SHEEP'S FEET AND PASTURE PLANTS

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In the early days biologists viewed Southland with interest, if with some concern, but as time passed European plants and animals were found to be well suited to the environment. With the help of technical advice, man with his ingenuity and energy continues to transform tussockland, forest, and swamp. With the pastures which he has developed, a farming pattern has evolved, of high stocking rate and complete utilisation of herbage, which is conventionally accepted as being first class. Is it good enough?

In the light of plant research throughout New Zealand it appears that farmers can still improve their lot. With this in mind, my task is to communicate some of the findings obtained from pasture studies made at Grasslands Division, Palmerston North.

Treading appeared to affect pastures, and, so far as is possible, an experimental technique is evolving for the study of this influence separate from the normal concomitant actions of defoliation and excretion. As normal grazing prohibits such a study, race type plots are used, the pasture herbage is mown and removed, and a convenient number of adult Romney sheep is driven up and down a predetermined number of times. After a regrowth period the process is repeated on all plots together, the effects of severe treatments being thus heightened. The over-al! effect of the treatment is that of a special or peculiar type of mob stocking. In 1957 some treading investigations, using this technique, were reported briefly (Edmond, 1957). The work has continued and has confirmed the early conclusion "that every effort should be made to prevent unnecessary treading at all times, but particularly when the soil is wet."

To study the importance of soil water in modifying the effects of treading, well established perennial ryegrass-white clover pastures, growing in Manawatu mottled silt loam, were used in the winter of 1957 and in the summer of 1957-58. Bulk density of the surface soil (O-2 in.) ranged about 0.95 and so-called "field capacity" appeared to be 40-45 per cent. In each experiment spray irrigation was used to complete treading treatments with the soil wetted to field capacity (moist) and to saturation (wet). An efficient mole and tile drainage system under both areas prevented the soil from becoming waterlogged, but also facilitated leaching

of nutrients in the summer, which eventually modified treatment effects. The treading treatments used were 6, 9, 12, and 18 sheep equivalents per acre in winter, and 6, 9, and 18 sheep equivalents per acre in summer. Winter treatments were applied on 20 June with a regrowth harvest 60 days later, and summer treatments: on 17 February with regrowth harvest 3 I days later, retreatment and second harvest 40 days later (the data are presented in Fig. 1). In the summer study the second regrowth harvest data depict the same pattern as did the first, and are presented because their greater size made graphing easier.

In each case treading reduced vigour, and, in general, increased intensity of treading caused increased damage, while in each case saturated soil facilitated greater treading damage. The relative insensitivity of perennial ryegrass in winter 1957, where the soil at treading was at field capacity (winter dry), is of especial interest. There was a similar tendency in summer 1957-58, but with the change of season other mechanisms were no doubt operating.
spp. were reduced in heavy "wet" winter treadings and in all trodden pastures in the summer. It is noteworthy that after a week of mild weather in July-August 1957, the severely damaged plots were well covered with newly emerged *Poa* spp. seedlings. White clover appeared to be relatively insensitive to treading except in heavy wet soil treatments, where damage was severe.

In earlier work short-rotation ryegrass was found to be relatively sensitive to treading with the soil moist in the summer, whereas in the winter this sensitivity was slight. At the same time white clover was sensitive in the winter and insensitive in the summer. There was a need to investigate the effects of treading on some of our main pasture species.

Accordingly species were selected for study-perennial ryegrass, short-rotation ryegrass, cocksfoot, timothy, browntop, white clover, red clover (all certified and of the best grade available), Yorkshire fog, ***Poa*** *trivialis,* and *Poa pratensis* (Kentucky bluegrass). They were sown pure in April-May 1957 and mown and fertilised until early December 1958, when treading treatments were applied using the race technique. Each time the treatments were applied with the soil at or near field capacity. Volunteer white clover appeared progressively in every plot, but the effect of treading on the main species remained prominent.

In January 1959 (Fig. 2), after two treatments, white clover appeared to be the only plant whose regrowth was not reduced, save at the heaviest rate of treading. From the outset perennial and short-rotation ryegrasses stood out as being the grasses which were least sensitive to the experimental treadings, as did timothy. The sensitivity of short-rotation ryegrass was less than was ob-

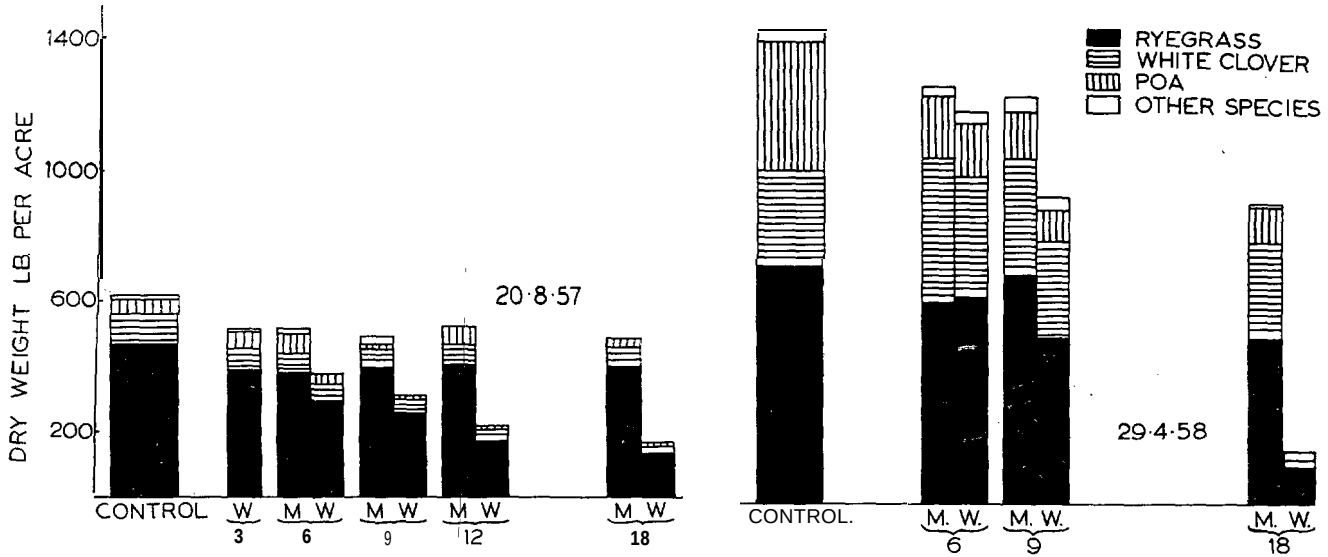

Fig. 1—Regrowth of established perennial ryegrass-white clover pastures, trodden at different rates, with the soil either moist or wet.

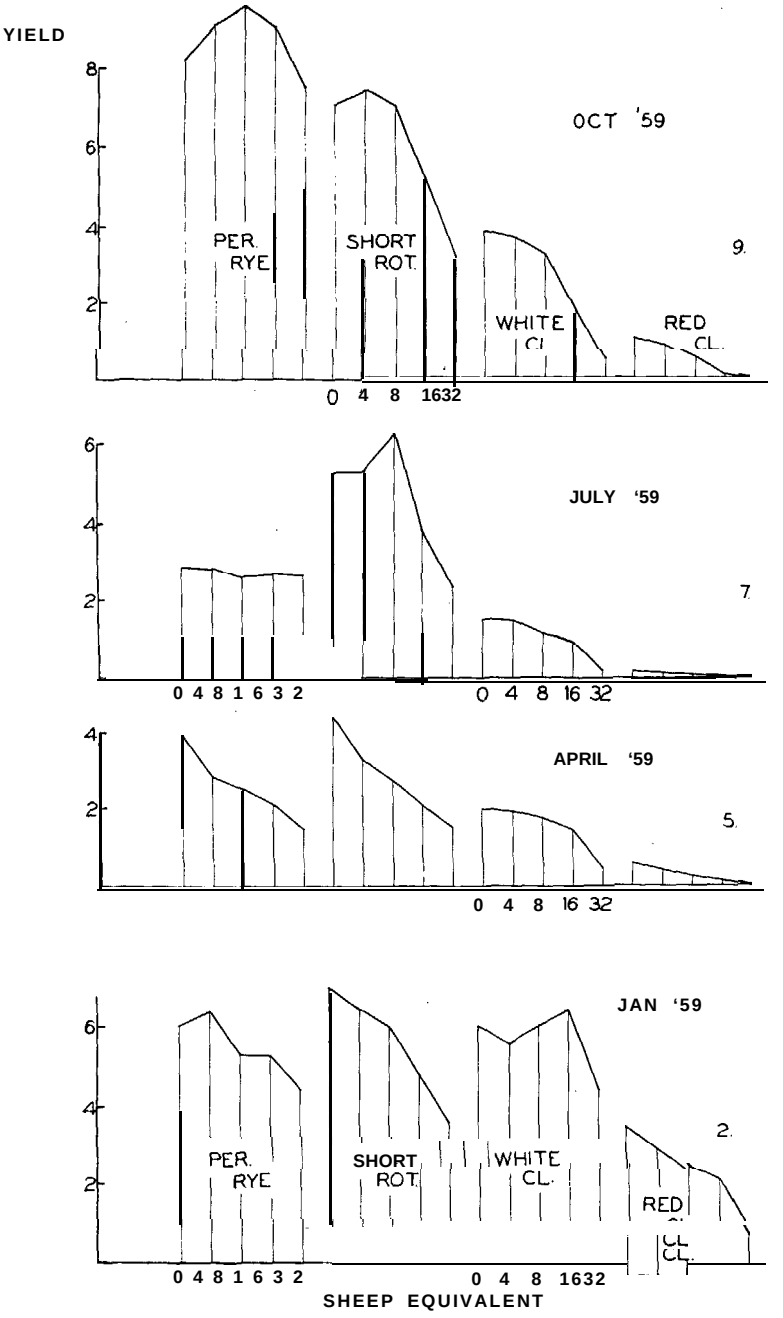

Fig. Z-Relative regrowth of some pasture species after two, five, **seven,** and **nine treading treatments, with the soil moist.**

served earlier, and there is no ready explanation for this. Red clover was hard hit, and, in the face of volunteer white clover competition, failed to develop in the heavily trodden plots.

In April 1959 after five treatments white clover remained the most insensitive species at all but the heaviest rate, but of course its growth was at a lower relative level, and the ryegrasses were still outstanding.

In July 1959 (Fig. 2), after seven treatments, perennial ryegrass demonstrated a striking tolerance of treading. The winter growing characteristic of short-rotation ryegrass was clearly evident, but its growth was reduced in the heavily trodden plots. White clover, slow growing in winter, appeared to be reduced by treading.

In October 1959, after nine treatments, perennial ryegrass was the oustanding species in the experiment. Only the severest treatment had reduced its growth, and then only by a relatively small amount. Short-rotation ryegrass had withstood treading better than most, but the effects of heavier rates were quite large. White clover was resuming active growth, but the effects of the heavier rates were similarly large.

Of the other species (Fig. 3), cocksfoot and Yorkshire fog were sensitive to heavy treading throughout the trial. Timothy was more sensitive than perennial ryegrass in July, but by October it appeared to be almost equally insensitive. Browntop was erratic in its response, but in general it was sensitive to heavy treading. *Poa trivialis,* a stoloniferous plant, appeared initially to be sensitive to treading, but subsequently its recovery growth failed to disclose great sensitivity. *Poa pratensis,* a rhizomatous plant, grew relatively slowly throughout the experiment, but it withstood heavy treading well, On occasions the only species to be seen in the most severely treated plots were the ryegrasses, white clover, timothy, and ***Poa pratensis.***

Discussion of the results could be lengthy. As the treading technique heightens the treading effects in the more severe treatments, the apparent insensitivity of perennial ryegrass in this experiment could be interpreted as suggesting that perennial ryegrass would benefit from treading in practical situations where treatments would be less frequent. In practice the high treading rates used here would seldom be reached, and so the species used were subject to a severe test. Clearly the physiological state of the plant is important, for example, short-rotation in the winter, but morphological state may well be of first importance. Mitchell (1960) explained the insensitivity to treading of certified perennial ryegrass by its propensity for growth of a rhizomatous-like nature. That rhizomatous growth form is a factor in the situation is sup-

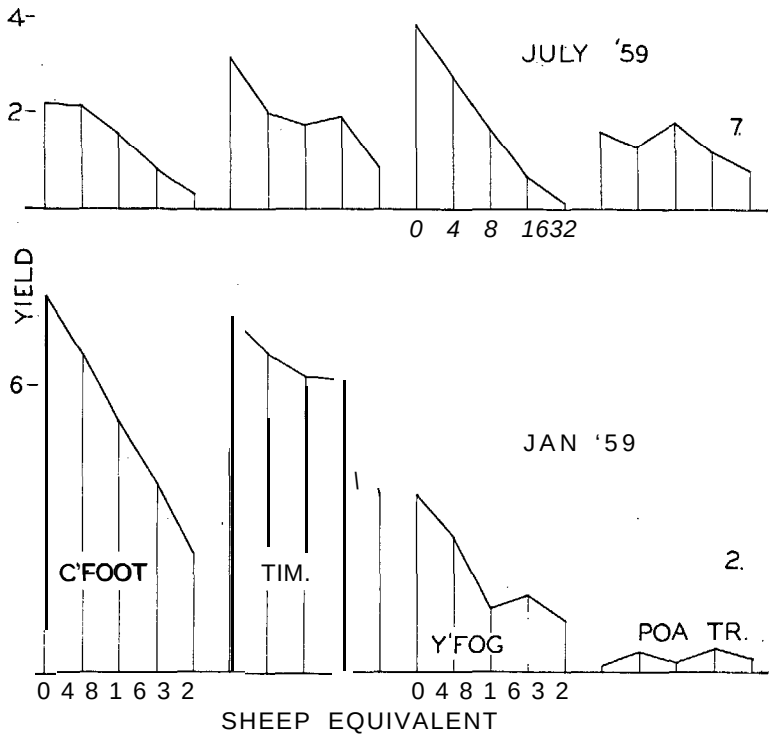

Fig. 3—Relative regrowth of other pasture species after two and seven treading treatments, with the soil moist.

ported by the persistence of *Poa pratensis,* but short-rotation ryegrass, in my experience, does not readily grow in this way, yet it persisted quite well. White clover, with its straggling, rooted runners and vigorous growth, survived well. Perhaps the success of perennial ryegrass is due in part to its physical toughness. The only ready explanation for the good performance of timothy is that the growing points are protected by a thick pad of tissue. The failure of cocksfoot may have been facilitated by the lenient pre-experiment treatment, but was probably due to damage to the growing points which appeared to be sufficiently accessible to the hoof to negate the protection of the thick basal sheaths. Yorkshire fog, which may be stoloniferous, was damaged quite severciy, whereas browntop and *Poa trivialis,* which often have a stolonifcrous form, were damaged less consistently.

From this study it may be deduced that perennial ryegrass gave the most generally satisfactory result, that white clover was vigorously persistent in the face of severe treading treatments, and that

timothy is worthy of further investigation, if only for its ability to withstand treading.

The results were modified by season. Study of the effects of treading on perennial and short-rotation ryegrass pastures in different seasons has been in progress since the spring of 1959. A rate of 10 sheep equivalents per acre has been used with the soil at differing levels of wetness appropriate to the season. Regrowth has been measured by a method similar to that of Brougham (1956), and a typical set of data produced Fig. 4. It is noteworthy that the recovery growth in trodden plots has been consistently delayed in the summer, autumn, and winter, but in the spring the results are inconclusive. Treading has reduced growth less in this experiment than in previous studies. Possibly the reason for this is that this latest work is being done on Manawatu silt loam, underlain with sand, which never becomes saturated with

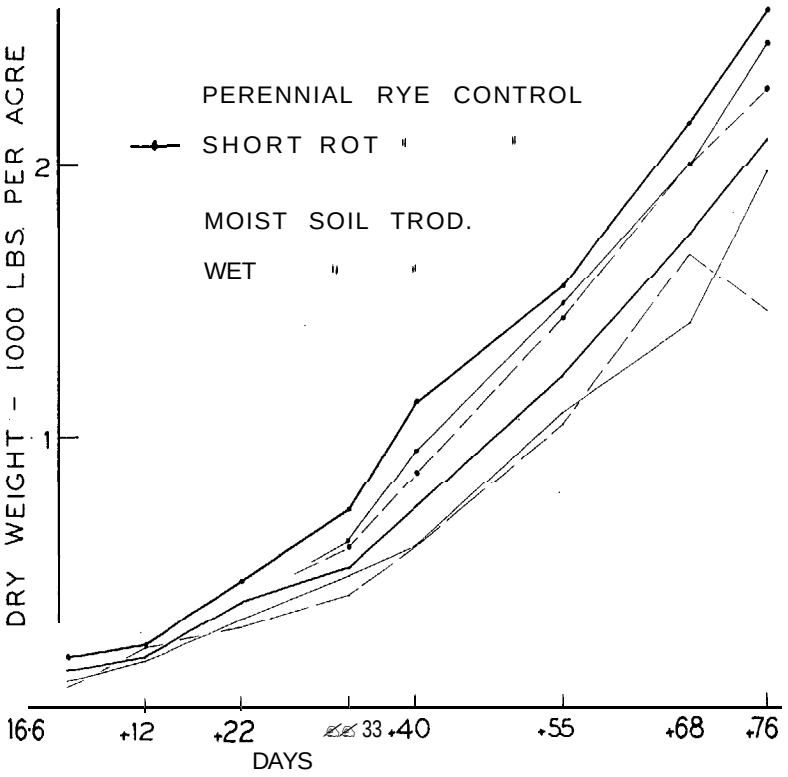

Fig. 4—Winter regrowth of ryegrass pastures, trodden with 10 sheep equivalent per acre, with the soil either moist or wet.

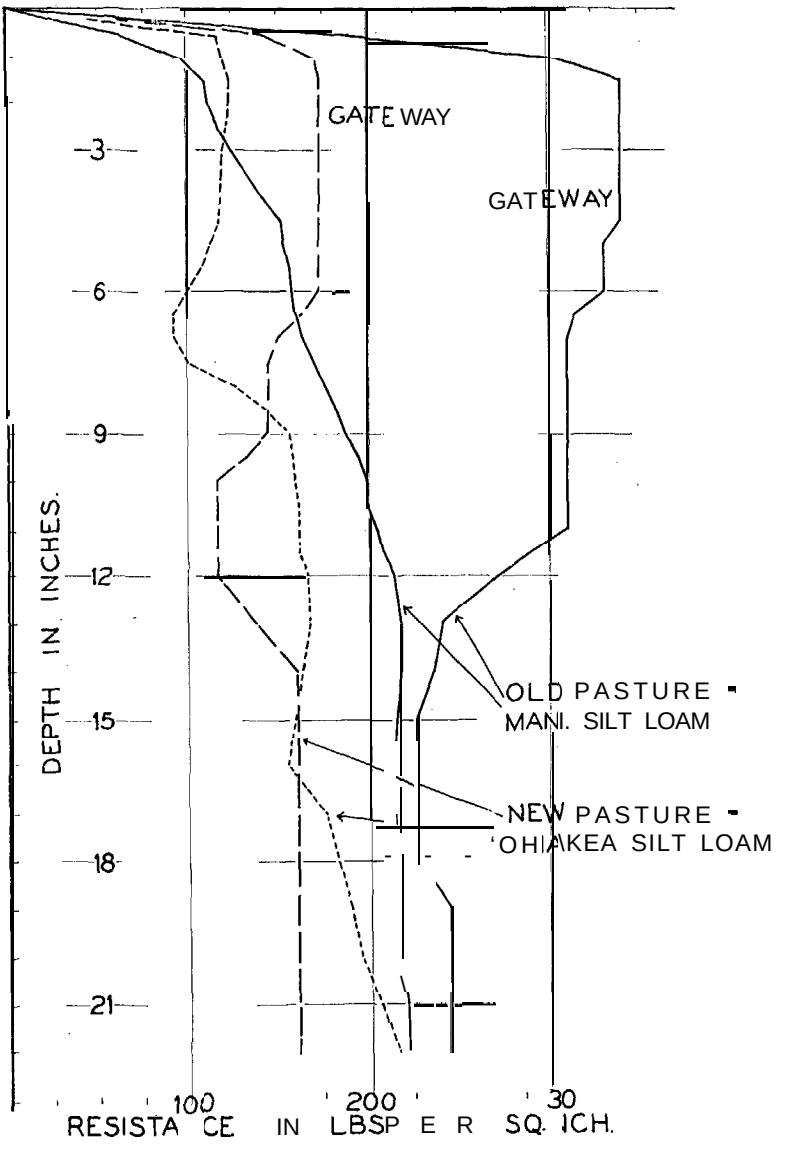

Fig. S-The resistance encountered down some soil profiles by the probe of a penetrometer.

water, whereas the earlier work used a Manawatu mottled silt loam, which can be saturated.

Soil is a most important consideration in treading investigations. Gradwell (1960) reported changes in soil porosity which point to the ease with which a pasture can be endangered. One heavy treading with the soil wet causes an impressive change in porosity, which may be significant to plant growth. Although in nature soil structure tends to be restored, continued heavy treading militates against this. Using a self-recording penetrometer designed by Mathieu (1958), in Canada, profile pictures of soil resistance to probe penetration were obtained on two pastures at Palmerston North (Fig. 5). Recordings were taken in the gateway and in the main area of each of an old established perennial ryegrass-white clover pasture growing in a Manawatu mottled silt loam and a new establishing perennial ryegrass-white clover pasture growing in an Ohakea silt loam. Hoof action *at* the gateways had hardened the surface layers of soil, apparently by increasing their bulk densities. Growth still persisted in the gateway of the new pasture but had failed in the gateway of the old pasture.

From the foregoing, tentative conclusions are that the main pasture species used in New Zealand arc also the least sensitive to treading damage, that soil moisture and soil type can influence the treading effect markedly, and that the effect can vary with season.

There is an opinion that the treading studies lack point until the set stock versus mob stock comparison is approached directly. It is true that the treading action cannot be divorced from defoliation and excretion, save in experiments, but you are aware that the results obtained so far provoke much thought. Some farmers have for the first time considered the action of animals' feet as a separate and controllable factor. The difference in sensitivity to treading between perennial ryegrass and Yorkshire fog has been used to advantage by some farmers. Hoof action is important throughout the year, even in dry summer. Eventually our pasture management systems may be altered on account of treading alone.

Experimental work has been confined to one highly fertile soil and to highly productive, weed free ryegrass-clover pastures. Treading has always reduced pasture vigour immediately, and it is difficult to imagine the opposite situation. But pastures can deteriorate if the hoof is absent (Sears, 1953). McKenzie (1960) expressed the opinion that in south Taranaki the beneficial effects of treading usually outweigh the harmful effects, the long-term reduction of weed grasses permitting better growth of ryegrasses and clovers. This agrees with Levy (1926), who urged farmers with poor pastures to crowd on the hooves to secure a shower of

dung and urine, and to crush out secondary growth. It seems that the idea of hoof cultivation means more than just pushing ryegrass plants into the soil. There may be a compromise situation between no treading and heavy treading, where a pasture is lightly damaged yet maintained in good order. In the absence of adequate animal behaviour information, the only suggestion can be that harmful idle walking should be avoided. In the winter, spreading animals all over the farm may be sensible in Taranaki, but it may be wrong in Southland or Manawatu. Each case should be considered on its own and no one answer may be generally given. On the heaviest stocked farms treading is a definite problem.

In the future, increased knowledge of the soil processes involved may make it possible to ameliorate the soil and to restrict or overcome some of the effects which treading produces in it. Our pasture species may need to be selected and bred for insensitivity to treading, a matter already in hand at Grasslands Division. Controlled grazing systems might be used more carefully and extensively. Feeding barns and yards might be used at critical periods, as alternatives to the sometimes successful sacrifice paddock system as used by Sears. But zero grazing, using normal pastures as a source of herbage, seems destined to be dogged with problems.

To conclude, the investigations have proved beyond reasonable doubt that the effects of animal treading must be carefully considered wherever animals graze pasture.

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DISCUSSION

Q. (Dr Corkill): Have you been able to identify some morphological characteristics by which plants can be selected for their ability to withstand treading?

A. No.

Q. (W. Jacques): Have you made detailed studies of the direct damage which treading causes in plants?

A. No.

Q. (Dr O'Connor): I do not want farmers to think of zero grazing but of normal well managed grazing. Are the effects of this as great as the compaction caused by the wheels of machines?

A. In California under lettuce it has been found that wheels produce a soil pan which impedes growth. I've had a similar pan developed under grazing.

Q. Does the practice of iiming affect treading damage?

A. An indirect answer might be best. In general, liming can lead to improved fertility, to better soil structure and to greater grass growth. This builds up the humus content of the soil, which can increase its capacity for holding water. It may be that the farmer will be embarassed by the moistness of his pasture soil when he goes to introduce the extra animals, to eat the extra grass. There is no generally applicable answer.

Comment (Mr R. Scott): At Invermay, trials investigating the effects of drainage have grazing treatments included. Some plots are ungrazed throughout the winter while on others the growth occurring between April and June is grazed off in June-July, as might occur in farm practice in Otago. No adverse effects have followed winter grazing although it is possible that any adverse effects of treading may have been compensated for by earlier returns of dung and urine.

A. I accept the fact that different results will obtain in different situations. The purpose of this paper is to point out the need for thought about treading-effects wherever grazing is practised.

Q. What is the effect of treading during a frost?

A. Mr McArthur, N.Z. Dairy Board, has suggested that, during periods of heavy frost, dairy farmers in the centre of the North Island might best be advised to hold their cows after the morning milking until the thaw has begun.

Q. (W. Jacques): Mr Edmond has dealt with soils that are moist. If hc was to study the damage done to the pasture in dry weather another story would be obtained.

A. Yes. The damage in the summer could show an effect in the autumn. The reduction in production could be 15-20 per cent. The composition of the pasture would be changed too.

Comment (Dr Sears): Consolidation would be of benefit to the properties of the soil.