is at all thin, to be capable of slowly gaining dominance over a range of native species.

Another ornamental, **Euonymus phellomana*, has in parts of Riccarton Bush assumed dominance in the shrub layer and its seedlings are so abundant on the floor of the forest that many seedlings of native species are smothered. Flooding of the soil during the dry summer period may in this instance assist the native species to play a more vigorous part in the community, as it seems that lack of soil moisture during the summer over a number of years was a factor which placed the native members of the forest community as a whole at a disadvantage as compared with the adventive species.

Climbers (*A*) versus *climbers* (*N*)

A micro-community of the Asiatic **Lonicera japonica* growing with *Muehlenbeckia australis* and *Tetrapathaea tetrandra* is particularly interesting, and all three species are intertwined through and over lower trees of the canopy: after some years of observation the final results are still uncertain, although recent indications are that **Lonicera* appears the most vigorous.

Despite the patchiness of the communities described here, the following points may reasonably be drawn:

1. In the interaction of native and adventive plant species, representatives of both groups have shown their ability to become relatively permanent members of mixed communities and to become dominants.
2. Certain native species have shown that they can adapt themselves successfully to modified original or even new artificial habitats and communities.
3. Modifying factors may exercise marked effects on the behaviour of species.
4. Species belonging to both floras and differing markedly in botanical relationships, growth habit and original habit, have become significant members of a wide variety of mixed plant communities.
5. Many mixed communities are still in process of development.

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SOME INTERACTIONS ON NATIVE AND INTRODUCED PLANTS IN NEW ZEALAND GRASSLAND

S. H. SAXBY

Department of Agriculture, Wellington

A study of the history of the development of grassland in New Zealand is also a study of a prolonged interaction between native and introduced plants in which there has usually been a strong and deliberately guided bias towards the supremacy of the introduced plants. Because much of the native vegetation does not meet the requirements of the farmer, he has tried to replace this with plants that do so.

This programme of replacement has been dependent on many aids. Fire, axe, plough, fences, fertilisers and animals have all played a part. Much of this programme was carried out as described by H. Guthrie-Smith in *Tutira*: " . . . stamped, jammed, hauled, murdered into grass." Although this refers to the conversion of bracken fern country into grassland, it is typical of the action taken under many conditions to destroy the

native plants in order that the more desirable introduced ones could establish, survive, and produce feed for domestic animals.

Because of the many tools which man has had at his command, and because he was usually able to call on them when required, it might be thought that the native plants would have had very little chance of survival. Experience has shown that although, on the whole, man has been very successful in his endeavours, he has experienced many difficulties in swinging the interaction in the direction which he desires.

Although the present grasslands of New Zealand have succeeded many different types of vegetation, it is proposed to consider only some of the ecologically interesting interactions that have taken or are still taking place. Examples are taken from three very different plant communities, namely rain forest, tussock grassland and fine turf.

RAIN FOREST ON UNPLOUGHABLE LAND

Rain forest was usually felled in the winter, burnt in the summer, and sown with grass in the still-warm ash. The ultimate success of the conversion of forest to grass depended to some extent on the strike of the sown grass. Success or failure depended mainly on the completeness of the "burn". A burn that destroyed all but the largest of the logs and stumps was the objective. This enabled the grazing animals, usually sheep, to eat and tramp not only the sown grasses and clovers, but also the native plants which germinated. On the other hand, an unsuccessful burn left large quantities of unburnt vegetation as a tangle of branches, logs, stumps and living plants. When such areas were sown, insufficient feed was produced to enable enough animals to be carried to graze both the sown introduced plants and the re-establishing and surviving native plants. In addition, the maze of unburnt logs and branches isolated many areas from the animals. In these areas the native plants rapidly established and flourished without hindrance from the grazing animals. Where there were many such isolated areas, the re-establishment of the natives was rapid and the whole area was ultimately engulfed by them because they were better able to survive in the competition for light than were the sown introduced plants. Such unsuccessful burns usually had to be abandoned for the time being at least. Some areas were later laboriously cut and burnt for a second time, sometimes with and sometimes without success. Others were abandoned completely for farming.

Examples of these interactions can be seen throughout country which was previously carrying rain forest: they emphasise two points. First, a good clean initial burn is of great importance if the balance in the interaction is to swing in favour of the introduced plants. Second, native plants can readily dominate following a burn unless enough grazing animals can be introduced to eat or mechanically destroy the seedling or surviving native plants.

Experience soon showed that, even after a successful burn, the hill country farmer was likely to be faced with further interactions which in turn he would have to try to swing in favour of the introduced plants if he was to survive as a farmer.

These interactions were between the palatable introduced plants and some unpalatable native plants. Two good examples of the unpalatable native plants that caused trouble are bidi-bidi (*Acaena* spp.) and hard fern (*Paesia scaberula*). Both of these low growing plants produce, and spread by means of, unpalatable runners. Under close and continuous grazing by sheep, they obtain ample light and are able to spread over and root in the closely grazed grasses of the pasture. This reduces the available feed, and if an attempt is made to carry the same number of animals on the area, these native plants, because of the intensity of the grazing, increase to the stage of dominance with the ultimate result that no stock can be carried. This of course leads to the ingress of other native plants and a gradual regrowth of forest.

On the other hand, the interaction can be swung in favour of the introduced plants by spelling the pastures. This spelling enables the grass to grow and causes the runners of the bidi-bidi and fern to be lifted. These are then destroyed by the grazing, trampling and fossicking of the animals, and so the balance is then swung in favour of the introduced plants.

Two further native plants which provide another interesting example are manuka (*Leptospermum scoparium*) and tauhinu (*Cassinia leptophylla*). Both are now much commoner than they were before farming started; and, from the farmer's point of view, both are serious induced weeds. Both have spread on farmland, manuka in many localities and tauhinu mainly on coastal areas. Their spread is associated with conditions of low fertility and consequent low production and low carrying capacity, conditions which became very common on much of the forest land which was converted to grassland. Such low fertility grassland has many open spaces in which manuka and tauhinu seeds can fall, germinate and establish. The seedlings of both are comparatively unpalatable, and are therefore not eaten and are only rarely damaged by trampling by animals; and they are soon able to grow so large that they form a canopy under which the sown grasses cannot survive. The farmer is then forced to remove his stock because of lack of feed, thus allowing the interaction to swing completely in favour of the gradual regrowth of forest. To reverse the interaction back in the farmer's favour, two processes are available. The first is to cut the manuka periodically before it develops a smothering canopy. This must be repeated while the fertility is low. The second is to raise the fertility to a stage that will enable at least a fairly dense productive pasture to be formed. Such a pasture not only reduces the opportunities for the establishment of these native plants, but also, and more important, enables stock to be crowded on to the areas. Under such conditions seedling manuka and tauhinu are both eaten and damaged in the very young stages. The present upsurge of aerial topdressing, if done with a full appreciation of ecological requirements, may well result in the most satisfactory long-term control of manuka and tauhinu that has yet been secured.

A further interaction of considerable ecological interest is frequently seen on either side of fence lines, particularly when an ungrazed road or railway verge is on one side and a close-grazed, low fertility pasture on the other. The grazed pasture tends to go to manuka, as already described; but on the other side of the fence bracken fern (*Pteridium esculentum*) is frequently dominant. The probable reason for this is that even if bracken fern is burnt, as often happens along railway lines, it revives and dominates before seedlings of manuka become established.

TUSSOCK GRASSLAND

Throuhout the tussock grassland there have been several important interactions, some of which have been deliberately guided by man, and some of which have been unintentionally guided by him despite his real wishes.

Of those which have been deliberately guided, the most striking is that in which the plough has played the most important part. Large areas of tussock grassland on the plains and rolling country of the South Island were ploughed, cropped and sown down with introduced pasture plants. Tussock grassland plants do not as a rule re-establish readily from seed in competition with introduced species and close grazing. Most of this conversion has been carried out successfully, but in some cases at least, particularly where there has been no build-up in fertility, it is very questionable whether the change has been advantageous.

An interaction of ecological interest has taken place in areas where the tussock grassland merged into rain forest often with a narrow inter-community belt of manuka. This tussock grassland was grazed and, in many cases, ploughed, cropped and sown to grass without any accompanying applied fertility. Such pastures, both the grazed tussock and the sown ones, were more open than were the unaltered tussock pastures. As a result of this opening up, manuka from the adjoining manuka belt was able to establish and compete successfully with both the altered tussock grassland and with the sown pasture. The result of this whole interaction has been a change from relatively stable tussock grassland, through unstable introduced grassland, to stable manuka scrub land. Thus the farmer's desire to replace tussock grassland with introduced grasses was completely upset by the interaction which favoured the dominance of manuka.

At the other extreme there is the interaction which has taken place in the low rainfall tussock grassland, where much of

the vegetation was destroyed by fire, sheep and rabbits. With a high population of rabbits, the only plants which could survive were those which were the least palatable to them. Of these, scabweed (*Raoulia* spp.) was the best fitted to survive, and became the dominant plant over large areas. During the last few years the rabbit population has been greatly reduced. The result has been the revival of plants that were so palatable to rabbits that they had been able to survive only at an almost insignificant level. At the same time as these have increased, so has the scabweed started to disappear. Provided that there were no side effects, it would be reasonable to assume that under light grazing by sheep, this country would very gradually be clothed with tussock again. There are, however, several significant side effects which may upset this change. One of these is the increase in sweet brier (*Rosa* spp.). This plant has been widespread in the tussock country for many years, but because it was eaten by rabbits when in the seedling stage, it increased only slowly. With the reduction in the rabbit population and only a small increase in the sheep population, sweet brier seedlings, which are comparatively unpalatable to sheep, have survived in very large numbers. The result is a striking increase in sweet brier on country that had been virtually bared by the rabbits. Unless this increase can be checked, in a comparatively few years sweet brier may create large areas of thickets impenetrable by sheep. This interaction, following the removal of rabbits, could favour an undesirable introduced plant at the expense of the more desirable native or introduced plants.

FINE TURF

Although not usually regarded as grassland, fine turf, as used for lawns and playing greens, provides some interesting interactions between native and introduced plants.

The main requirement for a bowling green, for instance, is a level surface with an even plant cover which will stand up to close and continuous mowing and a good deal of abrasion from the shoes of players. Investigations have shown that such a surface, with grass as its sole component, can be produced and maintained.

However, before suitable methods of maintenance had been found, many plants other than grasses were abundant in bowling greens. This was particularly noticeable in the southern part of the South Island, where repair and maintenance work on grass greens was very difficult because cessation of play in the autumn coincided with the cessation of grass growth. The stimulation of the grasses and the suppression of the weeds was so difficult that in many cases weeds continued to increase to an extent that they dominated the grasses. Some weeds did this so completely that they formed a satisfactory even surface under mowing and were then regarded as superior to the grasses. It is of considerable interest that of the "weeds" so favoured, most are native plants. The commonest are species of *Cotula*, *Hydrocotyle* and *Plantago*. For various reasons, under these conditions they are better able to survive and spread under close mowing than are the introduced grasses. In each of these plants the growing point is not injured by the mower because it has a prostrate growth form. In addition, *Cotula* and *Hydrocotyle* increase by means of rhizomes and stolons respectively. *Plantago triandra* increases by seeds which are conveniently set below the leaves, and are therefore well protected from the mower.

In each case the interaction between the native and introduced plants under these particular conditions favours the native plants. Nevertheless the interaction can be swung in the opposite direction by selective weed killers and suitable fertilisers.

From the foregoing examples of the interaction of native and introduced plants taken from very different scenes, it is apparent that as far as grassland is concerned the interactions must be deliberately guided; for without such guidance the final result will frequently be one that is entirely unfavourable to grassland and farming. Although much of this guidance is given through machines and animals, it cannot be carried out to the best advantage without an appreciation of the ecological significance of the various acts of guidance or misguidance that can be or are taken.