed production (9, 96, 111)

Major species
- red clover (7, 9, 10, 17, 20, 34, 53, 74, 80, 86, 90, 96, 97, 102, 103, 105, 116, 117)
- alsike clover (8, 10, 20, 34, 48, 53, 86, 97, 103-106, 112)
- white clover (10, 17, 20, 30, 31, 34, 48, 53, 69, 74, 80, 86, 97, 102, 103, 104, 105, 114)
- Lotus (17, 86, 102, 103, 106)
- lucerne (10, 48, 80, 86, 97, 104, 114, 115)
- cocksfoot (16, 34, 42, 48, 54, 57, 71, 74, 75, 77, 78, 80, 83, 88-91, 94, 98, 99, 102, 103, 105, 106, 114)
- tall fescue (54, 80, 91, 98, 100, 104)
- perennial ryegrass (16, 30, 31, 42, 48, 54, 55-57, 71, 80, 84, 88, 91, 92, 98, 99, 102, 108, 114)
- annual ryegrass (89, 99, 105, 106, 116)
- timothy (80, 94, 105)
- Yorkshire fog (34, 37, 48, 53, 77, 87, 91, 93, 114)
- browntop (34, 37, 48, 56, 71, 83, 87, 98)
- sweet vernal (14-16, 34, 37, 48, 53, 54, 71, 83, 87, 98, 114)
- ryecorn (11, 12, 89, 90, 103, 115, 117)
- short tussock (15-17, 34, 46, 47, 53, 61-63, 71, 74, 79, 83, 89, 115)
- snow tussock (13, 32, 40, 41, 52, 55, 56, 64, 66, 71, 83-85)
- sorrel (25-31)
- Celmisia (3-6, 59, 69, 76, 84, 85, 100)

Publications by Grasslands staff


44. - 1966: Land use potentials in the Mackenzie Basin Appendix II. Ibid.


You have, you know. But you’ve probably never seen it. The above diagram is a sonograph record of a familiar sound. It was recorded by Miss Sue Rogerson and Mr Peter S. Harris working in conjunction with the Tussock Grasslands and Mountain Lands Institute at Glenthorpe last year. While at the Yalanbee Research Station in Perth last year, Mr Harris met Dr Elizabeth Shillito of the Agricultural Research Council, Institute of Animal Physiology, Babraham, Cambridge, England. He told her about the sound he had recorded on tape and she asked to hear it. She had the sonograph recording made at Babraham. Her comment: “The sonograph shows that it is a sharp whistle — a lot of noise but the main frequency seems to be about 3kHz.” The sound? The warning signal of a Merino half breed!
The opossum threat

J. C. Aspinall

While many high-country runholders have little or no problems resulting from opossums, some do. Jerry Aspinall of Mt Aspiring run is one. The Matukituki River is one of those which seldom maintains a stable course. Planting of poplars and willows for bank protection has been necessary to prevent flooding (see Review 31: pp.44-48). The opossums of Mt Aspiring welcome such plantings and regularly strip such trees during spring and early summer. They enjoy other forms of valuable vegetation as well. In addition, it has now been established that they are carriers of bovine tuberculosis. The problem is: how to get rid of them? It all adds up to another example of man’s failure to look ahead and comprehend the effects of noxious animal introduction.

The first successful liberation of opossums (*Trichosurus vulpecula*) in New Zealand was made by a Mr Bastion who established some near Riverton in Southland in 1858. Descendants of a Captain John Howell, however, dispute this and maintain that opossums were introduced in the Riverton area before 1840.

Whatever the case, it appears that successive importations from Australia were made over a span of about 100 years ending in the 1930s (see Figure 1).

Some were brought in as pets, but the greatest incentive seems to have been visions of a lucrative fur trade on the part of various public bodies. The most enthusiastic of these bodies were various acclimatisation societies which pressured successive Governments into allowing importations and then protecting opossums in various parts of New Zealand.

The greatest number of importations was in the 1890-1900 decade when the then Premier, the Rt Hon. Richard J. Seddon, gave sympathetic support to and showed personal interest in the liberation of opossums on the West Coast. Tasmanian blacks and red-blacks were first established because of their superior fur quality. After about 1910 the greys were more popular and constituted the bulk of the importations.

What a pity it is that responsible and
well-meaning people could not visualise the damage that was going to occur to New Zealand's native vegetation from the introduction of uncontrolled animals into our virgin country— not only opossums, but rabbits, hares, stoats, ferrets, deer, thar, chamois, etc. Visions of a fur trade and unlimited sporting opportunities tragically overruled caution and thorough scientific investigation.

Varied diet

While some past reports have indicated that opossums must have half a dozen different diets to survive, there is no doubt that they eat a great variety of plants and, like other animals, are very fond of topdressed pastures. One need only go out at night with a spotlight to confirm this.

As shown in Figure 2, large numbers of liberations were permitted up to 1959 while the unauthorised and illegal transfer of opossums from one district to another was widespread. The result of all this misguided enthusiasm is that we now have opossums well established from North Cape to Bluff, from the West Coast to the East Coast, and on some islands as well. They have become New Zealand's most adaptable noxious animal, being able to thrive in the warmth of the north, the cold of the south, the wetness of the west and the drylands of Otago and Canterbury.

There are some seasons when the financial return on the export of opossum skins is of some value to the New Zealand economy. Last year, for example, such exports realised close to $4 million, but it is debatable whether or not this compensates for the damage caused. Skin hunters and trappers play an important role in opossum control and help prevent them from overrunning the country. But it must also be assumed that this method of control will never completely eliminate opossums. At this stage it is hard to say that the $4 million balances up the damage to unique native vegetation, production vegetation, the cost of tuberculosis eradication and neglect of rabbit con-

FIGURE 2: Liberations of opossums.

Figures 1 and 2 are from "Introduction and Liberation of the Opossum into New Zealand" by L. T. Prancy. New Zealand Forest Service, Wellington, 1962.
control where pest destruction boards are engaged in opossum hunting.

The discovery that opossums are carriers of bovine tuberculosis has highlighted a threat to our beef and dairy exports. Large sums of money are being spent by the Forest Service, Department of Agriculture and Fisheries and pest destruction boards to reduce opossum numbers and eliminate the threat to cattle in certain parts of the North Island, the West Coast and the Hokonui Mountains region of Southland. Pigs, goats, stoats and other animals are involved as well. It appears from published reports that where opossums and cattle are in an overcrowded situation and competing for food, the incidence of tuberculosis is higher. One cannot help but feel apprehensive, wondering where the problem will show up next.

In the podocarp forests of the West Coast there are many palatable shrubs favoured by opossums. It has been reported to me that they have just about wiped out the native fuchsia (Fuchsia excorticata) in Westland National Park. Other diet studies show that as much as 40 percent of their food intake there has been rata (Metrosideros umbellata). This particularly attractive native shrub will not stand this sort of treatment indefinitely and entire hillsides are reported as being dead or dying.

Opossums are also well known for the havoc they can create among flower gardens, particularly roses, and in orchards. Vegetable gardens also suffer. What saves us from a degree of these depredations is the fact that our dogs are mad on opossums. If there is one about, whether it be in the garden or in the rafters of hayshed, garage or woolshed, it is not long before the dogs have it. This can be disconcerting at times and causes delays when out mustering. I have known our dogs to temporarily abandon the exciting pursuit of cattle to take time off to dispose of an opossum before returning to their legitimate work.

Populations

In the beech forests where palatable animal fodder is not generally available to stock, opossums build up high population
numbers, then tend to decline. It is perhaps at this stage of overpopulation and semi-starvation that they are most susceptible to disease such as tuberculosis. Generally they are more numerous in scrub and most shrubs and trees in such areas show signs of having been chewed at. These include lancewood (Pseudopanax crassifolium), broadleaf (griselinia littoralis), kamahi Weinmannia racemosa), Fuchsia and various Neopanax, Coprosmas, and Olearias (particularly O. fragrantisma).

Opossums have also adapted well to the bracken and tussock country, particularly in patches of rock and scrub. We have seen signs and caught them in snow tussock at altitudes as high as about 900m.

One aspect of their feeding habits we have found particularly annoying is their ability to strip poplar and willow trees during spring and early summer. Over the past 20 years we have planted several thousand trees to assist in riverbank stabilisation and for shelter. It is not unusual for us to see poplar trees 12m tall completely denuded of leaves, willows barked and misshapen and pine trees (especially Pinus sylvestris) wrecked by opossums. They also delight in damaging the main shoots of practically all conifers which ruins their eventual value whether for timber or aesthetic purposes.

Summary

There is no doubt that the opossum is well established in New Zealand and with present known methods impossible to completely eradicate. While the skins are of some value they do not compensate for the damage to native and introduced flora and birdlife. If skin prices fall, we can only expect an increase in opossum numbers, more damage, more tuberculosis and the expenditure of more taxpayers' funds in the war to control them.
Resource
development
and management

A. W. Gibson

The following is the text of an address given by the Director of Water and Soil Conservation, Ministry of Works and Development, to the South Island High Country Committee of Federated Farmers at Timaru on 14 June 1976.

New policies and administrative changes have been adopted by the National Water and Soil Conservation Organisation since Mr Poole addressed the South Island High Country Committee of Federated Farmers in 1973. I propose also to refer to the changing role of catchment authorities which are now becoming involved in comprehensive planning, development and management of water and soil resources in their individual regions, as opposed to the trend in the past of tackling isolated erosion problems which were usually related to individual property owners rather than of communities. This new approach relates to the Regional Water and Soil Management Plan (RMP) which is at present being promoted by NWSCO and which I will discuss in greater detail later.

Clarify thinking

I think it is generally accepted that we must clarify our thinking as to what our priorities are and in what direction we should be heading in the development and management of our resources. This is particularly pertinent to the South Island hill and high country when you consider the ever increasing demand on these resources. The need to plan for their optimum use was never more evident than it is today. Success in achieving this will largely hinge on the degree of cooperation between the occupier of the land and the agencies involved in formulating the basic plan.

I am sure that the High Country Committee, as representatives of the occupiers of high country, appreciates the importance of its role in future resource management. There is certainly plenty of evidence that a spirit of goodwill prevails among those involved in guiding the destiny of this strategically important part of New Zealand's landscape. On the other hand, I have wondered if the committee fully appreciates the very real contribution catchment authorities have made in the past.

"... we must clarify our thinking as to what our priorities are and in what direction we should be heading in the development and management of our resources."

51
“There is certainly plenty of evidence that a spirit of goodwill prevails among those involved in guiding the destiny of this strategically important part of New Zealand’s landscape.”

30 years in tackling, in particular, erosion problems in our river systems and our hill and high country. I will elaborate on this later. Now to NWSCO developments since 1973. The first matter of significance was a meeting held in Christchurch to discuss the future use of land retired from grazing.

This was initiated by the Soil Conservation and Rivers Control Council. It was held in late November 1972, although the proceedings were not published until 1973. It was a particularly valuable meeting, as it brought together 26 organisations and Government departments with a common interest in the high country and its future use.

The most significant outcome was the unanimous agreement that Class VIII and eroding Class VII land should be retired from domestic grazing and that all noxious animals be eradicated. Following this decision, steps were taken to formulate what was to be known as the Joint Policy Statement.

This statement has been an important milestone towards establishing a uniform approach to a complex subject and I foresee significant progress resulting with a minimum of conflict, since the policy identifies the problems, roles and responsibilities of the signatories involved — namely the Lands and Survey Department, the National Water and Soil Conservation Organisation, and the New Zealand Forest Service.

The statement establishes that the prime use of retired and unoccupied land of the Crown be for soil conservation and water management purposes. All secondary uses are to be considered in relation to these requirements, and to be compatible with them. The land in question will be subject to a management plan based on catchment authority priorities which will be commissioned and carried out by the administering department, and will be subject to endorsement by the National Water and Soil Conservation Authority.

Establishment of the Mountain Catchment Committee

The MCC committee, together with a technical working group, was set up by the SCRCC in April 1974, for the purpose of advising Soil Conservation and Rivers Control Council or Water Resources Council, as appropriate, on the implementation of policy described in the joint statement as it relates to the National Water and Soil Conservation Organisation. I would emphasise that this committee operates entirely within the legislation administered by the SCRCC.

The Terms of Reference were:

1. **Responsibility**: The committee will be responsible to and report to the Soil Conservation and Rivers Control Council.

2. **Promotion of policy**: Departments, local authorities, farmer, recreational and other organisations interested in the high country will be fully informed of policy and proposals for implementation of it.

3. **Planning**: Co-operation will be fostered with agencies responsible for national, regional and local planning and assistance sought in setting guidelines and standards for planning.

4. **Resources**: Information will be solicited and the committee will give consideration to the availability of finance and other resources for implementation of investigations, research, surveys, planning and implementation of approved management proposals for South Island high country catchments.

5. **Priorities**: The committee will examine and make recommendations on national
priorities for studies and work in the high country.

6. Research: Research and surveys will be encouraged and fostered in all related fields where necessary and the co-operation of agencies sought in the provision of data for planning of works.

7. Proposals: Investigations and planning for proposals will be encouraged and fostered where necessary and the co-operation of agencies sought in the promotion of approved management proposals for South Island high country catchments.

8. Reviews of policy: Policy will be subject to constant review to accommodate changing circumstances.

9. Servicing: The committee will be serviced by the South Island High Country Technical Working Group to which additional members may be co-opted as required. It is intended that the technical group will work in small efficient teams of appropriate personnel to study and report on assignments. The finance for such assignments to the above terms of reference will be made available from Vote: Works Programme VIII National Water and Soil Conservation.

Activity – Administration and General: In addition general administrative servicing will be provided by Water and Soil Division, Ministry of Works and Development.

The Mountain Catchments Committee of 10 is made up of one representative from Lands and Survey Department, MWD, NZFS, Water Resources Council, 2 from SCRCC, one of whom is the Chairman, and 3 from South Island Catchment Authorities and another representing high country farmers. It has been in operation for more than 18 months, and in that time has assisted the SCRCC with a review of its policy in a number of matters including fencing standards and costs, subsidy rates for retirement fences, subsidy alternatives for provision of offsite grazing — either a grant or a one-for-one subsidy, depending on a farmer's preference.

At the SCRCC's April meeting the committee submitted a report on land retire-

"... the prime use of retired and unoccupied lands of the Crown is for soil conservation and water management purposes. All secondary uses are to be considered in relation to these requirements, and to be compatible with them.”

Noxious animals policy

The presence of noxious animals, deer and thar particularly, in high altitude country in South Canterbury has recently been the subject of public debate. NWSCO strongly adheres to the principle that every effort be made to totally eradicate these and other noxious animals as their continued infestation is quite clearly incompatible with soil conservation and water management. Noxious animals are a serious problem in many areas of New Zealand, and their presence in large numbers in some localities has created land use and management problems far beyond the land they inhabit. Because funds for eradication are limited, priority areas are being indentified by catchment authorities in order to make the best use of NZFS manpower and financial resources. It would be pertinent to
"The grazing rights and leases granted to high country runholders confer no privileges concerning noxious animals and take away no duties in relation to them."

mention that the revised Land Settlement Board's Pastoral Lands Policy, issued in November 1974, aims at total eradication of noxious animals on eroding Class VII and VIII land. Its policy also provides that, except in properly established deer farms as provided by legislation, game management, which is designed to provide a continuous yield of quality animals, is not permitted on Crown Land. The grazing rights and leases granted to high country runholders confer no privileges concerning noxious animals, and take away no duties in relation to them.

The Dunford Report — Reorganisation of the Water and Soil Division

The Water and Soil Division of the Ministry of Works and Development which services the NWSCO, was established in 1966. At the time, it was recognised that a section was needed to carry out soil conservation and water management research. In 1972 Government approved the engagement of Mr E. G. Dunford, former Chief of Watershed and Aquatic Habitat Research, U.S. Department of Agriculture, as a scientific consultant on the setting up of water and soil research. His report released in June 1973 recommended that research centres be set up in Palmerston North, Hamilton and Christchurch. This is in the process of being done. In the case of the Christchurch centre he considered it important that the Water and Soil Division become more directly concerned with research in the South Island high country. This is a logical step because, in spite of the outstanding contribution which the catchment authorities have made in the area of run and farm plans and river works, there are many urgent problems relating to the management of water and soil which remain unsolved. The research group will also co-ordinate the many survey activities of MWD and catchment authorities, which will have the effect of better deployment of manpower and financial resources.

All catchment authority requests for operational surveys will be technically assessed and programmed according to priority and to fit in with the annual financial allocation. These surveys will include river/shingle surveys, land use capability, catchment condition and trend surveys, hydrological surveys and collection of data for water allocation plans. Operational surveys will be co-ordinated by the MWD's district commissioners of works for their programmes. The Dunford Report also recommended that MWD appoint district water and soil officers who would report directly to the district commissioners of works, and serve as their chief staff assistants in all matters pertaining to water and soil resource management. These appointments have been made.

Their responsibilities include the provision of leadership at district level in the performance of national functions in water management and soil conservation giving administrative direction to hydrological and land use capability assessments and co-ordination with catchment authorities. In the research area they would keep close contact with the programmes conducted by research organisations, participate in annual research centre reviews, provide a direct link between research centres and catchment authorities, and help extend results to catchment authorities.

A further step to ensure a better liaison between NWSCO, catchment authorities, central and local government bodies and the farming community was made with the appointment of Mr J. H. Ford, who has had a lifetime experience in most facets of land management. He will be known to many since much of his experience has been in the
Table 1: Details of fire permits

<table>
<thead>
<tr>
<th>Region</th>
<th>Year</th>
<th>No. of permits</th>
<th>Area (ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Southland</td>
<td>1968</td>
<td>80</td>
<td>21,000</td>
</tr>
<tr>
<td></td>
<td>1975</td>
<td>41</td>
<td>11,000</td>
</tr>
<tr>
<td>Otago</td>
<td>1958</td>
<td>300</td>
<td>121,000</td>
</tr>
<tr>
<td></td>
<td>1971</td>
<td>110</td>
<td>42,500</td>
</tr>
<tr>
<td></td>
<td>1974</td>
<td>87</td>
<td>30,800</td>
</tr>
<tr>
<td>South Canterbury</td>
<td>1960</td>
<td>10</td>
<td>19,400</td>
</tr>
<tr>
<td></td>
<td>1976</td>
<td>25</td>
<td>2800*</td>
</tr>
<tr>
<td>Waitaki</td>
<td>1955</td>
<td>66</td>
<td>22,000</td>
</tr>
<tr>
<td></td>
<td>1971</td>
<td>31</td>
<td>7700</td>
</tr>
<tr>
<td></td>
<td>1975</td>
<td>24</td>
<td>4213</td>
</tr>
<tr>
<td>North Canterbury</td>
<td>1955</td>
<td>40</td>
<td>2280</td>
</tr>
<tr>
<td></td>
<td>1965</td>
<td>40</td>
<td>1838</td>
</tr>
<tr>
<td></td>
<td>1975</td>
<td>46</td>
<td>1838**</td>
</tr>
</tbody>
</table>

* 0.3% of total area of tussock and mountain land  
**0.15% of total area of tussock and mountain land

high and hill country areas of Otago and Canterbury.

Rural fires

Another subject which has been investigated and updated during the period under review and which I know has concerned both catchment authorities and land holders is the prevention and control of rural fires.

A study group was set up by the Minister of Forests and chaired by Mr A. L. Poole in 1972. It was commissioned to look at fire hazards on hill and high country and in 1973 brought down recommendations designed to improve the organisation and co-ordination of rural fire-prevention and firefighting authorities. It has resulted in the NZFS as the controlling authority responsible to encourage counties to develop rural fire plans and generally to ensure that catchment authorities and the Lands and Survey Department play their part in the extension of firebreak schemes, permit con-
trol of grassland fires, the monitoring of rural fire hazard and other support activities.

In most counties there is now a well co-ordinated fire control setup to meet most emergencies. However, this is a matter that will require constant review, particularly with the increased pressure from the public involved in recreational pursuits.

Another success story of catchment authority work has been the dramatic decline in the annual number of burning permits issued and areas burnt since they took over this task. I believe this has largely been due to a better understanding by the high country farmer of the limitations and dangers of this form of removing surplus vegetation and to the good relations that have developed between high country landholders and the catchment authorities. Statistics showing the decline in permits and areas burnt are not very accurate because some years ago substantial areas of low hill country were exempted from requiring a permit while some boards' records of burning permits are not as complete as others.

**Regional Management Plans**

The most recent development of significance in NWSCO has been the endorsement of Regional Management Plans (RMP). These plans, which I referred to briefly at the beginning, are expected to have far-reaching repercussions particularly in the future planning and management of catchment authority work. Members of catchment authorities will already have knowledge of this proposal.

An RMP is a water and soil management plan covering the whole of a catchment authority's district. Such a plan has three main components:

1. An assessment of land and water resources with their existing and potential uses.
2. An appraisal of resource development opportunities.
3. An outline of water and soil management requirements.

It is a coherent long-range plan for regional water and soil conservation activities, and is seen as paralleling or complementing district and regional schemes under the Town and Country Planning Act. I would make the point that an RMP as such does not commit or make arrangements for activities such as construction works.

The great virtue of a Regional Management Plan is that it will commit a catchment authority to wide ranging collaboration with central and local government agencies, ad hoc bodies, organisations and individuals involved in any way with the land and water resources within its region, before producing a plan for the future development and management of these resources. It will get away from the approach in the past, where land use and its problems have largely been considered in isolation. In other words, an RMP is designed to present a balanced, long range, broad based, flexible plan to meet the present and future needs of the community — locally, regionally and nationally.

NWSCO staff have recently assisted the Waitaki Catchment Commission on the production of a preliminary RMP statement for their district. It was apparent from the information supplied by the commission during a recent visit of the Water Resources and Soil Conservation and Rivers Control Council to their district, that they have embraced this concept with enthusiasm. They are, of course, fortunate that there is considerable data on their resources already available — both land and water. In the case of the latter an allocation plan is currently being compiled.

The preliminary statement has identified the land in the region as being in four zones — namely, mountain, pastoral, farming and urban. It has identified the objectives and priorities of these four land classes from a soil and water management point of view. It has listed the land and water resources as well as making a broad assessment of the likely development potential covering such areas as power, recreation, land use, irrigation, rural/urban water supply schemes and waste disposal, minerals and salmon.
fishery. The final section of this report covers critical soil and water management areas and also includes likely water and soil conservation works schemes.

This is a very brief rundown on the progress the Waitaki Catchment Commission has made, but it will give you an insight into what the framework of an RMP entails.

Best land use

I make the comment at this point that while New Zealand’s production of primary products has been a key factor in its development and prosperity, the evidence is all too clear that extensive areas of both urban and rural land have not in the past been put to their best use. We have been obsessed with primary production from all classes of land without stopping to consider that some may have uses other than for agriculture. We have also made many irretrievable mistakes in the citing of urban subdivisions particularly on first class agricultural land and on unstable hill soils.

If properly implemented, Regional Management Plans must go a long way towards ensuring that in the future each land class is utilized for its best purpose and in a manner that is within its capability whether it be water conservation, recreation, cash cropping or for grazing of domestic stock.

Work of catchment authorities

Before concluding, I want to mention the work of the South Island catchment authorities. It is now over 30 years since the first authority was set up and during that period an enviable record in the field of soil conservation and water management has been established. An important factor in this has been the dedication of technical staff who by virtue of their long service and extensive local knowledge have gained the confidence of the communities in which they work. Catchment authorities had to endure severe criticism in the early years of their existence. This was understandable when new concepts in land management were being advocated by little known staff.

Some criticism still exists today, much of which is uninformed. Surprisingly, most of it has come from the farming community, for whom so much has been done, with a substantial portion of the cost being borne by the Government. I suggest the farming community should be giving greater support and recognition to their catchment authority, whose responsibility it has been to administer this assistance. To back the work of catchment authorities is to assure the future well-being of the two essential components of farming, soil and water. In reflection, in the early 1950s there was no financial assistance and in the 1970s — well, I ask you the number of works on your properties that have been subsidised by the Water and Soil vote.

Apart from the catchment authority’s wide ranging activities in the area of river protection works and farm conservation plans, one of the most important bonuses which has come from their work has been the awakening of the community to the

“We have been obsessed with primary production from all classes of land without stopping to consider that some may have uses other than for agriculture.”
Table 2: Details of land retirement of South Island high country (hectares)

<table>
<thead>
<tr>
<th>Land retirement</th>
<th>Achieved</th>
<th>In process</th>
<th>Totals</th>
<th>Estimate of area to be retired from regular grazing</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Catchment schemes or SWCP</td>
<td>Other means</td>
<td>Stock removed</td>
<td>No stock removed</td>
</tr>
<tr>
<td>Southland</td>
<td>16,000</td>
<td>24,600</td>
<td>2000</td>
<td>-</td>
</tr>
<tr>
<td>Otago</td>
<td>35,351</td>
<td>-</td>
<td>48,744</td>
<td>3650</td>
</tr>
<tr>
<td>S. Canterbury</td>
<td>45,714</td>
<td>-</td>
<td>9777</td>
<td>2260</td>
</tr>
<tr>
<td>Waitaki</td>
<td>19,242</td>
<td>10,380</td>
<td>25,926</td>
<td>37,791</td>
</tr>
<tr>
<td>N. Canterbury</td>
<td>36,412</td>
<td>-</td>
<td>22,300</td>
<td>-</td>
</tr>
<tr>
<td>Nelson</td>
<td>6985</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Marlborough</td>
<td>87,149</td>
<td>187,493</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>TOTALS</td>
<td>246,953</td>
<td>222,473</td>
<td>108,747</td>
<td>43,701</td>
</tr>
</tbody>
</table>

necessity to conserve, protect and properly manage our primary resources. The recognition of this by the urban population in particular has been very rewarding.

Value of the high country

Reference is often made to the importance of the South Island high country as a contributor to the overall economy of New Zealand and, although primary production is not the greatest earner from this particular area, the ability to develop the resources and protect them for future generations is very much linked to those who are privileged to occupy this country.

I have no precise knowledge of the annual value of the tourist industry in the mountain areas of the South Island, but it is likely to be second only to power production, the present and potential net value of which has been assessed at $165 million per annum or, if you like to think in terms of what it would cost New Zealand to import oil to produce the same amount of energy, $330 million.

According to figures supplied by the N.Z.
Meat and Wool Board Economic Service
the gross value of the production from 350 South Island hill and high country properties, using 1975/76 prices for wool and stock, would be approximately $27 million or a net return after deducting expenses of $8 million.

I have given these figures to highlight the national importance of the contribution which the resources of the South Island high country are making and, of course, of equal importance is the big responsibility we all have to ensure that the resource value of this country is protected from any activity which may prejudice its ability to sustain production.

Run Conservation Plans

The first soil and water conservation plans were commenced more than 15 years ago. The basic formula for compiling and implementing a plan has changed little over the years but improvements in the format are subject to regular review. The Land Use Capability Survey material is, for example, now being considered as a tool to help determine stock limitations on a block basis rather than on the whole property which at times may not be in the best interests of soil conservation and water management on the most critical eroding areas.

I would comment briefly on retirement fences which have been the subject of criticism in some quarters. It is inevitable that minor errors in the placement of a fence will occur. On the other hand, apart from snowstorm disaster as happened in 1967, maintenance costs have been negligible. Even in that disastrous snowstorm the maintenance requirements were very low indeed. As a general statement, retirement fences have been sited on a line which not only has the farmer's endorsement, but is based on his own knowledge of the winter conditions of the country where the line is to be erected.

A matter which has concerned the Soil Conservation and Rivers Control Council is the tendency of late for some applicants for farm plans to want to compromise on the extent of the area which it considers should be retired from grazing. Unless there are exceptional or special circumstances, such an approach is contrary to the real objective behind the exclusion of domestic stock. Decisions to retire land from grazing are not made lightly. They are based on many factors although the land class, the degree of erosion and the future use to which the land may be put are the dominant factors. It has to be remembered that we are spending large sums of taxpayers' money on a farmer's property in an endeavour to protect a resource which is seen to be in jeopardy under the present form of utilization.

"The basic formula for compiling and implementing a plan has changed little over the years but improvements in the format are subject to regular review. The Land Use Capability Survey material is, for example, now being considered as a tool to help determine stock limitations on a block basis rather than on the whole property which at times may not be in the best interests of soil conservation and water management on the most critical eroding areas."

"It has to be remembered that we are spending large sums of taxpayers' money on a farmer's property to protect a national resource which is seen to be in jeopardy under the present form of utilization."
Oversowing lucerne in North Otago

D. J. Musgrave

The work done by Dr J. G. H. White and Mr J. A. Douglas (see Review No.20, 1970) did much to stimulate interest in the use of lucerne as an alternative legume to clovers in the semi-arid to sub-humid zones of the South Island tussock grasslands. Since that time a considerable amount of work has been done in the Omarama district of North Otago, to define the conditions under which the oversowing of lucerne will have some chance of success. This article is a summary of much of this work.

Why lucerne?

Perhaps the first question that should be answered is, should we be attempting to use lucerne at all, or would some other legume fill the role equally well? A limited amount of trial work has shown that lucerne will establish better than white clover on a dry sunny face and that, of the traditional legumes, only red and alsike clovers gave similar establishment.

Once established, on a low altitude (480 metres) sunny face, lucerne produces up to 4.5 tonnes/ha on average while Pawera red clover produces 1.8 tonnes/ha, Huia white clover 0.6 tonnes/ha and the resident vegetation 0.1 tonnes/ha, reflecting the superior drought tolerance of lucerne. However, on a sunny face at 1030 metres Wairau lucerne and Huia white clover on average produce similar amounts of dry matter at 2.2 tonnes/ha and 2.5 tonnes/ha respectively, while Pawera red clover averages 4.0 tonnes/ha. In slightly moister situations Pawera red clover could be a suitable alternative to lucerne, but on low altitude sunny faces the superior drought tolerance of lucerne makes it well worth attempting to establish.

The use of rhizomatous and creeping-rooted grazing type cultivars of lucerne will undoubtedly be necessary in view on the difficulty of correctly grazing larger blocks of lucerne. Even under a cutting regime grazing types are yielding as much as Wairau on oversown plots near Omarama.

Site selection and preparation

Since dry matter production per unit area increases up to a density of 10-15 plants per square metre, ideally one should aim for this level of establishment, but this has been achieved on relatively few occasions in trial work.

A more practically attainable establishment of 1-2 plants per square metre still gives 35-50 percent of the potential herbage production and seems to be a worthwhile level to aim for. Although a seeding rate of 10kg/ha is required for this level of establishment, the use of spreading grazing types may also offer the possibility of reducing this.

A number of sowings have been made at sites of varying rainfall and the results obtained suggest that worthwhile establishment can be expected on all aspects and altitudes on sites receiving a mean annual rainfall of greater than 500mm. On sites receiving less than 500mm rainfall our results suggest that worthwhile establishment can generally only be expected at higher altitudes (6-700m) on sunny faces or on lower altitude shady faces. Even on the
The driest sites some seedling establishment can be obtained, but failure of these seedlings to nodulate under these conditions often causes severe mortality.

Where some cover already exists on a site, such as on a previously topdressed area or on damper sites, spelling to increase the amount of cover gives a marked improvement in establishment. If the cover consists mainly of annuals, such as haresfoot trefoil, a light spray with 0.5kg/ha of paraquat to check the competition, costs approximately $18/ha applied and in trial work has given a twofold increase in establishment. If seed can be purchased for less than approximately $1.50/kg it could be more economical to just double the seeding rate.

Where the cover is a denser brown-top/danthonia type sward Nixon (1971) in Marlborough has shown that complete suppression of the vegetation with 4.5kg/ha 2,2-DPA and 1.1kg/ha amitrole is essential, at a cost of approximately $27/ha.

**Time of sowing**

Sowings have been made over several years to determine the optimum time of sowing, the success achieved being very dependent on the season. Douglas (1970) suggested that coinciding sowing with the rise in soil moisture in autumn should give a longer period for the seedling to establish. Further work has suggested that this is not necessary, rather that spring rainfall is more effectively available for seedling establishment, since it is falling on a soil already moist from the winter.

The optimum time for sowing in the spring varies depending on the nature of the site, being in early August for a low altitude sunny face and two to three weeks later for shady or slightly higher altitude sites. Sowing at these times in this environment should ensure that other factors, such as soil temperature, are optimal and that for any given rainfall, the best possible establishment will be obtained. Recent work has suggested that the optimum sowing date in spring can be predicted on widely differing sites from measuring soil temperatures, as lucerne establishment reaches a definite peak at a 10cm earth temperature of 9°C.

**Inoculation and pelleting**

Since strains of rhizobia which will nodulate lucerne do not occur naturally in
On the right: third-year lucerne. On the left: the remains of a once vigorous white clover sward after a dry summer.

high-country soils, inoculation with an effective commercial culture is essential. However, with our present strains, inoculating at higher than normal rates is generally beneficial. More importantly, some form of pelleting should be used, either an effective commerical product or a gum arabic/lime pellet, although even these cannot guarantee establishment under very unfavourable conditions. Considerable work is being done on further development of pellets which will give better protection to the rhizobia and some do show promise. However, even the use of presently available pellets offers the most practical means of increasing the establishment of oversown lucerne.

Conclusions

Using the currently available inoculants and pelleting techniques, establishment of lucerne by oversowing cannot be guaran-

teed on the very dry, low altitude sunny faces where lucerne is most likely to have the biggest agronomic advantage over clovers. However, there still remains a large area of dry steepland soils where the traditional legumes will not persist satisfactorily and where our results indicate that worthwhile establishment of lucerne can be obtained (see Site Selection).

Extension of lucerne oversowing into the driest areas is only likely to be made possible by improvements in the ability of inoculum and pellets to ensure nodulation of seedlings under adverse conditions and research is being continued along these lines.

References


The nutrient value of burnt tall-tussock

P. A. Williams and C. D. Meurk

Unburnt tall-tussocks (*Chionochloa* spp.) of the eastern South Island have never enjoyed a reputation for high acceptability to livestock. This has generally been attributed to their coarse rank growth and, more recently, to their natural low nutrient status (Connor *et al.* 1970). Burnt tussocks, on the other hand, may be grazed so heavily by sheep, cattle and feral animals as to be killed within a very short time. In this light, it would be surprising if these new “sweet” tussock shoots were as nutrient poor as the unpalatable shoots of unburnt tussocks.

**Sampling**

During a recent survey of the macro-element composition of tall tussocks, an opportunity was provided to sample some burnt tussocks adjacent to others that had not been burnt for many years. The site was on the Old Man Range in Central Otago, at 1220m on a 15° north-facing slope. Both narrow-leaved snow tussock (*C. rigida*) and slim-leaved snow tussock (*C. macra*) grow here, and small patches had been burnt on the dates shown in Table 1 (a, b, c). These were sampled in January 1973, together with some unburnt tussocks (d). Four or five shoots were taken from each of eight tussocks of each “treatment” and bulked into a single sample. Eight shoots were collected from unburnt plants of both species and analysed individually as an estimate of the variation between individual tussocks.

Details of the methods used to prepare

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**Table 1: Dates on which *C. macra* and *C. rigida* tussocks on the Old Man Range were burnt (a, b, c) and sampled (d).**

<table>
<thead>
<tr>
<th>Date of burning</th>
<th>Sampling date</th>
</tr>
</thead>
<tbody>
<tr>
<td>a</td>
<td>b</td>
</tr>
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</table>

| No. of months between burning and sampling | 16 | 11 | 4 | 0 |

| *C. rigida* | x | x | x | x |
| *C. macra*  | x | x | x | x |
and analyse the tussock shoots have been
described by Williams et al. (1976). These
give us the mean weight of an individual
shoot (the sum of all the leaves), and the
macro-element composition of sheaths
(basal part of leaf), green blades, and the
dead tips (see Figure 1). All values are
measured from the base line of each graph.
Diagonally divided columns indicated that
values for the two species are the same, or
the differences are too small to illustrate.
Caution is needed in interpreting the
heights of the columns, but for phosphorus,
nitrogen, potassium, magnesium, and calcium
in sheaths and blades of both species, they are 12 percent
of the mean. The average 95 percent confidence
limits of sulphur and sodium are 31 percent
of the mean and limits for all elements in the
dead tips, 41 percent.

The bottom right graph in Fig. 1 shows
that C. macra shoots are smaller than C.
rigida shoots and that burnt tussocks (a, b, c)
have smaller shoots than unburnt tussocks.
A comparison of (a) with (d) shows this
effect lasts for at least 16 months, although a
much longer period is required before shoot
growth patterns return to normal (I. Payton,
pers. comm.).

High concentrations

Looking at the left of Fig. 1, the top two
rows show dramatically higher concen-
trations of phosphorus and nitrogen in
shoots of burnt tussocks, compared with (d),
especially in the basal sheath portion.
Moreover, this effect appears to last for at
least 16 months. Similar differences in
potassium, magnesium, and calcium levels
are shown in the sheaths and green blades of
C. rigida, although the effect of burning
appears to be relatively short lived. In green
blades of C. macra, only potassium and
magnesium appear to increase to any ex-
tent.

One is tempted to explain the very high
macro-nutrient levels in the burnt tussocks
solely in terms of their younger tissue com-
pared with unburnt tussocks. In the main
part of this study, however, (Williams et al.
in prep), we found that even in the youngest
leaves of both C. rigida and C. macra, con-
centrations of phosphorus were never more
than three times those of the outermost
leaves. By contrast, some of the burnt
tussock components here have levels of
phosphorus that are six to eight times higher
than those found in unburnt tussocks,
notwithstanding the high proportion of very
young tissue in unburnt shoots. Comparing
these burnt tussocks with the wide survey of
tall-tussocks conducted by Connor et al.
(1970), the most recently burnt tussocks on
the Old Man Range have twice the average
levels of phosphorus and nitrogen found in
C. rigida and C. macra by these authors.

Low levels of nitrogen and minerals may
be a limiting factor in the utilization by
sheep of field grown C. rigida (MacRae and
O'Connor 1970). The present data, how-
ever, suggest that where they had access to
the regrowth of burnt tussocks, the sheep of
yesteryears' match and firestick graziers
would have had a food available to them
that was markedly superior to unburnt
tussock. The preference of sheep and cattle
for burnt tussock would suggest they have
known this all along. Certainly the graziers
recognised the value of burnt tussock.

With the growing experience of graziers
and scientific field-workers, especially over
the past 30 years, it became increasingly
apparent that tall-tussocks were ill-adapted
to fire and grazing in combination.
Furthermore, as nitrogen and phosphorus
are generally scarce in tall-tussock soils, the
very high concentrations of these elements
in the young tissue suggest a drain on the
reserves of the tussocks themselves where
tussocks were burnt and grazed repeatedly,
or at critical points in their seasonal cycle.
Such a drain of elements may have con-
Concentrations of elements (mg/g dry wt.)

Sheaths  Green blades  Dead tips

Sheaths  Green blades  Dead tips

Phosphorus

Sodium

Magnesium

Calcium

Potassium

Sulphur

Chionochloa rigid
Chionochloa macra
All drawn from base

Shoot dry wt. (g)
tributed to the rapid deterioration of extensive areas of tall-tussock grasslands. Certainly it is now clearer why this important source of fodder that once clothed and protected our steeplands and hill country was quickly depleted, particularly in the drier areas.

References

CONNOR, H. E., BAILEY, R. W., O'CONNOR, K. F. 1970: Chemical

Ecological pollution

Dr E. J. Godley, Director of Botany Division, DSIR, in a recent article in “Forest and Bird” has taken conservation societies, Government departments, regional authorities and local bodies to task for the indiscriminate planting of native species.

“People are putting plants where they do not belong,” says Dr Godley. This practice can seriously reduce the scientific value of reserves or of any area of indigenous vegetation.

Scientists trying to make accurate distribution maps of a species can be misled and scientific studies confused if species are planted outside their geographical range or in unnatural habitats. The planting of an incongruous mixture of species may also prove unaesthetic and does nothing to encourage a better understanding of the environment.

Dr Godley requests, therefore, that all native species planted should be grown from local seed or transplanted from local sources. Local means within a 5km radius.

For native species already planted a record would be valuable and information on the place, time of planting, and a list of species and their source should be sent to “Forest and Bird” or to Dr Godley. For large projects a general statement defining the locality and the extent of planting would still be valuable.

The Department of Lands and Survey in 1972 issued instructions about new plantings and advised caution until Dr Godley’s proposed paper was received. The Scenic and Allied Reserves Committee has now adopted general guidelines to ensure that the proper species are planted and that all plantings are documented on permanent file.

Exceptional circumstances may necessitate the introduction of a plant to an area where it does not exist at present, in order to prevent it (or another species of animal or plant dependent on it) from becoming extinct. Planting is also often required after extensive road works or other development when the alternative is gorse or broom. Scientific advice should be sought in these circumstances.

Each district is advised to arrange for local seedlings to be raised at approved nurseries and the departmental nursery at Taupo presumably keeps a careful record of its seed sources.

Many conservation societies and other groups are already aware of the need to avoid ecological pollution and are working for the preservation and containment of a truly local flora. — Nature Conservation Council Newsletter.
The late J. S. Engel

Committee of Management

John Engel who died recently was a close friend of the Institute and of the College. At the time of his death he was Fields Director of the Department of Lands & Survey, and represented the Department on the Institute's Management Committee.

He trained as Rural Field Cadet, and completed the six-year course in 1949, taking the Diploma in Valuation and Farm Management in that year. He was much admired during this period by those of us who were his contemporaries in the R.F.C. scheme. It was characteristic of the scheme that it knitted very strong bonds between the members. The 1944-49 group had a particularly close relationship which has persisted for 27 years, and this was reflected in the number of his old class mates who were present on a windy open hillside in Wellington where he was buried.

This seemed a particularly appropriate place for a man who has spent his whole working life caring for the land. He joined the Department as a Field Officer in Hamilton, and subsequently worked in Masterton and Gisborne, mainly involved in Crown Land administration and in land development.

He then went to Wellington as Supervising Field Officer where, in addition to other duties, he was responsible for the supervision of the Rural Field Cadet scheme. He was also involved in the administration of Maori lands. His next appointments were as Commissioner of Crown Lands in Hokitika and in Invercargill. In the latter office he had responsibility for the large Te Anau land development programme and for the Fiordland National Park.

Promotion to Assistant Fields Director took him back to Wellington, and later he became Fields Director.

Throughout his career John Engel clearly demonstrated the qualities required for a land manager in New Zealand. His wide-ranging experience had led him to a deep understanding of New Zealand's land, from Molesworth to the Hauraki Plains, and also to an understanding of an affinity with the people on the land.

Men with his understanding are scarce enough. We need many of them at this time when a comprehensive national land use policy should be paramount in our priorities. The country can ill-afford the loss of John Engel. He will be missed for his professionalism by his colleagues, and by his friends for all the qualities which promote deep friendships.

J.D.S.
J. G. HUGHES (p. 2) was well known to most high country runholders and served as Management Officer of the Tussock Grasslands and Mountain Lands Institute from 1962 until his untimely death in October 1975. K. F. O'CONNOR, Director of the Institute and Professor of Range Management at Lincoln College, is likewise no stranger to regular readers of this journal.

G. A. DUNBAR (p. 7) is Agronomist of the Institute and a frequent contributor to *Review*. He was appointed in 1964 after having done research at Tara Hills and having served as a senior scientific officer with the Farm Advisory Division. His major concern has been the revegetation of eroded lands in the high country. E. J. COSTELLO and I. R. FRYER are both Institute technicians.

H. R. ALDEN (p. 21) is professor of outdoor recreation at the College of Forestry and Natural Resources at Colorado State University. Under a Fulbright fellowship, he spent a year in New Zealand developing criteria for recreational uses of mountain lands in conjunction with a three-year research grant received from the Department of Lands and Survey for the programme.

C. C. McLEOD (p. 29) is District Agricultural Scientist for the Ministry of Agriculture and Fisheries and is based at Timaru. A Farm Advisory Officer from 1951 to 1964, he has also worked in Northeast Thailand as a Colombo Plan Advisor on forest clearance, tropical pasture establishment and cattle raising. He is currently engaged in research involving crops, pastures, soils, weeds and livestock.

DR DAVID SCOTT (p. 36) is with Grasslands Division, DSIR, at Lincoln and has been responsible for the Division's high country research programme since 1970. He was formerly at Godley Peaks station, Otago and Duke universities and the Plant Physiology Division, DSIR. His research interest is on the quantitative relationship between high country plants and various natural and management factors.
J. C. ASPINALL (p. 47) has spent his entire life at Mt Aspiring station. He is secretary of both local and Otago sections of the High Country Committee of Federated Farmers and a member of the Mt Aspiring National Park Board, N.Z. Alpine Club, Search and Rescue Organisation, Otago Catchment Board and the Noxious Animals Advisory Council. He is also active in promoting outdoor education for children.

A. W. GIBSON (p. 51) has been Director of the Water and Soil Division of the Ministry of Works and Development since 1971. He has been project engineer at Turangi, senior engineer at Mangakino and resident engineer at Aratiatia. He joined the Ministry in 1942 and took up an engineering cadetship at the Karapiro hydro-electric scheme in 1944 which he continued at Mangakino, Te Teko and Auckland.

D. J. MUSGRAVE (p. 60) is Officer in Charge of the Tara Hills High Country Research Station. He was appointed as the first agronomist at Tara Hills in 1970 and since has been studying pasture establishment techniques on both dry sunny country and on the infertile soils of the Mackenzie Basin. He joined the Ministry of Agriculture and Fisheries after gaining his M.Agr.Sc. degree at Lincoln College.

P. A. WILLIAMS (p. 63) holds an M.Sc. degree and is currently with the Botany Division of DSIR at Lincoln. He recently completed a study of the mineral composition and ecology of tall tussock grasslands for a Ph.D. degree at Lincoln College with fellowship support from the Hellaby Trust. C. D. MEURK is working on his doctorate in botany at the University of Otago studying tussock compositions.

Illustrations...
Photographs: Pages 10, 12, 13, 14, 15, 17, G. A. Dunbar; Pages 49, 50, J. C. Aspinall; Pages 61, 62, D. J. Musgrave; Page 67, Department of Lands and Survey. Maps, charts and graphs throughout by Miss Pat Prendergast who also drew the front and back cover illustrations.
In the beginning God created heaven and earth.

He was then faced with a class action lawsuit for failing to file an environmental impact statement with the HEPA (Heavenly Environmental Protection Agency), an angelically staffed agency dedicated to keeping the Universe pollution free.

God was granted a temporary permit for the heavenly portion of the project but was ordered to halt construction on the earthly portion pending further investigation by the HEPA.

Upon completion of His construction permit application and environmental impact statement, God appeared before the HEPA Council to answer questions.

When asked why He began the project in the first place, He replied simply that He liked being creative.

This was not considered adequate reasoning and He was told He would be required to substantiate this further.

HEPA was unable to see any practical use for earth since “the earth was void and empty and darkness was upon the face of the deep.”

Then God said: “Let there be light.”

He never should have brought up this point since one member of the Council was active in CARE (Cancel All Radioactive Emission) and immediately protested, asking how this light was to be made, would it require strip mining, would there be thermal pollution or air pollution? God explained that the light would come from a huge ball of fire.

None of the Council members actually understood this but it was provisionally accepted with three conditions: (1) There would be no smog or smoke resulting from this ball of fire; (2) a separate burning permit would be required; and (3) since continuous light would be a waste of energy, it should be turned off for at least one-half of the time.

So God agreed to divide light and darkness and said He would call the light portion Day and the dark portion Night. The Council said they didn’t care what He called it just so long as He complied with the regulations.

When asked how the earth would be covered, God said, “let there be firmament made amidst the waters; and let it divide the waters from the waters.”

One ecologically radical Council Member accused Him of double talk, but the Council tabled action since God would first be required to make application for a permit from the ALSB (Angelic Land Settlement Board) and further would have to obtain the necessary water permits from the UCC (Universe Catchment Commission).

The Council asked if there was to be only water and firmament and God said: “Let the earth bring forth the green herb, and such as may seed,” and the fruit tree yielding fruit after its kind, which may have sown itself upon the earth.

The Council agreed, provided only native seed would be used.

Asked about future development, God said: “Let the water bring forth the creeping creature having life, and the fowl that may fly over the earth.”
Here again, the Council took no action since God would first have to obtain approval of the Wildlife Division of the Department of Interstellar Affairs in conjunction with the Angelic Acclimitisation Society and the Heavenly Forest and Bird Protection Society.

It appeared everything was in order until God mentioned He wanted to complete the project in six days.

The Council told Him this was completely out of the question... HEPA would require a minimum of 180 days to review the application and environmental impact report and then there would have to be public hearings.

It would take at least 10 to 12 months before a permit could be granted.

God said: "To Hell with it!"

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**Wetlands preservation**

It was resolved at a recent inter­departmental meeting called by the Wildlife Service that each department having an interest in the preservation of wetlands would request their respective Minister to advise the Minister of Internal Affairs of his support in the application for a $1,000,000 Vote to be held in a suspensory trust account over a period of 10 years, for the acquisition of appropriate wetlands.

The preservation of wetlands is a crucial international concern and New Zealand has now signed the Convention on Wetlands of International Importance which came into force on 21 December 1975.

Scientists and conservationists are fully aware of the vital importance of wetlands to all kinds of wildlife and regret that large areas of marsh and swampland have been and still are being filled or drained. There is a long way to go in gaining full public appreciation of the value of wetlands.

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**Biological recording**

Dr D. G. Dawson has recommended to DSIR that a Biological Data Recording Scheme be established in New Zealand. The Nature Conservation Council supports this recommendation as the scheme will strengthen the work of environmental agencies, especially those, such as the Council, required to make reliable assessments and responsible recommendations to Government.

The scheme is intended to give reliable initial assessment on any given site or area...
and will not replace in-depth studies or the biological recording work now in progress. Originally designed to assist biogeographic studies in Britain, the scheme produces a series of distribution maps, in 10 km grid squares, indicating the presence or absence of species. Initially, Dr Dawson suggests two sections for a New Zealand scheme:

1 — mapping and site assessment for higher plants
2 — monitoring of bird populations.

One full-time botanist, a zoologist, secretarial assistance and data-punching facilities would be needed to operate the service. — *Nature Conservation Council Newsletter.*
In this issue:

- Fencing design
- Native revegetation
- Recreation criteria
- Gains from drenching
- Grasslands research
- The opossum threat
- Resource management
- Oversowing lucerne
- Burnt tussock nutrients
- J. S. Engel