TUSSOCK GRASSLAND PROBLEMS UNDER INVESTIGATION IN NEW ZEALAND

By J. M. HERCUS, Instructor in Agriculture, Department of Agriculture, Alexandra,

1. Introduction

This paper deals only with the tussock grasslands of the South Island. There are areas in the North Island-on parts of the Central Plateau, and above the bush-line on the higher mountain ranges-which are clad in tussock species, but these are of relatively small extent, and have not been considered an important problem.

Of the 23½ million acres of occupied land in the South Island, over half is described as tussock grassland. At the time of first settlement, this proportion was even higher, and from the 1850's until the 1880's, wool from this grassland vied with gold as the major source of revenue for the new colony. However, since 1880, there has been a steady deterioration in the relative value of the production from this hinterland, and today it is estimated to contribute less than 4 per cent of the country's export revenue.

Over the last 20 years there has been a world-wide awakening to the importance of soil and water conservation. A large proportion of the watersheds of the east coast rivers lies within the tussock grassland, and particularly since the passage of the Soil Conservation and Rivers Control Act in 1942, the importance of this new role has served to refocus attention on the need for gathering information as to the behaviour, requirements, and potential of this area.

It is the purpose of this paper to describe the overall problem facing the research worker in the tussock grassland, and to discuss the present efforts being made towards its solution.

2. The Problem

Tussock or bunch-grass species are, or were, the vegetative mantle covering a large part of the South Island east of the main mountain chain. Their range

extended over the whole length of the island, from sea level to over. 5000ft, and embraced a wide range of soils, climates, and habitats.

This natural grassland can be subdivided into 4 main groups on the basis of the visibly dominant species; there is the snowgrass *(Danthonia flavescens)* community of the higher altitudes and colder sites; the hard tussock (*Festuca novae-zelandiae) of* the lower hillsides and plains ; the silver tussock *(Poa* caespitosa) association of the moister hills and valley floors; and the red tussock *(Danthonia rigida)* of the wet, poorly drained areas. In their. primitive state these dominant species were all tall growing, their spreading leaves forming an almost continuous shade cover to the area'not occupied by their bases. In those spaces, enjoying a micro-climate vastly different from 'that of the exposed tussocks, was a substratum of grasses, herbs, and sedges. The tussocks were xerophytic, and generally coarse and fibrous, while the understory association not only contained a greater variety of species, but was more succulent.

With one possible exception, these 4 associations appeared to be in a state of equilibrium with their environments when the white man arrived. There were no grazing animals, and the earlier Polynesian settlement appeared to have exerted little or no influence. However, there is evidence to suggest that significant climatic changes had affected the forest/grassland balance in quite recent times, and any short-term rainfall fluctuations would maintain the forest/grassland and any grassland/desert transitions in a constant state of flux.

We cannot be sure of the composition, arrangement, or ecological status of 'any of these plant communities before 1850, but we do know that-the arrival of the European, with his tools, plants, and animals, quickly threw the whole ecosystem into a state of imbalance. The 4 main plant associations reacted in different ways, and at different rates, and responses varied with climate, slope, aspect, soil, and utilisation. The more critical the survival of the vegetation before settlement, the more profound its readjustment, and the induced semi-deserts of the arid inland basins provide an' extreme example. At the other end of the scale there are plant communities which remain dense and vigorous. There have almost certainly been changes in their composition, but the loss of any indigenous species has been made up by adapted exotic grasses and shrubs. Considerable areas of lowland

tussock grassland have been deliberately modified by cultivation and 'irrigation, but these have been restricted to valley floors and plains wherever soil depth, moisture, and topography permitted.

The problem could be defined as follows: The impact of deliberate utilisation on the apparently stable associations making up the tussock grassland has altered their composition and arrangement, and over much of the area there has been a deterioration in the quality and quantity of the plant cover.

3. History of Experimental Work

It is not possible to elaborate on the evolution of research activity in the tussock grassland, but a brief outline is necessary to provide the 'background to a discussion of the work now in progress.

From first settlement to the present day the run-holders themselves have been looking for ways and means to improve their country. They have been forced to rely on trial and error methods, and in such an environment the error of any practice is frequently apparent only when irreparable damage has been done. However, by 1880 the broad pattern of management had been set; the rabbit was firmly entrenched, especially in the so-called depleted country ; the manipulations of the fire-stick and of stock numbers had left their various lessons and legacies, and the economic vulnerability of this one-product enterprise had been established.

There were frequent attempts to draw attention to the need for investigation into this tussock grassland problem, but it was not until the Department of Agriculture was reorganised in 1910 that there was an organisation constituted and staffed to undertake it. However, by this stage in the country's development, extensive pastoral farming had been supplanted in importance by cropping and intensive agriculture, and it was natural that the primary concern of this new Department should be the arable country and downlands.

From among the array of problems requiring attention, tussock grassland was accorded a place, and the first article in Volume 1, Number 1 of the "Journal of Agriculture" is entitled "The Natural Pastures of New Zealand; The Effect of Burning on Tussock Grassland." Between 1910 and 1945 experimental work was restricted to part-time studies by a few individuals, and there were many gaps in its continuity. In 1945 the first full-time officer was appointed, and

today there are 6 full-time workers in the Department of Agriculture, and a number of officers of this and other Government agencies engaged part-time.

4. Problems Under Investigation

The first objective is a thorough stock-taking of this grassland complex. We can recognise the 4 dominant plant associations, but we require to know what areas are involved, what sub-associations are present., where these occur, and under what conditions they have developed; what, and where, are the most critical areas, and why are they so? The sort of soil and vegetation survey needed has been done on certain watersheds by local Catchment Boards, using techniques and classifications developed for each area. There is the danger, however, that the integration of the segments of this piecemeal approach may prove difficult, and there is a small research team working out a standard procedure for use anywhere in the tussock grassland.

Until such an inventory allows us to describe and define the tussock grassland accurately, selection of the sites and associations for study will depend on their apparent relative importance, on their accessibility and on the facilities presently available.

Before discussing the present investigational work, I would like to spend a few moments developing our original definition of the problem being tackled. There is Considerable variation in the amount and proportion of the types of country, but the runs of the tussock grassland are divided by altitude into two parts. Above the level of the normal winter snow level—corresponding with the snowgrass/fescue tussock transition-is the summer country, where the stock are carried from mid-summer until early winter, and below this, on the lower hillsides and valley floors, the winter country must carry the stock for the remaining months. In most cases, the small amount of supplementary feed which is grown is for replacement stock, and the bulk of the wintering is on standing growth.

There are two main parent rock materials in the tussock grasslands-the mica schist of Central Otago and the greywacke of Southland, Canterbury, and Marlborough. In the mica schist belt, the summer country (snowgrass association) is generally well clad, while the original fescue and silver tussock associations of the lower hillsides have been either completely lost or seriously depleted. In the greywacke, however,,

it is the summer country which appears unstable, while the lower hillsides and valley floors contain a vigorous plant cover except in those areas which receive less than about 20in. of rainfall per annum.

From 1910 to the present day the depleted winter country, of the mica schist country has received most attention, but since 1945 work has been done on the valley floors and terraces of the greywacke areas, particularly in the Waimakariri and in the northern part of‘ the Mackenzie Country. The development of the present approaches to improvement has been attended by its full share of growing pains, and they are still a matter for constant review and revision. For the purposes of this discussion I propose dividing the programme of investigation into two sections: The first is the improvement of the flat or undulating country, where implements can be used, and the second is the improvement of the hills and mountainsides above. There are certain improvement practices which cut across this division, and they will be discussed separately. All the methods involve manipulation of the plant, animal, and soil factors of. the basic plant-animal-soil-climate interaction, and the differences are only of degree and emphasis.

A, **On Flat or Undulating Country:**

Practically all properties in the tussock grasslands have some area of land where machinery can be used and where it is possible deliberately to destroy or check the present plant cover, to introduce new species **into** the ground, and to manage, the new association more or less intensively. The experimental programme involves plant testing, methods of establishment trials, fertiliser responses, grazing management requirements of superior species, and their seed increase.

(i) *Plant Testing.* In the depleted fescue tussock areas of Central Otago it seemed that the original vegetation was unable to survive utilisation, and it was felt that vegetation depended on finding suitable exotic material. The early nursery work was necessarily haphazard, but within the last few years it has been possible. to reorganise this whole programme. There is now a base area, where plant material is sown in replicated rows, and where production measurements are taken. Working in conjunction are a series of outlying nurseries, established wherever significant climate or soil differences are suspected, where the same material is sown and its behaviour observed

using a standard system of recording. Check species are included for actual measurement, to relate the results from the outlying and base areas.

(ii) *Fertiliser Responses:* These are introduced in. the nursery areas, and have been, restricted so far to the use of superphosphate with the legumes, and, this season, to the addition of artificial nitrogen for the grasses. It was long felt that artificial fertilisers could play no practical part in the improvement of extensive. natural grassland, especially where the rainfall is below 20in. per annum, but the results from such treatment in overseas countries, especially in Australia and in North America, have caused a re-examination of the position. We do have some evidence to suggest that moisture is the limiting factor in the use of *Trifolium* species in the under 20in. rainfall areas, but it may be that an initial nitrogen boost will make the difference between success and failure with grass establishment in such. areas.

(iii) *Grazing Management.* As soon as possible species showing promise are subjected to grazing trials. The nursery rows will have yielded some data on the amount and season of growth, and the next stage is to balance the plant requirements with livestock management. Wherever possible, grass and legume are sown together, in blocks of half an acre or more, and the animals are introduced as soon as the species are well established.

(iv) *Methods of Establishment.* It has been amply demonstrated **that** the results of putting suitable seed into the ground are far superior to those from putting the same seed on to the ground. There are parts of the tussock grassland where cultivation and thorough seed-bed preparation are possible, but there are considerable areas where the seed must be introduced with minimum disturbance of the soil. A number of machines are available for direct seeding, and the final stage of this programme is to find out the best way, and **the** best time, to obtain a good establishment in the different sites and associations.

(v) Seed Production. Once a species has established its superiority, small nucleus seed blocks are sown in the best ground available. Wide-spaced rows are being tried, and heavy fertilising is practised. However, the amount of seed from these areas is sufficient for further trial work only. It is considered that our function should cease at this point, and that large-scale seed production should be undertaken either by

co-operative ventures, such as that already organised by the runholders of the Mackenzie Country, or by the down-country small seed producers.

By this approach we have identified several grass and legume species which can be established wherever machinery can be used and whose production is many times greater than that of the existing cover. There may be only a small part of any run which can be so treated, but its improvement is an integral part of the development of the more difficult hill and mountain country. One acre below may do the work of 10 or more above, and, more important, it can do this at times which are critical for the growth and reseeding of the hill species. These valley floors and river terraces are usually readily accessible, their subdivision is not particularly difficult or costly, and the cost of their improvement is a function of the property as a whole, and not just of the area concerned.

B. **On the Hills and Mountainsides**

Here, too, the fact that most of the work has been done within the depleted country resulted in the dismissal of the native flora for revegetation, and concentration on looking for promising introductions. Any extension from the netted nursery areas was almost impossible because of the rabbit problem, but from such row trials and from small plots several species seemed worthy of more extensive sowings.

In 1948 the Rabbit Destruction Council was set up, and this body, working through local Rabbit Boards, has achieved remarkable results. Control of the rabbit has brought about some equally remarkable results on the part of the depleted lower hill slopes. To give an example, between 1951 and 1955 control of this pest was responsible for raising the carrying capacity of one run by 25 per cent and its wool production by 55 per cent. This increase was due very largely to the recovery of some of the native species long thought to have disappeared. The fact that most of these are the more palatable elements of the original association makes their rapid reappearance even more astounding.

There have been other reasons behind the present trend to explore the requirements and potential of the present species before hunting for suitable introductions. Even when it is known that an exotic species can survive the particular environment, successful establishment of grasses by surface sowing has been

the exception rather than the rule. Again, the present cover has been supporting a fairly stable sheep population for a good many years without our making any attempt to find out its requirements and fit these in to our grazing management. One further factor has been provided by careful studies of sheep grazing preferences in the only large-scale trial where oversowing of introduced plant material, coupled with three years' complete spelling, has allowed the animals a choice between sown and rejuvenated original species. Here, it has been found that the stock wintered on the native plant material.

The original sheep grazing studies are being extended into other parts of the tussock grasslands, and as the important species are recognised, their behaviour and requirements are being investigated. Some idea of the sort of improvement possible can be gained from the following example which happened more or less by accident. The block was some 1400 acres, carrying 1 sheep to 2 acres each year from early June until late December. Inspection of the area in May showed that, although there appeared to be no perennial grasses present, there were, in fact, numerous plants of *Agropyron scabrum,* but not a single seed stalk. A small trial was put down in the following spring, and this was fenced off at the beginning of December. Three months later, the trial area stood out from the rest of the block, not because of the trial itself, but simply because the *Agropyron scabrum* had been able to set seed. Removing the stock 3 weeks earlier than usual allowed natural reseeding, and also much better growth of the parent plants. The results were sufficiently striking for the runholder to fence this block in two the same year, and to adjust the stocking so that each part can reseed every second year.

It will take time to sort out the relative importance of the present species, and to find out their requirements. In some areas, especially in the worst of the depleted country, it may be necessary to accelerate artificially the increase of useful. species by oversowing favourable "nucleus sites." The improvement gained by this animal manipulation may not be sudden or spectacular, but under the prevailing conditions of climate, topography, and management it seems the soundest, and the surest, especially when assisted by the "replacement" development on the cultivable ground below.

There is another method of improvement which

shows promise in certain areas at least, The tussock 'grassland has no natural legume apart from a few species of *Carmichaelia*. One of the-best-known ways of. improving production is by improving the soil nitrogen status, and in the sown grasslands of New Zealand vigorous clover plants have been regarded as the most efficient nitrogen factory. With the recent improvement in the economic health of the high-country runholder, there has been an extension of this practice into the tussock grassland. Results from both run-scale oversowings and topdressing and small fertiliser trial plots indicate that worthwhile results can be obtained in areas below about 3000ft and where the annual precipitation is over 25in. Further work is being done to define the limits more closely, at least in terms of present knowledge, and to devise a system of management to best utilise and sustain the response obtained.

Summary

The broad problem presented by a century of utilisation of the tussock grasslands is described and the investigational work in progress is discussed. These studies are aimed at the rapid improvement of the areas of cultivable land, and the use of the increased production so obtained to permit manipulation of grazing times and intensities on the associated hillsides above. On the valley floors introduced plant material shows promise, while on the hill country the emphasis is on taking- full advantage of the presence, and the potential, of the present plant cover.

DISCUSSION

Prof. R. M. Love, U.S.A.: There is a great need in the South Island for a research station in the high country. I know it has been said that the income from the high country is not enough to warrant the establishment of a research station. This is a little short-sighted; it is very difficult to say whose research is going to pay for what. During the last war we were told in the United States that the use of hybrid corn more than paid for the research on the atomic bomb. You must do the actual work on the country itself; therefore a research station is necessary actually in the high country and in an area where you have long term use. of the land, not rented land. The agency to establish such a research station is Lincoln College. Governments have to regulate as well as assist. To get away from the suspicious attitude of farmers to Government put the research into the hands of the agricultural college.

R. D. Dick: I want to draw attention to tussock. It has a two-fold action, to protect plants and to reduce run-off into rivers. Are the Government Departments finding out what

proportion of tussocks we need on our grasslands so as to get good sheep grazing and a small run-off of water? In the North Canterbury Catchment Board's distritt we find that above 4,000 feet we have the vegetation consisting of 60 per cent grass and 40 per cent herbs and shrubby plants. Of the grass 40 per cent is snow tussock. On the hard or fescue tussock country we have 65 per cent of grasses and 35 per cent of other species. Of the grass 20 per cent is fescue tussock. We would like on our fescue tussock areas to have about 30 per cent of fescue tussock.

A. (J. T. Tothill): We are carrying out various technical studies which might eventually give an answer. In the meantime we cannot say.