IMPROVEMENT OF HILL COUNTRY PASTURES IN THE WELLINGTON PROVINCE

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INTRODUCTION

Of the 5¼ million acres of total occupied land in the Wellington district nearly 4 million acres are in sown pasture, the remainder being bush, natural tussock grassland, scrub and secondary growth. Of this sown area a large proportion comprises hill-country farms running sheep and beef cattle and carrying an average of 1 to 2 sheep per acre. From the sheep-farming point of view the Wellington district is of major national importance, contributing nearly 22 per cent. of the total sheep population and almost 19 per cent. of the total beef cattle. The region as a whole carries the heaviest concentration of stock of all New Zealand.

Most of the land was originally covered in bush, which has been felled and burnt over the last century. On the ash following the bush burn rape, turnip, grass, and clover seeds were sown with considerable success due to the inherent fertility of the soil' and to the liberal quantity of ash from the bush burns which acted as an ideal seed-bed. After the initial flush, deterioration set in, largely brought about by the decline in fertility resulting from erosion on the steeper areas, by the rapidly diminishing supply of phosphates in the already phosphate-deficient soil, and from the drain of minerals taken up in the growth of mature animals prior to their subsequent dispersal to the lowlands.

The sown grasses and clovers diminished with the fertility decline and because of the general practice of close sheep and cattle grazing found necessary to keep. bracken and secondary growth in check. Generally speaking deterioration is still continuing and in some areas fern and scrub encroachment is a serious problem. On most of this hill country it is impossible to plough to control fern growth, to bring fresh soil

to the surface and re-seed with -pasture mixtures. Large areas of hill country pastures have reached the stage where some method of improvement is necessary if production is to be maintained and increased.

In discussing the possibilities for hill-country pasture improvement this paper will draw largely on observations and experimental data obtained at Te Awa research station with occasional references to other trial areas. Investigations have been undertaken at Te Awa, Mangaweka, and in the lower Dannevirke district over the past four years and it is the data from these investigations which are discussed.

However, these areas are fairly typical of much of the hill-country in the province from a pasture and rainfall point of view, so that most of the information available from these research areas is undoubtedly applicable over a very wide region.

HISTORY OF LAND USED

In the Te Awa area the bush, comprising heavy stands of totara, rata, rimu, maire, hinau, etc., was felled in the 1880's and on the ash following the bush burn crop and pasture seed mixtures were sown. Pasture seed mixtures varied considerably, but generally speaking contained some ryegrass, dogstail, cocksfoot, timothy, browntop, red clover, white clover, and sometimes chewings fescue. Following in the footsteps of the Banks Peninsula farmers the early stands of grass were in some cases harvested for seed. In the case of the Te Awa research area, comprising 180 acres of relatively steep hill country, seed of cocksfoot, dogstail and chewings fescue was harvested for several years after the initial bush burn sowings.

In the early days of seed harvesting on the hills good yields were achieved due to the natural fertility of the forest. litter which had -accumulated on the forest floor over the centuries. Cocksfoot stands were estimated to be 3 to 4 feet high at harvest, when gangs of men harvested the seed. Some local farmers refrained from harvesting seed, contending that seed production on the hills would have a detrimental effect on the pasture ; however, those who harvested seed were soon able to freehold their properties, whereas those who did not were in financial difficulties for some years.

Under the lax management system. operating in those days few stock were carried and after the initial flush land began to revert to secondary growth—

bracken and scrub. In order to control -this secondary growth it was necessary to graze heavily with cattle and sheep to crush it out. From that time it has been necessary to close graze- and fully utilise the available pasture. The pastures have, however, gradually deteriorated and carrying capacity has diminished. Species such as cocksfoot under hard, close grazing have gradually been eaten out. Inferior strains of ryegrass and clovers have also faded out, leaving a poor, weedy, clover-deficient pasture.

The inherent fertility of much of our hill-country has rapidly diminished, partly due to the drain of minerals through 60 years of grazing without topdressing, and also to severe losses in topsoil resulting from surface erosion. In this latter respect the hill-country is losing more topsoil than the lowlands; similarly it is losing the valuable animal manure which on steep country IS washed off the hills and carried away in streams and rivers. The turf on the hills is now in itself insufficiently strong and dense to prevent soil loss by run-off and it is imperative that we improve our hill-country pastures from a production. as well as a soil conservation point of view.

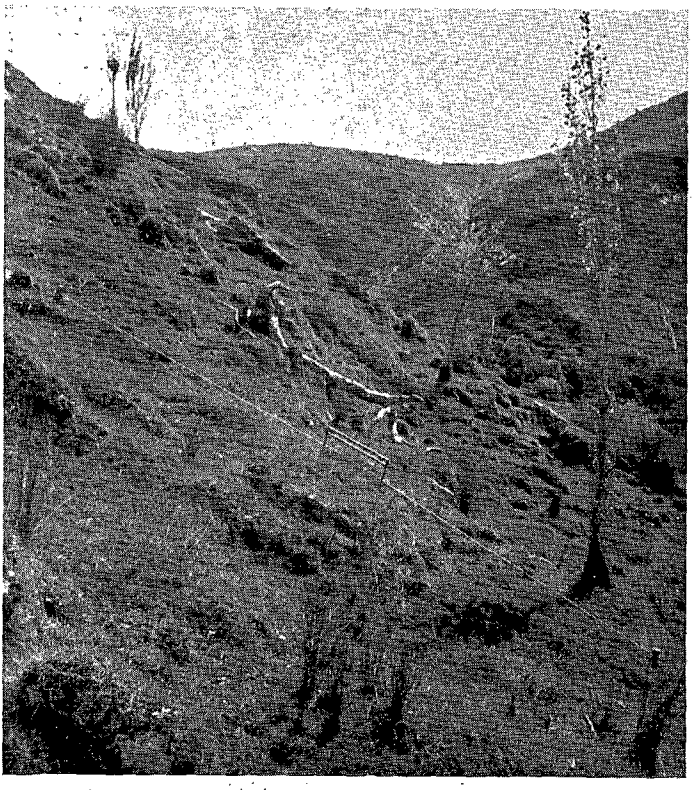
DESCRIPTION OF HILL-COUNTRY PASTURES

Hill-country pastures are, as already mentioned, becoming less productive, more weedy, and open, and in consequence more susceptible to erosion. The following table of species is an average of point analyses taken over 130 acres at Te Awa research area showing the distribution of species on untopdressed country, and is fairly typical of hill-country pastures in the Wellington district.

Species	% of ground covered by species (average of 13,000 points)
Bare ground	6.2
Browntop	21.4
Catsear	14.1
Sweet vernal'	10.7
Chewings fescue	7.5
Yorkshire fog	7.2
Ryegrass	6.8
Danthonia spp.	6.5
Crested dogstail	5.4
Cocksfoot	1.5
Other grasses	2.4
Suckling clover	3.8
White clover	1.5
Other species	4.7

It will be understood that hill-country is most variable from a sward point of view. The flat areas and hilltops, which invariably become stock camps are more fertile than the slopes, because they are usuallv less eroded and have a much greater depth of topsoil. Further, because of the flat or easy sloping nature of these areas, stock concentration causes high fertility through the return of dung and urine transferred from the slopes to the stock camping area.

In any hill pasture examined there are dry sunny slopes, shady slopes,. steep faces, slips, dry knobs, and wet hollows? all with different pasture plant communities according to local contour and conditions, and botanical analyses taken must, therefore, be grouped into similar micro-environments. The method em-



Permanent pegged line transects for recording 'pasture improvemerit." Point analysing apparatus along line.

ployed in pasture' analysis work has been therefore confined largely to line transects grouped for similar' pasture habitats. Averages of these groups thus give a reasonably accurate figure for pasture composition expressed as ground cover.

Generally. speaking the steeper hills are in the form of a stairway, the 'steps being carved out by constant tramping of stock during grazing, with relatively upright faces between each step. The grazing animal forages on the upright faces which comprise the greater portion of the area and the dung'and urine are dropped on the steps or stock tracks. On these upright faces the pasture is usually poor through lack of fertility through no return of nutrients from the grazing animal, and because they are so free draining in some cases that only danthonia and moss persist in the dry conditions. Other steep shady faces are constantly wet with seepage and on'ly moss, weeds, fog, vernal, and Gunnera survive.

The original comparatively high-producing pasture contained in its make-up very few of those lower-producing species so necessary to take up the. running when fertility, declined. Had more of these: poorer-producing species such as browntop and dantlionia been 'included in the original sowings, hill pastures would have been more densely populated with grasses to-day.

METHODS OF ASSESSING PASTURE PRODUCTION

In assessing pasture production three systems of measurement are used :-

1. Point analysis (1) which' determines the percentage ground cover by species and is a valuable guide in recording changes in composition of pastures.

2. The frame enclosure method of measurement giving yield of. herbage. Associated with this method is the herbage dissection technique. Sears in a recent paper (2) has dealt more fully with the relationship between herbage yield and ground cover.

3. Animal measurement. Records are kept of all stock grazing on the experimental area and the figures serve as an added guide to pasture- production.

METHODS OF PASTURE IMPROVEMENT

Consideration of pasture improvement on hill-country can be made under three main headings: 1.

Fertiliser, 2. Reseeding- or Surface sowing, and 3. Manage.ment.

1. FERTILISER

The natural phosphate deficiency of the hill-country is one of the most important factors limiting grass growth and producing the decline in production.: Insufficient phosphates in the soil have caused the higher fertility species such as white clover and ryegrass almost to disappear, and before increased production can be achieved phosphates must be added to the hills. so that these species can again be sown and have some reasonable chance of survival.

Whilst there is a definite need for phosphates on most of our hill-country, disappointing results from topdressing have' occurred. only too often. The point to be stressed is that applications of phosphate on pasture are virtually wasted unless clovers are present to utilise the phosphate applied. Topdressing on hill-country should go hand in hand with surface sowing to ensure- some success for the expenditure incurred.

This is amply demonstrated. from the pasture improvement point of view in Table II, where pasture analyses of plots at Te Awa, are summarised. After. 3½ years since the trial began, the oversown and top-dressed plots have changed in composition from an average of 11 hits per 100 points of total clovers in 1946 to 45 in 1949. Whereas the control plots which were similarly topdressed but not oversown have failed to respond, the total clovers in this latter area being 'largely- the annual species suckling clover.

It has been stated that lime is also necessary to reduce the acidity of. much hill-country to. enable the better grasses and clovers to grow.,, In order to effect an appreciable change in pH large quantities of lime would be necessary. This, of course, b-rings up the question of application, which is in itself .a problem. The recent trials with aerial- topdressing of phosphates give some hone for the future of the hills, but it will be some time-before lime will be spread in the neces-sary large quantities per acre by this method. pH figures at Te Awa range from 5.1 to 6.6 and over this range of acidity clovers are grown successfully when phosphate is applied. Recent investigations by McNeur at Grasslands Division, however, indicate that clovers thrive well at relatively low pH levels, a fact which may alter- our conception of clover culture.

-2. SURFACE SOWING

Another important method of hill pasture improvement is the oversowing of seed to introduce suitable species and strains of grasses and clovers according to climatic conditions. It could be said that oversowing is 'more important to the hills than topdressing because without clover in the sward phosphates cannot be utilised to the best advantage. Trials at Grasslands Division and Te Awa have shown that pastures without clovers, when topdressed, produce very little more than clover-deficient pastures without topdressing, whereas phosphates applied to pastures with ample clover have greatly increased the production.

It would appear, therefore, that oversowing should accompany hill-country topdressing. However, it would be advantageous to utilise the aeroplane to oversow large areas of hill country with *Lotus major* in the period between aerial topdressing trials and the eventual large-scale aerial topdressing operations when suitable machines are available. The *Lotus* then sown would establish and be on the spot to utilise the phosphates when eventually applied. The sowing of *Lotus* would ensure the establishment of some clover should topdressing be impracticable, as this species has the ability to survive and produce reasonably well on untopdressed acid soils where adequate rainfall is available.

On the steeper hill-country pastures where "terracing" has become very noticeable a large proportion of the area is steeply sloping or almost upright. Pasture improvement undertaken at Te Awa on this class of country has indicated that surface sowing of clovers has been most beneficial. On the sunny faces subterranean and white clover have been successfully introduced, while on the shady faces white clover and *Lotus major* have established and are making a valuable contribution to the sward.

A point worthy of note in this respect is the method used to surface sow the steep faces. Both the seed and fertiliser were thrown up into the' steeper banks rather than down the stock tracks as is usually the practice. In this way seed was successfully incorporated and the necessary fertiliser added to areas which in the normal course of stock grazing fail to receive the benefit of animal droppings. This point also raises the question of the limitation of aerial sowing and topdressing where seed and fertiliser are

rained down evenly .on easy country, whereas on the steep country the bulk of the seed and fertiliser eventually lands. on the ledges of stock tracks. In this respect the recent introduction of the "blower" topdresser appears -satisfactory when the fertiliser is blown'up hill.

To illustrate the point regarding the surface sowing of clovers on the steeper banks and upright faces, analyses were made at Te Awa to demonstrate that the small pellet-like clover seeds will penetrate and lodge in small cracks and crevices on these upright faces when thrown up into them. The figures (shown in Table 1) are expressed as hits per hundred points examined and show the results $3\frac{1}{2}$ years after sowing.

The main feature is the reduction of weeds, moss, and bare ground on the sown plots and the greatly increased clover content of the sward, particularly *Lotus major*.

On the foothills and lowland where cultivation is the prerequisite for a seed-bed, relatively high germination and establishment are often achieved. Frequently, however, under ideal conditions a 'poor strike has resulted. The steep and often deeply gullied hillsides preclude the use of the plough or any other method of cultivation and when surface sowing the farmer may expect losses in the establishment of seedlings due to a variety of adverse conditions which may arise at the time of sowing. Nevertheless almost certain success can be achieved with some species at least. when surface sowing and topdressing are carried out.

The interdependence of the practices of surface sowing and top-dressing may be illustrated by experiences at Te Awa, where in early April, 1946, 50 acres of hill country was oversown using a mixture of:

Pedigree perennial ryegrass	10 lb
Pedigree short-rotation ryegrass	10 lb
Pedigree white clover	2 lb
Subterranean clover	2 lb
Crested dogstail	2 lb
Lotus major	1 lb
Per acre	27 lb

The area sown had not been top-dressed previously and carried between $1\frac{1}{2}$ to 2 ewes per acre. The sward . consisted of browntop, danthonia, Yorkshire fog, sweet vernal, dogstail, and flat weeds. Some suckling clover was present and very little white

Typical hill-country pasture before topdressing and oversowing.

TABLE 1: ANALYSIS OF HERBAGE ON SOWN BANKS OR STEEP FACES COMPARED WITH UNSOWN (BOTH PLOTS TOPDRESSED). (Averages of 500 points on each Treatment).

Date	Treatment	Ground cover by species.																							
		Perennial ryegrass	Cocksfoot	Crested dogstail	Chewings fescue	Poa pratensis	Danthonia	Browntop	Sweet vernal	Yorkshire fog	White clover	Subterranean clover	Red clover	Suckling clover	Lotus major	Catsear	Moss	Gunnera	Other species	Bare ground	Total Grass	Total Clover	Weed Species	Moss	Bare Ground
9.9.49	Control plots topdressed but not over-sown' (steep faces).	0	2	1	8	1	20	3	40	5	0	0	0	0	0	13	27	3	1	8	80	0	17	27	8
9.9.49	Oversown and topdressed steep faces	Trace	4	1	5	1	13	2	31	6	7	1	1	0	26	8	17	5	0	4	63	35	13	17	4

clover. A dressing of 2 cwt. of superphosphate was applied in September, 1946, and further dressings at the same quantity in the spring of 1947 and 1948, making a total of 6 cwt. per acre in $3\frac{1}{2}$ years since the trial commenced.

Sowing was done by hand, the seed being sledged to the site and the bags roughly laid out according to acreage. It will be seen that a comparatively heavy dressing of seed was applied in this experimental sowing and the species used were of high quality in an attempt to establish pedigree strains of grasses and clovers on the hills. The sward had been grazed by sheep and cattle and although close grazed in the bottom had some seed stalk and roughage. A moderately dry summer preceded the sowing, and the annual grasses and clovers had not yet struck, which made the turf somewhat open.

There was an obvious visual improvement in the pasture composition following the oversowing and topdressing operations. A change was clearly evident in pasture composition and growth about 6 months after sowing. The clovers struck particularly well from an early April sowing, especially the subterranean and white clover, the *Lotus major* being relatively slow. In the *Lotus* seed there was a fair amount of *Lotus hispidus* impurity, but this established quite well on the dry knobs and is contributing some feed on these otherwise poor areas.

The overall effect of the treatment on the pasture cover is shown in the following tables wherein are detailed the changes in ground cover as measured by the point analysis method-on areas pegged for continuous measurement within the block. These transects have been grouped into eight major classifications according to aspect and topography because of the variability of the area under examination.

As can be seen from the data in Table II. the results from oversowing and topdressing differ according to location and the association of species initially present. Each type of location will be dealt with separately and. from the herbage analysis table it will be seen that the following changes have occurred in the ecological associations analysed.

(1) Dry danthonia face-A reduction of bare ground has occurred, the bare spaces being filled in with sown species and annual clovers. There has also been a reduction in weed content. In the original sward 4 points of clover were recorded as against 43

Pasture improvement by oversowing with clovers and topdressing with phosphate.

TABLE II.—GROUND COVER CHANGES BY SPECIES ON DIFFERENT TOPOGRAPHIC TYPES—Continued.

Date	Aspect	Description	Grasses										Clovers					Weeds			
			Ryegrass	Cocksfoot	Crested dogstail	Yorkshire fog	Browntop	Sweet vernal	Danthonia	Chewings fescue	Other grasses	Total grasses	White clover	Subterranean clover	Lotus major	Suckling clover	Total clovers	Catsear	Other species	Total weeds	Bare ground
	5	**Slips**																			
12.4.46		(a) Original cover	—	—	—	3	11	7	2	—	—	23	2	—	—	—	2	5	9	14	65
30.9.48		(b) Oversown & top-dressed	10	—	1	6	8	15	1	1	1	43	25	4	1	7	37	4	8	12	31
16.9.49		(c) Oversown & top-dressed	5	—	1	8	15	32	2	6	—	69	23	2	7	2	34	2	11	13	24
	6	**Sunny face**																			
12.4.46		(a) Original turf	1	4	12	13	42	19	18	2	—	111	4	—	—	10	14	33	6	39	3
30.9.48		(b) Oversown & top-dressed	7	2	11	6	29	13	11	5	tr	84	20	19	3	21	63	18	4	22	2
5.10.49		(c) Oversown & top-dressed	16	2	15	7	25	26	14	10	6	121	15	24	6	9	54	9	6	15	2
	7	**Shady face**																			
12.4.46		(a) Original turf	—	4	7	12	32	30	13	19	=	117	8	—	—	13	21	15	7	22	8
30.9.48		(b) Oversown & top-dressed	9	2	8	10	34	13	8	5		89	35	17	8	6	66	9	3	12	2
7.10.49		(c) Oversown & top-dressed	9	3	9	9	28	32	10	9	1	110	28	6	17	3	49	8	11	19	3
	8	**Original**																			
12.4.46		(a) Control plots. No topdressing	1	4	10	12	36	25	16	11	—	115	6	—	—	11	17	24	6	30	5
30.9.48		(b) Control plots. Top-dressed	2	3	8	9	32	19	15	7	1	96	6		—	19	25	19	6	25	8
16.9.49		(c) Control plots. Top-	2	2	10	7	29	27	17	12	1	107	2	—	—	10	12	14	19	33	6

TABLE II.-GROUND COVER CHANGES BY SPECIES ON DIFFERENT TOPOGRAPHIC TYPES-Te Awa Experimental Area for Periods as shown.

			Grasses									Clovers					Weeds			
Date	Aspect	Description	Ryegrass	Cocksfoot	Crested dogstail	Yorkshire fog	Browntop	Sweet vernal	Danthonia	Chewings fescue	Other grasses	Total grasses	White clover	Subterranean clover	Lotus major	Suckling clover	Total clover	Catsear	Other species	Total weeds	Bare ground
	I 1	**Dry Danthonia face**																			
12.4.46		(a) Original turf	1	4	6	7	15	19	32	1	3	87	2	—	—	2	4	26	4	30	12
30.9.48		(b) Oversown & top-dressed	2	2	6	7	13	21	36	2	5	94	3	6	—	22	31	12	3	15	8
16.9.49		(c) Oversown & top-dressed	3	3	7	4	13	28	31	8	5	102	8	18	1	16	43	12	3	15	7
	2	**Harsh open browntop face**																			
12.4.46		(a) Original turf		3	5	10	51	13	9	8	—	99	1	—	—	1	2	19	5	24	10
30.9.48		(b) Oversown & top-dressed	1	2	6	5	31	17	11	5	—	78	10	7	1	16	33	11	4	15	11
16.9.49		(c) Oversown & top-dressed		1	25	3	35	20	9	5	2	107	34	15	1	8	58	7	2	9	5
	3	**Good average face**																			
12.4.46		(a) Original turf	3	2	10	12	51	17	5	4	1	105	11	—	2	1	14	28	6	34	2
30.9.48		(b) Oversown & top-dressed	12	2	15	12	26	20	5	2	1	95	26	4	7	8	45	19	4	23	2
16.9.49		(c) Oversown & top-dressed	14	2	12	9	18	19	5	5	1	103	16	6	9	9	40	13	8	21	4
	4	**Stock Camp**																			
12.4.46		(a) Original turf	30	2	6	28	47	11	5	1	8	138	21	—	—	1	22	11	8	19	—
30.9.48		(b) Oversown & top-dressed	43	—	9	15	29	7	3	1	3	110	34	4	—	2	40	7	4	11	1
16.9.49		(c) Oversown & top-dressed	44	1	13	11	10	6	2	1	20	108	35	3	—	—	38	4	3	7	5

Table III.-HERBAGE PRODUCTION AND COMPOSITION, TE AWA AREA

For the Period 1.6.47-1.6.48-1.6.49

Period	Total P.M. per acre		Crude Protein		Botanical composition % of D.M.				Botanical Constituents D.M. per acre			
	Total Yield	% D.M.	% of D.M.	lb C.P. per acre	Rye & Dogstail	Other Grasses	Clovers	Other Species	Rye & Dogstail	Other Grasses	Clover	Other Species
					NO SEED OR MANURE							
1.6.47 - 1.12.47	1614	27.4	12.9	208	16.3	71.1	6.5	11.1	183	1149	102	178
1.12.47 - 1.6.48	1295	32.7	9.2	119	15.3	55.0	2.4	27.3	199	712	31	353
Total 1.6.47 - 1.6.48	2909	29.5	11.2	327	13.1	64.0	4.6	18.3	382		1861	135	531
(1, 2, 3)												
11.6.48 - 25-11.48	1.778	23.0	15.8	281.	16.7	67.7	9.8	5.8	297	1203	174	104
25.11.48 - 10.6.49	3711	25	16.5	612	26.4	56.1	2.8	14.6	961	2043	104	530
Total 11.6.48-10.6.49	5489	24	16	893	21.5	61.9	6.3	10.2	1258	3246	278	634
					SEED AND MANURE							
1.6.47 - 1.12.47	3625	20.4	16.6	601	19.2	62.8	14.7	3.3	698	2275	533	119
1.12.47 - 1.6.48	1504	29.0	9.9	149	17.4	57.6	23.9	1.1	262	866	359	17
Total 1.6.47 - 1.6.48	5129	22.4	14.6	750	18.7	G1.4	17.4	2.7	960	3141	892	136

points since oversowing, most of this being subterranean clover.,

(2) Harsh open browntop face-The establishment of sown clovers has reduced the proportion of browntop and weeds. In this case total clovers represented 2 points in the original, whereas there are now 58 points recorded. In this case white clover has featured much more.

(3) Good average face-Both ryegrass and white clover have increased considerably since oversowing. Originally ryegrass is shown at 3 hits per 100 points analysed and white clover 11. This figure has now risen to 14 of ryegrass and 16 of white clover, and the total clover figures are now 40 against the original figure of 14.

(4) Stock camps-There has been an increase in the amount of ryegrass and white clover and a corresponding decrease in the proportion of Yorkshire fog, browntop, sweet vernal, and weeds. Ryegrass has risen from 30 points to 44, white clover from 21 to 35, and total clovers from 22 to 38.

(5) 'Slips-Bare areas have filled in satisfactorily, with a good strike of white, subterranean, and annual clovers, and from the table it will be seen that the ground cover has increased from 35 per cent. to 76 per cent. Total grasses have risen from 23 to 69 and total clovers from 2 to 34.

(6) Sunny face—Ryegrass, white clover, subterranean clover, and *Lotus major* have increased considerably and the proportion of poor grasses and weeds has been reduced. Ryegrass has risen from 1 to 16, white clover from 4 to 15, and total clovers from 14 to 54.

(7) Shady face-Clovers and ryegrass have increased with oversowing and top-dressing with a corresponding reduction in poorer grasses and weeds. Ryegrass has risen from 0 to 9 and total clover from 21 to 49;

(8) The effect of top-dressing without oversowing on hill country pastures :

The application of 6 cwt. of superphosphate over 3½ years, has resulted in a slight increase in the annual species suckling clover in the first year after treatment. Other than this there has been no apparent difference due to topdressing by itself. Growth and botanical composition on this plot does not appear to be any' better than the adjoining paddock, which was not oversown or topdressed.

YIELDS OF PASTURE HERBAGE

Point analysis gives a picture of the ground cover changes and pasture composition, but it is the actual yield that is the real criterion of improvement. In addition to the measurement of ground cover changes, yields of herbage on the experimental area were recorded by the frame enclosure method.. The total herbage cut was weighed and sampled for dry matter content and chemical composition. Samples of the green herbage were, in addition, dissected into their component botanical species. These were dried and the' composition determined on the dry weight basis. Crude protein determinations were made on bulked samples from the various cuts within the periods shown, whilst the botanical composition was determined from the fresh material from each cut.

Because of the relatively small number of frame enclosures in use, it has not been possible to make a statistical analysis of the results, but it was clearly seen during the course of the work that the results have. been consistent 'both as regards yield and composition.

The herbage produced within the frame enclosure is hand cut with shears down to the height at which the surrounding pasture is grazed and the frames then shifted fortnightly to a new position within each sampling area. Both paddocks are under more or less continuous grazing and the frame measurements are not strictly applicable, as there was no doubt slightly more growth in the frame area than there was in the surrounding continuously grazed paddock. Nevertheless all the frame areas are treated similarly and the yield data obtained are comparable within themselves. These yield data are summarised in Table III.

DISCUSSION ON TABLE III.

When comparing the initial pasture with that treated with seed and manure after having been sown since April, 1946; and' top-dressed for three consecutive years at 2 cwt. of superphosphate per acre, a considerableincrease in yield has resulted and the increase in dry matter per acre for the period 'X947-48 due directly to the treatment is of the order of 80 per cent.

In the 1948-49 season because of summer rains and a mild winter the control area has produced considerably more than in the first year of measure-

Table III.-HERBAGE PRODUCTION AND COMPOSITION-Continued.

Period	Total D.M. per acre		Crude Protein		Botanical composition % of D.M.				Botanical Constituents D.M. per acre			
	Total Yield	% D.M.	% of D.M.	lb C.P. per acre	Rye & Dogstail	Other Grasses	Clovers	Other Species	Rye & Dogstail	Other Grasses	Clover	Other Species
(4, 5, 6)												
11.6.48 - 25.11.48	2611	21.0	18.1	473	14.9	61.5	23.4	Tr	390	1605	610	6
25.11.48 - 10.6.49	5028	27.0	14.3	719	26	46	18	7	1267	2259	876	344
Total 11.6.48-10.6.49	7639	24	16	1192	20.4	53.7	20.7	3.5	1657	3864	1486	350
SEED + MANURE + STOCK CONCENTRATION												
1.6.47 - 1.12.47	6616	16.1	19.1	1267	40.1	49.9	6.0	4.0	2655	3301	393	267
1.12.47 - 1.G.48	2722	25.5	15.9	433	52.1	30.4	5.2	12.3	1418	828	141	335
Total 1.6.47 - 1.6.48	9338	18.1	18.2	1700	43.6	44.3	5.7	6.4	4073	4129	534	602
(7, 8, 9)												
11.6.48 25.11.48	5439	16.5	118.2	990	55.9	36.6	3.1	4.4	3038	1992	170	239
25.11.48 - 10.6.49	8999	18.5	18.0	1620	52.0	32	9.9	5.3	4688	2922	893	485
Total 11.6.48-10.6.49	14438	17.5	18.1	2610	53.9	34.3	6.5	4.8	7726	4914	1063	724

ment. The per centage production on the treated area even with this exceptional season is approximately 40 per cent. higher than the control or untreated area during the same period.

There has been a definite increase in succulence in the pasture. This is also indicated in the reduction of the percentage. dry- matter of the herbage as cut. Also important is the increase in crude protein yield. This increase for the 1947-48 period is 129 per cent. and for the 1948-49 period approximately 33 per cent.

The stock concentration area produced 14900 lb of dry matter per acre, almost equal to the amount produced at Grasslands Division on flat country.. There has been a definite increase in the ryegrass and clovers brought about by the increased return of dung and urine from the increased stock carried. This exceptionally high production is due also to the transference of fertility from the slopes: and other areas to the stock camps. The botanical composition, measured by the herbage dissection technique, has changed considerably. The sown grasses and clovers have increased and the existing grasses have thickened up, smothering out the flat weeds and filling in the bare spaces. In other words the action of the rhizobia on the added clover roots is supplying the necessary nitrogen for grass growth. This increased pasture production in turn is converted into dung and' urine by increased stock numbers to again encourage extra grass growth.

There is no climatic limitation to increased production in this district. The limitation is more associated with the difficulty in establishing the higher-producing species and strains of grasses and clovers on the dry knobs, steep faces, and slopes which by virtue of their topography and droughty nature only allow the survival of associations such as danthonia, sweet vernal, annual clovers, and flat weeds. This moisture factor is illustrated on areas which are subject to seepage where clovers establish and thrive equally on steep banks and upright faces. The animal is also a limiting factor in obtaining a complete pasture improvement on hill country. Very little dung or urine is dropped. or finds its way on to the steeper areas ; consequently the stock tracks become over fertilised to the detriment of the steeper banks and faces where much of the animals' foraging is done.

We have followed the trends in pasture improvement measured by the point analysis method giving a picture of ground cover changes. The production of

dry matter and herbage dissection and now the effect of oversowing and topdressing are discussed in 'relation to carrying capacity. The figures given' in table' IV.' refer to the actual stock carried on the 49-acre experimental trial area. The initial carrying capacity is estimated, at 1½ to 2 ewes and after three years of treatment has reached 3.6 ewes per acre.

TABLE IV : INCREASE IN CARRYING CAPACITY FOLLOWING TOPDRESSING AND OVERSOWING. TE AWA 49 ACRE PADDOCK.

Conversion Figure Used : From Oct. 1st.

1 Lamb = ½ Ewe
1 Yearling = 3 Ewes
Calf
1 Cattle Beast = 5 Ewes
1 Cow and Calf = 6 Ewes

Year	Cattle expressed as Ewe Days	Ewe Days	Total Ewe Days	Carrying Capacity	% Increase on Previous Year
1946-47	15,421	31,229	46,650	2.6	—
1947-48	18,095	41,700	59,795	3.3	28%
1948-49	20.635	43,695	64,330	3.6	10%

Taking the initial carrying capacity at 1½ ewes per acre = an increase in carrying capacity of 140 per cent: or at 2 ewes per acre an increase' of 80 per cent.

It has been demonstrated that oversowing and topdressing have given increases in production over a three-year period, and that it is essential that seed' and fertiliser should both be applied. Successful sowing is therefore vital for ultimate success in the programme. Variable results have been obtained in oversowings and in this respect it was considered that the season of sowing- was obviously likely to be important. Experiments were carried out to determine- the best month for oversowing at Mangaweka, Horoeka, Titree point, Mangahei, and Coonoor.

Although autumn was recognised as being the best season to oversow grass and clover seed, no precise information was available as to the best month for oversowing.

In 1948 some 104 acres of hill country was over-

sown experimentally with clovers 'and grasses and in most cases the areas sown were topdressed for the first time in the same year as the sowings were completed. In this paper I will deal with the strike and early establishment of sown seed in the lower Hawke's Bay and Mangaweka districts, although similar results were obtained over the wide area embraced by the experiment. On each of the five trials dealt with the sowings were made at 6 different times of the year in an attempt to establish the most suitable month for oversowing grasses and clovers. The areas were all hand sown, care being taken to get as even distribution as possible over each individual block of one acre.

A complex seeds mixture was sown consisting of:

10lb perennial ryegrass
10lb short-rotation ryegrass
3lb crested dogstail
2lb broad red clover
2lb Montgomery red clover
2lb subterranean clover
1lb white clover
1lb strawberry clover
½lb *Lotus* major
½lb *Lotus hispidus*

Sowings were made in March, April, May, August, September, and October, and the strike of the sown species was estimated by counting the seedling plants in, square. foot quadrats taken at random over each acre block.

The effect of date of sowing on seedling establishment of different species is shown in Table 5. The seedling establishment is expressed as a percentage of the viable seeds sown.

From this experiment it would appear that early March was easily the best time for oversowing.

Arising from the detailed counting of the strike of seed on the sown areas, several points of interest were noted and the factors militating against successful germination. and establishment were noted and are set out in the following discussion..

After dry summer periods the pastures. become open, due to the grasses and clovers drying off. This openness was probably the factor which allowed for the most satisfactory introduction of new species where seed was oversown in early autumn. The later sowings were not favoured with such suitable conditions; the annual grasses and clovers had struck with

TABLE V.

Locality	Month of Sowing	Red Clover	White Clover	Lotus Major	Strawberry Clover	Subterranean Clover	Ryegrass	Crested Dogstail
Mangahei	March	42	32	4	14	58	6	16
	April	22	27	2	0	0	2	7
	May	3	11	4	Trace	0	0	0
	August	2	19	0	3	0	Trace	0
	Sept.	10	8	0	0	0	0	0
	Oct.	11	4	1	0	2	0	0
Coonoor	March	46	29	6	0	94	10	1
	April	45	35	3	17	98	16	2
	May	8	10	Trace	14	1	0	0
	August	11	6	Trace	1	18	Trace	0
	Sept.	19	14	3	0	16	0	0
	Oct.	24	11	1	0	13	1	0
Titree Point	March	2	4	22	0	16	98	8	1
	April	45	19	2	0.	87	4	3
	May	1	1	Trace	0	2	2	0
	August	7	7	2	0	0	Trace	0
	Sept.	3	2	0	0	13	Trace	0
	Oct.	1	Trace	0	0	7	Trace	Trace
Mangaweka	March	14	45	65	17	98	49	11
	April	7	26	32	0	51	28	6
	May	1	Trace	1	1	7	Trace	0
	August	9	21	10	2	4	2	0
	Sept.	10	14	Trace	2	14	1	Trace
	Oct.	31	42	9	3	12	1	Trace
Horoeka	March	2	4	5	1	0	65	b	1
	April	6	3	0	0	0	2	0
	May	2	3	0	0	1	0	0
	August	2	4	2	0	0	Trace	0
	Sept.	2	0	0	0	5	0	0
	Oct.	Trace	Trace	0	0	0	0	0

the first rains and the sward had thickened up with these' annual species.

Previous experience had shown that early autumn, sowings in February may be subject to light showers sufficient to germinate seed but not to ensure establishment, hence no experimental sowings were carried out: in February. The late autumn sowings went into the winter. as small plants and some seedlings were destroyed. by frost. This factor was especially true in the case of red clover when the March and, April sowings gave. the best strike in. all trials, but the late autumn .and spring sowings suffered, except at Coonoor and Mangaweka, when, the October sowings struck moderately well.

Similarly white clover struck best in March, most of the seedlings from winter and spring sowings succumbing to frost, except at Mangaweka, where a seedling establishment of 42 per cent. was obtained from the October sowing. The influence of date of sowing on rate of establishment was even more marked in the case of subterranean clover. In all localities early autumn sowings were successful, whereas late autumn and spring sowings failed almost completely. The percentage strike of *Lotus* major and *Lotus hispidus* was extremely low from all sowings except those made in March and April at Mangaweka. Past experience with *Lotus* has shown that the high percentage of hard seed may be responsible for delayed germinations.

The grass species sown showed a poor strike in all cases, best results being obtained from the March and April sowings, although even with these the results were not good. The grass seed tended to lodge in the existing sward rather than penetrate to the soil as did the heavier clover seed. Germination occurred with the first rains and the seedlings dried off with wind and sun. The majority of ryegrass and dogstail seeds which established were found in places such as hoof marks or bare faces, where the turf was open, in the crowns of flat weeds, or where the seed had been pressed into the soil by stock tramping,

In the late autumn and early spring sowings a large quaitity of seed was consumed by birds. Observations taken at various sowings pointed to a particularly heavy loss from this cause. The smaller seeds such as red clover, white clover, strawberry clover, and *Lotus* were not affected to the same extent as were grass and subterranean clover seeds.

Detailed examination of seedling plants showed a loss due to slugs and insects. Several plants were found with cotyledon leaves eaten off. Close grazing by sheep on the sown area was a factor particularly noticeable on the more open areas where seedlings had struck and were providing a fresh green bite. Many plants were thus pulled out or chewed off below the crown. Trials recently undertaken have shown that heavy stocking with sheep for a short period following sowing has given improved germination, which, if time is given for establishment under spelled conditions, has resulted in a good seedling establishment rate, the consequent tramping bringing the seed into close contact with the soil. In some instances

losses were 'noticed due to the washing of seed and, seedlings from the-steeper faces.

It was immaterial whether the sward was long or 'short, providing it was. open, although the, coyer afforded, by the longer swards may have had a. beneficial effedt from the' point of view of preventing drying-o,@ of seedling plants.' The strike was consistently poor on 'denser ' swards of. danthonia, fog, or -sweet vernal: due to lack 'of penetration of the seed.. The comparatively -poor' results obtained from all sowings at Horoeka may be attributed to the thin layer of soil overlying argellite rock which is 'a feature of the district. Moderately high rainfall and a reasonable spread of rainfall throughout the year do 'not help seedling establishment when this thin skin of soil rapidly dries out with persistent strong winds. Much difficulty has' been experienced with establishing clovers in. the past and it is only by heavy applications of. subterranean clover seed that improvements have been achieved.

Observations failed to 'reveal what particular factors accounted for the failure of *Lotus*, strawberry clover, and subterranean. clover seedlings- to establish from sowings in late autumn and early spring. It wohld appear, however,. that there is a correlation between, soil temperature and germination, but. this opens ,a further field of research.

Notwithstanding some 'failures, these trials indicate that oversowing .is sufficiently successful. 'to warrant further' oversowing of hill-country pastures during -the early autumn; i.e., March. The work to date indicates that sowings should be carried out as early as possible 'in the autumn, that is, late enough to ensure continuity of moisture supply but not so late 'that damage by frost may result. Topdressing with artificial fertilisers should accompany surface seeding, and ensures almost certain success of some species at least.

Further investigations are being undertaken to ascertain the relative. importance of the different factors contributing to successful establishment from oversowing hill pastures...

SLIP SOWINGS

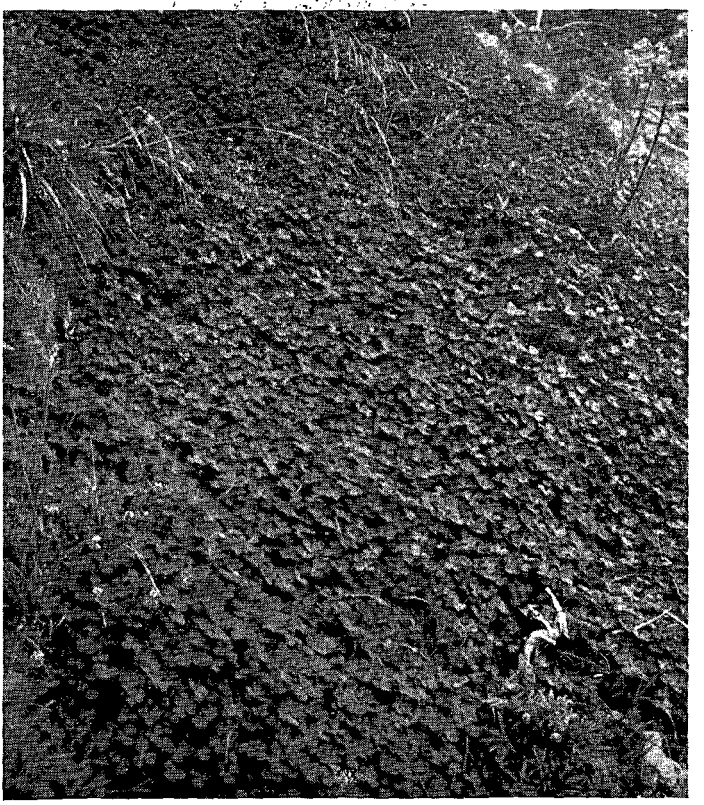
To ensure a- successful strike in some localities special treatment is required.

From the results of various:sowings made on slips

Slip sowing in spring shortly after slips occur.

at Te Awa it was found that spring sowings were more satisfactory than autumn sowings. In the spring, shortly-after the slips have occurred, the slip face is granulated or "rubbly" and forms an excellent seed-bed, whereas for autumn sowings the slip face has become baked hard with the summer sun and, is far less satisfactory as a seed-bed.

Analysis figures show that on these oversown slips pedigree white clover has become dominant with some subterranean clover, iyegrass, and volunteer species present. However, to establish seed successfully on the poor sub-soil exposed after a slip. has occurred it was found that a- mixture of 1 part sulphate of ammonia to 2 parts ,of superphosphate at



An excellent strike of white clover following spring sowing on.. slips.

2 or 3 cwt. per acre considerably improved the strike: of grasses and clovers..

The resulting pasture developed on these slip faces. has proved to be much superior to the original sward before the slip occurred. The once dry, low-producing faces and knobs become high-producing moist hollows with the added advantage of containing in the sward such species as pedigree white clover and pedigree ryegrass instead of danthonia, browntop, and weeds.

Trials were also undertaken to study the effect of sulphate of ammonia on oversown hill-country pastures. Plots were laid down using 2 cwt. of superphosphate and 1 cwt. of sulphate of ammonia and compared with applications- of 'superphosphate alone at 2 cwt. per acre. The sown clovers on the sulphate of ammonia plots were markedly superior in their early establishment. to the establishment' of clovers on the' superphosphate alone. plots. This fact confirms. the result of previous trials carried out at Grasslands Division. The addition. of a' small, amount- of nitrogen to newly sown pastures ensures a good take of clovers.

MANAGEMENT

A third factor in hill-country pasture improvement is pasture management. No accurate data are available as to the most suitable sheep to cattle ratio, but -observations have. shown that by eliminating set stocking practices and adopting rotational grazing systems increased production has resulted. Close selective grazing by sheep has done much toward the deterioration of the sward on hill-country and some improvement can be expected when sheep numbers are reduced and more cattle are used.

Experimental trials on hill-country' management are under way at Te Awa. It is too early to- draw any conclusions, as the trial has been under way for only a little over a year. At the completion' of the nedessary'period results. will be available on the comparative virtues of set stocking, periodic spelling, continuous close grazing; rotation'al grazing, and the effect of these grazing systems on hill-country pastures.

COSTS

On the Te Awa area records were kept of the labour, transport, and materials involved in top-

dressing and oversowing 180 acres of hill country. The. costs are- recorded here mainly. because of the interest shown in comparing hand distribution with aerial topdressing.

In the first application of 2 cwt. of superphosphate per acre in September, 1946, the application costs were 10/- per acre, which includes sledging and packing the fertiliser on to the line. The second application' cost was also 10/- per acre (both on the high side because, in topdressing the experimental area, care was taken to make the distribution as complete and uniform as possible, which necessarily increased the time taken to complete the work and thus raised the cost). Prior to the third application in September, 1948, a bulldozer track was formed through the experimental area which enabled motor transport 'to deliver fertiliser to the spot and saved considerable time in sledging and packing on to the line. The application costs on this occasion were 5/- per acre and a total of £1/7/6 per acre., The cost for oversowing a total of 170 acres averaged 4/1 per acre. Here again care was exercised in obtaining an even distribution because of the experimental trials to be undertaken on the area,

Recent figures quoted by the Soil Conservation and Rivers Control Council for aerial topdressing are 15/- per acre for the transport and distribution of 2½ cwt. of superphosphate. Subterranean clover seed was sown over 600 acres by air at 2 lb per acre for 5d. per acre transport and distribution cost.

CONCLUSION

Under the climatic conditions prevailing in the Wellington district surface sowing of improved strains of clovers has been successful and has resulted in considerable increases in dry matter production and carrying capacity when dressings of superphosphate have been applied simultaneously. On the other hand. the strike from oversown grass seed has so far been disappointing. In view 'of our experience to date it is recommended that farmers in the Wellington district who are seeking to improve hill pastures by oversowing should use the following mixture:

2lb subterranean clover - 1lb Tallarook
1lb Mt. Barker
1lb white clover (pedigree or of pedigree origin)
½lb *Lotus major*

Total 3½lb per acre.

Wherever possible. these, quantities should be increased, as there is no doubt that heavier seedings achieve' results more rapidly than'light sowings ; however, cost is the limiting factor regarding seed quantities. The two strains of subterranean clover are used, largely to get a spread of production over a longer season, Mt. Barker is a mid-season and Tallarook a late season strain.

In the more fertile hill-country pastures some perennial ryegrass could be included. It may become established and helps considerably in the distribution of the clover seed. If only a small quantity of 'the ryegrass seedlings establish, a nucleus of potentially high-producing grass will be incorporated. and as the fertility rises through the increased stocking, brought about by the more abundant clovers supplying nitrogen to the existing grass sward, so also will the ryegrass gradually increase as the fertility conditions become more suitable for this species to thrive;

It has, been most noticeable on various sowings which have been carried out that apparently poor strikes of seed have improved out of sight after the first year following their sowings. In places at Te Awa areas which were apparent failures have after three years turned. out to be excellent strikes of clovers. *Lotus major* is one species which shows very little evidence of establishment for the first two years after sowing until it becomes well established.

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