

In the case of the forests this broad approach is made automatically. It will be more difficult in the case of the tussock grasslands where there is fragmentation of responsibility and divided control, but it is none the less essential. The South Island tussock grasslands are at least as important in the field of soil and water conservation as the mountain forests.

The very first requirement in management of any wild crop is a thorough ecological survey and stock-taking. This would be the first thing done by any forester responsible for management of a forest, but for the tussock grasslands no inventory has yet been made. We do not even yet know how many types of tussock grassland there are, or the precise extent of one of them. For every forest, also, the forester responsible is called upon to make an early decision with respect to the objects of management, timber production, control of water yield, recreational development, and so on. In the management of tussock grasslands there has been but the one objective for all lands offering a promise of grazing at an immediate profit, wool production.

Our national thinking on this subject has been grossly illogical. The public, including most scientists, condone exploitative grazing of tussock grasslands, even in critical river catchments where they would promptly veto any attempt at exploitation of forest re-

sources. The forester might be certain that he can grow a second crop as good or better than the first, while the grazier can promise nothing. But this makes no difference.

If we are to be logical we should look at both the forests and the grasslands of the mountains from the one standpoint, control of water yield. Only after this is assured should we seek wool, timber, or game production. Logging of the high mountain forests is at least as justifiable as grazing of the high altitude tussock grasslands. The resource inventory must be the first step in management. Multiple use and sustained yield must be the principles of management. These terms are part of the alphabet of all foresters, and should equally be part of the thinking of all who deal with tussock grasslands.

Foresters and rangeland specialists have much in common. Management objectives overlap, management and research techniques are closely comparable, philosophies of land use are, or should be, identical. In many countries of the world these facts are recognised by placing both forests and rangelands under the one administration. No claim is made that this should be done in New Zealand. The discipline of forestry can supply clear-cut philosophies of land use, tried, tested and proved. The science of rangeland management is, after all, an historical daughter of the science of forestry.

## Discussion

H. E. CONNOR, in opening the discussion, said it was apparent there was a big field of tussock-grassland research in front of us. The views of the speakers lead us to take a long-term view of the development of tussock grassland. Mr. Raeside had described three cycles—one warm and wet, one cool and dry and the latest phase out of equilibrium. An elaboration of the effect of the changes in climate and vegetation in the tussock grasslands would clear the way for any discussion on their utilization. The pre-European history seems more important when we consider treatment of these grasslands today. Perhaps some of the recent carbon 14 techniques, or pollen analyses could be of use. Also, what has happened

to species of plants in the tussock grassland flora following the migration of the tussock grassland into new ecological niches? A full understanding of the early history and development is needed before the question of present use can be brought into the major discussion.

MR. RAESIDE said that we have no absolute evidence to illustrate these cycles, but many small items all point in the same direction. A cool, dry grassland cycle in early European time was preceded by a warmer, wetter cycle, supporting a mixed podocarp-broadleaf forest. The temperature was at least 3°C warmer, and the rainfall on the coast was probably 46-ins. where it is now 25-ins. Three samples of wood from pre-

historic trees on sites where that particular tree does not now grow were aged by carbon 14 determinations, giving the range of age from the 7th to the 14th century. On the eastern mountains, above the timber line, snow tussock grassland replaced forest without any great erosion catastrophe between. Further inland where the snow tussock grassland did not replace forest, it was stable through both cycles.

MISS MOORE mentioned work by Miss Barker, who at Hunter Hills found no change in the present vegetation indicating where the original lower level of the snow tussock might have been. She found that the soils were inclined to be the same under all the fescue tussock up to the snow tussock boundary.

MR. HOLLOWAY, replying to a question from K. E. LEE, said there are very few places in the North Island where the mountain tops are high enough to reach snow tussock altitude.

N. L. ELDER said the pumice soils affected the forest line on the North Island ranges in the neighbourhood of 4500-ft. There was evidence of a retreating forest line in the northern half of the Ruahines, and of tussock and scrub working down.

P. B. LYNCH asked whether tall vegetation similar to snow grass was necessary to combat erosion.

MR. RAESIDE answered that snow tussock was very well designed to provide protection from frost on slopes. There could be violent alternation of freeze and thaw. Any attempt to introduce plants that would thrive in that habitat and provide a predominant grassland must take this into consideration. The precise bulk of foliage and depth of litter necessary under snow tussock was not known, but before any introductions the minimum amount of frost protection necessary must be established. The plant must also grow fast enough to cope in its early stages with frost lift.

R. J. SCARLETT said that before the introduction of cattle and sheep browsing and grazing animals, the big moas, were found in considerable quantities.

R. D. DICK said we now look at a river system rather than a particular species of animal or plant. The tussock grasslands at

about 3000-ft. were in quite an unstable state a century ago.

MR. RAESIDE said the soils for the most part were held in place where the vegetation was present. Some records suggested that on the inland mountains where there was no forest the snow-grass tussock had existed from the warm, wet cycle. If so, in the cool, dry cycle they would be relict grasslands, not necessarily in equilibrium with the environment.

DR. G. W. BUTLER asked about the microbial flora of a tussock association as compared with a lowland grassland association, and about the nitrogen economy of the tussock grassland.

DR. THORNTON answered that they had no comparative evidence for tussock grassland as opposed to a short rotation lowland grassland. The vegetation appears to suit the general limits of the microbial flora. As regards nitrogen, there are no legumes, but some free-living nitrogen-fixers may be there.

W. B. BROCKIE asked about the effect of land disturbance on forests. Old podocarps were up to 600 or 800 years old. Disturbance of their roots might be worth considering in regard to the deterioration of forests. The lowering of the water-table could be investigated from the angle of stream erosion.

MR. HOLLOWAY said that in working out the broad changes we try to discount secondary changes, these are going on the whole time and distort the changes that arise from a climatic cause.

C. E. IVERSON called the tussock plant a colony; maybe a certain amount of pruning could be done without harming it. He put in a plea for land use of this country.

MR. HOLLOWAY wondered to what extent the sheep eat the tussocks and what part they lightly prune. The sheep remove the highly palatable species more completely than any forester removes trees. Others are often left. In the United States worse land is held under grazing by moderate land use, but most of it is flat or rolling land, not steep mountain sides.

MR. BROCKIE said that in the sub-antarctic islands the large tussock has been eaten down by sheep and there is none in access-

ible places. Probably the bigger herbaceous plants were eaten before the tussock.

W. J. WENDELKEN said that climatic change and relict vegetation being accepted, and the imposition on this vegetation of man and his animals, could anyone give an indication of native grasses, shrubs or trees which could withstand the activities of these animals under present conditions? Could anyone give an indication of the relative amount of damage caused by the various animals, sheep and others?

MISS MOORE said that the question of plants that could withstand the onslaught depended on what part of the tussock grassland was discussed. In many areas mata-gouri could stand it and push the animal off, as could scabweed.

MR. RINEY said that apparently there are some plants that can withstand a considerable amount of browsing, several *Coprosmas*, and the silver beech. In production forests the amount of browsing the plants can stand is not very much. The main thing is to get these plants maintained and regenerated. It would be handy to know how to age lichens on rocks. How long does it take for rocks and fence posts to get covered over with lichens or algae?

MR. ELDER said lichens took a long time. He had seen two grow to the size of sixpence in three years.

A. P. DRUCE said that rocks had been covered by lichens in five years. On grasslands he remarked that Mt. Egmont was free from grazing animals. In areas still stable there is volcanic ash on top, and these grasslands appear to be approaching a climax development. The tussock cover is complete; even at 5000-ft. it shows a range of all age-groups and sizes of tussocks. In eroded areas once the covering tussock grassland has gone there has been no replacement even though nearby there are numerous young tussocks. Some factor other than climatic change seems to be important. The tussock once disturbed does not seem to be able to maintain itself. That the change may be hastened by climate is possible, but climate may not be the primary factor. In the red tussock grassland near Waiouru bare areas are forming after burning and grazing and there is no replacement in the tussocks. The regeneration of the tussock grassland in high altitudes may depend on initiating the develop-

ment of the cycle of soil and tussock grassland from the beginning again. An indication of this is given on Mt. Egmont where on a very large slip, over a mile wide and extending from 7000 to 3000-ft. at least, no soil has developed, and although climate is favourable, there are no young tussocks come back into the bare areas of sand and gravel. All the young tussocks are situated in already developed vegetation, and it appears they have to develop in established covering vegetation.

MR. KELSEY said the whole tussock cannot be considered without the inter-tussock vegetation too, particularly in regard to grazing animals. In the limited time we have been working the inter-vegetation has been grazed first, and the tussock itself is grazed off by the sheep down to about nine inches. Regarding insects, you get small pockets up to three or four acres, but the more usual type of insect-feeding is up to half-acre patches. Insect damage occurs to a greater extent on the northern faces of slopes.

P. C. BULL, on a question of rabbit damage to tussock, said he believed that rabbits moved in and colonized an area when tussock was destroyed and prevented regeneration of the tussock. Rabbits appear to be the symptom of disturbance of the tussock, and not its cause.

DR. BUTLER wondered whether stabilisation of the tussock association was possible by the introduction of a bushy legume of desirable growth habit to the tussock.

DR. M. MAYER said when there is disturbance the tussock goes first, and the inter-tussock goes next.

MR. CONNOR said that in a very favourable environment the silver tussock would grow to 18 inches in 12 months, fescue to 12 inches, silver tussocks to 3-ft. in two years. Tussock in good condition can grow very quickly and very well, even better than the rye grasses.

DR. BUTLER said that this bore out that when there is no nitrogen stress tussocks will do very well. White clover was not enough, because of frost heave. You have to have a vegetative buffer of bushy forms.

MISS R. MASON said that *Danthonia australis* was spreading. She only knew it in

Nelson where there are no rabbits. It would survive treading.

MR. DRUCE said that on Mt. Egmont inside patches of tutu the tussocks are three or four times larger than those outside.

THE CHAIRMAN said that recent evidence would suggest that one of the reasons why tussock plants did not grow is a lack of sulphur. Very little sulphur is coming down from the atmosphere, and legumes need sulphur to fix nitrogen.

MISS MASON said that *Coriaria* produced nodules which are said to contain bacteria, and there is a distinct possibility that these may produce nitrogen. There are other plants beside legumes which produce nitrogen, some of them similar to some of those species growing in the tussock.

MR. CONNOR said there is a very positive response to nitrogen in the size of the fescue or silver tussock in the tussock grassland itself.

L. D. BASCAND said he had seen no posi-

tive increase in size but probably more colour.

H. M. SIEVWRIGHT said that when clover was introduced amongst the fescue tussock you got a response in the fescue tussock itself after one year's growth, provided the clover is thriving.

MR. DICK, speaking of the tussock grassland, said that the productive beech forests are equally important as water control agents. He asked what progress is being made in publishing information about the deteriorating beech forests in Canterbury.

MR. HOLLOWAY said that of tussock grassland there were 20 different types in the Waimakariri area, of beech forests 4. Much material was ready to be published. We do know precisely what to do with our beech forests, which is more than anybody knows about the tussock grassland.

THE CHAIRMAN, closing the session, said there had been an exhaustive discussion, although he did not know whether we had solved many of the practical problems of the tussock grassland country.

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