PASTURE DEVELOPMENT ON UNPLOUGHABLE LAND

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In this paper it is not the hill-country on which cultivating implements can be used that we are concerned with; it is all that steeper country which has been regarded variously as "marginal" or "deteriorated land," and which also is the really difficult country to manage and keep in a productive state.

This class of -country may be coastal or well inland, and it may, be in. any of the diverse climatic zones of the North. Island or many-parts of the South Island.

Features common to all the classes of hill-country being considered now are deterioration of the pastures and. reduced carrying capacity. The prime factors which have caused this deterioration are :-

1. A natural reduction in the fertility of the soil since the land was cleared of bush.

2. Weakening of the pastures through the sowing of grasses and clovers unsuited. to the natural conditions.

3. Overstocking either to get enough revenue to meet commitments or to control second growth.

4. Establishment and spread of second growth, fern, manuka, and weeds.

5. The felling and burning of second growth and not sowing suitable seeds after the fire.

6. Soil erosion, both incipient "sheet" erosion and "slips" or "earth-flow" erosion.

Observations on hill-country throughout New Zealand reveal that a fairly bad state of affairs exists in so far as pastures are concerned, and it is also apparent that little of the fault can be attributed directly to the early settlers or their successors. In almost every instance when the land was first settled the farmer was of the opinion that bush or forest country was reasonably or highly fertile. The degree of fertility was frequently gauged by the types of trees growing on the area. A good deal of this 'kind of assessment was sound, but not infrequently some

factors other than soil fertility were responsible for the various forest types; thus the pioneers were sometimes sadly misled.

Invariably the farmer was given additional confidence in the potentialities of his selected block by the statements made about it, its unimproved valuation, and the price he was required to pay.

It is easy to see, then, why in nearly every instance the farmer' sowed seed mixtures composed mainly of high-producing species such as ryegrass, cocksfoot, timothy, crested dogstail, meadow foxtail, red clover, white clover, and alsike.

Some mixtures did not contain all these species, while others had still more added to them. For instance English trefoil, prairie, grass, *Poa trivialis, Poa pratensis,* *meadow fescue, yarrow, and red top were often used also, either because the farmer himself wished it or because the seed merchant felt he should make up a complex mixture and hope that at least some of the grasses and clovers would grow. Some farmers included a sprinkling of turnip seeds in the mixtures, and if these produced good crops, as they often did on new bush burns, then it was possible to feed large numbers of sheep. The turnips were mature enough for feeding off while the grass was still young, and although tramping and consolidation were supposed to be beneficial to young grass, the excessive tramping in the immediate vicinity of the turnip was destructive to seedling grass plants. The resulting bare ground provided the seed-bed for weeds such as thistles and fireweed.

At the time of these early sowings the requirements of our many pasture plants were not understood as they are to-day. Little was known of the fertility standard required to maintain high-producing species; the moisture requirements of different grasses and clovers were not fully considered and the knowledge regarding management and performance of each species waslimited. Also little thought was given to the compatability of species.

In deciding on the seed mixture the farmer was influenced by supplies of seed available, 'by publicity, and to no less an extent by costs. It will be realised from these -remarks that the whole of the grassing. of cleared bush land in the early days was-done with good intentions but with insufficient knowledge. This state of' affairs continued until the second and third decades of this century, but to a less extent as time went on.

Modifications in seed. mixtures recommended from time to time point clearly to .the fact that people were becoming more enlightened regarding the performance of different species under various soil and climatic conditions. Some of the high-fertility demanding grass and clover seeds in the mixtures were replaced wholly, or in part, by seeds of danthonia, ***Lotus*** *major*, ***Lotus hispidus,*** chewings fescue, browntop, and lovegrass, but always ryegrass, cocksfoot,. and white clover formed the bulk. Paspalum, ratstail, and Yorkshire fog. were used to a limited extent in some seed mixtures.

In this more enlightened age and reflecting back on seeds mixtures sown until about twenty odd years ago, it is quite apparent that poor types of ryegrass, cocksfoot, and clover were used extensively,, and this no doubt was because of their cheapness. This is another reason why the so-called best grasses, or English grasses as they are sometimes called, failed to persist; they were just not perennial by nature, as has been proved in recent years by testing various strains of grasses and clovers.

It might be'wondered then why the lower fertility demanding grasses which were included in some mixtures did not replace the so-called better species when these failed. The answer seems fairly simple. For a short time after the initial bush burn the surface soil -was' highly fertile.' During this period ryegrass and cocksfoot made rapid growth and practically smothered the slower-growing pasture plants, so that few of these existed in the sward by the time the ryegrass weakened.

At this stage it must be pointed out that there is really only one time to sow seed on unploughable hill-country. That time is immediately after a fire.. No opportunity must be lost after a bush burn or scrub burn-to get the most suitable grasses and clovers established. It is most unfortunate that some farmers have foolishly sown cheap bush-burn mixtures and have thus lost rare 'opportunities of developing good pastures. What they have done,' however, is to introduce a variety of useless grasses and undesirable weeds through using. this so-called "cheap seed." We know the state of' so much of our hill-country and we, know many of. the reasons why. the pastures are not as good as they should be.

Our problem, therefore. is to find 'out now how we can raise. the quantity and. quality of the pasturage.

Topdressing with phosphate can improve pas-

tures, but not until responsive species are present in the sward. It is regrettable **that** so much faith is pinned to phosphate topdressing- without a full realisation of just what part this fertiliser plays in pasture improvement. We have seen pastures composed almost wholly of chewings fescue, or danthonia, or perhaps browntop, and containing little or no clover. Without clovers the phosphate can play only a small part in pasture improvement. This fact has been amply demonstrated in some intensive plot trials at the Grasslands Division, 'where the respective dry matter yields per annum were as follows:

Period: May, 1947-May, 1948	Per Acre
Grass only + superphosphate + lime . .	1,586lb
Grass + clover + superphosphate + lime	10,927lb

The striking increase in **the** second case 'is entirely due to the presence of adequate clover in the sward.

It may seem superfluous'at a conference such as this to explain just how phosphate, clovers, and grasses all work together, but the necessity of so frequently telling this story makes us feel that to tell it again here may serve some purpose.. The principle is this ; phosphate feeds and stimulates clovers and these produce in their root nodules the nitrogen which is so essential for grass. growth. Also, through the extra clover growth there *is* more feed, feed rich in protein which, when passed through the animal, adds nitrogen to the soil to further help the grasses.

With the benefits which can be derived from the use of phosphate we must expect substantial increases in the areas to be topdressed. For this reason and because phosphate cannot give an economic response when used on pastures which are more or less devoid of clover, the Grasslands Division has set out to learn as much as possible about ways and means'of introducing suitable clovers into the hill-country pastures.

To get a fairly wide variety of conditions areas were selected in the Taumarunui and King Country districts, in Whangamomona and inland Taranaki, in Southern Hawke's Bay, Wairarapa, and East Coast. Three or four farms in each of the above districts were. selected and sowings were made on six one-acre plots, three at monthly intervals in autumn and three more in the following spring; A mixture- of grasses and clovers was sown in almost all 'cases, the grasses -perennial ryegrass; -short-rotation ryegrass, and

crested dogstail-being regarded as better utilisers of any increased fertility brought about by the clovers and the phosphate topdressing.

All oversown plots were topdressed with superphosphate at a minimum rate of 2½ cwt. per acre during the autumn when seed was sown. The adjacent areas which were to be sown in the following spring received fertiliser at the time the autumn-sown plots were topdressed. Some of the selected areas had been topdressed with superphosphate the previous year by the farmer, but unfortunately it was not always possible to choose small paddocks for these trials. Thus, in some instances, our six one-acre plots are in large paddocks typical of much hill country and, of course, it has been quite impossible to stock them in the best way to give young seedlings good conditions for establishment; However, despite these shortcomings it was felt that much could be learned on a field scale of what the farmer himself might have to contend with.

The soils were of quite different types and the climates in the respective districts ranged from fairly dry with poor distribution of rain to those having a moderately heavy and well-distributed rainfall.

To suit such diverse conditions the following clovers were included in the seeds mixture :—

Pedigree white clover at	1lb per acre
Pedigree Montgomery red clover at	2lb „ „
Pedigree broad red clover at	2lb „ „
Mt. Barker subterranean clover at	1lb „ „
Tallarook subterranean clover at	1lb „ „
Lotus major containing some *Lotus hispidus*	1lb „ „
*Strawberry clover at	1lb „ „

*The ordinary commercial strain was used in all trials. A variety which. apparently withstands dry conditions on. the hills has been observed and is being propagated with a view to future use in hill-country sowings.

At intervals subsequent to the sowings counts have been made of the number of established clover plants, but not in all places could the sown clovers- be considered. For instance, in the Whangamomona and Taranaki areas' *Lotus' major* was strongly and fairly thickly established for some years.' In some places in the Wairarapa and Southern Hawke's Bay there was a. sprinkling of subterranean clover over

the plot ***area.*** Invariably ***these cldvers*** had' spread from other parts of the 'farm, although in some instances they may have been sown on the selected plot site in earlier years. White clover was also established on the moister or richer parts of some paddocks and therefore accurate establishment counts could not be made in those instances.

TABLE I

SEEDS SOWN PER SQUARE FOOT OF AREA

Species	Seeds per lb	Rate Sown	Seeds per sq. ft.
Pedigree white clover . .	670,000	1lb per acre	15.4
Montgomery red clover	240,000	2lb „ „	11.0
Broad red clover	240,000	2lb „ „	11.0
Mt. Barker subterranean clover	60,000	1lb „ „	2.75
Tallabrook subterranean clover	60,000	1lb „ „	2.75
Lotus major	900,000	1lb „ „	20.6
Strawberry clover	250,000	1lb „ „	5.7
TOTALS	2,420,000	9lb „ „	66.45

TABLE' II

COUNT OF PLANTS ESTABLISHED PER SQUARE FOOT OF AREA.

District	Month Sown	SUNNY FACE White Clover	SUNNY FACE Red Clover	SUNNY FACE Sub. Clover	SHADY FACE White Clover	SHADY FACE Red Clover	SHADY FACE Sub. Clover
Taranaki		.5	.5	.1	.5	.3	0.0
Taumarunui	March	.4	.6	.6	.2	.3	0.0
Wairarapa		3.9	2.5	2.3	--	—	
East Coast		.1	.1	.1			
Taranaki		.6	.6		.9	.5	0.0
Taumarunui	April	.6	.3	.1	.4	.4	-0.0
Wairarapa		2.9	.7	2.0			
East Coast		0.0	0.0	0.0	—	—	—
Taranaki		.6	.5	0.0	.4	.3	0.0
Taumarunui	May	.3	.3	0.0	.1	.2	0.0
Wairarapa		5.0	2.0	.7	—	—	—
East Coast		0.0	.1	0.0	—		
Taranaki		.5	5	.1	.1	.3	0.0
Taumarunui	August	.5	.1	0.0	.6	.6	0.0
Wairarapa		2.1	.2	0.0	—	—	—
East coast		0.0	0.0	0.0	—	—	—
Taranaki		.6	.3	.1	.6	2	.1
Taumarunui	Sept.	.4	0.0	0.0	.2	.6	.1
Wairarapa		.8	.5	.3			
East Coast		0.0	3.0	0.0	—	—	—
Taranaki		.6	.2	.3	.6	.4	0 . 0
Taumarunui	Oct.	.9	.1	0.0	.8	.1	0.0
Wairarapa		.7	.2	.2	—	—	—
East Coast		0.0	0.0	0.0	—	—	—

Average of all plots for each month in each. area. Counts were confined to the above three species in all eases, The remaining species sown either failed. to establish or were already present to such an extent in the sward as to render a count impossibie.

Summarising the main points brought out in Table 2, the following are worthy of note:—

1. In all cases establishment compared with number of seeds sown is extremely poor.

2. Autumn sowing gives a better overall establishment than spring sowing, and early autumn is better than late autumn.

3. Season (i.e., rainfall, temperature, drought, etc.) plays a big part. In the case of the Wairarapa plots no rain fell from the time the March sowings were made until after the April sowings were completed.

4. Open swards in autumn in the drier eastern districts gave a better strike than the denser swards in the damper western districts.

5. Strike on shady faces was better than that on sunny faces where measurement of both on similar areas was possible. Counts were rendered difficult in almost all cases since some white clover, subterranean clover, or *Lotus major* plants (according to climate and locality) were already present, and distinguishing between these and plants from the sowings was not always possible. In cases of doubt the plant in question, was not counted, so that the figures given are definitely conservative.

6. In only two cases -(one in Wairarapa and one in Taranaki) was strawberry clover seen to have established and then only very sparsely.

There is yet much to be learnt about surface conditions of the soil as well as density of the pasture. Over the areas covered by the trials the soils varied from heavy clay overlying "papa," through. various intergrades, to the light soils of the pumice type.

In all cases the sown areas were subjected to normal farm management and grazing.: (What is now required are further experiments where grazing can be controlled, especially during the first few weeks after the seed is sown. During the following spring and summer period it may be imperative to remove all stock so that the newly introduced species can flower and set seed. Preferential grazing of' such species as white, red, and subterranean clovers has' been repeatedly observed on these trials, and the effect.

is accentuated where the topdressed trial area is surrounded by the untopdressed pasture of a large paddock.

Closing up to allow seeding is a recognised practice on first-year subterranean clover areas, and the spread of *Lotus* **major** has almost certainly resulted from the spread of seed consumed by stock with roughage on one part of the farm and deposited in the dung on other paddocks.

The type of pasture cover and the length and density of the sward at time of oversowing have a definite effect on the success of establishment of oversown clovers. Generally speaking, the most favourable conditions would appear to exist when the cover is fairly long, but not too dense. In these circumstances there is sufficient cover to prevent birds from obtaining easy access to seed, and the moderate density allows penetration of the seed to the. soil surface. In dense cover the seed often remains in the vegetation and does not reach the soil. Particularly, on the steeper slopes is a mqderate cover necessary. In these places large heavy seeds such as subterranean clover tend to roll down a bare or sparsely covered face and accumulate on the easier slope at the base, giving a good strike there but leaving the steeper parts almost bare of sown seed.

Grass seeds from their' light weight and bulk appear to have difficulty in reaching the ground surface and, if they do so, in becoming sufficiently covered. Cases were observed of germinating seeds being lifted $\frac{1}{2}$ inch above the ground by the developing root. The effect of hot drying winds on such exposed seedlings can readily be imagined.

In one locality at least strikingly better, results occurred on the bare faces of old slips 'as compared with the establishment in existing pasture on the same plot.

Some danthonia-dominant swards are dense, especially under regular close grazing, whereas others under lax grazing tend to remain more or less open. Clover establishment on these two types of swards requires further study. In no cases has it been possible to use big mobs of sheep to tramp the seed into the soil. On dense turfs sheep hoofs may not cut into the sward sufficiently to bury the seed, but on open and closely. grazed pastures tramping may have more successful results. From experience on.. a small scale in the Poverty Bay district it would seem that

soil. conditions again play a big part in determining success or failure, and .it is unusual, except following a drought, to have pasture and soil conditions in early autumn really ideal for the. tramping in of -seed by stock.

It was mentioned earlier that chewings fescue was included in some seed mixtures and where the soil was dry and poor this grass has become dominant. It has. formed a dense sod-bound sward of very low carrying capacity which wiil. be very hard to improve because of the difficulty .in getting clovers established under such. conditions. One such area has, been oversown and topdressed,. but to date the results have been discouraging.

Just as chewings fescue presents problems when it becomes sod-bound, so does browntop. However, as this latter grass usually grows. on somewhat moister and slightly more fertile soils, there is distinct hope of some improvement by oversowing. and topdressing. Lovegrass, which is spreading appreciably in some districts and has formed a dense turf which stock will' scarcely. ever eat, presents a problem rather. similar to the chewings fescue one already mentioned.

To establish clovers in some of these difficult situations it may be necessary to resort to grass fires in late autumn to remove surplus vegetation and to provide an ash cover for the seeds. Naturally before resorting to such drastic measures it will be necessary to carry out proper trials, but there is direct evidence that grass fires can provide good seed-beds.

While it is recognised that all endeavours possible must be made to establish the highproducing clovers; this will be expensive, slow, and difficult unless it is on country where topdressing with superphosphate can -be undertaken fairly regularly. There, will be a time lag in any case, because no doubt much country is still far from fertile enough for our good clovers, even. after. it has been topdressed several times.

Our observations throughout the. hill-country reveal that there are valuable clovers which can produce relatively well on quite poor country. For instance, *Lotus major* grows exceedingly well on untopdressed and somewhat poor country in -Northland and Auckland 'Provinces, in the King Country and .Taranaki, in parts of the East Coast, and in the whole of the Westland district -of the South. Island. Likewise,

Lotus hispidus, an annual, grows well on poorer and drier soils in several of the warmer regions.

Other clovers which could serve a useful purpose and which have been observed growing well when enabled to do so under light stocking are suckling,- clustered. and striated clovers *(Trifolium dubium, Trifolium glomeratum,* and *Trifolium striatum* respectively) . Because these clovers are sparingly established, they are severely grazed. and have little chance to assert themselves in country which is suitable for their, growth. It is our opinion that if considerably more of these plants could be established in our hill-country there would be a relatively better pasture, especially where the carrying capacity is too low to justify the expense of topdressing at present. Also consideration must be given to pasture improvement on those vast tracts of land which are not likely to be topdressed until many hundreds of thousands of tons more superphosphate are available.

From the ecologist's point of view we regard the situation along these lines:-Where for various reasons a good high-producing clover cannot be grown we should accept and encourage the lower-producing types which nature has endowed with the ability to persist and grow on poorer, harder, and drier soils. For this reason in some of the small plots in the East. Coast district we tried clustered clover, haresfoot trefoil *(Trif olium arvense),* and striated clover. Over the first few months the annual clovers rose to 20 per cent. of the pasture cover on the sown plot compared with 9 to 10 per cent. only in the general pasture of the area. During subsequent seasons, however, the sown plots rapidly lost their higher proportion of annuals and approximated to the figure for unsown areas. It is presumed. that the stock management-was a major factor in preventing any spectacular re-establishment and growth. Had it been possible to spell the sown areas, there is no reason to suspect **that** these clovers would not have grown well and reseeded, because they are already sparingly established on the paddocks or in the immediate vicinity of them.

We attribute considerable losses of both sown seed and seedlings to the depredations of birds, and one way of overcoming losses to some extent at least may be by pelleting of seed with both fertiliser- and a bird-. repellant.

Observations on this much more difficult country

have been interesting in that very useful clovers have been seen growing in odd corners and places difficult for stock to reach.

What we want is a series of small substations,—mere paddocks would serve in some, cases,—so that we can sow,, stock, and manure these as needed. We must continue our trials until we solve the problems of :

1. 'What clovers to use in each of the main pastoral and climatic regions ;
2. Now and when to introduce the selected clovers for those habitats;
3. What degree of spelling is necessary and at 'which seasons to enable the plants to establish and also to set seed ;
4. To ascertain the area within each farm or' paddock which it is necessary to seed and fence off so that grazing can be controlled.. Seed produced on such areas would be consumed as roughage' by stock. in late 'summer or 'autumn, and this seed would be distributed in the dung on various parts of the paddock 'or farm. In almost any pat of dung on hill country which has produced clover seed. there will be numerous clover seedlings.

This natural method of seed dispersal has the added advantage of supplying 'the' seedlings with ample natural fertiliser in the early stages of growth, an important factor on country of low fertility where a good start may make all the difference between successful establishment or early death. In addition, observations indicate that the nitrogen provided by the dung has a very beneficial effect on clover growth in the early stages before the root, nodules become established, and this effect has been confirmed in trials in several 'areas where. nitrogenous fertilisers have been applied. In one case which has been observed subterranean clover is now firmly established along. a ridge top in a paddock where the species has not been sown. Enquiry revealed that cattle brought in from an. outside area had carried the seed and deposited it- in dung on the camp. areas of the ridge. Many plants could be found established in pats of disintegrating, dung, and all were healthy and well established, looking much better than plants in a plot sown later on the same paddock which received no fertiliser except a dressing of superphosphate applied several months after sowing the seed.

As will be apparent from another paper presented

at this conference, the soil acidity factor, provided the range is not extreme, does not play a very big part in clover establishment, and success or failure of a sowing cannot fairly be attributed to this factor. For instance, soils in the Poverty Bay area, which vary from light to heavy, range from acid to near neutral, and some soils derived from bentonitic papa may even be decidedly alkaline. Rainfall in the district varies from 45 inches, badly distributed over the year, to 140 inches, well distributed.

At this stage it is appropriate to mention some of the problems which are already apparent in hill country in various districts. For instance, with the up-build of fertility through topdressing there has been an increase in sheep numbers. This has resu'lted in greater numbers congregating on stock camps, thus raising the fertility of the soil in these places. Following this there have been some remarkable but quite disconcerting changes in the pastures on these camps. Whereas they were once dominantly say danthonia or browntop, we now find a totally different sward. In some cases they become perhaps ryegrass dominant and too fouled for stock to graze. Where conditions have been favourable to it subterranean clover has dominated all other species and has formed an excellent cover until it died out in summer. Then one of three things. would happen: (a) wind and water erosion would remove the rich topsoil and seed, leaving the area bare or almost so in the following season; (b) subterranean clover would re-establish, or (c) plants such as Scotch, winged, or variegated thistle would establish and smother the clover. In the event of this last result stock are forced to seek new sites and start the above process on fresh areas.

Other troublesome features of raising the fertility of the soil too high on camps are the invasion of these by annual weeds such as barley grass. and storksbill, both of which produce seeds that are harmful to sheep and detrimental to wool values.

Actually there are likely to be several problems and repercussions arising from topdressing and raising the carrying capacity of our unploughable hills, and all these inter-related factors must be considered and investigated in the general scheme of future research.

If the disappointing results of trials to date have shown nothing else, they have amply demonstrated

that simple surface sowing without regard to the factors of season, species sown, pasture management, and stocking is both expensive and wastful of valuable. seed. It may be that the problem, though simple enough at ‘first thought, is actually far from as easy as it appears, and that we will have to take into account many unanticipated facets and plan our seed mixtures and management accordingly.