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FOREWORD

BY

E. S. Clayton, H.D.A., Commissioner.

The conservation concept covers such important aspects as working with nature; wasting nothing on the farm, neither organic matter, soil or water; holding and using as much as possible of the rain that falls on a property; diversifying the farming and producing as much as possible of one's own requirements from the farm.

In Australia we have not realised the fine facilities we have for fish farming on both coastal and inland farms. We have neglected the old-world art of fishpond farming. In this country good edible fish could be produced without difficulty on all farms where there are dams or ponds. Without the addition of fertilisers, dams can produce about 150 to 200 lbs. of edible fish per acre per annum, but with the addition of fertilisers up to 400 lbs. of fish per acre is readily obtainable. This is a lot of fish, and any farming family with such a dam can keep themselves in fish food, not to mention the pleasure of catching them.

The Chinese have always had their fishponds. Fish has been an important article of diet, adding variety as well as protein to the dish of rice. In Germany, and, in fact, over much of Europe, fish farming has been common for years. A variety of cold water carp is used. It breeds freely and grows quickly to a good size and is very edible, being quite different from the golden carp which is often seen in Australia. Trout, another cold water fish, is also used very successfully in Europe.

Fish farming has made rapid strides in the United States of America. Americans, with their resourcefulness and thoroughness, have experimented with their fine indigenous breeds of fresh water fish to find the most suitable for fish farming in both their cold and warm regions. They have also found out a great deal about pond management and the use of fertilisers. Under good management and heavy fertilising a pond of an acre in surface area can carry over 1,500 fish and provide over 400 lbs. of full-grown edible fish per annum.

The nutrient cycle upon which fish production is based is very interesting. On land, as we know, only plant life can assimilate nutrients direct, and the same is true in the water. Minute forms of plant life floating in the water can absorb the nutrient in solution therein. Minute animal forms of life in the water then feed upon the tiny plants, next come acquatic insects, etc., then forage fish, which eat these insects and other forms of life, the forage fish, in turn, being eaten by the food fish. Some of the forage fish, together with the food fish, escape this fate and grow up to pan size. The application of fertilisers to the pond supplements the amount of plant food contained in the natural waters. This normally increases the growth of the minute floating plant life or algae. So rapid is the growth of this minute plant life that if the pond is too heavily fertilised it gives the water a green colour. The application of fertilisers must be regulated so as to keep the water slightly tinted with plant life but not enough to prevent the penetration of sunlight. The more plant life the more growth and development of the other forms of life which feed thereon, and, of course, more food fish will be produced as the final result.

The fertilisers used are nitrogen in the form of sulphate of ammonia or nitrate of soda, phosphoric acid as superphosphate, potash as either sulphate or muriate, and calcium in the form of finely ground limestone.

The system favoured in the United States is to put two breeds of fish in the pond in correct proportions. One would be a forage fish, such as their Blue Gill, and the other the Large Mouthed Black Bass. The Bass feed heavily on all small fish. This prevents the overpopulation of the pond which would inevitably result if Blue Gill alone were present. Both the Blue Gill and the Bass can then grow to pan size and both are good eating. The heavier the pond is fished, the more food available to those which remain; consequently the faster and bigger they grow. It is practically impossible to overfish a well managed pond with rod and line.

The advantages of a farm fishpond, especially in inland Australia, are so obvious that they need no emphasis. We can have farm fishponds, but unfortunately at present no exact information applicable to Australian conditions is available and everything has yet to be found out. Research and investigation to furnish a guide to farmers in this country is required. We have many fine native fish, including the famous Murray Cod, but we must know more about them. No doubt farmers will find out a great deal by trial and error, but it would be a great advantage to this country if proper investigations were carried out by qualified men to determine which fish to use, and in what proportions, also to test the possibilities of some of the best foreign breeds and to determine appropriate techniques for fishpond management.

The provision of accurate information for Australian conditions and the supply of suitable young fish to farmers at reasonable cost would quickly result in the establishment of well stocked fish dams for food throughout New South Wales.

* * *

NOTES ON THE SNOW LEASE SECTION OF HUME CATCHMENT AREA.

BY

R. T. Morland, B.Sc.(For.), Soil Conservationist.

This article follows an earlier article in Vol. 5, No. 1, outlining the investigations being carried out in Hume Catchment Area. It deals with Section 3 of the Catchment. (See Fig. 1.)

The areas of Hume Catchment held under Snow Lease constitute a more or less compact and independent section, with features of climate, vegetation, and soil erosion, quite different from the rest of the catchment.

This Snow Lease section (shown shaded on the map, Fig. 1) comprises the eastern alpine and subalpine part of the catchment, the headwater country of the three rivers which converge to form the Upper Murray River—the Tooma River, Swampy Plain River, and Indi River.

The key importance of the section lies in the fact that more than a quarter of the water flowing into the Hume Reservoir comes from this one twentieth of the catchment area. It is the heart of the Upper Murray catchment. An area of less than 300 square miles, it contributes 800,000 acre feet of the 3,000,000 acre feet average annual flow into the reservoir. This is half of the flow from the New South Wales part of the catchment.

Nearly a third of the Snow Lease section flow comes down in summer, and is well over half of the Upper Murray summer flow, which averages 425,000 acre feet per year at Jingellic from December to May.

Table I shows some interesting figures of the flow and water yield from the Snow Lease parts of the three river catchments.

TABLE I.

Showing importance of the Snow Lease section of Hume Catchment Area in N.S.W. as a source of water. A mean annual flow of about 800,000 acre feet is contributed by only 283 square miles. Data in first three columns supplied by W.C. and I.C. Flow at Hume Weir was obtained by compiling flows at other stations. It does not agree with the flow at Albury and is probably about 10 per cent underestimated. Other figures estimated.

Catchment. (Stream flow gauging station in brackets).	Area (square miles).	Mean Annual Flow acre feet).	No. of Years.	Water Yield (acre feet/sq. mile year).	Snow Lease Part (N.S.W.) Area. Acres.	Square miles.	Mean Annual Flow (appr.) acre feet.	Water Yield (appr.) acre feet sq. mile year.	Run off (appr.) inches year.	Remarks.
Tooma River (Fossum Point).	150	350,000	22	1,050	62,000	96	275,000	2,850	53	Flow does not include Tumbarumba Creek.
Swampy Plain River (Khancoban).	220	486,000	22	2,200	92,000	14	425,000	2,950	55	Flow does not include Khancoban Creek.
Indi River (Rixon's) ..	520	419,000	12	800	28,000	43	100,000	2,[illegible]	43	Approx. half the flow is from Victorian side. Stream measurements for short period only. Probably 10 per cent. above actual mean.
Total ...	920	1,255,000	...	...	182,000	283	800,000	...	...	
Murray River (Jingellic).	2,520	1,849,000	57	730	..	..		..	..	Approx. 400,000 ac. ft. of flow total is from Victorian side.
Murray River and Mitta Mitta River (flow into Hume Reservoir).	5,900	2,928,000	57	500	...	5%	2[illegible]%	...	...	Approx. 1,600,000 ac. ft. from Victorian side. Flow probably 10 per cent. underestimated

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Stabilisation of this region is therefore of much greater importance than its area may suggest. Firstly, to prevent erosion and consequent movement of soil debris down to the reservoir. (It must be remembered that, because of the very high precipitation, soil movement from unstable areas is very rapid.) Secondly, to preserve the highest possible water absorption and water retaining capacities. The more water from winter and spring precipitation that can be absorbed and retained for release during the summer, the more will be available for irrigation.

Fig. 1.

ACCESS.

From the Murray Valley, fair motor roads go as far as Possum Point near the junction of Tumbarumba Creek and the Tooma River, and to Waterfall Farm a few miles upriver south of Khancoban. From the Monaro side, a good road goes right to the summit of Mt. Kosciusko. There is a very rough motor lorry track from Adaminaby to the Grey Mare Goldmine near the head of the Bogong Creek. In addition, during last summer rough roads were constructed

for the Snowy Mountains Hydro-electric Authority, one from Possum Point due east to meet the Tooma River at about 4,000 feet, and one from Khancoban to Geehi.

Apart from these, all access is by horse. Bridle tracks cover most of the area. However, there are large areas off the tracks which are accessible only on foot. Transport is by packhorse, although bullock teams are used occasionally on the easier routes.

There are some eleven stockmen's huts scattered at intervals through the area, used when the stock are brought up in early summer, and at mustering time in autumn, also occasionally during the summer.

As regards population, there would not be half a dozen stockmen spend the whole summer in the mountains, and these are mainly occupied in shepherding sheep. A number of hikers and horse parties pass through in summer. Skiing parties may spend a week or two in winter.

PHYSIOGRAPHY.

The central pivot of the region is Jagungal, about 25 miles north of Mt. Kosciusko, an old volcano core rising to 6,755 feet. This mountain is the source of three major rivers. To the north flows the Tumut river, to the west the Tooma River, and to the south the Swampy Plain River.

Surrounding the mountain is the Murray Plateau at about 5,500 feet, somewhat dissected by streams but with the main ridges on approximately the same general level.

The Swampy Plain River heads in the large, treeless, undulating to hilly, part of the plateau south of Jagungal. From about 5,200 feet it falls into a steep sided, rugged gorge, from which it emerges at Geehi at 1,400 feet.

The Bogong Creek flows down a rugged gorge between two high ridges. Scammel's Ridge on the west is the boundary of the Snow Lease country.

The Grey Mare range, between the creek and the Swampy Plain River, is a broad, uniform ridge over 5,000 feet, which maintains its elevation well down towards Geehi.

The Tooma River flows through a hilly valley about 1,000 feet below the general level of the plateau. The gradient is gradual until its falls steeply from 4,000 feet to 2,000 feet at the foot of Black Jack. On the east the Divide is fairly uniform at about 5,200 feet. On the west is a series of mountain peaks, 5,000 to 5,500 feet, marking the boundary of the snow country.

At the southern end of the Murray Plateau rises the Kosciusko Massif, a boulder strewn, massive structure about ten miles long by three miles wide, 1,000 to 2,000 feet above the plateau level. Mount Kosciusko itself is one of the four main peaks and several minor peaks, all over 7,000 feet, of the Massif. To the west and at the northern and southern ends are very steep to precipitous falls.

South of Mt. Kosciusko, the Indi River flows through steep, rugged mountains, but does not itself rise into the higher country over 4,000 feet. However, large tributaries flow down from the steep upper slopes of the Dividing Range. This southern extension of the Snow Lease section is more broken and irregular than the main area in the north. It is merely the upper western slopes of the Divide.

To summarise, much of the section, especially the headwater areas of the Tooma and Swampy Plain rivers, is hilly and undulating. On the outer parts, where the rivers are falling down from the plateau to the lower level of the Murray Valley, are extensive steep slopes and rugged gorges.

Practically all the true Snow Lease section is over 4,000 feet, the main grazing areas being between 4,500 and 6,000 feet.

The approximate area is 200,000 acres.

GEOLOGY.

The section is predominantly granite. Several forms, of different composition and texture, are apparent, and there is a large area of very acid gneissic granite. At higher elevations are numerous large boulder and rock outcrops, and the surface is littered with smaller fragments and boulders. Amount of surface rock decreases with decreasing altitude.

Fig. 2.—E. gigantea association (alpine ash), showing also the scattered undergrowth and good grass that occurs at the higher altitudes.

Fig. 3 – E. gigantea association (alpine ash), suffering severe fire damage in the Swampy Plain River gorge.

Several belts of metamorphic rock occur—rather mixed complexes of siliceous slate, slate, quartzite, and in the extreme south some limestone or marble.

Basalt occurrences are the old volcanic plug of Jagungal, and several flat basalt cappings on mountains to the north. (These basalt caps are a feature of the region, extending as far as Kiandra, Batlow, Tumbarumba and Tooma.) It is an interesting point that beneath the basalt are often found old river gravels, and sand and lignite deposits, indicating that the lava flowed down the bottom of river valleys. Protected by the hard basalt, these levels, once the lowest of the topography, are now the highest, and are one to two thousand feet above the present river levels.

Alluvial gold workings can be seen at Toolong Diggings, worked about 1865 to 1875, and at the Tin Mines, abandoned in 1940. Reef gold is being mined by the recently established Grey Mare Goldmine Company. (The alluvial workings, now abandoned, do not constitute any erosion risk. The reef mine is relatively small at present, but debris disposal may need watching in the future.)

The influence of parent material on soil type is small, not nearly so great as at lower elevations. However, the parent material does determine subsoil type.

CLIMATE.

Unfortunately, there are no recording stations within this section of Hume Catchment.

The nearest stations are Kiandra 4,569 feet, Kosciusko Hotel 5,018 feet, and Kosciusko Chalet 5,800 feet. These probably give a fairly good impression of the Snow Lease section climate, but whereas the Murray side gets practically all its weather from the west, these stations are on the Monaro side of the Divide and get much of their weather from the east, while being sheltered from the west by the Divide.

Temperature conditions are probably very similar to those at Kosciusko and Kiandra. Precipitation, however, may be expected to be somewhat higher.

	Kiandra, 4,569 feet.	Kosciusko Hotel, 5,018 feet.	Kosciusko Chalet, 5,800 feet.
Annual Mean Maximum Temperature	54·7	52·5	47·9
Annual Mean Minimum Temperature	33·8	34·1	30·1
Mean Maximum Temperature Hottest Month	69·3	65·9	60·9
Mean Minimum Temperature Coldest Month	23·4	24·9	18·6
Mean Annual Precipitation	62·18	48·73	79·88

Precipitation is about 60 inches per year, probably higher on the Kosciusko Massif and on the plateau areas south and west of Jagungal, and considerably lower south of Mt. Kosciusko. As in the rest of the catchment, almost exactly 60 per cent. of the precipitation falls during winter and spring (June to November).

A large part of the winter precipitation falls as snow, the proportion increasing with altitude. There are usually one or two light falls in March and April, with the heavier falls commencing in May and continuing into October. At Hotel Kosciusko snow is recorded 30 to 40 days a year, and rain on about 100 days.

A good deal of the rain falls as light, misty drizzle.

Temperature in summer is generally pleasantly cool during the day, with light frosts common at night.

The winter is cold, snow falls lying each year from several weeks at 4,000 feet, to six months at over 6,000 feet. Small drifts may remain all summer on southern aspects of the Kosciusko Massif. Generally the higher the altitude, the colder are the temperatures.

The prevailing wind is from the west. Strong wind is common at the higher exposed altitudes, especially the western upper slopes of the Kosciusko Massif, which are subjected to gale force wind for days on end.

LAND UTILISATION.

The whole area is Crown land, and lies within the Kosciusko State Park, which was reserved by Act of Parliament in 1944. The Park is administered by a trust of ten members, empowered to regulate all activity in the area.

Fig. 4.—*E. gigantea* association (alpine ash). A close view of the severe fire damage. All old crop trees killed, dense sapling regrowth.

Fig. 5.—*E. Dalrympleana*—*E. pauciflora* association (mountain gum and snow gum.) Forest moderately fire damaged and semi-cleared.

For summer grazing, the 200,000 acres is divided into forty Snow Lease blocks, varying in area from 1,800 acres to 10,000 acres.

The grazing available totals 46,000 acres of treeless grassland, and 27,000 acres of semi-cleared snow gum woodland, together with very large areas of forest, of fair to negligible grazing value.

Sheep are grazed on the more open, mostly treeless, blocks, where because of the danger of dingos, they are more or less shepherded. The rougher, timbered and semi-cleared blocks are grazed by cattle, mostly Herefords and Aberdeen Angus. All stock do remarkably well on the leases.

Grazing was first commenced in this region in the 1860's, after the gold discoveries at Kiandra. While practically no timber has been cleared by ringbarking, large areas have been greatly thinned out by burning. Very little has been completely cleared by fire.

The Snow Leases have been used in two ways. Firstly, by nearby landholders of the Upper Murray and Monaro for regular summer grazing in conjunction with winter grazing on their freehold at lower elevations. Secondly for drought relief grazing by landholders usually from more remote districts.

The present regulations provide for strict control over the management of the leases. Blocks have been leased for seven year periods and are applied for by tender, a fixed upset annual rental being set. A maximum stocking rate is fixed for either sheep or cattle for each lease. No agistment is allowed.

Cultivation is permitted only for fodder crops or pasture improvement. Actually in practice there has been neither cropping nor pasture improvement to date.

The grazing season allowed is from 1st December to 31st May each year. Owing to the risk of snow, sheep are taken off in March, but cattle are not mustered until May, except on the higher leases where they are taken out in April.

No timber may be ringbarked or burned.

Pasture burning has been allowed only before 1st December and after 15th March. Not much regular burning is now carried out.

Preference of tenure for the following period is given to the previous lessee, provided the regulations have been adhered to.

These regulations are fairly well policed by several park rangers. Most mobs of stock are counted as they come into the mountains.

The maximum stocking permitted on all leases for the last period totalled 45,000 sheep and 7,000 cattle per year, a total equivalent to 85,000 sheep (assessing one beast equivalent to six sheep). There are no rabbits.

Although there are fine stands of excellent timber (alpine ash) not destroyed by fire, the forests have never been logged and no sawn timber is being produced at present. Access is difficult, almost impossible in many places, and furthermore, the area is remote from transport and markets.

One mine, the Grey Mare Goldmine, employs half a dozen men. It has only been operating for three years.

In the sphere of recreation a limited number of hikers and a few fishermen visit the area in summer, while skiing parties may go to the head of the Swampy Plain River in winter.

VEGETATION AND EROSION.

On the treeless grassland areas, it is considered that the condition of the pasture, as evidenced by the degree of erosion, is due to previous stocking intensity, in so much as, either stock have initiated erosion by grazing and trampling, or where erosion had already been initiated by burning or casemoth damage, the stock have prevented or delayed recovery. Therefore, excepting recent fire or casemoth damage, deteriorated condition of pasture, and the accompanying sheet erosion, can be attributed to stock.

Fig. 6.—E. Dalrympleana—E. pauciflora association (mountain gum and snow gum). Moderate sheet erosion of the forest floor due to repeated burning of the snow grass.

Fig. 7.—E. pauciflora association (snow gum). Forest moderately fire damaged and reduced to savannah woodland. There is scattered regeneration.

On forested and semi-cleared woodland areas, any soil erosion is the direct result of fires. Destruction of undergrowth, grass cover, litter, and soil organic content, renders the soil vulnerable to water erosion.

Erosion of the forest areas directly caused by grazing is negligible.

A summary, by area, of the composition and condition of the vegetation is given in Table II.

TABLE II.

Summary of the Composition and Condition of the Vegetation of the Snow Leases in Hume Catchment Area.

Approximate total areas.

(Data from detailed field examination of each lease.)

Formation.	Association (and altitude range).	Area.		Sheet Erosion (grassland).	Area.
		Acres.	%		Acres.
Alpine Grassland	*Poa caespitosa, Celmisia longifolia.* 6,000–7,300 feet.	11,000	6	Light and no sheeting ... Moderate sheeting	7,000 4,000
Alpine, Woody Shrub (or High Moor).	*Prostanthera cuneata, Orites lancifolia, Phebalium ovatifolium,* etc. 5,000–6,000 feet.	22,000	12	Light and no sheeting ... Moderate sheeting	9,000 13,000
Mostly now replaced by Poa grassland.	*Bossiaea foliosa, Epacris petrophila.* 4,000–5,000 feet.	13,000	7	Light and no sheeting ... Moderate sheeting	10,000 3,000
				Fire Damage (forest).	Acres.
Alpine Sclerophyll Forest ...	*Eucalyptus pauciflora* ... ... 4,500–6,000 feet.	62,000	33	Light and no damage ... ... Moderate and severe damage (semi-cleared). Severe damage (dense coppice regrowth). Extreme damage (cleared) ...	3,000 24,000 32,000 3,000
	E. pauciflora, E. Dalrympleana 3,500–5,000 feet.	14,000	8	Light and no damage ... ... Moderate and severe damage...	9,000 5,000
Wet Sclerophyll Forest	*E. gigantea* ... ... 3,000–5,000 feet.	64,000	34	Light and no damage ... ... Moderate damage ... ... Severe damage ... ... Extreme damage (cleared) ...	23,000 8,000 32,000 1,000
TOTAL	... ...	186,000	100		
Sclerophyll Forest should not be considered as "Snow Lease.")	*E. radiata complex*	21,000	...	Light and no damage ... ... Moderate and severe damage...	16,000 5,000
		207,000			

WET SCLEROPHYLL FOREST.

Eucalyptus gigantea association (alpine ash).

The greater part of the alpine ash in the catchment is included in this Snow Lease section, where there is a total area of 100 square miles—one-third of the section. There would be another 15 square miles adjacent to the Snow Leases.

The forest occurs in pure stands at the lower altitudes, mainly in wide belts between 3,500 and 4,500 feet, but descending to below 3,000 feet, and coming up to 5,000 feet on sheltered south and east aspects. Generally on steeper slopes, the main occurrences are at the northern end of the Tooma River catchment, on the slopes of the Bogong Creek and Swampy Plain River gorges, and on the lower slopes south-west of Kosciusko. Topography makes access into this forest type most arduous.

Precipitation is probably 50 to 60 inches per year, much of it snow. Temperature in general is warm to cool in summer, and cold in winter. Snow falls may lie several weeks in winter.

The tree prefers to avoid the drier north-west aspect and ridges.

Soil on granite formation is brown, or red brown, loam one to two feet deep, with yellow brown, or light yellow, sandy loam subsoil, also one to two feet deep. The underlying C horizon of decomposed granite

Fig. 8.—*E. pauciflora* association (snow gum). Forest severely fire damaged. All old crop trees killed, dense coppice regrowth.

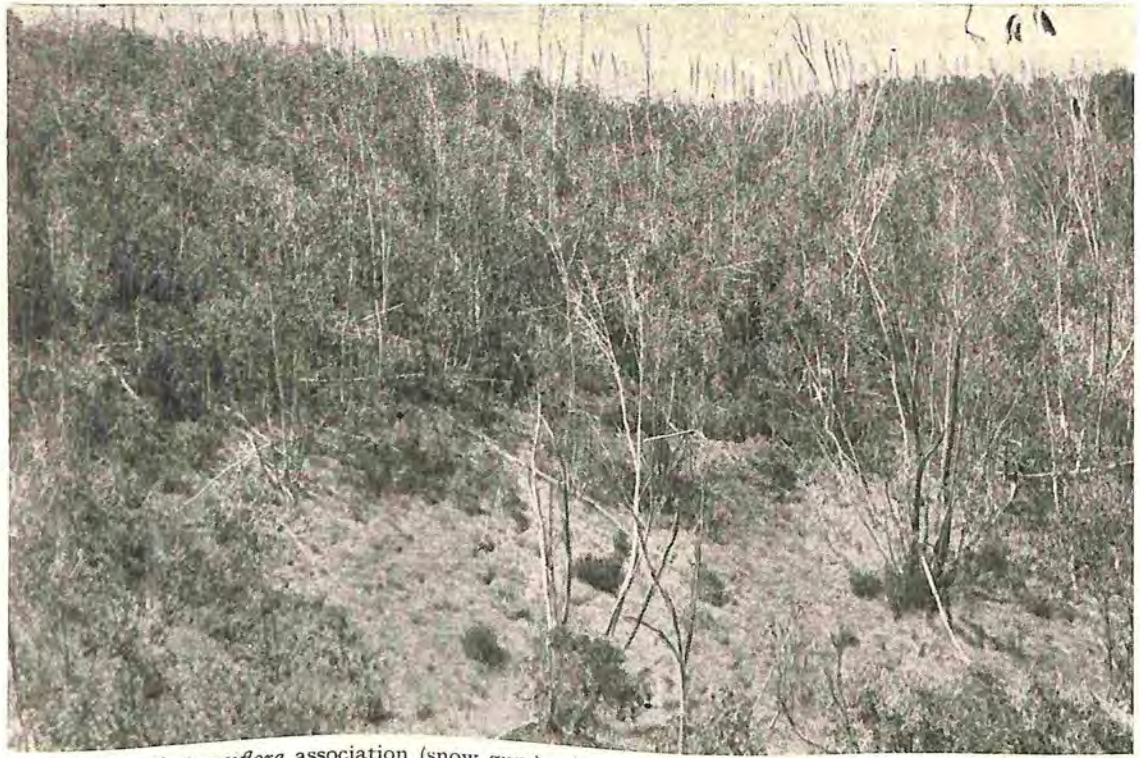

Fig. 9.—*E. pauciflora* association (snow gum). Forest severely fire damaged. Shows the dense coppice regrowth. A previous coppice stand has been fire killed. The original crop of old trees has disappeared completely.

may be of many feet. The metamorphic rocks give a much shallower soil, with clay loam to light clay subsoil, and very shallow C horizon.

The stands occur pure, except on marginal sites where other species may come in a little. Trees are tall, with a long, clean, straight trunk, and yield excellent timber. Quality of the stand decreases with increasing altitude, the trees at higher altitudes being less than 100 feet high, low branched, small in diameter, and frequently crooked. Height of the stand varies from 150 feet to 90 feet depending on quality. Diameter of mature trees varies from 35 to 60 inches in good quality stands, to 20 to 35 inches in poor.

The undergrowth varies somewhat. At lower and medium altitudes, it is dense, 3 to 6 feet high, largely of mesophytic species. Snow grass cover is weak to fair, and litter is two to three inches thick. At higher altitudes, however, it is more open and park-like, and of more xerophytic species. There is good snow grass cover and light litter.

It should be noted therefore, that the forest at lower and medium altitudes can well be termed "wet" sclerophyll, but that at higher altitudes it is not true "wet" sclerophyll.

There is quite fair grazing in the accessible forest, especially on the hilly areas at higher altitude, where the snow grass grows strongly. Cattle do not penetrate far into the steep gorges, or into the severely fire damaged parts, which are practically inaccessible to man or beast, and carry very little grass anyway.

Fire Damage.—The forests have been subjected to intense fires, and damage has been very severe over half the total area.

This forest type in most summers is rather wet and does not burn readily. However, periodically a very dry season renders the undergrowth very inflammable, with the result that fierce fires sweep through. The great intensity of the fires is due to the steep slopes, the high density of the undergrowth, and the heavy litter and debris.

Alpine ash is a very fire sensitive species, easily killed. It does not coppice, and rarely recovers by epicormic growth, as do most other Eucalypts. There are several degrees of fire damage:—

(i) *Extreme*: all old crop trees killed, and no regeneration. That is, the timber cover is completely wiped out. As yet there is only a small total area of this type—several areas of 50 to 100 acres—but it indicates the future condition to which the forest could be reduced.

Extreme damage is most evident at the higher elevations, where conditions for seedling regeneration are most exacting.

(ii) *Severe*: about 80 to 90 per cent. of the old crop trees killed, the remainder badly damaged. About half the alpine ash area is in this condition, a mass of white shafts.

Usually a dense regrowth of tree saplings, wattle, and hopbush, rapidly comes up and restocks the burned areas. Therefore, the ground surface is actually vulnerable for only a short period following fires.

However, alpine ash does not bear seed until about twenty years old, and therefore another severe fire, before the trees have reached seed-producing age, kills the young stand, and leaves the area without seed for regeneration.

It is clear that these forests cannot stand more big fires without much of them being reduced to treeless areas.

(iii) *Moderate*: about 30 to 50 per cent. of the mature trees killed. This type usually occurs on hilly or undulating areas, where fires are not so intense as on the steep slopes. Scattered seedling regeneration slowly restocks the damaged areas. (Damage by stock to regeneration would be very slight.)

The remaining mature trees are commonly butt scarred and vulnerable to termites. They are gradually weakened and die.

Fig. 10.—High Moor (*Bossiaea foliosa* association) on lower slopes at 4,500 feet. Snow gum forest on upper slopes.

Fig. 11.—High Moor (*Bossiaea foliosa* association) at 4,500 feet. Snow gum and alpine ash on upper slopes. Shrubs completely replaced by snow grass.

Fig. 12.—Alpine grassland at 6,500 feet, with a patch of woody shrubs on the warmer aspect.

Fig. 13.—High Moor (*Prostanthera cuneata* association). Shrubs replaced by snow grass. A few shrubs in foreground at about 5,500 feet.

Fires bring up a thick crop of undergrowth, with consequent suppression of grass and poorer grazing.

Erosion.—Soil erosion on unburned forest country is negligible, the ground surface being protected by undergrowth and grass, and also by the heavy litter.

While damage to the forests is certainly spectacular, the actual soil erosion caused by fire in timbered areas is somewhat indefinite.

A severe fire makes a clean sweep of young trees, shrubs, grass and litter. Heavy sheeting of the loam soil occurs immediately after burning. But the thick undergrowth and saplings which rapidly establish, provide a good protective soil cover, so that the surface is vulnerable for only a short period, and subsequent sheeting is very light.

However, repeated burning, destroying litter and undergrowth, will lead to frequent heavy sheeting, and thus to soil degeneration. Fortunately, the moist conditions of the ash forest areas favour development of strong undergrowth. Nevertheless the undergrowth which can be supported by the degenerated soil becomes progressively poorer and less efficient in holding the soil.

The main danger seems to be the small landslides — debris slides — occasionally noticeable on the completely fire cleared areas. Without tree roots, the grass and shrubs cannot hold the deep, loamy soil on these slopes. Mass movement of saturated soil after heavy rain becomes inevitable.

Watercourses.—Although often on steep gradients, the watercourses are well protected by vegetation and are stable.

ALPINE SCLEROPHYLL FOREST.

There are two associations constituting the alpine sclerophyll forest—

(i) *E. Dalrympleana—E. pauciflora association* (mountain gum—snow gum); and

(ii) *E. pauciflora association* (snow gum).

E. Dalrympleana—E. pauciflora assocation
(mountain gum—snow gum).

Is a small forest association, 20 square miles in all, which occurs on the drier ridges and north and west aspects, within the alpine ash range of altitude. Its main range is from 3,500 to 4,500 feet, but it sometimes extends to 5,000 feet. Where high moor occurs along the lower slopes of valleys, it often forms a narrow belt between the moor and a higher alpine ash belt. It never occurs higher than the ash, except on the drier, exposed sites.

In the extreme south, at about 4,000 feet, is an extensive area north of the Pilot. Apart from this, occurrences are fairly small.

Climate is similar to the alpine ash climate, but because of the exposure of the aspects to the hottest sun, day temperature is much higher, and soil moisture conditions much poorer.

Soil is similar to the alpine ash soil types, but shallower and generally with numerous rock fragments.

Composition of the forest varies from almost pure mountain gum to almost pure snow gum. The poorer the site, or higher the altitude, the poorer the quality of the forest, and the greater the proportion of snow gum. Depending on the quality of the forest, height varies from 60 to 90 feet for mountain gum, and 40 to 60 feet for snow gum, the snow gum being generally 20 feet lower than the associated mountain gum. Diameter is 25 to 50 inches for mountain gum, and 10 to 25 inches for snow gum.

Undergrowth is low and fairly light. It is xerophytic. Snow grass gives good ground cover, and litter effectively covers the surface between tussocks.

The forest gives fair to good grazing.

Fire Damage.—The mountain gum is far less fire sensitive than alpine ash or snow gum, and the association is generally in fair condition. Small areas show severe damage, where most of the mature trees have been killed. Dense seedling regrowth has restocked these.

Repeated light fires on some parts have gradually weakened and killed about half the old crop trees, and especially damaged

Fig. 14.—Alpine grassland. Wind erosion on the Divide at 7,000 feet. Soil removed to the "C" horizon.

Fig. 15.—Alpine grassland. A "scour." Note size of hat lower right.

the snow gum. Practically all snow gum trees are butt scarred, successive fires burning deeper and deeper into the butt, until eventually the trunk collapses. Scattered patches of seedling regeneration will restock these areas, unless killed by further fires.

Erosion.—Light fires which destroy the litter and burn back the snow grass tussocks to short stubble, have resulted in light sheeting, moderate on steeper slopes, in the moderate fire damaged areas. The grass soon recovers, and sheeting is controlled, but repeated burning every couple of years is keeping some areas in a continually unstable condition.

E. pauciflora association (snow gum). Is a low forest type and occupies one third of the Snow Lease section area; it is widely distributed on the upper slopes and ridges between 4,500 and 6,000 feet.

Included in the association is the dwarf snow gum, *E. niphophila, syn. E. pauciflora var. alpina*, which is better considered as merely the dwarf, small-leaved form of *E. pauciflora*, over 5,000 feet. As altitude increases, the snow gum becomes more stunted and the leaves smaller.

The association as a whole is classed as "forest." However, over the higher part of its range it is not true forest, but approaches the "woodland" formation of wider spaced, low branched trees, with discontinuous canopy.

The usual distribution is for high moor to occupy the colder lower slopes of the valleys, and snow gum the upper slopes and ridges, with perhaps a belt of alpine ash between the two. As altitude increases the proportion of snow gum forest to high moor decreases, until over 5,500 feet the snow gum is limited to ragged patches amongst the boulder outcrops on the ridges. The upper limit is over 6,000 feet. The timber line on the exposed western slopes is somewhat lower.

Precipitation is probably over 60 inches, a large part of it snow, which may lie up to several months in winter. Temperatures are cool in summer, and cold to very cold in winter.

Soil is generally of granitic origin and very deep; there are several inches of dark brown to black humus loam over a brown loam, with light yellow or yellow brown sandy loam subsoil.

The association occurs as a pure stand. Trees are only 20 to 40 feet high, 10 feet high on the most exposed sites, and 10 to 35 inches in diameter. They are commonly low branched, crooked, and twisted. Undergrowth is very light, consisting of scattered shrubs, one to four feet high. There is excellent snow grass cover.

The association provides good grazing.

Fire Damage.—Snow gum is very fire sensitive, and practically all the snow gum areas show either severe or moderate damage.

(i) *Moderate*: Semi-cleared. About one third of the total area. In the past this type has been subjected to frequent light fires to burn off grass and suppress scrub, as well as to the occasional severe fires. This has resulted in killing of more than half the old crop trees, and reduction of the stand to a savannah woodland. Practically all the remaining trees are butt scarred and gradually dying out. There is scattered seedling regeneration, several feet high, sufficient to restock the stands, and in the absence of fires this moderately damaged snow gum type will gradually revert to the original forest condition. Growth is very slow and many seedlings are killed by periodic light fires.

(ii) *Severe*: Coppice. On steeper slopes, where fires are more severe, there are very extensive areas over which all old crop trees have been killed and replaced by a dense regrowth of coppice. The coppice comes up abundantly at ground level from the butts of the fire killed trees. The regrowth is commonly almost impenetrable.

This type of damage has occurred over half the snow gum area.

Occasionally there are patches where old trees have been killed completely, but with no subsequent coppice growth, and the area has regenerated densely by seed.

At the higher altitudes, the coppice growth is more scattered and open, due probably to the rigorous winter conditions.

Fig. 16.—Alpine grassland. A " scour " in the deep humus soil.

Fig. 17.—Snow grass (*Poa caespitosa*). No sheet erosion.

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Further severe fire in these areas of dense coppice can be expected to leave large areas bare of tree cover.

(iii) *Extreme*: Cleared. On a limited area, the fire damage mentioned above has gone a step further and the stand reduced to grassland with only very occasional old crop trees.

Erosion.—Light sheeting, sometimes moderate, may occur on the semi-cleared woodland areas, when the grass and litter is burned. Otherwise sheeting is negligible.

On the coppiced areas sheeting is very variable, light to severe, over small distances. Little grass, if any, establishes, so that where soil structure has been broken down by burning of the high organic content there are numerous small unstabilised masses of moving soil. This is evident especially on the north and west aspects where the light soil dries out rapidly. On the east and south aspects soil moisture remains higher and the soil is more stable.

After a time (several years) these areas become covered by litter and a certain amount of grass establishes, and they are stabilised. Nevertheless, the balance remains very fine, and always liable to be upset by a light fire.

There is a strong probability that more severe fires will leave much of the coppice regrowth areas completely bare of timber. The coppice is only small and will take many years to grow to mature condition. In the meantime, because of its density and small size, it is vulnerable to fire.

The steepness of these exposed slopes makes it impossible for the soil to be held effectively by snow grass tussocks alone, particularly if the grass is to be burned every few years.

Sawfly Damage.—Mention might be made of a few areas, aggregating several hundred acres, where snow gum has been completely killed by sawfly larvae. Altitude is about 5,800 feet and topography hilly rather than steep. The larvae strip all foliage from mature trees, and later attack and kill any coppice shoots which appear. Strong snow grass cover has established good surface protection.

ALPINE WOODY SHRUB FORMATION (OR HIGH MOOR).

This formation was probably the climax vegetation type covering large areas at high altitudes. The shrub species are very fire sensitive and by systematic burning, practically all the type has been converted to snow grass pasture (Poa caespitosa), only scattered individuals and patches of shrubs remaining.

Exactly how much of these areas was originally shrub, and how much was grass is not clear, but it is considered that the greater part was dominated by a close formation of shrubs, and that open snow grass was limited to the coldest, and low lying parts.

Very few of the shrub species are at all palatable to stock.

The main weight of the Snow Lease grazing falls on this formation, together with the higher alpine grassland formation, and the semi-cleared snow gum woodland.

Bossiaea foliosa—Epacris petrophila—etc. association.

Occupies the undulating and hilly bottomlands and lower slopes of the valleys, between 4,000 and 5,000 feet. It increases from only a narrow strip along the creeks at 4,000 feet, to extensive open plain between 4,500 and 5,000 feet. Above the shrub association, on the upper slopes and ridges, is snow gum forest or woodland. There may often be a belt of alpine ash between the two.

The factor determining the occurrence of the shrub type seems to be temperature. Snow drifts are deepest and remain longest on these lower slopes and bottomlands, and it seems probable that the shrub association occupies the areas which are too cold for the survival of snow gum.

Total area is somewhere about 13,000 acres, but is difficult to assess because the association is very broken and widely dispersed. Most of the type is in the Tooma River valley, with smaller areas south of Kosciusko.

Precipitation is over 60 inches per year. Temperatures are cool in summer, with frequent frosts, and cold to very cold in winter when snow falls lie one to several months. Climate is probably very similar to that at Kiandra.

The soil is characterised by a surface horizon of one foot or more of brown humus loam. This humus soil develops on all rock formations and seems independent of parent material type. Underlying it is usually a deep, light brown or yellow brown clay loam, with numerous small rock fragments. There are occasional surface boulders.

The shrub association has several dominant and subdominant species, distribution of which depends on local soil and microclimate conditions, and also to some extent on previous burning and grazing practice. Composition of the association is therefore very variable, and furthermore, varies from one locality to another.

The shrubs develop a closed formation from two to five feet high. The species are generally erect and not particularly compact in habit. Stems are woody, but fairly slender, except for a thick main stem.

Small alluvial flats and the bog type minor watercourses are occupied by various minor shrub and hydrophyte communities. Although these are quite an appreciable proportion of the area, they are considered essentially part of the main association.

Effect of Fire.—The shrub species are rather inflammable of themselves and are also very fire sensitive. Over the greater part they have been killed by systematic burning, and have been replaced by snow grass pasture.

However, if not burned for several years, patches of shrubs rapidly regenerate from seed and encroach on the grassland, suppressing the pasture. Consequently the stockmen burn patches regularly. Nevertheleiss it has been noted that the shrubs come in strongly mainly on moderately sheeting steeper slopes—that is, where they are of value in reducing sheeting.

Erosion.—Except for some limited scouring along main stock tracks, there is no gully erosion.

Sheet erosion is in general absent or light on undulating and hilly slopes, but moderate on steep slopes.

Sheeting of the light, friable soil is easily initiated by stock trampling, grazing, or burning. On this shrub association, bare soil surface is usually colonised fairly rapidly by various annual Compositae, sorrel, and other small ground species. Sheeting is therefore controlled before much depth of soil is removed.

(Sheet erosion on snow grass grassland is discussed more fully in the following section.)

Case Moth Damage.—At the higher elevations, about 5,000 feet, several extensive areas of grassland have been completely killed by case moth larvae, and are moderately to severely sheeting.

(Discussed more fully in next section.)

Watercourses.—Streams are on gentle gradients, slow and meandering. Banks are well protected by shrubs and water plants, and are stable.

Minor watercourses are of a boggy, swampy type, a chain or two wide, with peat soil several feet deep. They have been little affected by fire or stock, and are in excellent condition.

Prostanthera cuneata—Orites lancifolia—Phebalium ovatifolium—etc. association.

Occupies about 22,000 acres and occurs between 5,000 and 6,000 feet, most of it being in a large, unbroken area on the hilly plateau at the head of the Swampy Plain River. It also extends down the Divide as far as Kosciusko, forming a belt between the upper limit of the snow gum and the lower limit of the alpine grassland formation. On the plateau area patches of snow gum persist only on the warmer rocky ridges. The shrubs may go somewhat higher than 6,000 feet on warm, sheltered north-west slopes.

Precipitation is probably about 70 inches per year. The greater part would be snow, which lies for several months in winter. Frosts are common during summer. Temperature ranges would be similar to those at Kosciusko Chalet.

The soil has a characteristic upper horizon of dark-brown to black humus loam. There are frequent boulder outcrops on ridges and scattered boulders and rock fragments are numerous throughout the area.

The association is made up of several main dominant species, the proportionate occurrence of which varies with altitude. Thus composition is by no means constant. Large areas of the one species commonly occur pure. All species have a compact, spreading, rather recumbent habit, and have heavy woody stems. Height is two to four feet. The shrubs grow in close formation, with practically no grass or herb layer. Beneath the stand develops a thick bed of fragmentary litter of decomposing small leaves and twigs.

Several hydrophyte communities occur on lowlying small swampy flats and on boggy type watercourses.

Effect of Fire.—The close shrub formation with its mass of ground litter burns readily, and the shrubs, being very fire sensitive, are easily killed. Systematic burning has converted nearly all the area to snow grass grassland. Scattered individuals and occasional small patches of shrubs still persist.

The snow grass seems permanently established. Shrub encroachment, if any, is very slow. Burning is therefore no longer practised to suppress the shrubs.

Grass growth is very vigorous and gives excellent grazing, better than on the lower shrub association.

Erosion.—Fairly extensive deep moderate sheeting is evident over a great part. Generally sheeting is lighter, often negligible, on the south and east slopes, where soil moisture remains high and snow grass tussocks form a dense cover. But serious sheeting is taking place over the remainder, on hilly and undulating as well as on steep slopes.

Soil between tussocks has been removed to a depth of two to six inches. Although erosion is deep, there is still approximately a fifty per cent. surface area of grass, and the sheeting is classed as moderate. Very small areas of severe sheeting, where tussocks occupy only about twenty per cent. of the surface area, occur on open undulating areas.

Snow grass has a tussocky habit, and never forms an interlocked pasture, the surface between the large, vigorous tussocks being covered by the overhanging growth. The deep, humus loam soil is light and uncompacted. It dries out rapidly where exposed, becoming very loose and powdery. Therefore bare soil surface is highly erodible.

Factors initiating erosion are burning, grazing and trampling, and casemoth damage.

(i) *Burning.* Although formerly a widespread annual practice to destroy old rank grass and to bring on a young, sweet growth for the following season, burning of snow grass is not now commonly undertaken. Nevertheless, it would seem that the previous burning is responsible for a large part of the present erosion.

When fired, the tussocks are burned back to a short stubble, leaving a large proportion of bare unprotected soil surface. Furthermore, the organic fraction of the soil itself is partly burned, destroying its structure and reducing it to a loose, friable, highly unstable condition. The soil is then very vulnerable, and rapidly eroded by heavy rain, until the new growth of grass develops. Stock do quite well on unburned pasture, even though many stockmen prefer the succulent young growth of burned pasture.

(ii) *Grazing and Trampling.* It is probable that in the past the Snow Leases have been subjected to periodic seasons of very heavy stocking, due to drought conditions elsewhere, and the pastures seriously overgrazed. Due to the present regulation of the stocking of leases, this is now precluded, but it probably has contributed considerably to the present deteriorated pasture conditions.

In my opinion, far more serious than the grazing is the trampling effect of stock. Trampling cuts away the very soft soil between the tussocks, and once the grass root mass is broken through, and sheeting initiated, it is difficult to arrest. Especially

serious is the trampling effect on already deeply eroded areas, where both sheep and cattle walk on the bare soil surface, preventing recovery and gradually worsening the condition. It is noted that habitually sheep grazed areas are generally in poorer condition than cattle grazed, which is very likely largely due to the more severe cutting effect of the smaller hooves.

(iii) *Casemoth Damage.* Discussed under separate heading.

Once deteriorated, recovery of snow grass pasture is very slow. Unlike other pasture types, which have a vigorous winter growth period under favourable conditions, the snow grass must remain dormant during winter and rely on summer growth, the period when it is under grazing and when rainfall is often unreliable.

Any exposed soil surface is kept in a more or less continual state of instability. Frequent frosts loosen the surface, the high organic content of the soil absorbs and retains moisture, keeping it uncompacted, and exposed soil readily dries out becoming loose and powdery.

Colonisation of this unstable soil is difficult. Although sorrel and a few annuals establish on favourable sites, their effect is small, and snow grass, or gradual growth of shrubs, must be relied on to slowly regenerate the sheeted areas from seed.

If the snow grass areas are to be stablised, it is thus essential that complete grass cover be established, and then permanently maintained. Recovery of an area allowed to degenerate cannot be expected in a year, or even in five years.

Casemoth Damage.—A most disturbing feature in the snow grass country is the widespread damage done by concentrations of casemoth larvae (*Plutorectis caespitosae*). Throughout this association area are frequent patches of dead grass, from several acres to a hundred acres in extent, killed by the larvae. The grass is completely killed, leaving only the dry stubble, which slowly disintegrates. No grass returns, and the areas are gradually recolonised, over several seasons, by woody shrubs.

During the interim between decomposition of the dead grass and colonisation by shrubs, the soil surface is exposed, and is extensively deeply sheeted. It probably is many years before a strong shrub cover is established.

The larvae are present in millions and radiate from an original centre, each year spreading further out from the perimeter of the previous year's growth. The only effective control so far appears to be burning the perimeter of the dead patches during February and March, when the larvae are almost mature but before pupation. Burning earlier may not be possible, because the grass where the larvae are working, is not killed and dried out enough to burn until they have been feeding on it for some time. Another form of control is highly desirable, however, because of the evil effects of burning as indicated above.

Watercourses.—These are on gentle gradients. They are rocky, with numerous boulders and irregular rock fragments. Banks are generally well protected by snow grass and low shrubs.

Small creeks and soaks are somewhat boggy, but narrower and less extensive than those in the lower shrub association, and have a distinct, rocky, central channel. These raised bogs and small moss beds are in good condition.

Along the main streams, fairly large areas of previously swampy flats are now dried out, probably following burning and grazing, and are sometimes sheet eroding.

ALPINE GRASSLAND FORMATION.

Poa caespitosa—Celmisia longifolia association

(*snow grass—tufted snow daisy*).

Is a climax grassland and occupies all the highest elevations, 6,000 to 7,300 feet. It occurs in the one compact area of about 10,000 acres on the Kosciusko Massif, the only other occurrences being a few areas on the highest ridges between Kosciusko and Jagungal.

Precipitation would probably be over 70 inches a year. Snow covers the ground for almost six months, a few small drifts usually remaining all the year. The area is exposed to very strong cold winds reaching gale force. For much of the time it is covered by low misty cloud. Temperatures are cool to cold in summer, and very cold in winter.

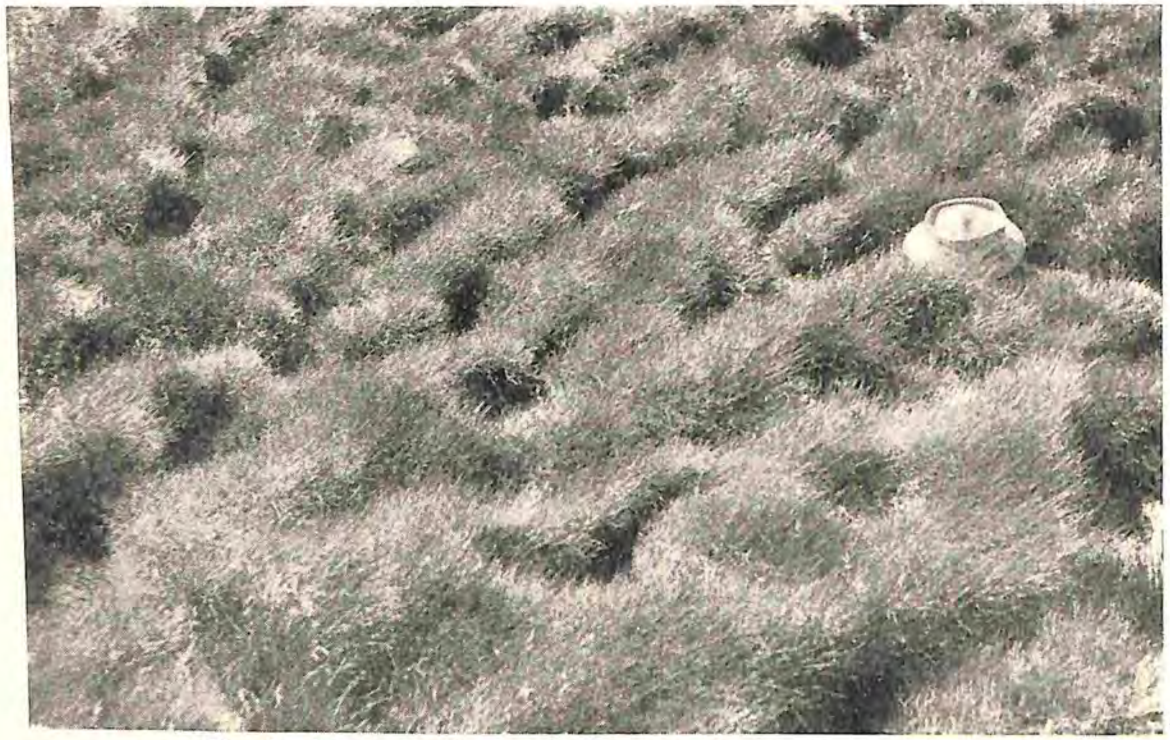

Fig. 18.—Snow grass (*Poa caespitosa*) country, showing light sheet erosion.

Fig. 19.—Snow grass (*Poa caesp''osa*), showing moderate sheet erosion.

Soil is a dark brown humus loam, one to two feet deep, underlain by a brown to yellow clay loam, or light clay, subsoil, varying from a few feet to only a few inches deep, and several feet of decomposed granite. Small rock fragments are numerous in the subsoil. The whole area is strewn with boulders and large rock fragments. High rock outcrops are extensive on the ridges.

The grassland includes a considerable area, up to fifty per cent., of dense pure beds of "snow daisy," a low tufted perennial Composite. Quite a number of annuals, mostly Compositae, are present. With the snow grass, and very similar to it in appearance, is often a considerable percentage of the coarse grass, *Danthonia nudiflora.*

This association is a true climax grassland, as distinct from the disclimax grassland, which, as a result of burning, has replaced the original climax shrub associations of lower altitudes.

Erosion.—Undulating, hilly, and steep, south and east aspect slopes are reasonably stable. However, deep moderate sheeting is frequent on steep and some hilly, north and west slopes.

Sheeting is commonly six to ten inches deep between the grass tussocks. Once the grass root mass is broken through, the soil just seems to melt away.

Small areas often break down completely into "scours"; these are short, shallow, V-shaped gullies, eroded in the centre down to the subsoil. Snow grass finds it very difficult to stabilise the shifting, rapid drying soil.

Initiating causes and general features are similar to those previously mentioned for the grassland on the upper high moor association. Trampling by stock, especially on minor tracks, is most likely the major contributing factor.

Casemoth damage on this grassland association is not as severe as on the grassland occupying the high moor association site. Only about fifty per cent., or less, of the tussocks are killed, the remainder recovering. Nevertheless much of the deep sheeting, and scouring, can be attributed to this damage.

Wind erosion is restricted to a few small areas of very severe wind erosion, several acres in extent, along the fairly flat parts of the top of the Divide. Soil has been removed to the C horizon, a depth of one to two feet. Colonisation by plant species is extremely difficult on the exposed, bare surface, and is absent except on the leeward parts, where a species of the Compositae may form a matlike cover.

The occurrence of wind erosion is slight on granite formation, but severe on slate. Whereas granite provides numerous boulders and surface fragments which give good wind protection, the slate breaks down to small fragments, and leaves the ground surface unprotected.

Wind eroded areas spread easily and are only restricted by topographical limits. Initiating factors require further investigation.

Watercourses.—These are very rocky, almost cascades. They are protected by the boulders and rocks, and a strong growth of low hydrophytes.

FIRE OCCURRENCE.

It is quite safe to say that 99 per cent. of the fires in the mountains are started by a match, most deliberately, a few accidentally.

Fires may be divided into two classes, light and severe.

Light Fires.

These are fires that destroy litter and a certain amount of undergrowth and grass, but, while damaging mature trees and killing young tree growth, are not of sufficient intensity to kill many mature trees.

Even so, it must be emphasised that damage from successive light fires cannot be ignored as of little consequence. The widely held opinion that a light fire does no harm is a very dangerous one.

Butt scars are burned deeper and deeper into the trunks. Crowns are burned, partly destroyed, and gradually degenerated. Termites enter through fire scars and reduce trunks to a mere outer shell. Thus the mature trees are slowly weakened and killed out. At the same time, the seedling and sapling regeneration is destroyed so that there is no regrowth to restock the stands.

Fig. 20.—Snow grass (*Poa caespitosa*) country, showing moderate/severe sheet erosion. The elevation is about 6,000 feet.

Fig. 21.—Snow grass (*Poa caespitosa*). View of moderately sheeting hillside at about 5,500 feet.

Again, considering the soil, by frequent destruction of litter and undergrowth, the soil surface is kept continuously unstable. Especially on the deep loam forest soils, each successive fire, with the consequent sheeting, further lowers the capacity of the soil to support adequate vegetation cover.

The process of degeneration is slow and may hardly be noticed, but the cumulative effect is inevitable. It leads to heavy erosion and siltation, denudation, and increasingly severe floods.

Light fires originate either on the lower country around Groggin, Geehi and Khancoban, or on the Snow Leases themselves. On the Snow Leases, fires may be started to burn off grass, or to suppress tree and shrub growth. The practice is not nearly so common as it has previously been, but would be better avoided altogether.

On the lower country, mostly held under Permissive Occupancy, a frequent practice is to burn off undergrowth in an attempt to promote better grazing. It is also common to clear a patch of scrub or fallen timber debris off the stock routes and tracks by dropping a match into it. While greatly damaging the timber on the lower foothills, these fires do not often penetrate far into the higher Snow Lease forest.

Severe Fires.

These are the occasional big fires, which sweep into the mountains every ten years or so, during a very dry summer, and do tremendous damage to the alpine ash and snow gum forests.

They usually start well outside the mountain country, on the freehold of the Upper Murray Valley, or perhaps in Geehi or Groggin. As with the 1939 fire, on a "blow-up" day they may travel fifty miles to the mountains in a period of hours.

Severe fires make a clean sweep of litter, grass, undergrowth, and the smaller trees. Most of the mature trees are killed, the remainder badly damaged.

Severe fires on record occurred in 1918, 1926, 1929 and 1939, all during January. The seasonal period of major fire hazard is late December, January and early February.

CONCLUSIONS.

Stabilisation of the Snow Lease section of the Catchment requires two measures. Firstly, rehabilitation of the snow grass grassland, and prevention of further damage. Secondly, the elimination of all fires.

(i) To ensure recovery of the grassland, I consider that reduction of stocking on the sheeted areas will be necessary. Furthermore, future stocking rate must be regulated and never allowed to rise above a safe maximum, and again deteriorate the pastures.

If the practice of light burning can be eliminated altogether, then one of the main initiating causes of past erosion will be removed.

(ii) As regards fires, practically all the light fires would be prevented if the landholders and stockmen of the district could be educated to realise the damage done by frequent burning of forest, and persuaded to abandon indiscriminate use of the match. Regular cleaning of the stock routes and main tracks would go a long way towards reducing the necessity for burning of obstructions.

The main danger is from the periodic severe fire, which comes into the mountains from well outside. This type of fire can only be suppressed by direct action, preferably before it reaches the main forest country, or if this is not possible, in the mountains themselves. Such suppression cannot be expected without detailed organisation of manpower, equipment and access routes, well beforehand.

Finally, it can be said that degradation of these mountain areas is still in the early stages. Nevertheless, evidence in other countries, especially those bordering the Mediterranean, shows clearly the absolute denudation of mountains that can result from uncontrolled grazing and fires. Prevention is relatively easy.

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SOIL CONSERVATION IN NEW ENGLAND.

Laurel Dale Demonstration, Armidale.

BY

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EXTENDING the activities of the Soil Conservation Service in the northern sector of New South Wales, the Laurel Dale Demonstration was undertaken as the first in the New England district. This demonstration was carried out at the Armidale University Farm. Prior to the addition of this farm to the University the land was cultivated for many years; the main crops sown were maize and oats for green feed and fodder conservation.

The farm includes cultivation and grazing areas on rather hilly to undulating country. Most of the cultivation is on steep slopes falling from stony hills. Most of the arable land is of basalt origin, and the main cultivation areas are the black self-mulching soils, typical of many of the higher New England areas.

EROSION PRESENT.

Although the erosion problem was not particularly serious, it was evident that sheet erosion had been going on for some years causing silt deposits on the lower levels and in existing dams. Several minor gullies and one deep gully were present on the older cultivation areas, caused by the loss of soil by running water. The farm was treated at this early stage, which is undoubtedly the best time, as most of the top soil was still left. Unless control measures are carried out early, valuable top soil is lost from the area. In most cases this top soil is lost forever, or is deposited on the lower areas where it is not needed for the production of crops.

CLIMATE.

Armidale is situated at a height of 3,265 feet above sea level, and the severe winters experienced are a major set-back to permanent soil cover. The absence of good soil cover during the winter is due to the slow growth of all species; no growth is evident in summer growing perennials and the annuals are set back after the first few frosts. The establishment of winter growing species are a necessity in these colder areas.

The 1949 rainfall at Armidale of 49.92 inches exceeded the 1948 reading by more than 20 inches. Two-thirds of the years rainfall was recorded during the last half of the year, when more than 32 inches of rain fell. Heaviest falls in 1949 were recorded in August, when the total of 11.33 inches created an all time record. In October there were 6.35 inches, and November 5.39 inches.

The monthly average for 1949 was 4.16 inches, as compared with 2.44 for 1948 and 3.27 for 1947.

CONTROL MEASURES.

The control measures on this Demonstration consisted of the following:—

Diversion Banks.—These were constructed on a 0.25 per cent. grade as high up the slope as was practicable, with the earth moving equipment available, to carry the run-off water from the grassed areas above each paddock into well grassed natural

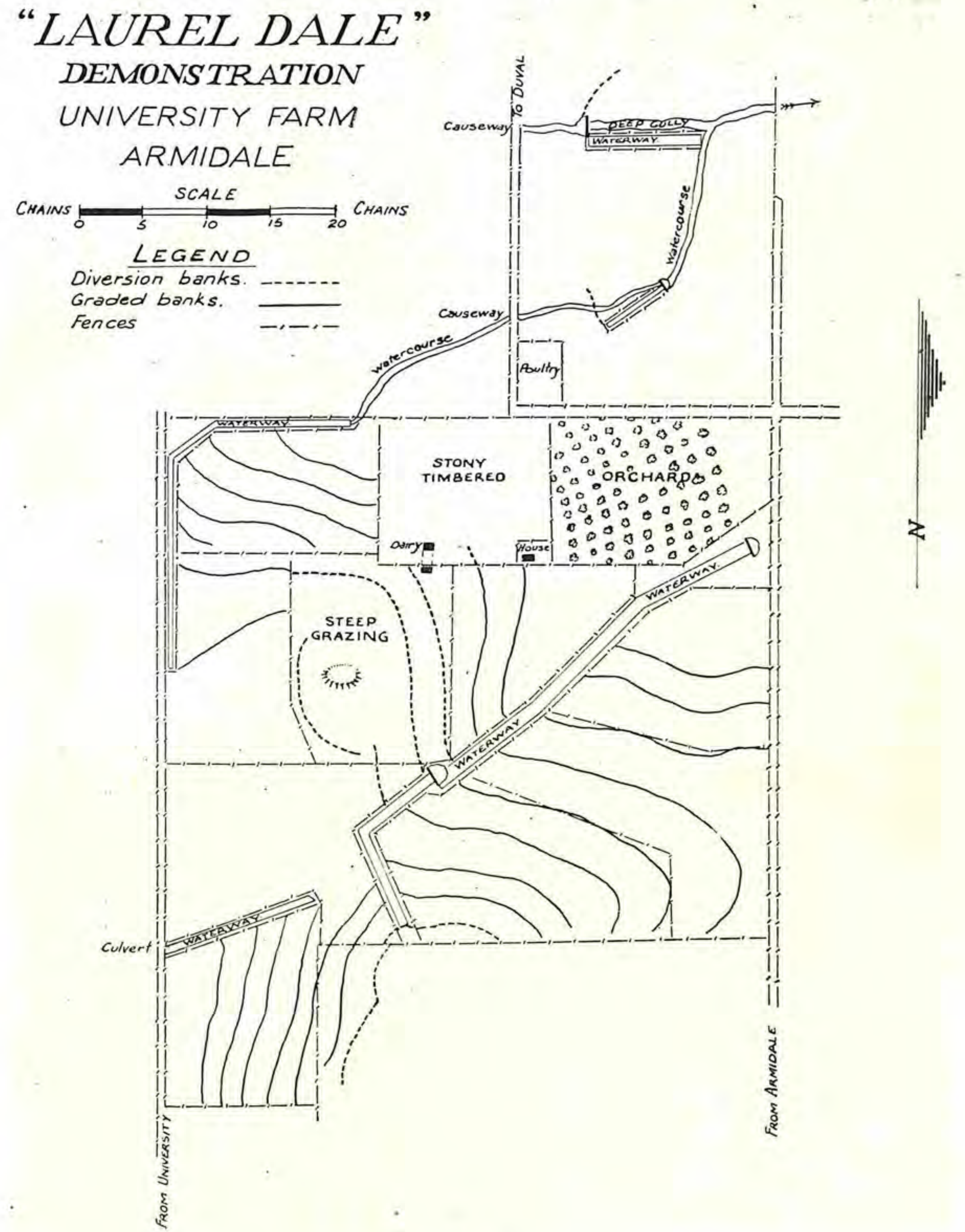

Fig. 1.

waterways or watercourses leading to existing, or constructed dams. The largest possible catchment was given to these dams to provide an adequate water supply for the farm.

Graded Banks.—A total length of 363 chains of these banks were constructed throughout the cultivation areas. The banks were of the broad-based type with flat channels common in most parts of the State, and were built on a grade of 0.25 per cent. The banks discharge the excess water from the cultivation areas into the waterways and then to the dams shown in Fig. 1.

Pasture Improvement.—As the farm is used mainly for grazing with dairy cattle and sheep, permanent and temporary pastures play an important part in both farm management and soil conservation. New pastures are being sown and the existing ones improved. See Fig. 4.

On the unimproved grazing land such species as Wallaby Grass (*Danthonia semi-annularis*), Barley Grass (*Hordeum leporinum*), Prairie Grass (*Bromus unioloides*), Kentucky Blue (*Poa pratensis*), and Windmill (*Chloris* spp.) are found. The *Danthonia* grasses are the best native winter grasses of New England and are being encouraged in every way possible on the farm.

A striking contrast to the native pasture areas is presented where introduced plants are established, this being due to the "mat formation" character of the introduced species.

The most useful of these introduced species are:—

Paspalum dilatatum, Couch grass (*Cynodon dactylon*), Toowoomba canary grass (*Phalaris tuberosa*), Cocksfoot (*Dactylis glomerata*), Perennial rye grass (*Lolium

Fig. 2.—A well-grassed natural waterway at " Laurel Dale."

perenne), Tall fescue (*Festuca elatior*), Wimmera rye grass (*Lolium rigidum*), Perrenial red clover (*Trifolium pratense*), White clover (*Trifolium repens*), Subterranean clover (*Trifolium subterraneum*) and Black medic (*Medicago lupulina*).

Fencing Programme.—The Demonstration is fenced as nearly as possible on the contour or at right angles to it, and along the waterways, forming paddocks of approximately equal area. This allows judicious rotational grazing to be carried out with the stock present on the farm using the hill shown on Fig. 1 as an overnight camp.

This method of stocking enables each pasture paddock to receive the required care, as the species in certain pastures or the pastures themselves are not "flogged out" as happens in most cases. By keeping an ample cover on the soil the landholders work away from erosion and not towards it.

The waterways on this particular Demonstration were not graded to a level cross-section owing to the abundance of cover produced by clovers and grasses, and the satisfactory cross-section of the natural drainage lines which were used as waterways. Rather than destroy this good cover, which is necessary for a waterway, by ploughing and grading, a cross-sectional area was obtained as level as possible and levee banks thrown up on either side from outside the edges of the waterway. The levee banks varied a little from the true level in most cases by one to two inches, and the waterway itself had a slight depression along its centre line.

The waterways are a good demonstration of what can be done with depressions and stabilised watercourses in the New England district.

Dams.—Dam No. 1 was situated in a central position to allow for watering of adjoining paddocks, and for a supply to the

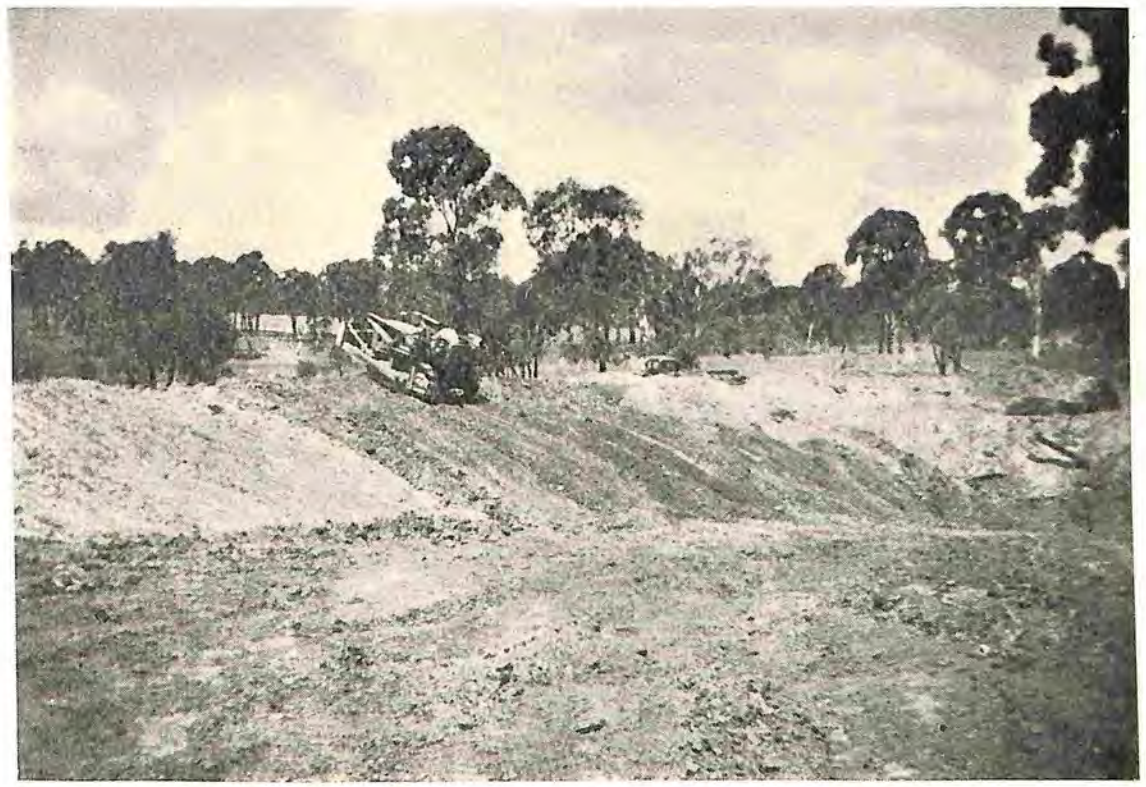

Fig. 3.—" Gully Block " dam under construction.

dairy by gravitation, as underground water could not be obtained. The dam is shown in Fig. 2. The overflow from this continued down a well grassed waterway to an existing dam on the lower boundary fence line.

Dam No. 2 was situated in a gully ten to twelve feet deep (see Figs. 3 and 5). The dam was constructed by the erection of a wall across the gully utilising the gully as a water storage basin. This dam provided a safe inlet for water from grazing land above with the spillway leading into dense natural pasture and re-entering the natural watercourse at a stable point. This dam prevented further gully erosion and provided water for stock in the natural pasture grazing paddock.

TREE PLANTING.

A tree planting programme will also be carried out on the Demonstration, including windbreaks, shade and shelter trees of suitable species to be established in existing woodlots and in additional areas.

CONCLUSION.

Laurel Dale is to be used in conjunction with the Animal Husbandry Course carried out at the University. The stock include dairy cattle, beef cattle, sheep, poultry and pigs. The sheep will be used for the production of fat lambs on the farm. It was realised from the outset by the University authorities that adequate soil conservation measures were necessary to arrest the erosion position and ensure the continuous productivity of the area.

Further to the livestock an orchard has been planted on the contour of the farm, arranged in co-operation with the Department of Agriculture.

The Soil Conservation Service appreciated the co-operation of the Warden and the Farm Manager in the establishment of this soil conservation demonstration.

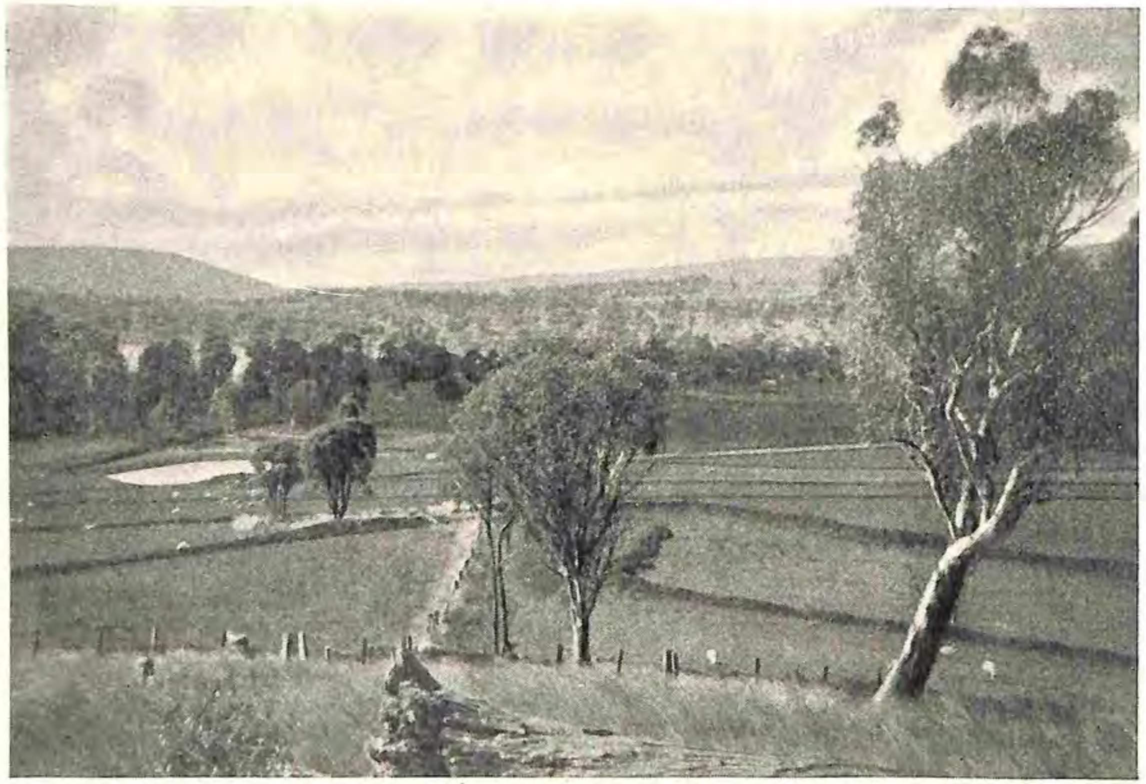

Fig. 4.—Sheep on red clover at " Laurel Dale."

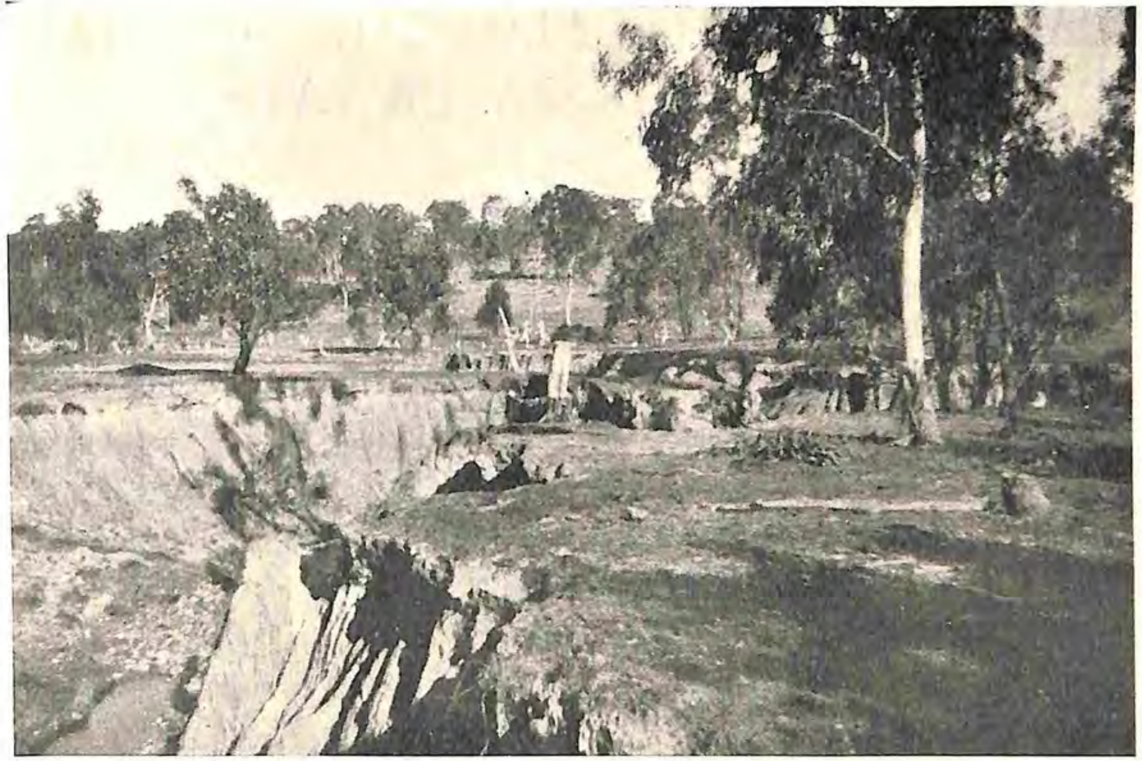

Fig. 5.—Severe gullying prior to soil conservation treatment.

ERRATA.

In Vol. 6. No. 4. p. 165, the areas shown on Fig. 4 should read: A = 4 acres; B = 16 acres; C = 28 acres; D = 24 acres; E = 15 acres; F = 14 acres and G = 4 acres.

On pp. 193, 194 and 195, captions were omitted. These should read—

Fig. 5.—Square planted orchard, illustrating how "across the slope" cultivation is not always successful in preventing erosion.

Fig. 6.—Square planted orchard contoured with large banks after planting to control erosion.

Fig. 7.—Contour-planted orchard. Heavy black lines show surveyed rows. Light black lines show assumed grade rows. Broken lines indicate short rows.

CALCULATION OF FLOWS IN GRADED BANKS AND WATERWAYS.

BY

J. DILLON, B.Sc.,Agr., Soil Conservationist.

It would appear that the need for a rapid method of calculation of flows in graded banks by Manning's formula is very great. At present there is available both an arithmetical and graphical solution of this formula. The former solution is rather too unwieldy for use by field officers and extension officers, and the latter is rather limited in accuracy. Also it is more often required to determine the design of bank required to cope with a certain flow of water than to find the amount of water discharged by a certain bank. To determine this by the present methods available involves considerable calculation.

Manning's formula as applied to discharge reads as follows:—

$$Q = \frac{a\ 1{\cdot}486\ R^{\frac{2}{3}} S^{\frac{1}{2}}}{n}$$

Where Q = carrying capacity or discharge in cubic feet per second.

a = cross sectional area of channel in square feet.

n = coefficient whose value depends on the degree of roughness or irregularity in the channel.

R = a/p = "hydraulic radius," which is the quotient of the cross sectional area divided by the "wetted perimeter," p. or length of the cross line of contact between the water and the channel sides and bottom.

S = grade or rate of fall in feet per foot.

This requirement has prompted the design of an instrument by the use of which any unknown factor in bank design can be rapidly solved. The principle of the instrument is a series of logarithmic circular scales on which the various factors are plotted and the scales then mounted concentrically. A transparent pointer (Fig. 1) rotates on the same axis.

The first scale A (Fig. 1) consists of a simple logarithmic scale from which discharge in cusecs is read. Adjacent to this is a scale B (Fig. 1) on which the grade of the channel is plotted. Actually $\sqrt{S}$ is plotted, but the scale is graduated as values of S, i.e., 0.25 per cent. indicates the position of $\sqrt{0.25}$ per cent. on the log scale. This considerably simplifies multiplication. This scale is a fixture relative to scale A, unity being coincident with 1.486 on scale A. The reason for this is that 1.486 is the only constant used in the formula.

The next disc is of slightly smaller diameter, such that when mounted on the first disc scales A and B are not obscured. On this is carried scale C, which is a reciprocal logarithmic scale showing various values of roughness coefficients. The use of a reciprocal scale enables this division to be carried out as a multiplication and reduces complications in calculation.

The final log scale is on a disc of still smaller diameter D (Fig. 1). This scale indicates the values of $\frac{a^{\frac{5}{3}}}{p^{\frac{2}{3}}}$ which in effect is area multiplied by hydraulic radius. The use of this factor eliminates the final multiplication of velocity by area to calculate discharge. This factor has been termed the AR factor, and its relation to area and wetted perimeter is found by reference to graph 1 (Fig. 2).

These scales are mounted concentrically in the order given with the pointer rotating on the same axis.

In graph 1 area is plotted against wetted perimeter logarithmically and lines joining points which give equal values for $\frac{a^{\frac{5}{3}}}{p^{\frac{2}{3}}}$ are plotted. It is obvious that many designs

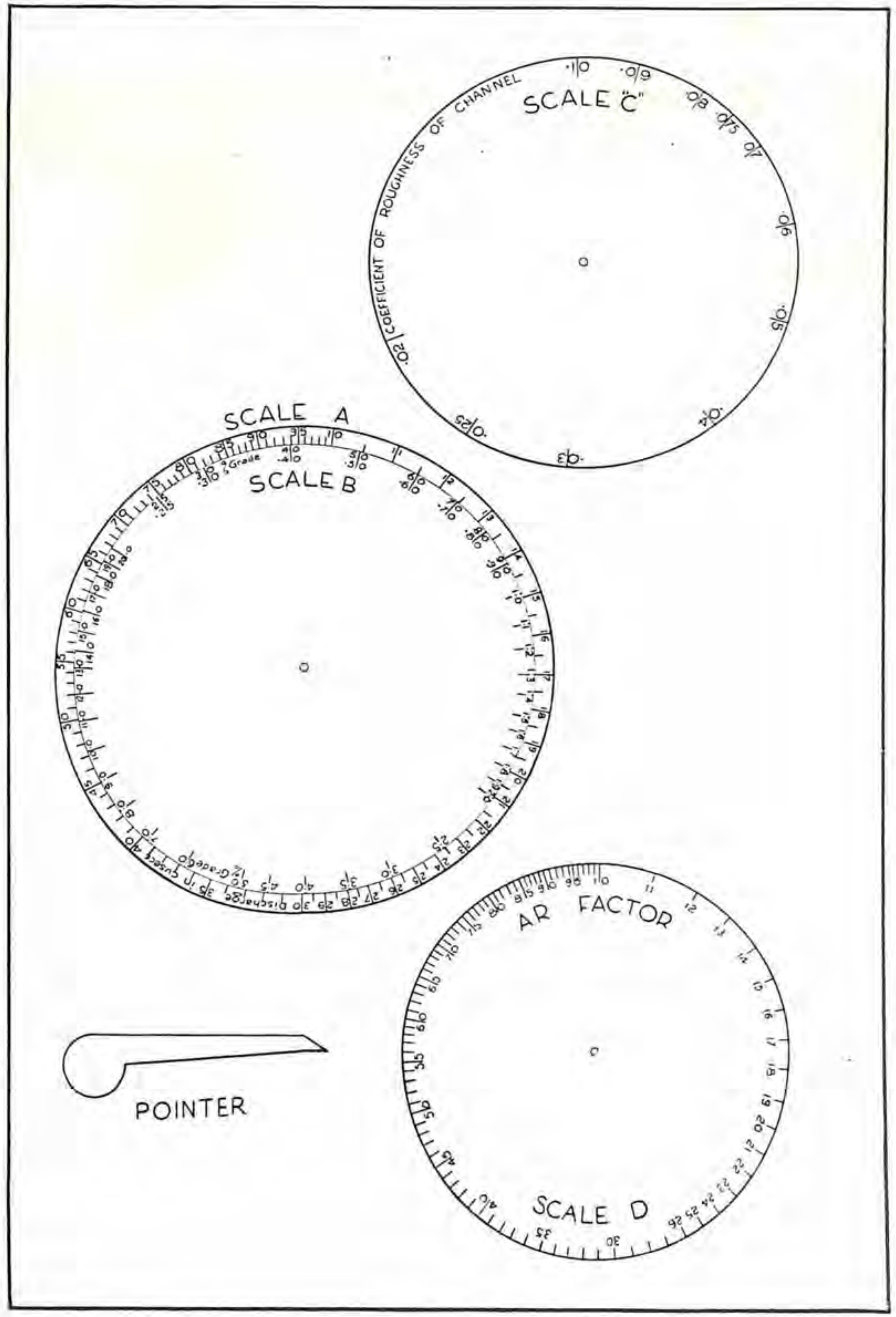

Fig. 1.

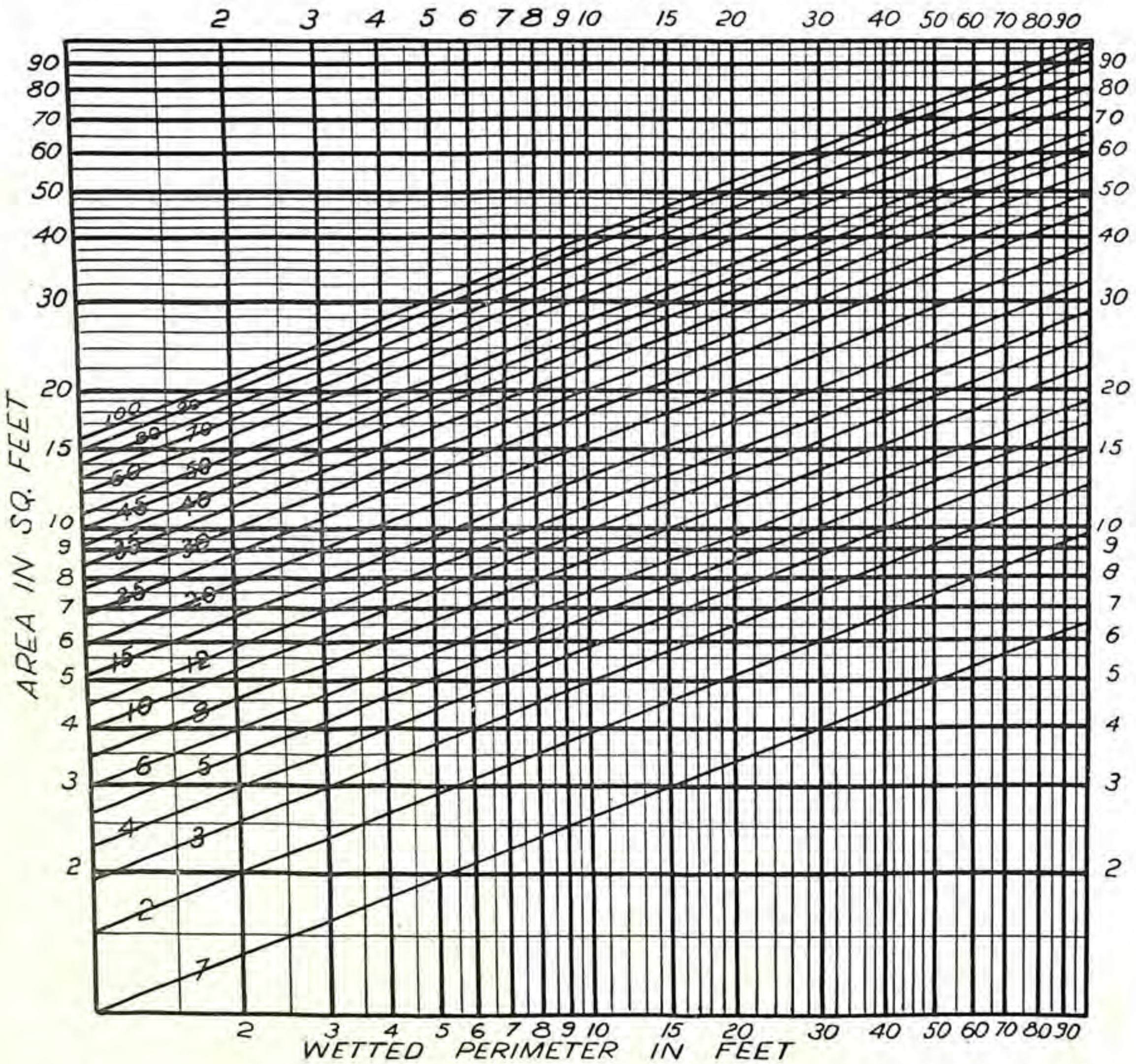

Fig. 2.—Graph 1, showing values of AR relative to cross-sectional area and wetted perimeter of a channel.

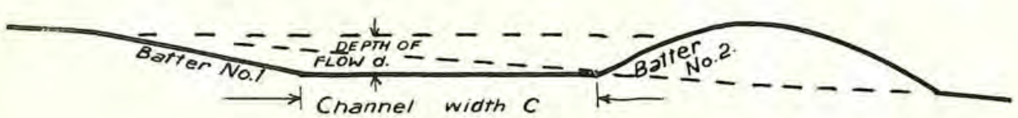

Fig. 3.—Typical cross-section of a graded bank.

of banks on the same grade will give equal discharge capacities and every design is shown on this graph, although of course some are impracticable. The hydraulic radius is arrived at by selecting a cross sectional area which when multiplied by the required velocity gives the total discharge for which provision is to be made.

Assuming that plant operation allows of four major designs of banks (Fig. 3) depending on the cross slope of land, graphs have been drawn to give area and wetted perimeters at different channel widths and depths of flow. It will be found that most banks approximate to one of these designs reasonably accurately. (Figs. 4, 5 and 6.) A further graph for waterways, with inside batters four to one, is shown in Fig. 7.

EXAMPLES.

The solution of a number of concrete examples by this method will serve to indicate the method of using the instrument.

Example 1.—Suppose it is required to ascertain the discharge of a grassed waterway which has been constructed down a 5 per cent. slope, of width 20 feet and having banks of sufficient height to allow water to flow safely at a depth of 1 foot. The roughness coefficient is assumed to be 0.05.

(*a*) by instrument.

From the graph Fig. 7, for a waterway of these dimensions $a = 24$ ft. and $p = 28$ ft.

From Fig. 2, AR value = 21.5

Set scale C of the instrument with unity coincident with 5 per cent. on scale B. Set scale D with unity coincident with 0.05 on scale C. Place the pointer on 21.5 on scale D. The discharge in cusecs is then read off on scale A as 144 cusecs.

(*b*) by arithmetical solution.

$$a = (20 + 20 + 4 + 4) \times \tfrac{1}{2}$$
$$= 24.$$
$$p = 20 + 2\sqrt{17} \times 1$$
$$= 28{\cdot}24$$
$$R = a/p = {\cdot}85$$

$$Q = \frac{a \; 1{\cdot}486 \; R^{\frac{2}{3}} \; S^{\frac{1}{2}}}{n}$$
$$= \frac{24 \times 1{\cdot}486 \times {\cdot}85^{\frac{2}{3}} \times {\cdot}05^{\frac{1}{2}}}{{\cdot}05}$$
$$= 143{\cdot}1 \text{ cusecs.}$$

Example 2.—Suppose it is required to find the dimensions of bank to be built by a bulldozer of discharge 15 cusecs on land of average cross slope 10 per cent.

It may be assumed that the No. 1 batter will be 5 to 1, and the No. 2 batter 3 to 1. The grade is to be 0.25 per cent., and the roughness coefficient is assumed to be 0.04. The required velocity is 1.5 ft./sec.

(*a*) by instrument.

Set scale C with unity coincident with 0.25 per cent. on scale B and set scale D with unity coincident with 0.04 on scale C. Set the pointer on scale A at 15, and the AR factor is found to be 8.2.

On Fig. 5 the point at which the line AR = 8.2 crosses $a = 10$ gives a channel of wetted perimeter of 14.

From Fig. 9 the intersection of $a = 10$ and $p = 14$ gives a bank with channel 4.5 ft. wide and depth of flow 1.15 ft.

(*b*) by arithmetical solution.

$$R^{\frac{2}{3}} = \frac{Q.\,n}{1{\cdot}486 \times a \times S^{\frac{1}{2}}}$$
$$= \frac{15 \times 0{\cdot}04}{1{\cdot}486 \times 10 \times 0{\cdot}25^{\frac{1}{2}}}$$

(cross sectional area will equal 10 sq. ft. since when multiplied by the velocity 1·5 a product of 15 cusecs must be obtained).

and R = 0·72.

Now $a/p = 0{\cdot}72$, and $a = 10$, therefore

$$p = \frac{10}{0{\cdot}72}$$
$$= 13{\cdot}9$$

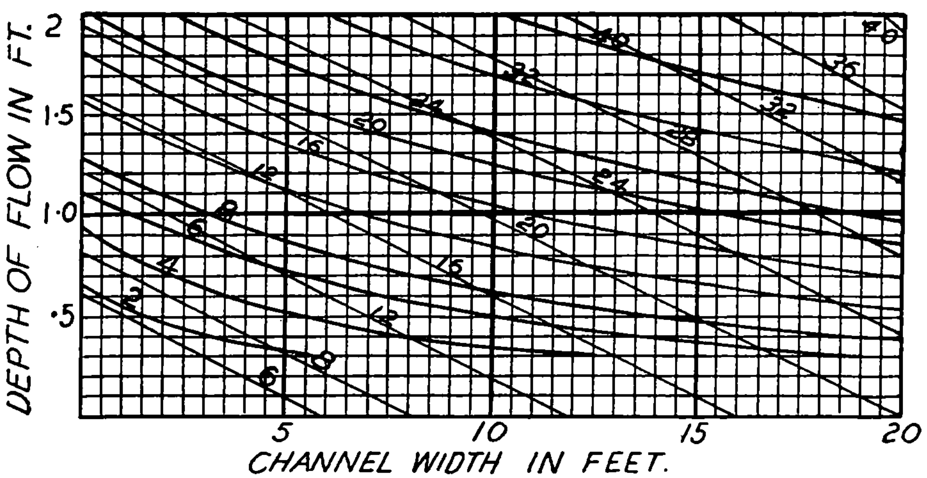

Fig. 4.—Graph showing " *a* " and " *p* " for various sizes of a bank, having a No. 1 batter of 7 to 1, and a No. 2 batter 5 to 1. A grader built bank on land of 5 per cent cross slope would approximate to this design.

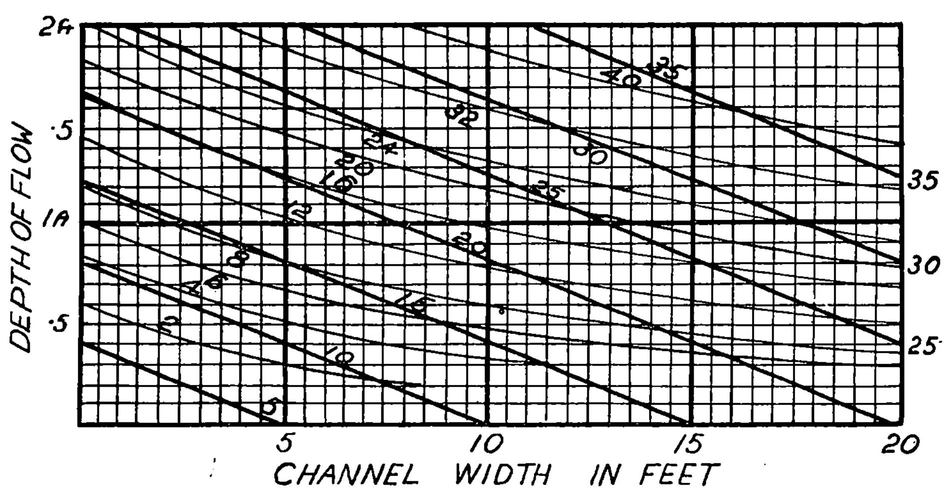

Fig. 5.—Graph showing " *a* " and " *p* " for various sizes of (*a*) bank with No. 1 and 2 batter 5 to 1—grader built bank on land of 10 per cent. cross slope would approximate to this design; (*b*) bank with No. 1 batter 7 to 1 and No. 2 batter 3 to 1—dozer built bank on land of 5 per cent. cross slope would approximate to this design.

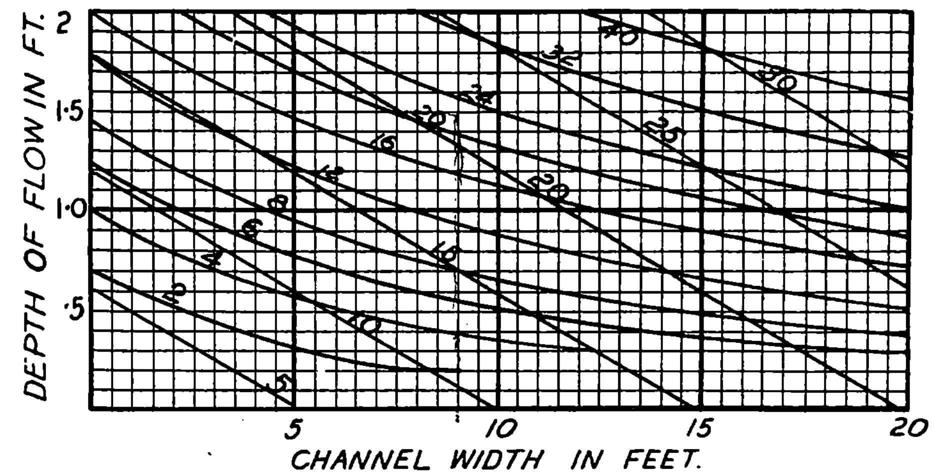

Fig. 6.—Graph showing " *a* " and " *p* " for various sizes of a bank with No. 1 batter 5 to 1, and No. 2 batter 3 to 1. A dozer built bank on land of 10 per cent. cross slope would approximate to this design.

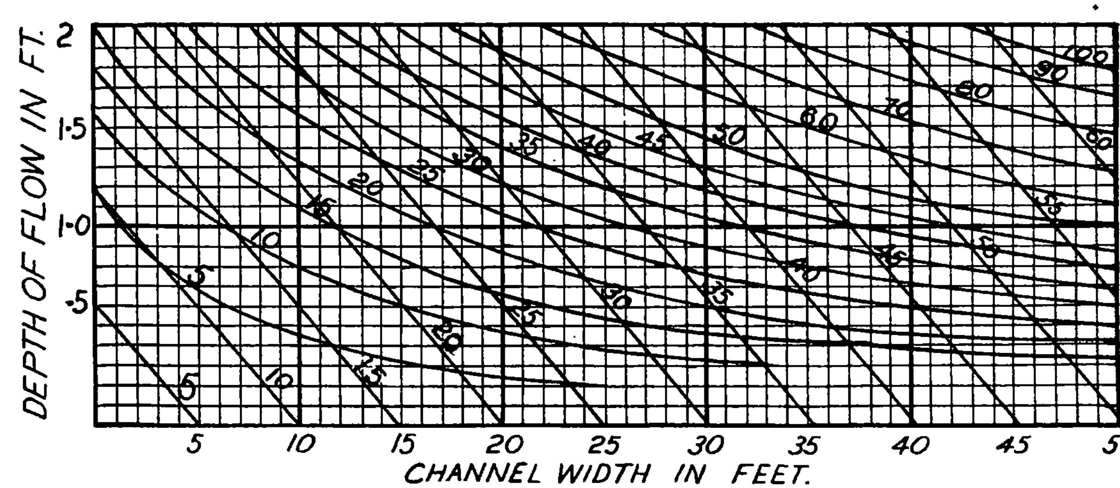

Fig. 7.—Graph showing " *a* " and " *p* " for various sizes of waterways with batters 4 to 1. In Figs. 4, 5, 6, 7 " *a* " is represented by the curved line, " *p* " by the straight line.

also $p = c + 2\sqrt{17}d$ where c is the channe width and d the depth of flow

$$\therefore 13{\cdot}9 = c + 8{\cdot}24d$$
$$\therefore c = 13{\cdot}9 - 8{\cdot}24d$$

now $a = (2c + 8d) \times \frac{d}{2}$ (from the area of a trapezium)

substituting for c,

$$10 = (13{\cdot}9 - 8{\cdot}24d + 4d)\, d$$

which simplifies to

$$4{\cdot}24d^2 - 13{\cdot}9d + 10 = 0.$$

$$d = \frac{13{\cdot}9 \pm \sqrt{13{\cdot}9^2 - 4 \times 10 \times 4{\cdot}24}}{2 \times 4{\cdot}24}$$
$$= \underline{1{\cdot}1 \text{ ft.}}$$
$$\text{and } c = 13{\cdot}9 - 8{\cdot}24 \times 1{\cdot}1$$
$$= \underline{4{\cdot}8 \text{ ft.}}$$

Thus the channel width would be 4.8 feet and the depth of flow 1.1 feet.

Example 3.—Suppose it is required to determine the grade on which to place a bank having a No. 1 batter of 7 to 1, a No. 2 batter of 5 to 1, a 10 feet channel and capable of carrying water flowing one foot deep so that it will discharge 25 cusecs. $n = 0.04$.

(a) by instrument.

From Fig. 4, $a = 16.0$ sq. ft. and $p = 22.5$ ft.

From Fig 2, the AR factor is seen to be 12.5.

Set the pointer on 25 on scale A and move scale D so that 12.5 also lies on the pointer. Move scale C so that 0.04 coincides with 0.1 on scale D. The required grade is given by the reading on the scale B coincident with 1 on scale C, and is seen to be 0.28 per cent.

(*b*) by arithmetical solution.

$$a = (2 \times c + 12d) \times \frac{d}{2}$$
$$= 16 \text{ sq. ft.}$$
$$p = c + 26d^2 + 50d^2$$
$$= 22{\cdot}2$$
$$R = \frac{16}{22\ 2} = 0{\cdot}715$$

$$S^{\frac{1}{2}} = \frac{Q \times n}{a \times 1{\cdot}486 \times R^{\frac{2}{3}}}$$
$$= \frac{25 \times {\cdot}04}{16 \times 1{\cdot}486 \times 7{\cdot}15^{\frac{2}{3}}}$$

and S is found to be 0·26 per cent.

CONCLUSION.

Thus it can be seen that, starting with any of the factors in bank design as an unknown, a solution can be obtained accurately and simply. The accuracy of the instrument appears to be of the order of 2 per cent.

The major disadvantages appear to be:—

1. Although wetted perimeter and area can be applied to all banks, the final readings of channel width and depth of flow can only be applied to a few banks of fixed design.
2. A reading of 105 could mean 1.05 x 10^n cusecs, but this is overcome by fixing the decimal point from common knowledge of bank discharge.

I am of the opinion that the advantages of speed of calculation far outweigh the above disadvantages, and the answers obtained are within the limits of accuracy of the plant in common use for constructional purposes.

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THE VALUE OF SOIL CONSERVATION MEASURES AT WELLINGTON.

BY

J. M. Logan, H.D.A., Soil Conservationist.

The subjection of soil conservation works to periods of heavy rain is an event to which both the Soil Conservationist and the farming community look with interest, as it is then that the value of such measures is demonstrated. However, such rainfalls are irregular in occurrence in the central wheat belt, and so at Wellington Soil Conservation Research Station, although mechanical structures have been installed for some five years, they have only recently had to cope with very large quantities of rain falling in a short period. The land use and water disposal schemes on this Station have already been fully described in previous issues of this Journal, but as they were published some years ago they are again briefly described.

Land considered too steep for cultivation has been reverted to either natural pasture or grazing lucerne, and where necessary pasture furrows have been constructed to prevent run-off. On the arable lands a rotation including a period under grazing

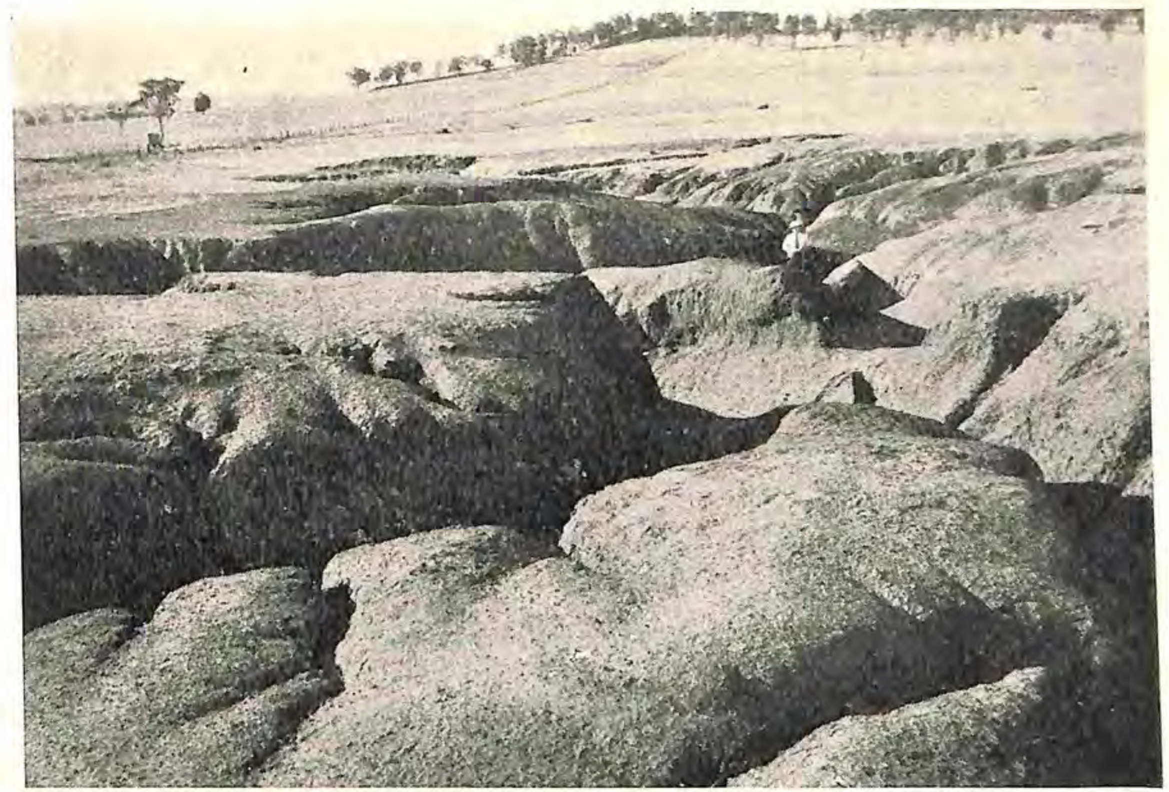

Fig. 1.—Sheet and gully erosion in the front paddock of Wellington Research Station in 1945, prior to Soil Conservation measures.

lucerne, retention of stubble and cropping not more than once in two years has been put into operation. These cultivated paddocks are also protected by graded banks draining into grassed waterways which safely carry the run-off from the property. In addition to the discharge from these banks, the excess run-off from an area of some 420 acres of steep grazing land is also handled by the Station water disposal system.

In this article it is proposed to discuss the results of these measures following a prolonged period of heavy rain.

AMOUNT AND NATURE OF THE RAIN.

Over a period of ten days from the 29th March to the 7th April, 1950, a total of 703 points was recorded. Table I gives the hour-by-hour record of the rain. It can be seen from this table that the rain fell consistently over practically the whole of the period. Heavy falls were recorded on the 29th and 30th March and the 2nd and 7th of April, those on the 2nd May causing the highest run-off and soil loss. Table II gives the details of the heavy falls of the period.

TABLE I.

Hour-by-hour Record of the Rainfall in Points.

Date.	Time recorded (in hours from midnight).																								Totals.
	0 to 1.	1 to 2.	2 to 3.	3 to 4.	4 to 5.	5 to 6.	6 to 7.	7 to 8.	8 to 9.	9 to 10.	10 to 11.	11 to 12.	12 to 13.	13 to 14.	14 to 15.	15 to 16.	16 to 17.	17 to 18.	18 to 19.	19 to 20.	20 to 21.	21 to 22.	22 to 23.	23 to 24.	
March 29	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	10	28	42	40	26	154
„ 30	50	24	...	6	2	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	80
„ 31	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	2	6	...	...	...	...	8
April 1	46	8	...	...	1	...	1	6	8	18	2	1	2	5	3	1	...	2	...	...	...	...	...	...	104
„ 2	...	...	...	...	...	...	...	1	14	5	2	...	19	36	3	...	5	4	26	22	4	40	3	...	185
„ 3	...	2	4	4	4	4	3	2	2	4	6	8	...	...	15	...	...	...	4	3	...	...	...	...	65
„ 4	...	...	...	1	2	...	...	3	1	2	3	5	...	...	1	3	...	5	7	...	...	...	...	...	33
„ 6	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	1	1	...	...	...	...	2
„ 7	...	...	61	3	...	...	2	4	...	2	...	...	...	...	...	...	...	...	...	...	...	...	...	...	78

TABLE II.

Details of Heavy Rainfalls in Points.

Date.	Duration.					
	5 min.	10 min.	15 min.	20 min.	30 min.	1 hour.
March 29–31	14	19	24	27	32	58
April 1 ...	12	20	23	30	36	41
„ 2 ...	15	30	31	32	40	50
„ 2 ...	11	22	24	26	30	38
„ 2 ...	10	18	26	34	36	38
„ 7 ...	30	38	44	51	58	63

The three heavy falls of the 2nd April, fell within a period of nine hours, the last two being within three hours. Higher intensities than these have been recorded at Wellington, but by the 2nd April soil conditions were such that the run-off coefficient was very high. An indication of the state of saturation of the soil on the fallowed land was given when, on the 3rd April, water was noted coming to the surface in the form of a spring, although no heavy rain had been recorded for some fifteen hours. An examination of the daily rainfall records for the past sixty-nine years reveals that rains of similar duration and quantity have been recorded on two other occasions only. (In 1926, 951 points were recorded in ten days, and in 1941, 870 points in ten days.)

Fig. 2.—Run-off from arable land being discharged slowly and safely by graded banks.

Fig. 3.—Water flowing from an uncontrolled fallow, Bodangora Road, Wellington, following 100 points of rain.

EFFECT OF MECHANICAL STRUCTURES.

Erosion control structures on the Station all functioned effectively and provided adequate disposal for the water that was not absorbed into the soil. No run-off was noted from the lucerne paddocks, each of which was carrying a very tall and dense cover, but some run-off resulted from the natural pastures. However, this was prevented from reaching any appreciable concentration, damaging any fallowed area or adding to the load on the waterways, by the well-designed system of pasture furrows.

Two of the arable paddocks protected by graded banks had been fallowed in the previous October and because of the high summer rainfall had been reworked to keep down weed growth. Before control works had been installed these paddocks had suffered from severe sheet erosion and were dissected by numerous gullies which, besides making cultivation almost impossible, hastened the run-off to the final outlet. (Fig. 1.) Now, the water is intercepted by the graded banks before sufficient quantities can accumulate to cause rilling, and is then slowly taken off the paddocks, thus increasing absorption and decreasing the final discharge. (Fig. 2.) During the period under discussion, practically no interbank erosion was evidenced and all banks safely carried the excess run-off. Fallowed paddocks on other properties in the district, on the other hand, showed signs of extensive sheet and rill erosion, with large accumulations of silt along fence lines and roadways. Figure 3 shows a large quantity of run-off from a relatively flat uncontrolled area.

Grassed waterways proved their efficiency in handling large quantities of water, as previously to this rain the dam which is designed to buffer the discharge from the 420 acres of grazing land outside the Station was almost full and it over-flowed after the first day of rain. Thus the waterways had

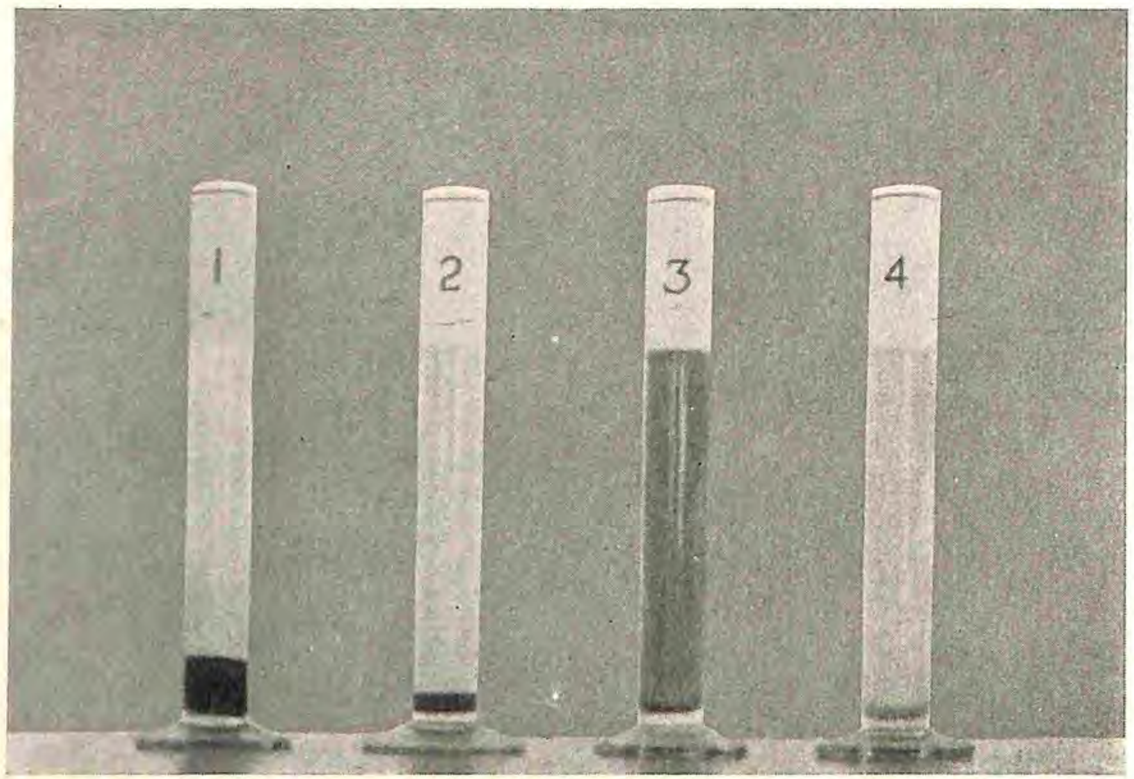

Fig. 4.—Samples 1 and 2 show differences in soil loss from the same area under different vegetative cover.

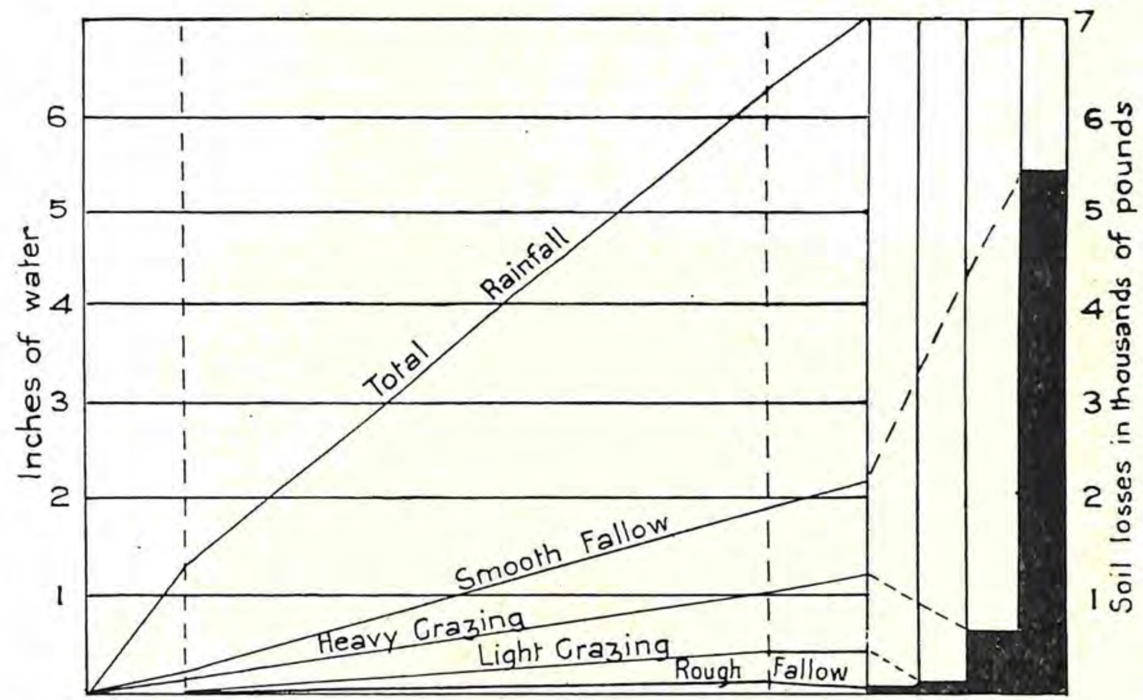

Fig. 5.

to carry the run-off from this area as well as that from the graded banks. They not only did this safely, but also decreased the quantity, because their slow flow brought about considerable absorption over their length as well as greatly reducing the silt content. (Fig. 4.)

EFFECT OF IMPROVED LAND USE.

An examination of Figure 5 will indicate the effect of judicious stocking of pasture land on both run-off and soil loss. The effect of grazing rate on soil loss is further illustrated by Figure 4 in which samples "1" and "2" show the silt load of water running from the same grazing paddock. When sample "1" was taken the paddock was in a relatively bare condition, compared with the heavy grass cover when sample "2" was taken during the recent rains.

On the Research Station all cultural operations are carried out on the contour (Fig. 6), and this considerably reduces the run-off as each furrow acts as a miniature absorption bank. Figure 7 shows this effect, whilst in the background of Figure 3 furrows can be seen running down the slope, thus draining the water off the land. (A full discussion on contour cultivation was published in this Journal in April, 1949.)

The rough fallow of Figure 5 had heavy stubble incorporated when fallowing was carried out and was left in a relatively rough state, contrasting with the smooth fallow which had been worked much more frequently. The difference in the soil loss figures—17 pounds per acre as against 5,466 pounds per acre—shows that the early preparation of a very fine, smooth seed-bed can greatly increase the erosion hazard. This fact was further illustrated on the Station paddocks where some of the fallowing had been done with a rigid tyne cultivator which left a ridged surface, and some with a disc plough which left a smooth, fine surface. It was observed that run-off from the ploughed area was considerably greater than that from the portion of the paddock where the contour ridges held much of the rainfall.

The efficiency of contour cultivation and the effect of the roughness of the fallow are also shown when the run-off figures for the experimental plots are compared with those for a graded bank on one of the paddocks. The run-off from the plots which were relatively smooth and cultivated down the slope was 40 per cent., whilst that from the bank on a paddock that had been contour-cultivated and was in a comparatively rough condition was only 11 per cent.

CONCLUSION.

In the Wellington district, the heavy rain of the period under review caused appreciable erosion despite the fact that good seasons had been experienced for some years. It is considered that run-off and soil losses from many of the areas that suffered the greatest erosion—the high value arable lands in the course of preparation for the current year's crop—would be at least equal to if not greater than the loss recorded from the Station experimental plots, viz.: 2.2 inches of water and 5,466 pounds of soil per acre. On the other hand, it is known that run-off and soil loss from the Station paddocks was very much less than that from the experimental plots.

Fig. 6.—Sowing wheat on a graded bank.

The success of the mechanical control measures installed on Wellington Research Station, together with the land use policy governed by soil conservation principles, clearly demonstrates that erosion can be effectively controlled. The additional fact that control works have to be more intensive and more costly when the severity of the erosion has increased should indicate the necessity for immediate soil conservation operations on all farms presenting any erosion hazard.

Fig. 7.—Contour cultivation on Wellington Research Station. Every furrow acts as a miniature absorption bank and prevents run-off.

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CONSTRUCTION OF GRADED BANKS WITH THE ANGLE DOZER.

BY

J. W. Mackie, H.D.A., Soil Conservationist.

Sidonia Soil Conservation Demonstration is located on the north-western slopes near Gravesend in the Inverell Soil Conservation District. On this Demonstration one 40-h.p. crawler tractor with cable operated angle dozer, one 35-h.p. crawler tractor, one ripper, one grader terracer and one wheeled scoop were used. The problem which the field staff had to solve was to find a method to keep both tractors fully employed with the subsidiary equipment available. A large proportion of the control measures was the installation of graded banks in cultivation areas. The problem was solved by using the 35-h.p. tractor for ripping and grading and using the 40-h.p. machine with angle dozer attached for moving the soil into place in the banks, the final shaping to be done by the grader terracer and the 35-h.p. tractor. In practice this proved to be most successful, and both tractors were fully occupied; the time employed in ripping and grading was equal to that required for moving the soil into place for the bank, at the same time it was found that the angle dozer had considerable advantages over the grader terracer in this class of work.

METHOD OF BANK CONSTRUCTION.

The method adopted was as follows:—When the grade line had been pegged the 35-h.p. crawler and ripper was used to rip on the peg line and following trips were done on the upper side of the first rip mark until the width was equal to the width of the area of soil to be moved in forming the bank. When this was completed the angle dozer, set at the angle, made the first cut by moving along the peg line of the bank depositing the soil on the lower or downhill side. Subsequent trips were all above the original cut and the bank was constructed from above.

The general routine was therefore as follows:—

1st trip—cut and deposit on grade line.

2nd trip—cut ½ blade distant from 1st cut.

3rd trip—carry over soil from second trip and deposit hard against first ridge.

4th trip—cut.

5th trip—carry over.

6th trip—cut.

7th trip—carry over.

8th trip—cut.

9th trip—carry over.

10th trip—cut batter.

11th trip—carry over half-way.

12th trip—complete carry over and smooth channel.

The width of each cut should not exceed half blade width, preferably slightly less, so that the succeeding carry over will deposit the soil firmly against the preceding ridges.

Depth of channel is obtained by both cutting and carrying trips; the dozer cuts down on the heel of the blade, unlike the grader which cuts down on the toe, and depth is readily obtained and regulated. When conditions are suitable, two cuts may be made to one carry over and the number of trips reduced. In these operations it is essential that the tractor be operated with a slight dip to the lower side so as to maintain pressure on the heel of the blade. The final cut which forms the batter is made by keeping the upper track on firm ground and the lower track in the channel. The slope of the batter is regulated by the distance the lower track is kept from the lip of the preceding cut.

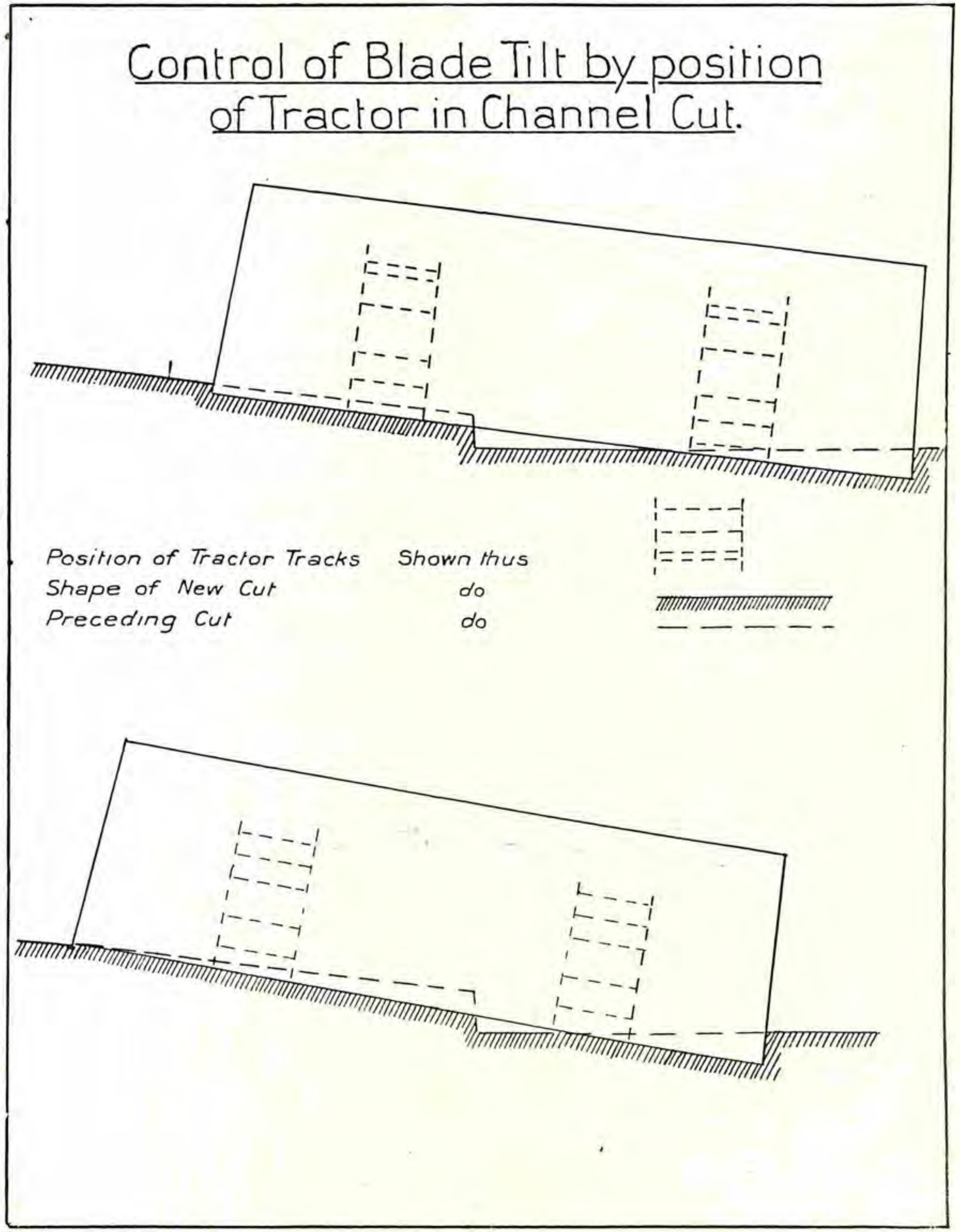
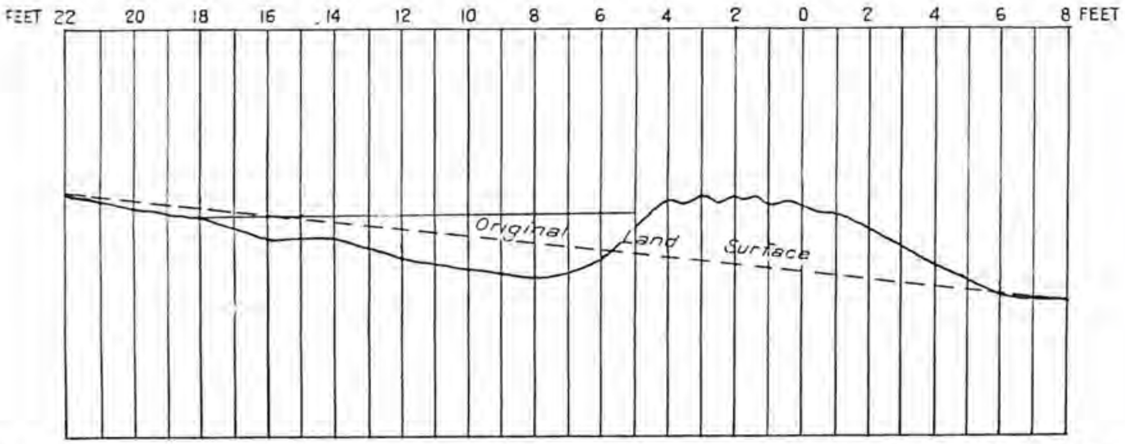
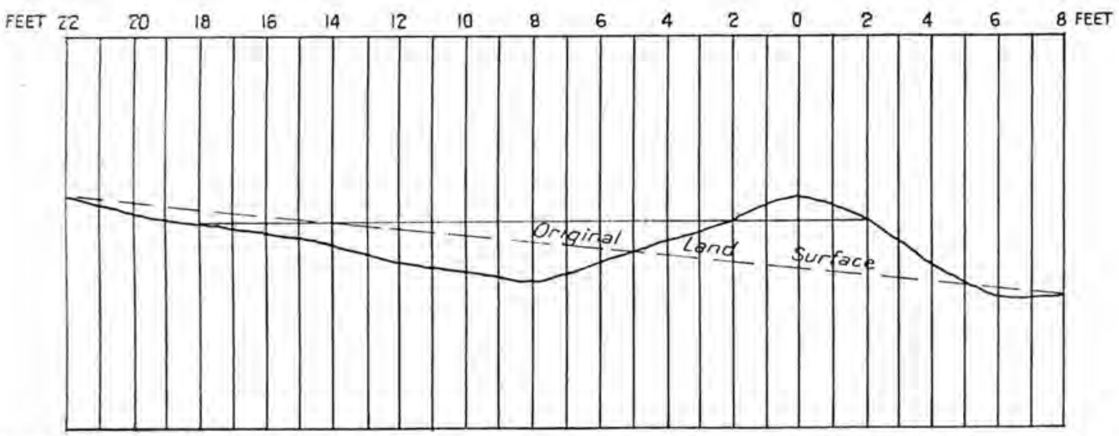


Fig 1.

Cross Section of Graded bank Construction by Angle Dozer.



Cross Sectional Area of Channel = 6·75 Square Feet. Area of Cut = 5·395 Square Feet
As built by Angle Dozer



Cross Sectional Area of Channel = 8 Square Feet Area of Cut = 5·525 Square Feet
Volume of cut per 100 feet of bank = 19 Cubic Yds. Hydraulic Radius ·482

As completed by Grader Terracer.

Fig. 2.

The sketches (Figs. 1 and 2) show how the dip or tilt, *i.e.*, the angle to the horizontal, can be altered by moving the position of the tractor tracks in relation to the top edge of the preceding cut. In Fig. 1 the upper track is close to the edge of the preceding cut and the upper corner of the blade is cutting under surface level, leaving a distinct step on the surface. In Fig. 2 the upper track has moved away from the edge and the lower track has moved closer to the edge. In this position the upper corner of the blade is just above surface and a smooth unbroken surface results. Together with the limited adjustment on the dozer blade attachment this practice of varying the line of travel in relation to the previous cut gives quite a surprising amount of variation in the tilt of the blade in relation to the surface.

FINISHING BANK AND CHANNEL.

When completed by the dozer the bank is level and fairly wide on top with a number of ridges and furrows running along the top. These are removed and the bank is given its final shape by the grader terracer. Typical cross sections are given in Figs. 1 and 2.

The bank cross sections were taken during construction and are of a typical length of bank. The cross section of the angle dozer work shows the typical ridge and furrow top as left by the angle dozer. At this stage the total bulk of the soil has been placed in position for final forming. It is of interest to note that the cross sectional area of the channel 6.75 square feet is increased to 8 square feet by the two trips of the grader terracer, one blade stroke on either side of the bank commencing with the forward or downhill side of the bank. The excellent shape of the upper batter was obtained by use of the angle dozer only. The bank shape is such that no difficulty is found in subsequent cultivation and seeding.

Where the position of the channel to the pegged grade line has to be determined this is done in the ripping procedure. To bring the channel on to the line of pegs ripping should be completed above the line to a reduced width and two or three trips done under the peg line, the procedure of construction remaining as above.

The dozer blade measured 9 feet 8 inches on the cutting edge with a height of 2 feet 6 inches. This blade has sufficient width when angled for the transported soil to clear the line of track travel and no packing of the soil occurs.

ADVANTAGES OF ANGLE DOZER.

The angle dozer method of construction reduces the amount of labour required when compared with the usual method of tractor and tractor-drawn grader terracer, as no grader operator is required. The direction of travel of the blade is under better control, as well as being directly under the eye of the tractor driver, the blade does not tend to swing in and out to the line of travel as is the case with the grader terracer owing to the distance of the blade from the tractor, and the tendency to cut corners on a concave curve or the flattening of curves on a convex curve is eliminated. This control has the additional advantage that the soil is packed firmly against the previous deposits without further disturbance and as the soil is handled less often a better texture is maintained. A greater quantity is moved per trip and less trips are required and there is no wheeled traffic on the new formation, so that in texture the bank is more uniform and the dust nuisance is kept at a minimum.

Some objection may be made to the amount of soil carried on the blade of the angle dozer, as this weight of soil is carried the full length of the bank, but against this there is the saving of the weight of the grader terracer and the frictional resistance of its wheels so that the loss of power may not be so great as would be expected. In practice no appreciable loss was apparent. As the angle of the dozer blade to the line of travel is fixed the angle dozer may not suit soils of a sticky or resistant nature as well as the grader terracer. The dip or angle of the dozer blade in relation to level is very limited and this outfit cannot be used to trim up the bank to its final smooth outline.

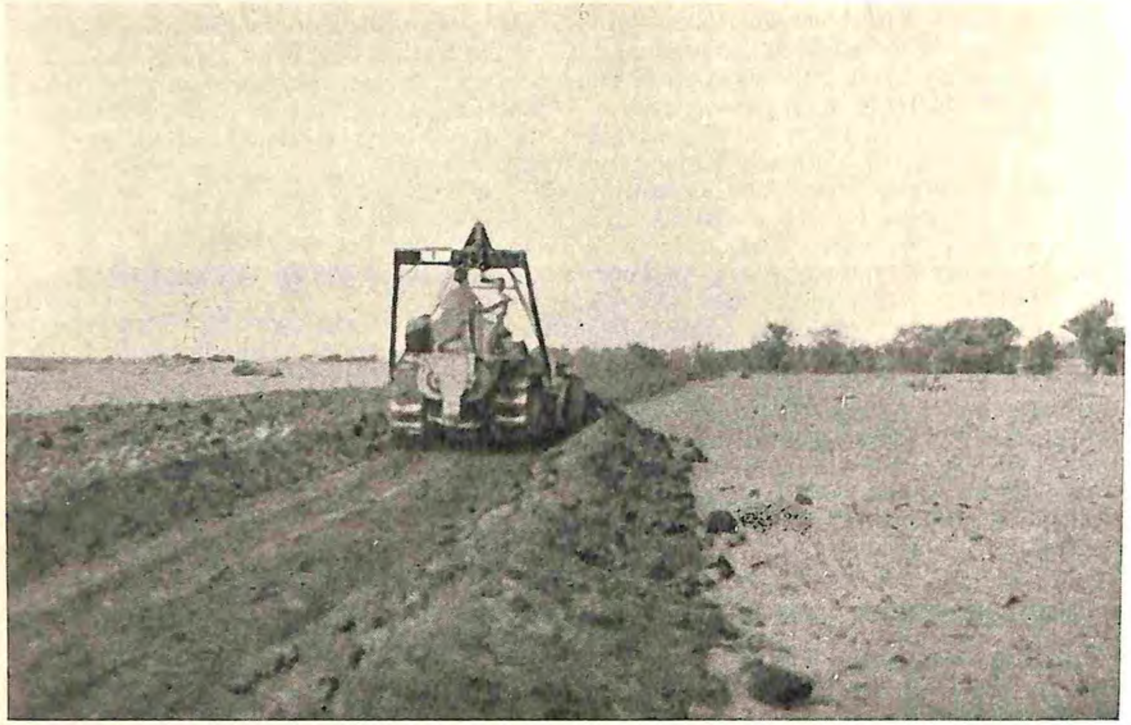


Fig. 3.—Rear view of the angledozer on the first cut following ripping.

Fig. 4.—The final cut by the angledozer, forming the batter.

Fig. 5.—The bank and channel at completion of work by the angledozer.

Fig. 6.—Trimming the lower side of the bank with grader-terracer.

CONCLUSION.

The angle dozer is not a machine to use for the complete construction of graded banks as the cross section of the bank, as left by this equipment, will show ridges and furrows on the top, which if left would concentrate run-off on top of the bank, causing rilling along the top and eventually down the side. In addition the capacity of the bank will be small in proportion to the amount of soil moved unless the grader terracer is utilised to give the final shape to the bank. The great value of this implement lies in its ability to move the soil to the desired position quickly, accurately and economically.

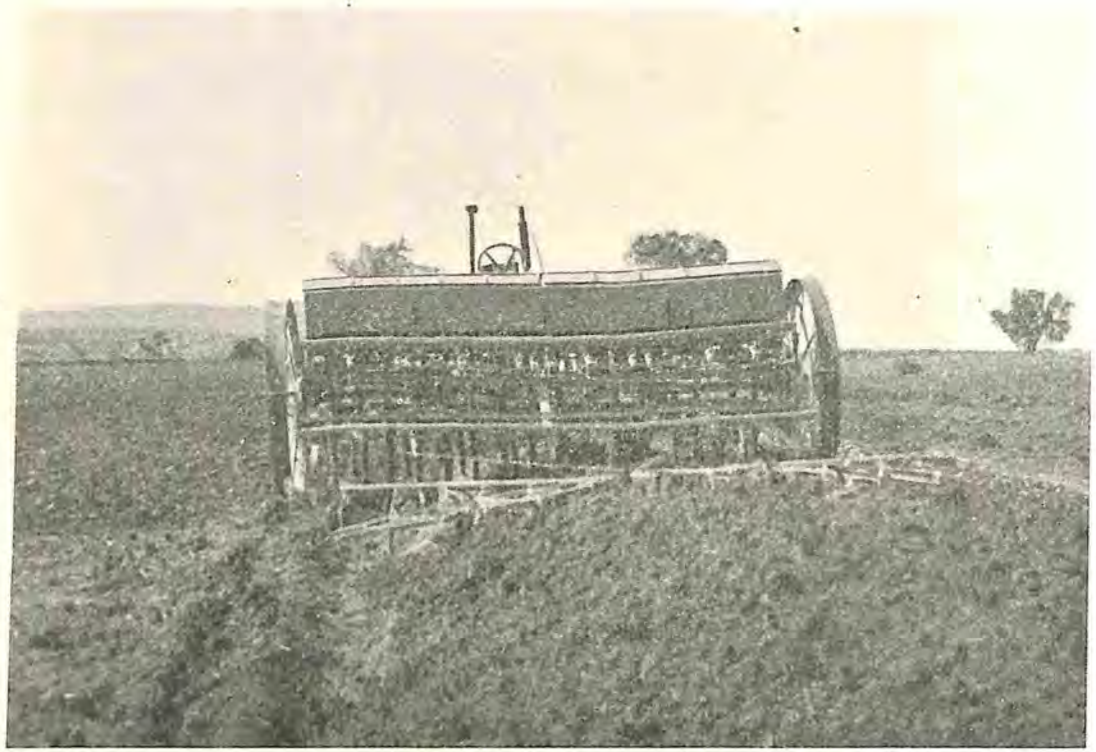


Fig. 7.—The finished bank.

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EROSION CONTROL AT MUDGEE. ERUDGERE DEMONSTRATION.

BY

W. J. RHODES, D.D.A., Soil Conservationist.

ERUDGERE Demonstration, situated in the Erudgere Valley, seven miles to the west-north-west of Mudgee on the properties of Messrs. M. F. and F. A. Hughes, is a typical example of the positive control of soil erosion.

Reference to Fig. 1 will reveal the importance of all erosion control carried out in this area, as the Mudgee Sector encloses approximately half of the 5,360 square mile catchment area of the Burrendong Dam, which is now under construction.

Damage by erosion is extremely serious in this Sector, and has a two-fold importance; not only is great damage being done to arable and grazing land, but this silt load carried by the Macquarie and Cudgegong Rivers and their tributaries will greatly reduce water storage in Burrendong unless extensive soil conservation work is undertaken.

Despite a succession of excellent seasons giving an abundance of vegital cover, samples of silt carried throughout the feeder rivers of this catchment have revealed silt loads of up to 2 per cent., which gives an indication of the seriousness of the problem.

EROSION PRIOR TO COMMENCEMENT OF WORK.

Reference to Fig. No. 2 will show the position of major gully lines, which, in places, were cut to a depth of 7 feet and were the result of an unrestricted run-off from a steep hilly catchment. This grazing area ranged in grade from 20-35 per cent., and all the run-off from this area flowed across the two lower cultivation paddocks. Also contained in this hilly area were extensive areas of sheet eroded land which largely contributed, by reduced absorption, to the large amount of run-off to the lower areas. Each successive rainfall was causing increasing depositions of silt on the lucerne flats below, carried from these gully lines.

METHOD OF CONTROL.

The first stage in the control of this area was the reduction to a minimum of the run-off from this hilly area. Commencing from the top of the catchment, 142 acres of land were pasture furrowed on a three feet vertical interval using a ripper and a road grader. All furrow lines were ripped to a depth of one foot, utilising three tynes of the ripper at the widest setting. The soils of this area proved very difficult to work as large loose rock was encountered below the surface. This was more than compensated, however, by the greatly increased absorption obtained by disturbing hidden rock and shattering the soil to a much greater depth. All sheet eroded areas were ripped on the contour prior to the construction of pasture furrows in preparation for the sowing of wimmera rye and clovers. (Fig. 3.)

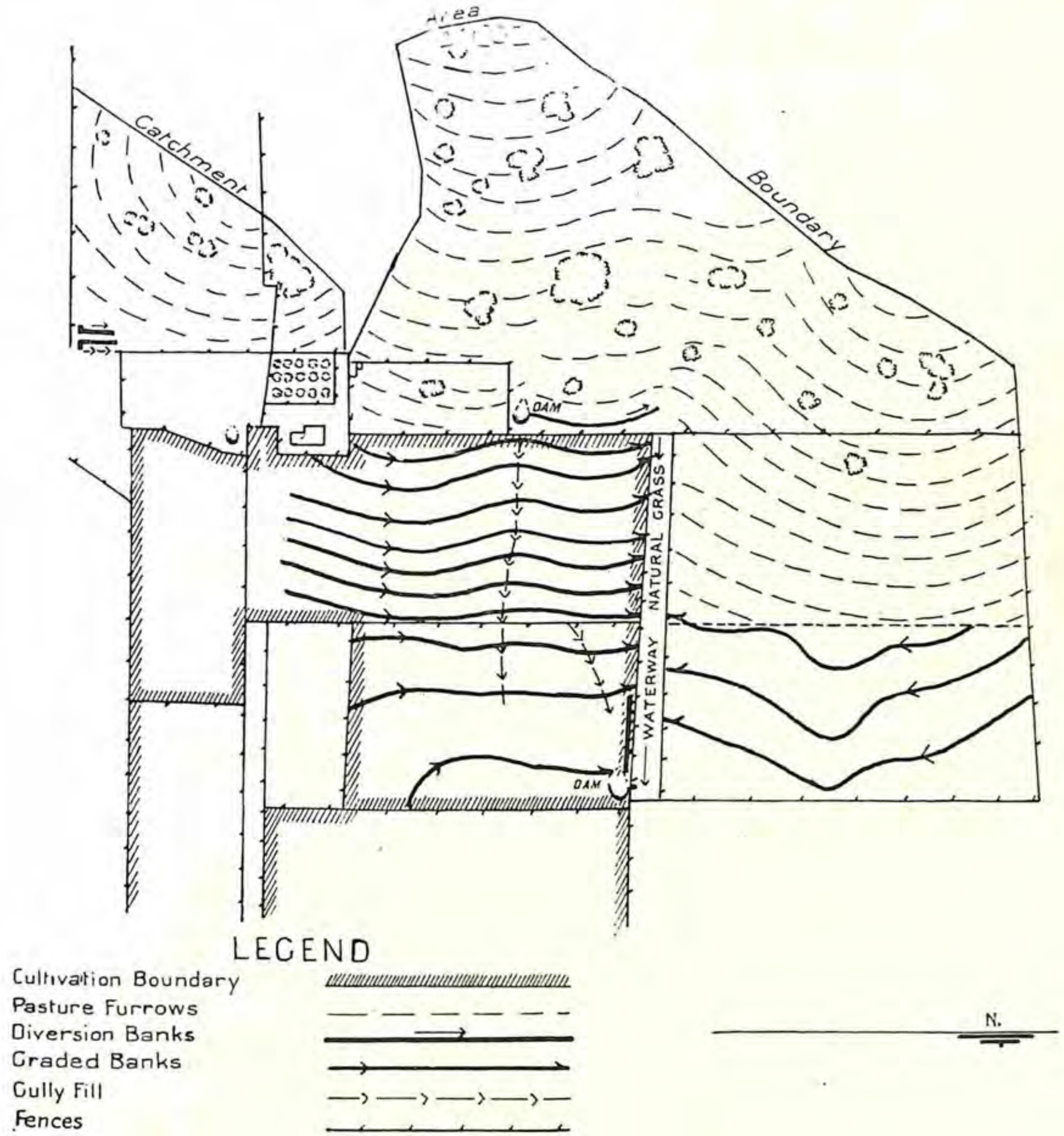
The second step was the control of run-off from this area by means of a 500 cubic yard dam situated at the head of the flow line immediately above the head of the existing gully. While the rate and amount of absorption has been increased to a maximum by means of pasture furrows the area has by no means been completely sealed off from all future run-off. Where previously large concentrations of water flowed from the area there is now a well-distributed seepage. This

BURRENDONG CATCHMENT AREA

SCALE

MILES 0 4 8 12 16 32 MILES

Fig 1.



ERUDGERE DEMONSTRATION

MUDGEE DISTRICT

SCALE

CHAINS 0 2 4 6 8 10 20 CHAINS

Fig. 2.

water now flows from the dam to the waterway by means of a diversion bank which was constructed by crawler tractor and dozer.

Prior to the commencement of work a natural grass waterway had been located following a cross-sectional survey and all water which cannot be absorbed on the demonstration now flows along this waterway. This area was fenced and all stock excluded. Small banks were constructed on the waterway to give an even distribution of water flow where small irregularities would tend to concentrate water. Kikuyu grass was sprigged along several stock tracks and on areas where it was thought that the greatly increased flow might result in a loss of soil.

It was not until every provision for the safe disposal of water had been taken that the gully was filled with the dozer. Advantage was taken of several rains to consolidate and settle the fill which was again filled, prior to the construction of graded banks.

These banks, averaging 25 chains in length, were built with the grader, on grades of a variable percentage of 0 per cent. to 0.4 per cent. along the length of each bank. A 7-foot vertical interval between the banks gave an inter-bank distance ranging from 1½ to 3 chains. The uppermost bank was constructed with the dozer as a greater cross-section of bank and channel on a uniform grade of 0.5 per cent. was required to cope with the additional flow from the area above, which was not covered by the dam and its diversion bank.

The final work undertaken was the construction of a 1,300 cu. yd. dam, adjacent to the lower end of the waterway. A small level bank sodded with paspalum was placed to pick up water from the flow from the waterway and direct it into the dam, which on becoming full permits all later run-off to by-pass the dam, and flow down the waterway. (Fig. 2.)

REMARKS ON DEMONSTRATION.

Eighteen months have now elapsed since the commencement of work on Erudgere Demonstration. The following list of rainfall registrations indicates the amount of run-off successfully handled.

Month.	Points.	No. of Wet Days.	Month.	Points.	No. of Wet
May	137	6	January	384	5
June	245	8	February	800	8
July	244	7	March	327	11
August	85	5	April	707	5
September	468	13	May	186	(Incomplete.)
October	361	13			
November	253	11			
December	305	5			
Total	2,098	68	Total	2,404	(Incomplete.)

As a result of removal of stock and the increased water, which actually flood irrigates the waterway, a remarkable improvement has taken place in the growth and regeneration of white top (*Danthonia* sp.), natural medics and kikuyu, and the waterway is now densely vegetated.

There is also a very evident indication that the vertical spacing of the graded banks in the cultivation paddocks should not be greater than 7 feet on this soil type and grade, which ranges from 7 per cent. to 14 per cent. on a light sandy loam covering an impervious clay subsoil.

It has been noticed that very little water has flowed from the pasture furrowed area and constant soaks have developed which have increased the growth of natural grasses and the introduced grasses sown on the furrows and scalded areas which have been ripped.

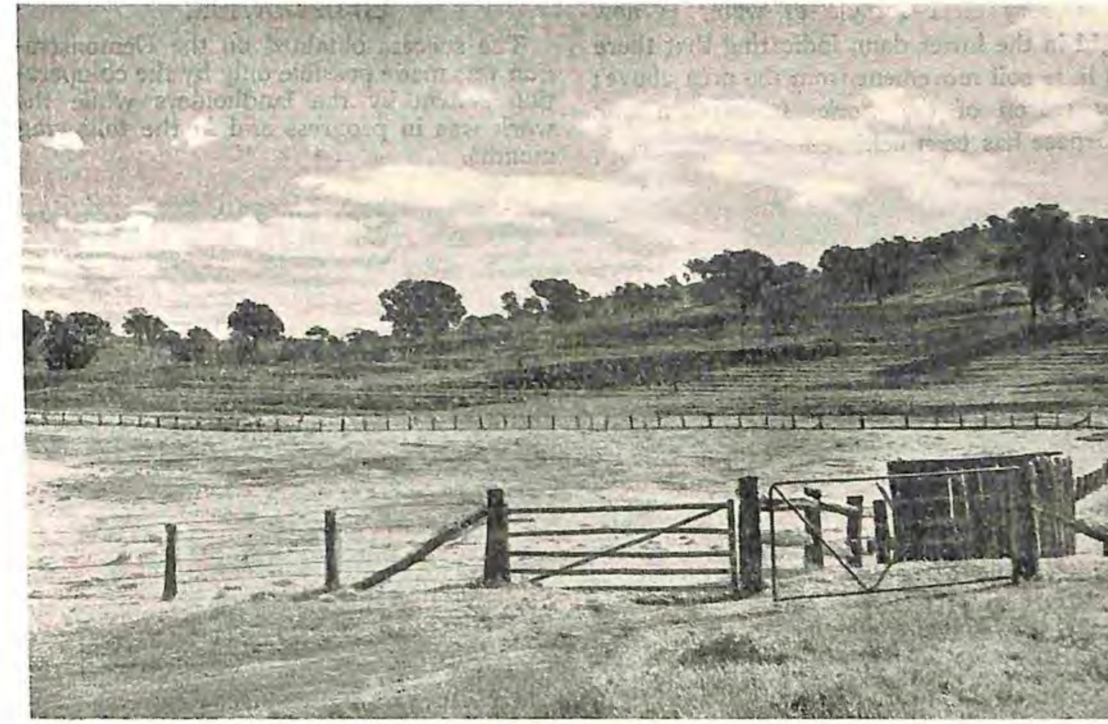


Fig. 3.—A hillside contour furrowed to prevent sheet erosion.

Fig. 4.—A well-vegetated diversion bank leads water to a safe outlet.

A very clear sample of water is now held in the lower dam, indicating that there is little soil movement from the area above; by reason of the works undertaken our purpose has been achieved.

CO-OPERATION.

The success obtained on the Demonstration was made possible only by the co-operation shown by the landholders while the work was in progress and in the following months.

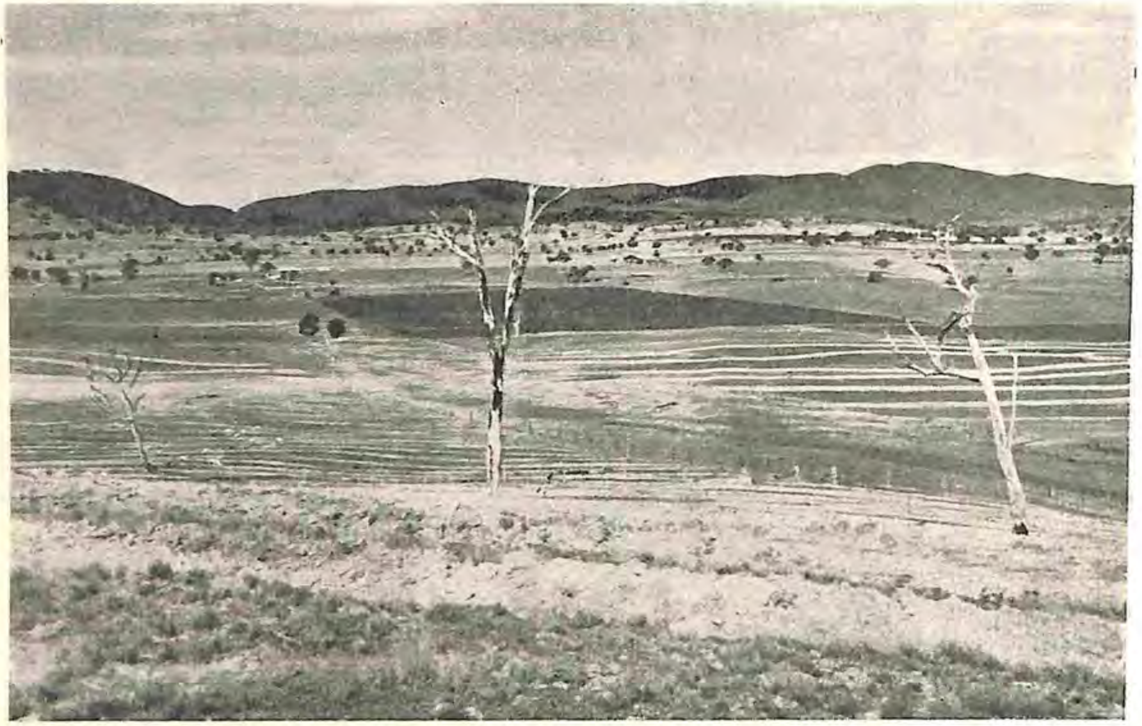


Fig. 5.—Pasture furrows and absorption banks on grazing land and graded banks on sloping arable land.

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SOME COMMON ERRORS IN SOIL CONSERVATION PRACTICES.

BY

G. A. Barnett, H.D.A., Soil Conservationist.

Before the establishment of the Soil Conservation Service in this State, there were many creditable attempts made by landholders to mitigate erosion on their properties, but unfortunately, due to a lack of full knowledge of the factors involved, more often than not these early attempts were unsuccessful. Even in the last decade, since the inception of the Soil Conservation Service, some landholders have undertaken the difficult task of controlling erosion without being fully informed as to the principles involved and some serious errors have occurred. These errors have resulted in not only an aggravation of the problem but also in some cases a fatalistic attitude towards soil erosion.

WATER DISPOSAL.

In any scheme of soil conservation utilising mechanical means the object is to slow the rate of flow of the water down slope. To do this, obstructions of some kind (usually earth banks) are placed across the slope, but it is necessary to provide an outlet for the water collected in these banks. Failure to provide a safe outlet for the water thus collected has been one of the principal causes of the failure of whole erosion control schemes. It is only natural that if the run-off from a large paddock is concentrated by the banks at one point, serious gullying undoubtedly will occur, as illustrated in Fig. 1. This not only ruins the land onto which the banks empty, but also causes destruction of the banks themselves, as the gullies cut back along the channel of the bank by waterfall action. Eventually these gullies will extend laterally from the banks into the interbanked area of the paddock. The same effect is obtained by emptying the bank into an existing gully.

Another result of not providing a disposal area for the water from the bank is that these will be shortened at each storm by the water flowing around the end and carrying away the end of the bank. Eventually the run-off will be flowing down the inside of the controlled paddock instead of outside it.

The ideal disposal area is well grassed flat land with a natural stream flowing through it. Alternatively a well grassed sloping grazing paddock adjoining the area to be controlled can be utilised as a disposal area, but caution must be exercised to see that the paddock has a permanent grass cover. The main difficulty here is that in all probability the grass cover will disappear during drought years, leaving the disposal area bare, with the result that the drought-breaking rain will cause serious gullying. However, it is often more desirable to utilise a grazing paddock for water disposal than to incur the expense of constructing a waterway. Pasture improvement carried out on a natural disposal area would be an obvious advantage in reducing the danger of erosion which might result from the additional water deposited on the area from the banks.

Grassed Waterways.—Where a suitable natural disposal is not available, it becomes necessary to construct a grassed waterway. The design and method of construction of grassed waterways has been adequately covered previously in this Journal. However, certain precautions must be taken if the waterway is to be successful, because, if incorrectly constructed, these are useless and will also be gullied.

A grassed waterway is an area down the slope, of sufficient width to cope with the run-off which must be calculated accurately and which has been graded to a level cross-section with retaining banks on either side. These are usually sown with grasses to provide a protective cover for the soil. If faulty grading has resulted in the waterway not having a level cross-section the water will naturally concentrate on the lower side and cause gullying. In a waterway 40 feet wide a safe error would be a two-inch variation from one side to the other.

Where it has been necessary to fill a low side of the waterway the fill must be higher than is required to allow for settling of the freshly moved earth. This settling will at times result in a variation of up to three inches (depending on the type of soil and the depth of fill) between the constructed and the eventual settled levels of the waterway.

The provision of a good cover grass is an obvious but important factor. The species chosen should provide maximum growth during the season of the high intensity storms. A perennial with a creeping habit is preferable to an upright annual species. To ensure a maximum grass cover it is necessary to fence off the waterway from stock and rabbits, as most of the grasses used on waterways are palatable.

In most cases it will be found necessary to construct the waterway several months before the banks, so that the grass will be established sufficiently to enable water to be turned into the waterway immediately the banks are built. If, however, it becomes necessary to make the waterway at the same time as the banks a temporary outlet down the side of the waterway will have to be provided, with the bank finishing a few yards short of the waterway. This may result in the formation of a gully which can be filled when the banks are joined to the waterway.

Fig. 1.—Failure to provide a waterway for the disposal of water from the banks caused this major gully and the extension back along the bank channel.

BANKS.

Although serving a different purpose in a soil conservation scheme, graded, diversion and absorption banks are similar in their construction and will therefore be dealt with together.

Design.—Here again, as with all erosion control measures, design is of prime importance. Such factors as incorrect fall of the bank, insufficient number or capacity of banks, and uncontrolled run-off from higher ground, all decrease the effectiveness of the works and lead to the ultimate breaking down of the whole system by overtopping, with resultant damage to the other banks and the country below them. A comprehensive article on the design of banks appears in Vol. 2, No. 3, of this Journal.

Perhaps the greatest single error made by landholders in combating soil erosion on their properties is that of building banks without taking levels. It is extremely difficult to tell with the naked eye which way a line falls, and it is virtually impossible to peg a line with a specific fall without the aid of some levelling device. Banks which are put in on levels determined by eye are doomed to failure.

The grade of a drainage bank will depend on several factors but in most cases it should not exceed 7 inches in 100 feet. At increased grades there is a serious risk of a gully forming along the channel of the bank as illustrated in Fig. 2. Also, if there is insufficient fall along a graded bank there is a likelihood of siltation occurring and reducing the effective height of the bank. The flow of the water along the bank should not be fast enough to cut a gully, nor slow enough to cause excessive deposition of silt.

An insufficient number of banks, and also banks which are too small to handle the anticipated run-off, have an obvious, but disastrous result. In both cases the amount of water collected is greater than their capacity and overtopping will occur. The construction of banks which are too long produces a similar result. It is generally advised that graded banks should be no longer than 30 chains unless these are built at lower vertical intervals than is usual or with very large cross-sectional area.

Uncontrolled run-off from higher country can have serious consequences on soil conservation programmes if no attempt is made to control it. In a large percentage of cases where erosion control schemes are instituted

Fig. 2.—This gully formed in the bank channel because of excessive grade.

it becomes necessary to control the run-off from land above the area to be controlled. This land may be steep, rocky or timbered country where absorption banks cannot be used, or it may be cultivation or grazing land held by an unco-operative farmer. In these cases the run-off can only be controlled on the landholder's own property by a large diversion bank or series of diversion banks. A problem of this nature was encountered at "Toryburn" Demonstration near Gunnedah. A large, steep, rocky hill immediately behind the area to be banked was responsible for a high rate of run-off. To prevent this large body of water from damaging the lower graded banks, a series of diversion-absorption banks were built between the cultivation and the hill as illustrated in Fig. 3.

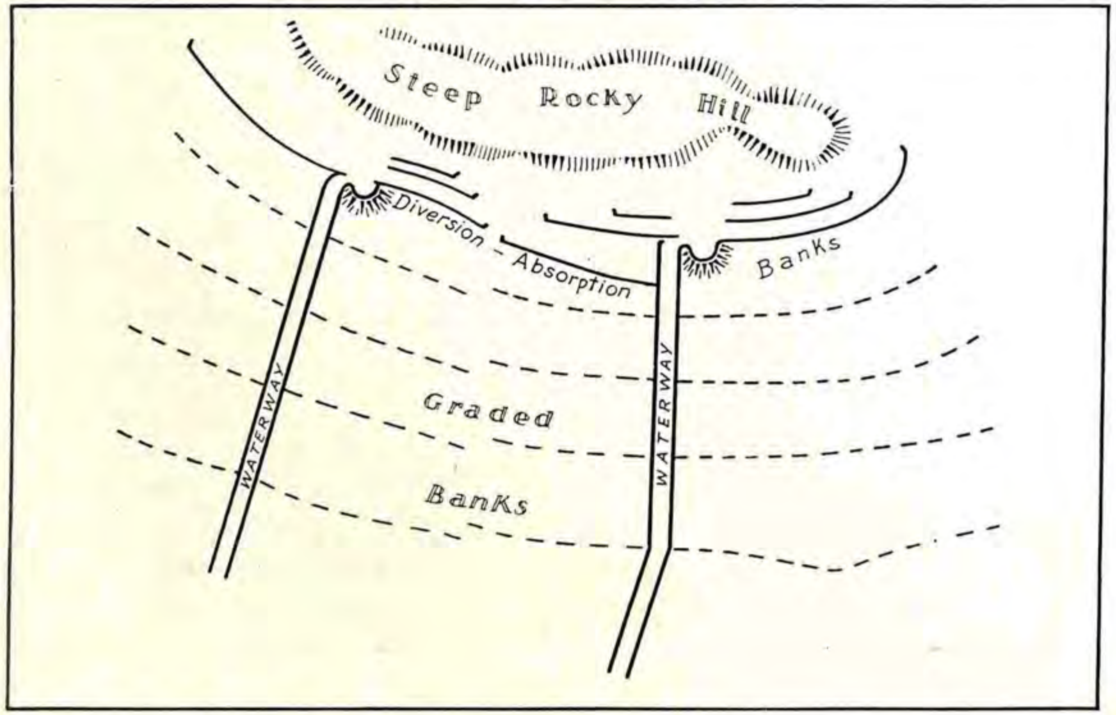

Fig. 3.—**Sketch showing method of controlling run-off from steep country to protect a system of graded banks at Toryburn Demonstration, near Gunnedah.**

This design enabled the full body of water to be handled without danger of overloading the works as each bank caught the run-off for only a portion of its length (about 500 feet) and was protected for the remainder of its length by the bank immediately above it.

Where the size of the catchment does not warrant a scheme of the size outlined above, satisfactory results may be obtained by constructing one large diversion bank with a suitable outlet, to carry off the excessive run-off. Here again design is important to ensure that the banks are capable of handling the anticipated flow. Otherwise the success of the whole scheme is jeopardised, as a break in this top protective bank would most certainly break the graded banks below it and cut a deep gully through the paddock.

Construction.—Banks can be constructed with a variety af implements ranging from a plough to a bulldozer but in all cases care must be exercised if they are to do their work effectively.

Once the banks are surveyed, they should be constructed on the surveyed line. Any deviation up or down the slope will result in a considerable variation in the effective height of the bank and will increase the risk of damage from overtopping. To ensure that no error has been made in the construction of the bank, it is advisable to check both the channel and the bank with a levelling instrument after their completion. This will show up any irregularities which can be corrected before damage can occur.

Where a soil conservation scheme involves the construction of a series of banks, the banks must be built in order from the top. Beginning with the top diversion bank at the head of the catchment area, the banks are then constructed in descending order down the slope. If the reverse procedure is adopted, *i.e.*, the bottom bank built first, serious damage can be caused if a storm interrupts the work, because each bank is designed to cope with only a portion of the water from the area, whereas, in the latter case, it will receive the entire run-off.

Where it is necessary to construct banks across gullies, particular care should be taken in filling the gullies. The fill must be packed in well and should extend for several feet above and below the bank. If this is not done, it will be found that the water will seep through the loosely packed earth and eventually undermine the bank with serious results to the lower banks.

Consideration must be given to the fact that banks, whether constructed with a grader or bulldozer, will settle down to a lower height than originally built. Allowance should be made for this settling which at times will result in a reduction of height by as much as 15 to 20 per cent. of the constructed size. Thus, to be safe, a bank should be given additional freeboard, equivalent to 25 per cent. of the depth of fill.

These remarks on settling of newly moved earth apply to a greater extent to silt traps and dams, as the amount of soil used is much larger. The damage to the silt trap shown in Fig. 5 was due to the settling of

Fig. 4.—**The damage to this absorption bank was caused by the water seeping through the bank, where it crossed a gully and eventually undermined it. This could have been prevented if the gully fill had been properly packed.**

the wall, which reduced the safety margin from 3 feet 8 inches to 4 inches in a matter of weeks. This was, of course, insufficient to cope with the heavy rains which followed.

Maintenance.—Another factor to be considered is maintenance of soil conservation works. It often happens that after the banks are installed, a certain amount of silt will collect in the bank channels over a period of time. This silt lowers the effective height of the bank and must be cleaned out with a grader, plough, scoop or other implement when required. Under certain conditions it may be necessary to carry out maintenance every year or even less, but normally with correctly designed banks and proper land use, it will not be necessary more often than once every two or three years.

Stock, particularly sheep, will often be responsible for cutting tracks across the banks (particularly newly constructed banks), thus destroying their effectiveness by reducing the height of the banks at these points. The water which runs down a sheep pad will carry a greater amount of silt, which is deposited in the channel of the bank immediately below. Because of the higher channel and the lower bank there is then a danger of the bank overtopping. Regular maintenance will minimise the danger of any damage resulting from a broken bank.

GULLY CONTROL.

A common yet unwise practice is that of ploughing in small gullies which result after a heavy storm. Farmers who thus emulate the ostrich by burying their heads to the warning signs of nature are only postponing the day when their paddocks will become seriously damaged. No matter how well these gullies or rills are filled, there will always be a depression which will collect a greater amount of water at each storm to wash out the ploughed-in soil unless the

Fig. 5.—A badly-designed silt trap. Settling of the wall caused the water to flow over the top of the wall instead of through the outlet.

flow is controlled. Eventually deep gullies will develop which cannot be crossed with farming implements or filled without the use of heavy equipment.

When these small rills appear, it is an indication that remedial measures are required. This may mean a change in land use or the installation of banks or both, but the amount of water flowing down these rills must be reduced before effective control can be obtained.

Where it is intended to reclaim existing gullies, the most common control measure is the building of small soil-saving dams in the gullies. These may be made of straw, brush, wire netting, timber, stone, earth or concrete, but in all cases care must be taken with their installation. Many structures of this nature can be seen standing as memorials of incorrect design or construction or both. The water has either undermined them or cut around either side leaving them standing in the middle of the gully entirely useless.

The structure should be built on firm ground and must be embedded well into the side of the gully. The overflow must be of sufficient size to cope with the anticipated flow and an apron of suitable material on the downstream side of the dam will prevent undermining.

After the construction of the soil-saving dams, stabilisation of the gully can be hastened by planting grasses or trees along the sides and in the bed of the gully.

CONCLUSION.

It will be seen that there are many pitfalls to be guarded against when undertaking the conservation of soil. However, a great deal of technical advice and practical assistance is now available in most districts of New South Wales and there is no reason why the landholder should not be able to do a great deal towards saving his soil, which, after all, is his principal asset.

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