# FOREWORD

BY

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

MISTAKES in land use have been made in the past and are still being made, but to a lesser degree as results of past mistakes become more apparent. It is obvious that in order to make headway in remedying the erosion which has already occurred it is necessary to first stop causing it. No matter how unwittingly it may be done it is most unwise to deliberately sow the seeds of erosion by putting lands that are perhaps too steep, perhaps too shallow, to agricultural or pastoral uses for which they are quite unsuited, and then belatedly try to stop the inevitable soil destruction by expensive but ineffective erosion remedial measures. Prevention is, of course, better than cure. It is wiser in the first place to use lands within the limitations of their physical capacities. Then it will be much easier and cheaper to hold the soil in its place without loss.

This is why land use determinations in the first instance both by the nation as well as by the individual in their respective spheres are so important. As we know by experience, wrong land use determination by the nation can commit unsuspecting farmers to a life-time of wasted effort, poverty and human misery. In his efforts to wrest a living from unsuitable land the farmer also injures the land itself, causing severe soil erosion and loss of soil. Nor does the damage end there. Consequentially the streams also suffer. Increased water run-off causes greater flooding, siltation of the stream bed and impairment of the continuity of the stream flow.

All these things happen when inaccessible timbered lands, too steep or too shallow for grazing, are cleared and settled, or when they are stocked too heavily.

It is one of the tragedies of man's history that too often he is called upon to use the natural resources at his disposal, before he has properly assessed them, and before he has learned how to use them. The nation's as well as the individual's interests are best served when great caution is exercised and expert knowledge is availed of before land use determinations are made. Steep rugged and shallow country at the headwaters of the streams is safest when it is under trees. It is also then carrying its best as well as its safest crop. The vital water resources are also maintained and floods mitigated by this land use of the steepest parts of the catchment. The same principles apply when we leave the national plane and consider that of the individual landholder. Here, too, the individual farmer must exercise the same careful assessment of the topographical features of his country and the depth and nature of his soils so that he can use his lands in agreement with nature.

If he applies these principles, his yields will be better. He will prevent erosion and he will more easily remedy any soil loss that does occur. Also his farming will be more permanent. The grassed waterways, banks and furrows he constructs will be much more effective and his farm can improve in productive capacity each year.

On the national level in this State the vital facts are sought and the highest technical knowledge on land utilisation matters is made available. Also in respect of lands on the headwaters of the major rivers the Catchment Areas Protection Board has been functioning in such matters as the determination of suitability of areas for settlement, and where settlement is permitted, of protective conditions. On the individual farm plane the landowner has the guiding principles of wise land use that have been enunciated to aid his judgment, and in New South Wales, if he cares to use it, the advice and guidance of the Soil Conservation Service on his own particular farm is available to him. Soil Conservation Officers have now been located at most of the vital country centres.



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# SOIL CONSERVATION SERVICE EXHIBIT.

BY

R. E. Herrington, Q.D.H., Soil Conservationist.

THE Soil Conservation Service exhibit once again attracted considerable attention at the 1951 Sydney Royal Easter Show. Situated in the Agricultural Hall this exhibit has become an important link with the public, serving as it does to draw attention to the nature and urgency of the erosion problems in New South Wales, and the way in which this threat is being met by progressive landholders with the assistance and co-operation of the Soil Conservation Service.

The highlights of this year's exhibit were two large transparent colour photographs of scenes in the central west of the State. These showed respectively the ravages of erosion and the changed face of pastoral land on the first Soil Conservation Demonstration in New South Wales at Gulgong. The photographs attracted much favourable comment.

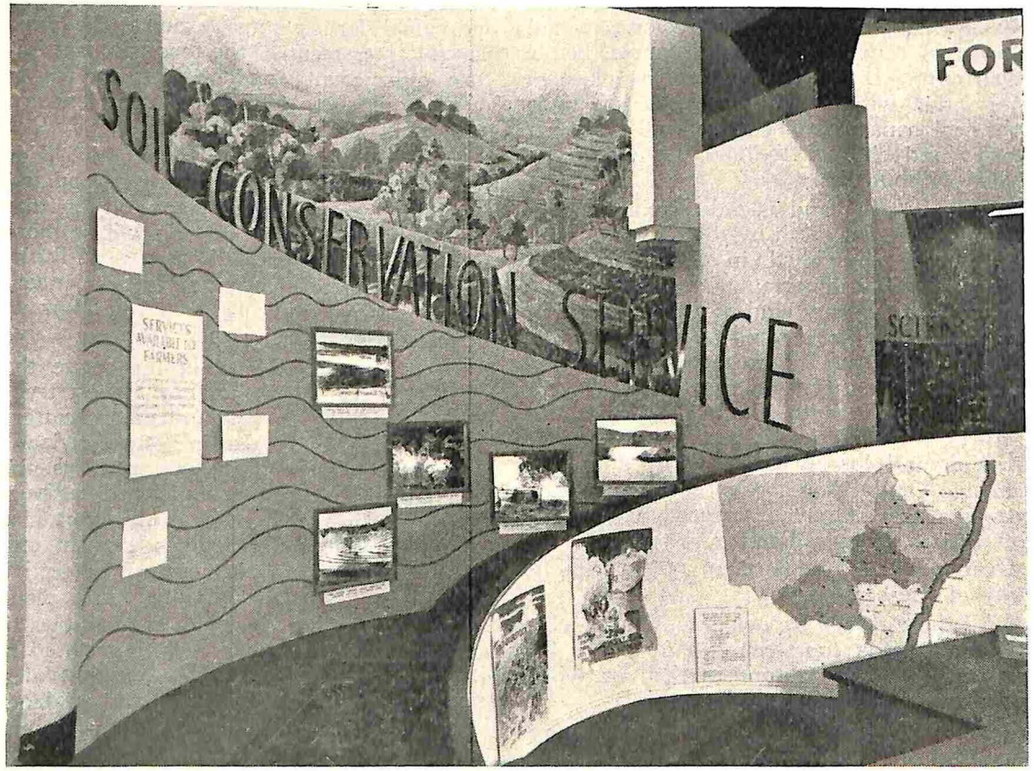


*Fig.* 1.—The 1950 Soil Conservation Service exhibit.



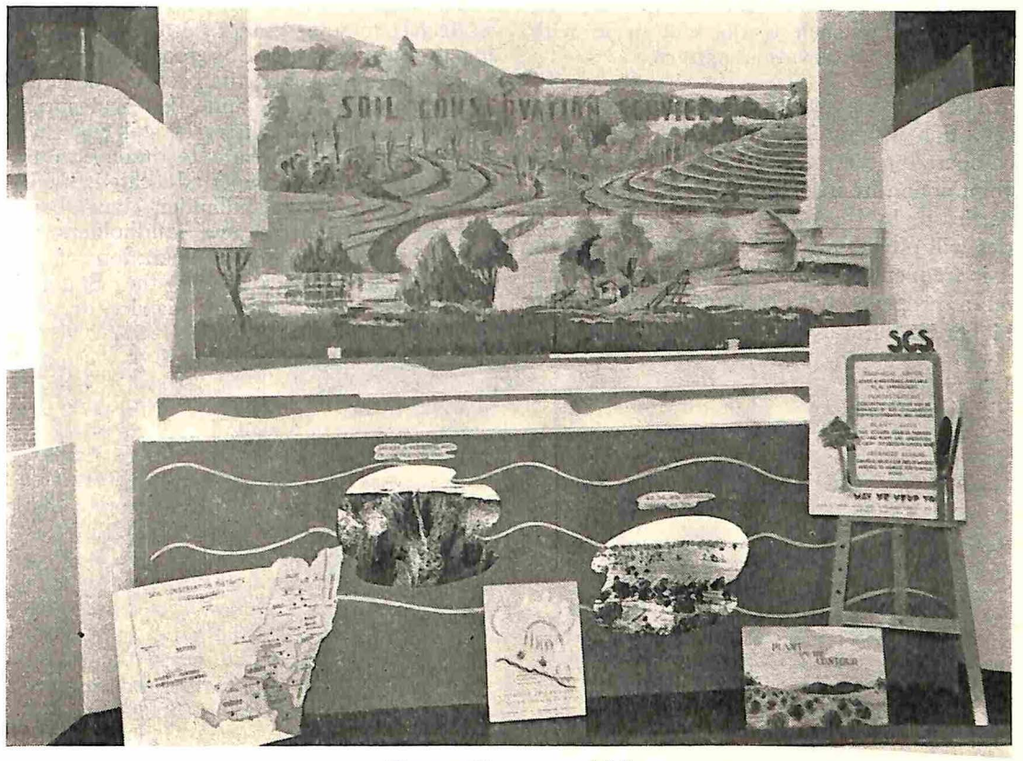


*Fig.* 2.—The 1951 exhibit.

A well illustrated booklet emphasising the need for conservation practices and outlining the organisation of the Service, the assistance available to the landholders and the location of country officers, was again distributed to the public.

A very pleasing feature of these exhibits has been the growing acceptance and understanding, among farmers and general public alike, of the need for the adoption of well designed conservation practices. That this interest is evident also in school children is very gratifying. The Soil Conservation Service has always taken a particular interest in the children, for it is they who, for better or worse, will inherit the land.

Acceptance of the need for conservation of the soil is also evident in the large number of landholders now awaiting assistance through the Service's Plant Hire Scheme. In some districts there is a waiting list of several hundred applications for plant hire and even with recent additions to plant and staff many requests cannot be met for some considerable time.

However, many farmers can carry out much of this work with their own farm equipment. These should contact their local Soil Conservation Service officer who will advise them on methods suited to their conditions and assist them in layout and design.

Each particular problem requires its own solution—contour cultivation, graded or absorption banks, pasture furrows, waterways, silt dams, realignment of fences, changed land use and new agricultural practices all have their place in conservation farming. Often too, while waiting to hire Service plant, the farmer can establish waterways, realign fences and cultivate on the contour. Erosion is thus reduced and when the banks are later built the outlets can be turned into the stable waterways without delay. Advice as to the most suitable location and design should, however, be

sought from the local Soil Conservationist to ensure that such works will fit in with the general conservation pattern.

The carrying out of an effective soil conservation programme demands the greatest co-operation between all interested parties. Joint action by owners of neighbouring properties or by the farmers and road authorities will often simplify the problem—indeed, it is frequently impossible to control erosion on a property until run-off from a farm higher up the watershed has been controlled.

The urgency of the erosion problem in this State has to some extent been masked during the past few years by good seasons and high prices. However, the progress achieved during these years and the widespread acceptance by landholders of soil conservation practice is adequate testimony to the soundness of the concepts advocated. Facilities available to landholders are being increased every year and landholders are assured of the ready co-operation of the Service officers throughout the State, if inquiry is made at local district or sub-district offices.



# SOIL CONSERVATION AND THE FARMER

BY

T. P. Taylor, H.D.A., Assistant Principal
Soil Conservationist.

IT is unfortunate that there is a general conception amongst both farmers and general public, that any form of soil conservation work or erosion control involves merely the use of earthmoving machinery and equipment, as typified by a modern crawler tractor and dozer, or a "bulldozer" as so many people like to call it. The "bulldozer" by its herculean efforts in pushing tons of soil about at a time has no doubt become a "glamour" machine and has produced a "dozer complex" that is not altogether conducive to a proper approach to the problem of erosion control and soil conservation.

The tractor and dozer has a place, and a very important one too, in the reclamation of severely eroded areas, and its value in this field cannot be over emphasised. On severely eroded lands on the north-western slopes, the Hunter Valley and other parts of the State, where practically the whole of the surface soil has been removed and the subsoil gullied to bedrock, the powerful crawler tractor and dozer is the ideal implement for undertaking initial soil conservation measures; without these machines huge areas of severely eroded land could not be treated economically at the present time.

However, it should be clearly understood by all that soil conservation work is not confined solely to the spectacular reclamation of abandoned eroded areas by large

*Fig.* 1.—Contour furrows constructed on hilly grazing land in Kangaroo Valley. The mouldboard plough in *Fig.* 2 was used for construction.



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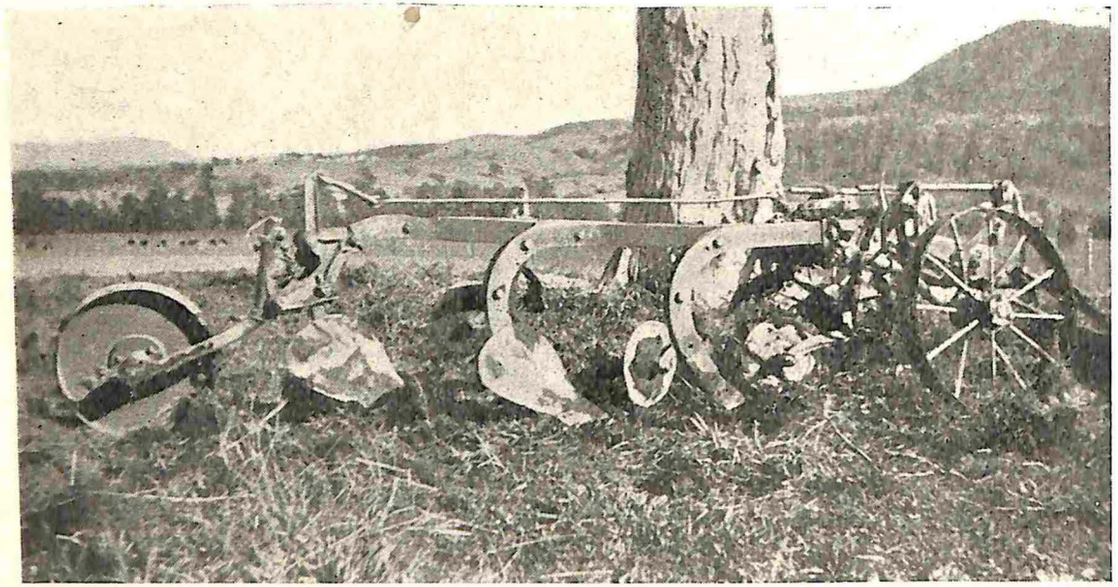

*Fig.* 2.—The type of mouldboard plough used, showing the front mouldboard and share detached.

earthworks, but that it is also necessary, and much more desirable, to treat erosion in its early stages rather than to wait until the services of a dozer and heavy machinery become essential.

## PREVENTION AND CONTROL OF EROSION.

The basis of all sound soil conservation work and erosion control is to protect the soil and prevent it being removed by wind or water. The best form of protection is that afforded by vegetation, and soil conservation measures are designed, therefore, with the object of establishing appropriate vegetation and increasing soil fertility. In many cases of severe erosion it is first necessary to control the run-off water before revegetation can be undertaken and this is done by mechanical measures using suitable implements. Mechanical measures consist of contour furrows, contour or graded banks, diversion banks, waterways, absorption areas, spreader banks and holding dams, which are designed and constructed according to the degree of erosion present, the climate, district and soil conditions.

Erosion prevention and control, especially in the early stages, is obtained by maintaining the fertility of the soil and this can be accomplished only by the adoption of sound farming and agricultural methods. Wise land use, judicious stocking, pasture improvement, crop rotation, fodder conservation and contour cultivation are essential practices if success in this direction is to be achieved.

Soil conservation, therefore, can be approached from two directions. *The first* is largely designed to prevent erosion, or to check it in its early stages, by wise land use and sound agricultural methods, and *the second* is designed to control and restore land that has already reached an advanced stage of erosion and requires the adoption of special mechanical measures.

In practice the degree and extent of erosion varies considerably from district to district, from farm to farm, and even from paddock to paddock. Similarly, control measures must be designed to meet the requirement of every part of each holding. The severely eroded areas will require extensive and special treatment, whilst the lightly affected areas can be controlled by simpler practices, or by a change in farming methods. It is in the latter case that a true appreciation of the erosion problem and the soil conservation methods required to effect improvement are of paramount importance, and the farmer can do much by



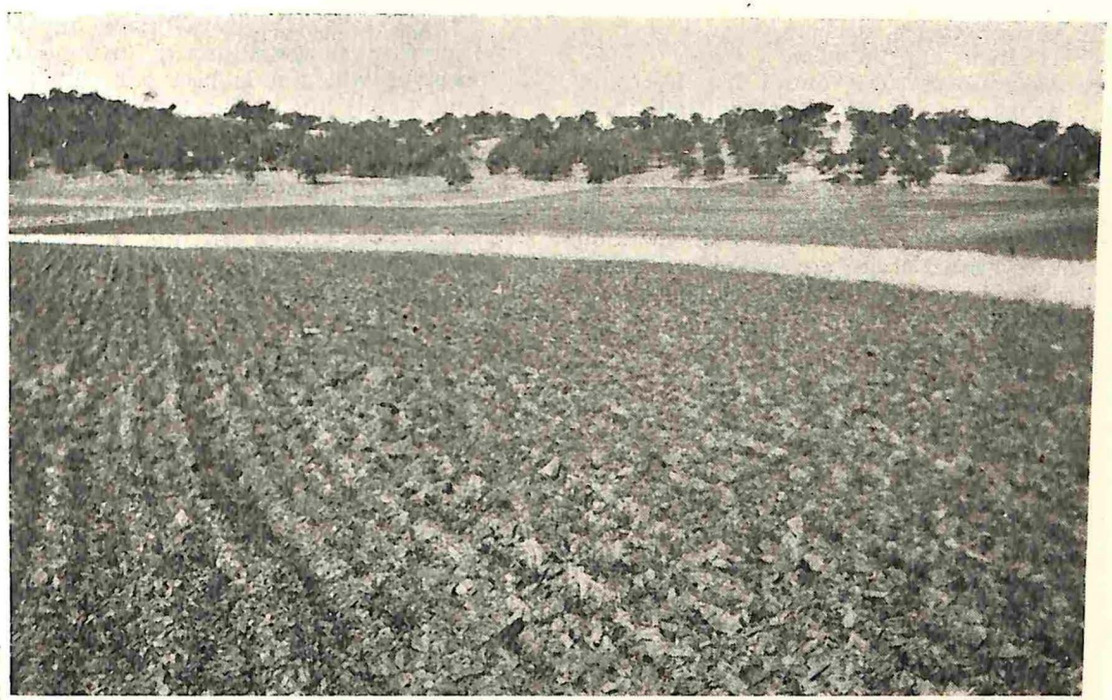

*Fig.* 3.—An unploughed naturally grassed drainage line in the Yass district.

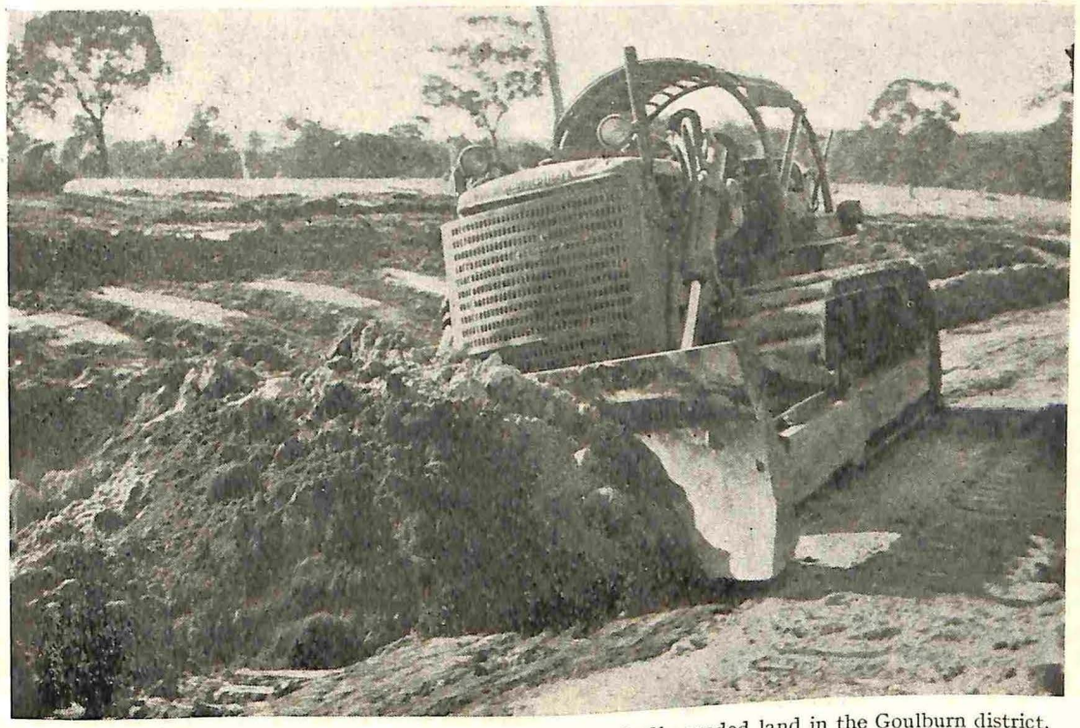

*Fig.* 4.—A 90 h.p. crawler tractor and dozer gully filling on badly eroded land in the Goulburn district.

his own methods, machinery and labour to effect such improvement. It should be realised also that the control of soil erosion is primarily a matter for the individual farmer and not one that can conveniently be left to the State. It is the farmer's responsibility to farm his land and to protect the soil from erosion and deterioration. The extensive State-wide facilities of the Soil Conservation Service are available to assist the landholder and demonstrations, plant hire and technical advice have been provided, but the key to the problem lies in the concerted efforts of each and every landholder, who is in any way affected by soil erosion.

## PREVENTION MEASURES.

Erosion can largely be prevented in the main agricultural areas by the adoption of the following practices:—

*Wise Land Use.* By this is meant using the land agriculturally for the purpose for which it is best suited. This immediately implies that there is a limit to the amount of cultivation that can be carried out on sloping lands and that it is wrong to continue to cultivate these areas year after year. Cultivation should be limited to the flats and gentler slopes, leaving the steeper areas to pastures, unless it has been specially prepared and protected by contour or graded banks. Ploughing and cultivation across drainage hollows or watercourses should be avoided, and if this were done, much gully erosion in the cultivated areas would be prevented. Similarily, on grazing areas the inferior stony or gravelly ridges should not be overcleared, whilst in many cases clearing should not be undertaken on these areas at all.

*Fig.* 5.—Erosion controlled by pasture improvement in the Goulburn District. The Wimmera ryegrass is establishing on eroded areas.



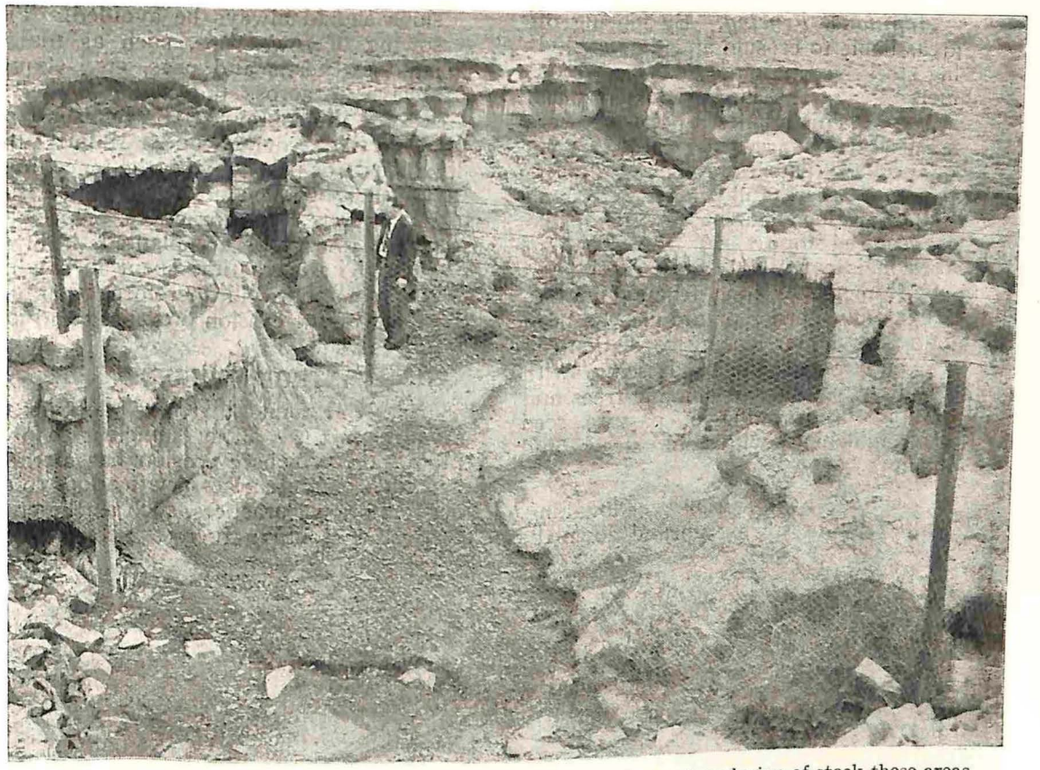

*Fig.* 6.—Gully head erosion in the Goulburn district. By fencing and exclusion of stock these areas can be stabilised vegetatively.

*Judicious Stocking.* The depletion of pasture cover by overstocking or by the depredations of rabbits is one of the main causes of erosion on grazing areas at the present time. To prevent erosion the soil must be protected, and a good pasture cover is one of the best forms of protection. Where pastures are allowed to recuperate and are not continually eaten out, a satisfactory grass cover is obtained and the soil is protected and run-off and erosion reduced.

*Rotation of Crops.* One-crop farming is one of the main causes of erosion in all farming areas. Besides reducing soil fertility it is found that the cultivation methods associated with one-crop farming, such as fallowing, leave the soil unprotected and vulnerable to erosion. A rotational system that reduces the time the soil is vulnerable to erosion, such as when pastures are introduced to the rotation or a different crop is grown, or the straw is left on the ground, will considerably reduce the extent to which erosion can take place.

*Pasture Improvement.* By increasing the pasture cover, greater protection is offered to the soil, infiltration increased and the tendency towards erosion is reduced considerably. Pasture improvement work, provided it is not followed by overstocking, is one of the best methods of preventing or controlling erosion. Suitable pasture species are recommended for each district, within the agricultural areas of the State, and expansion of this work is playing a major part in soil conservation in New South Wales.

*Additional Fencing.* By fencing off areas liable to erosion and thus excluding stock, vegetation is encouraged and in most cases an improvement is soon achieved. This applies especially where small isolated areas of sheet erosion, or "scalded" patches are already in evidence or where gully heads and small gullies are included. Frequently all that is required to prevent the spread of erosion is a few extra chains of fencing from the existing fencing lines to fence out a corner or around the head of a gully. After fencing vegetation can be encouraged by topdressing with fertiliser, planting of suitable trees and shrubs, broadcasting of pasture seed and mulching with old straw and manure.

*Contour Cultivation.* Ploughing, cultivating or sowing up and down the slope should always be avoided. The sowing of row crops, such as maize, potatoes, beans and peas, etc., should always be across the slope, or better still, on the contour. It is realised that ploughing round and round the paddock, or parallel with the fence, may be easier, but the amount of erosion that can follow these practices, especially where row crops are planted, is often great. The extra time spent in sowing on the contour will, therefore, be amply repaid by the erosion prevented and the soil saved.

## CONTROL MEASURES.

Where it is found that the adoption of the above practices is not sufficient to prevent erosion, or where erosion has already occurred, it becomes necessary to adopt some special additional practices, such as the construction of contour furrows, contour or

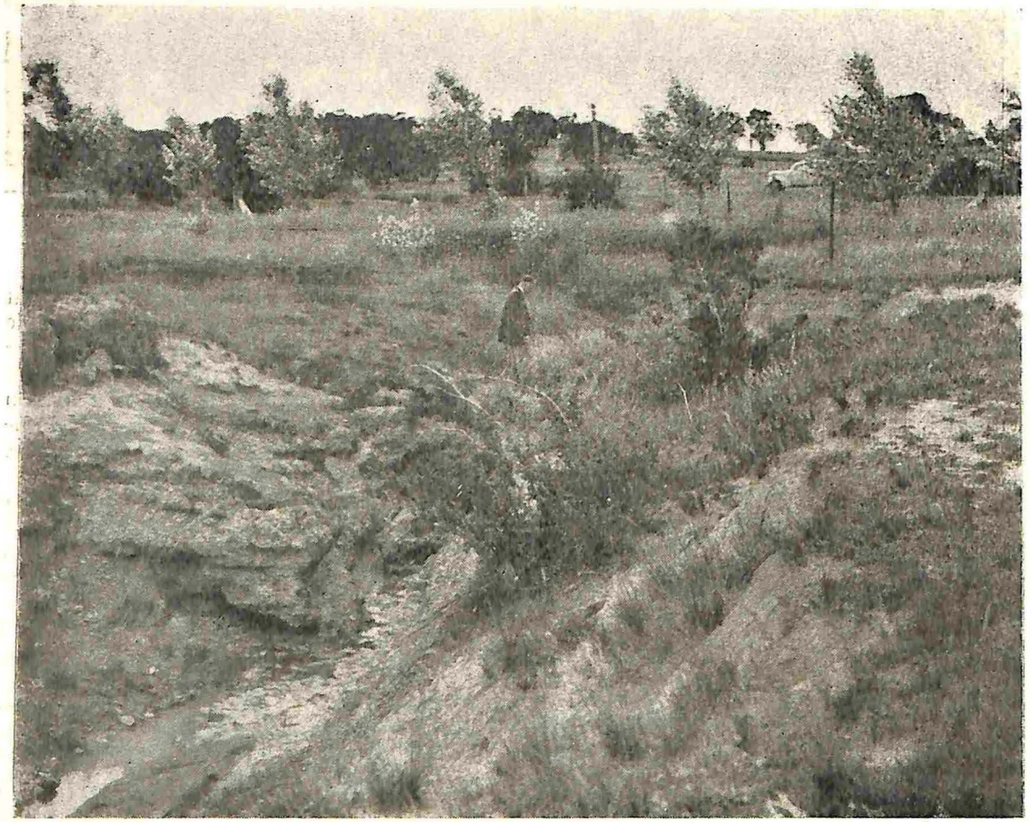

*Fig.* 7.—Gully head erosion controlled.



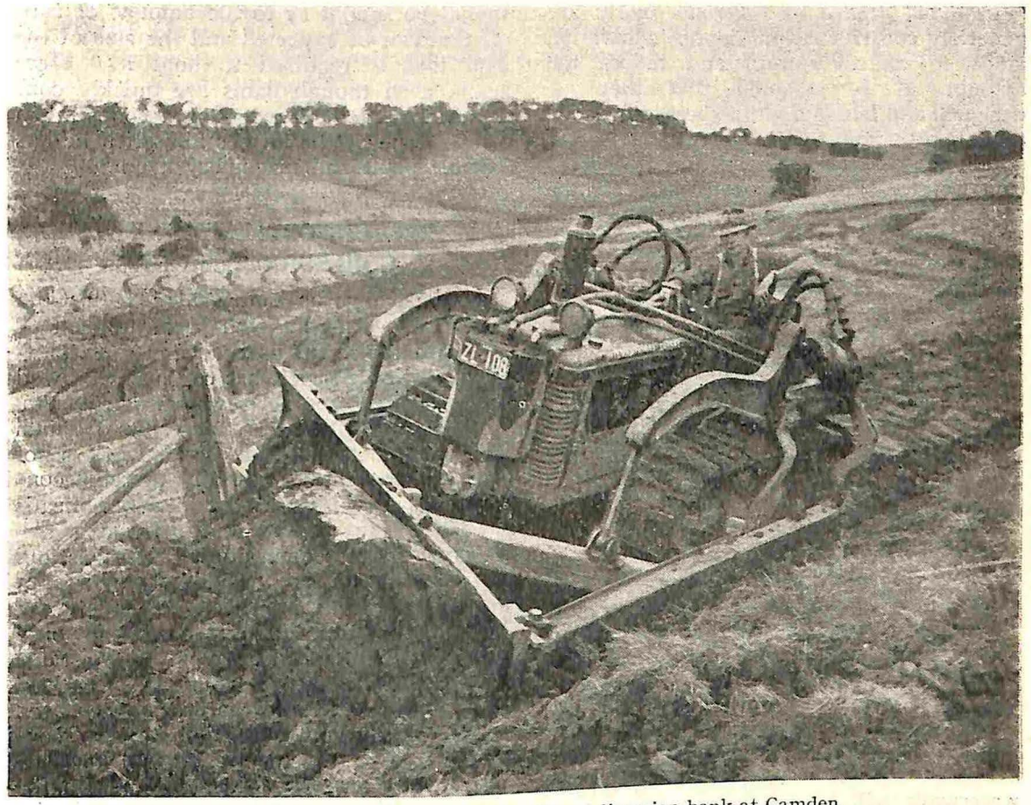

*Fig.* 8.—Tractor and dozer constructing a diversion bank at Camden.

graded banks, waterways, diversion banks, absorption banks, or holding dams. Most landholders will require some guidance and assistance before these measures can be adopted and, therefore, in such cases it is advantageous for the landholder to utilise the facilities of the Soil Conservation Service, which are freely available to him in all districts.

*Contour Furrows* are usually constructed on undulating grazing lands, where erosion is taking place due to depletion of the grass cover by overstocking. They are constructed across the slope from the top to the bottom at intervals of approximately a half chain apart and nine to twelve inches wide and deep. They are level from end to end and the object is to prevent run-off by holding the water and allowing it to soak into the soil. The Soil Conservation Service assists farmers with this work by marking the contours and generally advising how the furrows should be made.

Contour furrows can be constructed with a road plough where the soil is hard or gravelly, or with a heavy single furrow mouldboard plough. In some cases disc ploughs have also been used satisfactorily, especially the reversible type. Light tractors with plough attached have been used and have given excellent results, where the soil conditions are suitable. Multiple horse-drawn ploughs have also been used by removing one or more of the mouldboards or discs. The actual construction of contour furrows can be carried out with many types of farm ploughs, and there is no reason why this work should not be undertaken, where necessary, by the farmer as part of ordinary routine farm work.

*Contour, graded or diversion banks* are generally constructed on sloping cultivation lands to control run-off and reduce the amount. It is essential that they be designed and laid out with expert knowledge and here again farmers are advised to obtain the assistance of the Soil Conservation Service. Actual construction can be undertaken with modern earthmoving equipment, such as a dozer, or grader, or by means of a small grader ditcher, delver or disc plough. Undoubtedly, the bigger and modern machinery is best if large areas are to be treated or the erosion is severe, but if only small areas are to be treated a grader ditcher, delver or disc plough is quite suitable. There is a knack in building banks with a disc plough, but with a little experience, and the soil in the right condition (not too dry), it will be found that suitable banks can be made.

*Waterways and absorption areas* are required to take the flow from contour, graded or diversion banks. Wherever possible, natural waterways or drainage hollows should be preserved and used to take the flow from constructed banks. By not ploughing or cultivating across them and leaving these areas firm and well grassed, erosion and the likelihood of gullies forming will be avoided. In some cases, however, formed waterways will be necessary with a level cross-section and sown with a suitable pasture mixture to take surplus run-off from constructed banks. Here again the Service should be consulted as to suitable design and capacity. The construction work is usually carried out with a grader or grader ditcher and can be undertaken by the farmer himself after he has received advice as to requirements, except where large areas are to be treated.

Absorption areas consist of comparatively level areas, where the flow can be spread and absorbed using spreader banks where necessary. This may be a natural pasture area or it could be sown to lucerne or suitable pastures.

*Holding dams* are constructed primarily to hold up run-off and reduce flows on to lower areas and thereby reduce erosion. They can also serve as stock or domestic water supplies. Their construction is similar to that of ordinary dams, but information should be sought as to the amount of run-off that can be expected and the size of the dam that is required to hold it. Here again, even though dams are quickly constructed by modern dozers and scoops much can be done by the farmer himself if he has suitable plant and machinery available.

## RESULTS OBTAINED IN THE GOULBURN DISTRICT.

In the Kangaroo Valley, Mr. H. O. Cox, of Melross, with his own plant and labour and with advice and assistance from the Soil Conservation Service, has contour furrowed approximately 100 acres of his dairy farm. He is quite satisfied with the results obtained and claims that the value of this work is not only in preventing run-off, thereby controlling erosion, but that it is also a means of conserving rainfall and increasing soil moisture to such good effect that grass and pasture growth is considerably increased and soil fertility improved by conserving beneficial organic materials which would otherwise be washed away by heavy rains or storms. The treated areas have improved to such an extent and the erosion has been so completely controlled that he now considers it is worthwhile treating all undulating to hilly grass and pasture lands in the district with contour furrows, not only for the conservation of soil, but also for the retention of the rainfall on land where it falls and where it is most needed for plant growth, with a view to maintenance of soil fertility and increased production.

In the Goulburn district at Pomeroy, on the estate of A. A. Dalglish, large areas of contour furrows have been constructed on grazing country with a tractor and road plough to control gully and sheet erosion. Assistance with regard to contours and levels was given by the Soil Conservation Service, but all the construction work was done by the landholder. The work has been most successful and erosion in the areas concerned is definitely under control. Recently more contour furrow work was done on this property using a wheeled tractor with an attached mouldboard plough. This equipment did a particularly good job, especially where and when the soil was in good condition. Checks or stops within the furrows were made automatically by raising the plough with the hydraulic lift and lifting it out of the ground as required. With machines that have a hydraulic lift it is a simple matter to raise and lower the plough quickly without stopping the tractor. The unploughed portion then provides an excellent check within the furrow, which prevents the water concentrating and overtopping at low places.



## CONCLUSION.

The foregoing results are examples of what can be done by the landholder when he is prepared to tackle the erosion problem.

Landholders, provided they are given the necessary advice and assistance, can do much with their own plant and labour and, by adopting modern soil-conserving methods of farming, prevent or control erosion before it can become a problem on their land. There are many farmers who have obtained outstanding results in the direction indicated. Some have done this by changing from one-crop farming to rotational cropping, others by means of pasture improvement or by contour cultivation, especially where row crops are grown. Outstanding results have followed judicious stocking and the elimination of overstocking to such an extent that bigger returns and more bales of wool of better quality have been obtained from the same property in similar seasons when the number of sheep has been reduced by 10 per cent. or 20 per cent.

The use of heavy earthmoving machinery, although essential in many cases, should be considered as an adjunct to and not the sole basis of successful soil conservation practice.

# RESULTS OF WISE LAND USE ON WELLINGTON RESEARCH STATION

BY

G. M. PETTIT, H.D.A., District Soil Conservationist.*

WELLINGTON Soil Conservation Research Station is situated amongst farm lands which, while generally highly productive, are nevertheless subject to water erosion which, by removing fertile topsoil, scouring out gullies (fig. 1) and depositing the eroded material on lower lying land (fig. 2) in stream beds and in stock water supplies is slowly but surely reducing their productive capacity. Prior to the acquisition of the Research Station lands by the Service, the erosion processes had progressed to a degree which rendered farming difficult and uneconomical.

The widespread incidence of erosion throughout the fertile mixed farming lands of the Central Western Slopes is revealed by the findings of the erosion survey undertaken by the Service.

TABLE I.

*Areas and percentages of the various classes of eroding land in the Central Western Slopes as revealed by the erosion survey undertaken by the Soil Conservation Service.*

| Severe Gully Erosion. | | Moderate Gully Erosion. | | Sheet Erosion. | | Moderate Wind Erosion. | | Severe Wind Erosion. | | No Appreciable Erosion. | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Sq. miles. | Per cent. of Total Area. | Sq. miles. | Per cent. of Total Area. | Sq. miles. | Per cent. of Total Area. | Sq. miles. | Per cent. of Total Area. | Sq. miles. | Per cent. of Total Area. | Sq. miles. | Per cent. of Total Area. |
| 29 | 0.2 | 3,850 | 26.0 | 5,660 | 38.3 | 336 | 2.3 | 44 | 0.3 | 4,862 | 32.9 |

## SOIL AND WATER LOSSES ARE LARGE.

Some indication of the amount of soil and water lost from arable land subjected to normal farming practices is indicated by the results from experimental plots on this Station (Table 2). The plots concerned were cropped to wheat during 1950 and the results refer to the period from fallowing to harvest. The year under review was one of unprecedently high rainfall, but the rainfall characteristics and other factors were by no means so conducive to erosion as could easily be the case in a similar period of smaller total rainfall.

* Formerly Officer-in-Charge, Wellington Research Station.



TABLE 2.

*Soil loss in lbs. per acre and run-off in inches from experimental plots sown to wheat, for the period fallowing 1949 to harvest 1950. Total rainfall 58.28 inches.*

| Plot No. | Soil Loss lb. per acre Fallowing to Sowing. | Run-off in inches Fallowing to Sowing. | Soil Loss lb. per acre Sowing to Harvest. | Run-off in inches Sowing to Harvest. | Total Soil Loss lb. per acre. | Total Run-off in inches. |
|---|---|---|---|---|---|---|
| A7 | 5,582 | 1.647 | 2,521 | 4.565 | 8,103 | 6.21 |
| B4 | 6,119 | 1.529 | 3,902 | 7.483 | 10,221 | 9.01 |
| C1 | 5,826 | 1.390 | 4,462 | 7.211 | 10,288 | 8.60 |
| Mean ... | 5,842 | 1.522 | 3,628 | 6.419 | 9,470 | 7.94 |

Reference to the above table shows that from the time the preparation of the land commenced until the crop was harvested, a mean total of 9,470 lbs. of soil per acre were lost while 7.94 inches of rain, or 13.6 per cent. of the rainfall, ran off the plots. The figures quoted in Tables 1 and 2 show beyond doubt that erosion involving great losses of topsoil is taking place from extensive areas of land and emphasise the need for protective measures. Soil Conservation Research Stations were established to investigate erosion problems and to test and demonstrate methods of reclaiming eroded land.

## DEVELOPMENT OF THE STATION.

Development of the Research Station proceeded along three complementary lines—

(1) The establishment of a water disposal scheme to deal safely with surplus water from the Station and also with the concentrated drainage from some 420 acres lying to the east of the property.

(2) The implementation of a farming plan aimed at the restoration and maintenance of the fertility of the pasture and arable land.

(3) The installation of the structures, devices and instruments essential for the conduct of research into erosion control problems and the collection, analysis and recording of the data so obtained.

## THE EROSION PICTURE IN 1944.

When acquired by the Soil Conservation Service the property presented a depressing picture of depleted fertility and erosion damage. The dominant soil type is the red-brown earth on which so much of the district's wheat is grown. Over most of the property the soil is of considerable depth and when exposed erodes readily, deep gullies forming along drainage lines (Fig. 1). Dissecting the 450 acres comprising the property were more than 300 chains of gullies of sufficient size to impede the passage of farming implements. In addition the whole area had lost topsoil through sheet erosion (Fig. 3).

## WISE LAND USE A MAJOR FACTOR IN EROSION CONTROL.

While there are large areas of arable land which can only be made safe for continued cultivation if protected by mechanical structures, either on the land concerned or on adjacent areas, the construction of these earthworks is but the first step; unless they are aided by conservation farming practices the results are likely to be disappointing. A conservation programme to be truly successful must aim not only at holding the soil in place but also at maintaining that soil in the highest possible state of fertility.

It was with this aspect well in mind that the farming plan for the Research Station was adopted. So that their behaviour might be investigated and their use demonstrated a wide range of earthworks has been constructed, comprising pasture furrows, graded banks, grassed waterways and dams. The infrequency with which these are taxed to anything approaching capacity is a measure of the efficiency of the farm practices in reducing run-off.

## THE FARMING PLAN.

The accelerated erosion present on so much of our land may be attributed largely to single crop farming, often with stubble burning a regular feature; up-and-down-hill cultivation, at times on slopes too steep for safe cropping; overgrazing, either by domestic stock or rabbits, and the removal of timber from much country little suited for agricultural or pastoral purposes.

Care has been taken that these undesirable features be eliminated from our land use. Single-crop farming has been replaced by a crop rotation which has no place for stubble burning. Cultivation has been restricted to safe slopes, generally not in excess of 8 per cent., steeper slopes having been sown to permanent pasture, or left under natural pasture, and stocking is maintained at a level which permits improvement of the sward, rabbits being closely suppressed. All cultivation is performed along the contour.

## THE CROP ROTATION.

In this district the choice of an alternative crop to wheat is limited and a pasture including lucerne is utilised. A rotation has been adopted in which each arable paddock is sown to pasture and devoted to grazing for a number of years, following which three crops of wheat are grown in alternate years with a return to grazing for a further four years following the third crop.

## THE RECLAMATION PROCESS.

The paddock suffering most severely from sheet and gully erosion and which appeared to be the least productive was chosen for the establishment of the first pasture leyland, less affected areas being selected for wheat growing. The first grazing period of the rotation was completed in 1948 and the paddock was sown to wheat

*Fig.* 1.—Gullies such as this formerly dissected the arable land on Wellington Research Station.



*Fig.* 2.—This silt pan, composed of coarse material and sand, covered more than an acre of arable land to depths ranging from one to two feet.

in 1949. A summary of the yearly progress may be of interest—

1944: Sheet erosion and gully present to an alarming degree (Fig. 3). Little vegetation with many completely bare patches. Treatment included gully filling, as on these 78 acres there were some 60 chains of gullies large enough to interfere with cultivation, and pasture furrows to decrease run-off and protect earthworks in progress on lower land.

1945: Sown during autumn with lucerne 3 lbs., Wimmera rye 2 lbs., with 100 lbs. of superphosphate per acre. Excellent germination occurred with very heavy growth following. Wet weather rendered early grazing impracticable and mowing was resorted to for the control of excess growth. Some grazing was secured later in the year.

1946: Moderate grazing available. Lucerne proved its suitability for this soil and climate by persisting through a period of low, poorly distributed rainfall (Table 3).

1947: Stock carried at the rate of 1 sheep per acre. Pasture sward improved in vigour and density despite severe grasshopper infestation during the summer months (Fig. 4).

1948: Stock carried at the rate of 1.7 sheep per acre for the twelve months, although the paddock was ploughed in November to prepare for wheat in 1949. Lucerne stand very dense and vigorous when ploughed in.

1949: Sown to wheat in late May at the rate of 63 lbs. per acre with 50 lbs. superphosphate. Crop yielded 36 bushels per acre (Fig. 5).

1950: Left in stubble until October when preparation for the 1951 wheat crop commenced. A good quantity of feed was available

throughout the year, including trefoils, self-sown wheat, black oats, Wimmera rye and some lucerne. Stock carried at rate of 1.6 sheep per acre.

Future use will be: 1951, wheat; 1952, stubble; 1953, wheat; 1954, stubble; 1955, pasture for a further four years.

## VARYING RAINFALL.

During the six years since the establishment of the Station annual rainfall has varied within wide limits.

TABLE 3.

*Monthly Totals in Points,* 1944-1950.

| Year. | Jan. | Feb. | Mar. | April. | May. | June. | July. | Aug. | Sept. | Oct. | Nov. | Dec. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1944 | 34 | 79 | 17 | 78 | 153 | 17 | 95 | 189 | 38 | 41 | 45 | 29 |
| 1945 | 395 | 136 | 81 | 219 | 210 | 495 | 155 | 334 | 13 | 133 | 107 | 106 |
| 1946 | 160 | 229 | 107 | 83 | 86 | 56 | 69 | 33 | 88 | 199 | 113 | 186 |
| 1947 | 19 | 317 | 238 | 87 | 184 | 78 | 271 | 140 | 243 | 225 | 385 | 367 |
| 1948 | 317 | 263 | 139 | 155 | 137 | 263 | 58 | 84 | 152 | 44 | 132 | 152 |
| 1949 | 90 | 385 | 129 | 178 | 274 | 213 | 119 | 86 | 413 | 340 | 212 | 93 |
| 1950 | 413 | 491 | 471 | 461 | 240 | 460 | 433 | 384 | 217 | 868 | 695 | 137 |

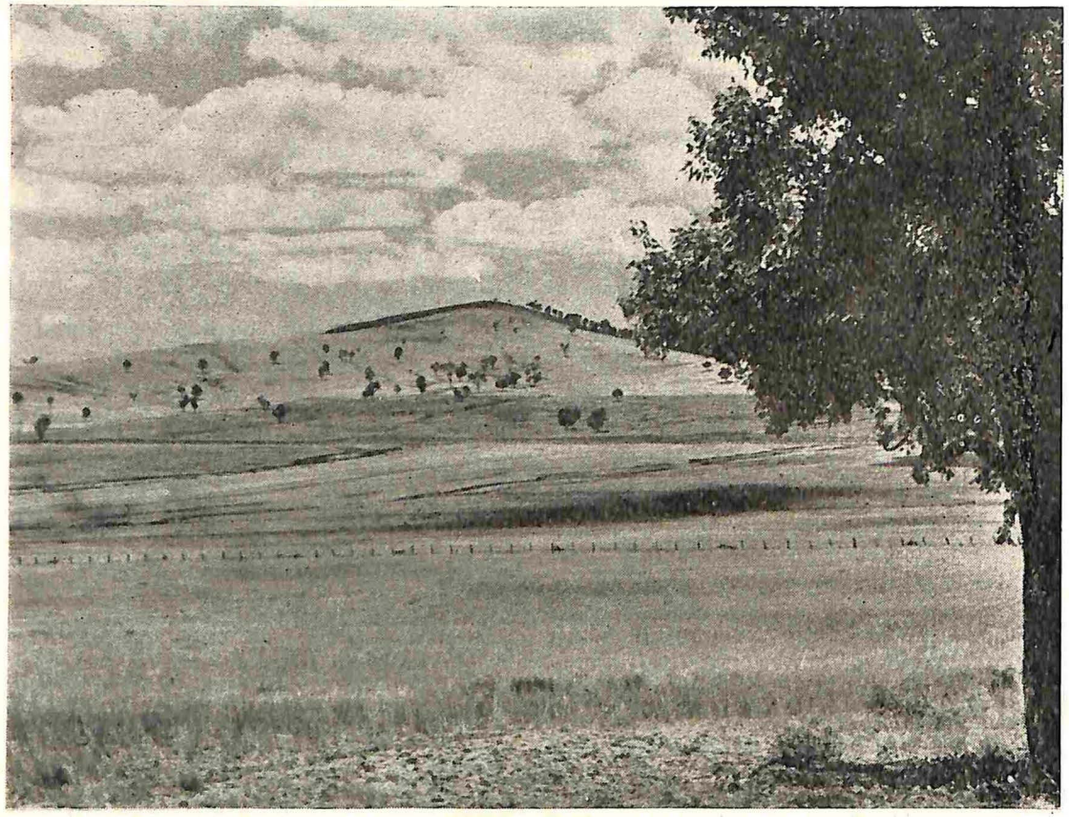

*Fig.* 3.—Portion of Wellington Research Station in 1944. Sheet erosion and gully formation on arable land.



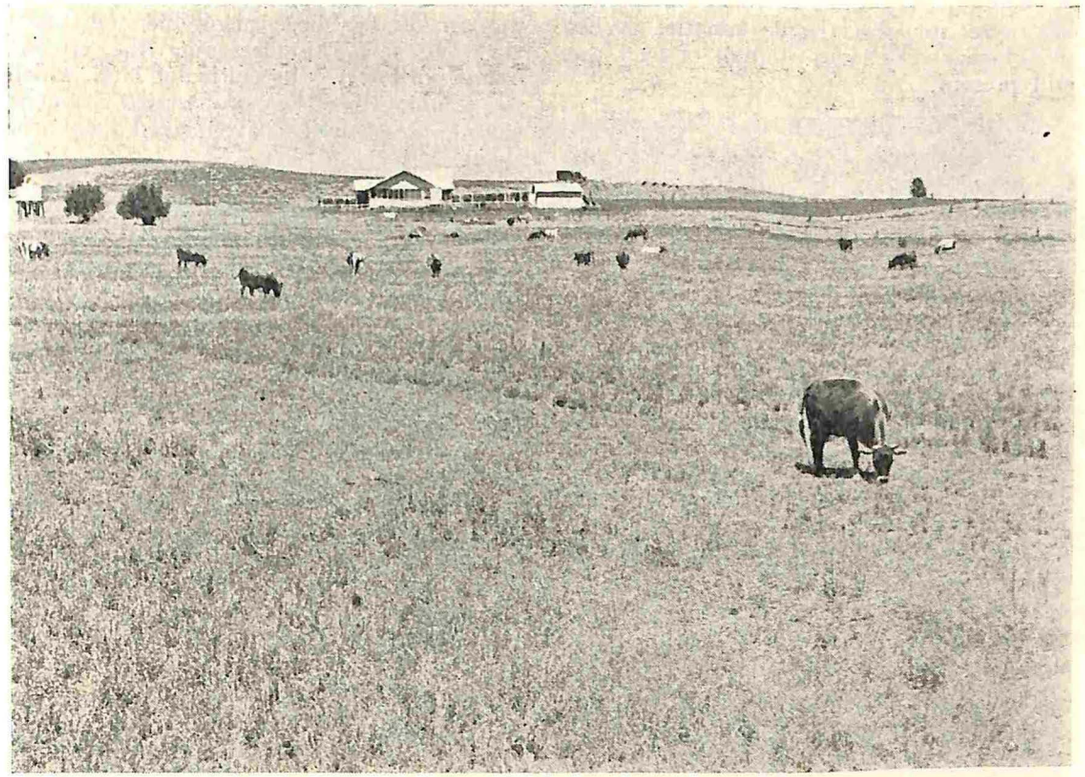

*Fig.* 4.—Lucerne and Wimmera rye grass growing on the area shown in *Fig.* 3 four years later.

## RUN-OFF REDUCED.

Run-off from some 60 acres of the paddock referred to above enters a 1,500 cubic yard dam which also receives water from the public road. It was not until August, 1950 that this dam overflowed for the first time since 1944. Reference to Table 3 shows the rainfall for the period. The erosion pictured in Fig. 3 is evidence that prior to 1944 run-off from the area must have been considerable and it is interesting to note that this reduction in run-off and hence in soil loss has been entirely due to altered land use; there were no earthworks in the paddock during this time. It is obvious that the lessened run-off means that more water enters the soil, a valuable consideration in a district where soil moisture is so often the limiting factor in plant growth.

## INCREASE IN FEED VALUE OF STUBBLES.

In those paddocks devoted to wheat growing in alternate years there has been a very notable increase in the feed value of the stubble. The trefoils (*Medicago hispida* and *M. minima*) show to particular advantage. This may be attributed to their increased seed production, because the stubble is not burnt, and to the benefit obtained from the superphosphate applied to the wheat crops. In turn the wheat benefits from the increased legume growth, the droppings of grazing animals and from the greater return of organic matter to the soil.

As an indication of the grazing which may be expected from stubble under these circumstances the case of a paddock of 57 acres may be cited. Following harvest in 1948 the stubble was grazed until the end

of October, 1949, at a rate equal to 2.4 sheep per acre for the twelve months. When ploughed a very large amount of feed was still present.

## GOOD PASTURES REDUCE RUN-OFF.

Subdivision fences were relocated so that areas previously cultivated but considered too steep for such use were divided from the arable land. These portions have in some cases been sown to permanent pasture and in others the grasses and legumes already present have been relied upon. The increase in the vigour and density of the sward has been one of the most striking results secured and is due to controlled grazing, topdressing with superphosphate and eradication of rabbits. In addition to topdressing the sown pastures are renovated each autumn with a scarifier or combine fitted with lucerne points.

The value of well managed pasture land in erosion control has been amply demonstrated. It has been observed that, although those areas devoted to pasture comprise the steeper portions of the property, the run-off has been negligible. This is a very big factor in lessening the erosion hazard for lower lying cultivated land, which so often receives the accumulated drainage from overcleared, overgrazed country above.

## CARRYING CAPACITY OF PASTURES.

The good condition of the grazing paddocks has been achieved by regulating stock numbers in accordance with the state of the pastures. On acquisition the pastures were in a deplorable state; as these have been improved stock numbers have been increased. The fact that leyland pastures are also there for the protection and improvement of the soil has been kept well in mind. The present condition of lucerne stands managed in this way since 1945 shows the wisdom of the practice. To quote an example, a paddock of 39 acres sown to Wimmera rye and lucerne in 1945 has, for the past three years, carried stock at the rate of 2.5 sheep per acre. It is safe to

*Fig.* 5.—Wheat growing in 1950 on the same paddock as shown in *Fig.* 3 and *Fig.* 4 yielded 36 bushels per acre.



*Fig.* 6.—Eucalypts border the entrance drive and provide shelter for adjacent paddocks.

say that the stand of lucerne present now is better than at any previous time, and soil loss is now negligible.

Average rate of stocking over the whole property for the past three years, computed on an area of 450 acres is 1.2 sheep per acre. Actually the figure 450 is misleading as not inconsiderable areas are reserved from grazing for experimental purposes, tree nurseries, grass garden, woodlots, homestead enclosure and roadways. On 60 acres, therefore, grazing is restricted because of research requirements and approximately 125 acres are used for cereal cultivation, or fallow, each year.

## TREE PLANTINGS.

At the time the property was acquired there were on 430 acres not more than thirty trees, mostly in one paddock. The remaining 20 acres is lightly timbered with second growth white box. Thus in most of the paddocks there were neither shade nor shelter trees for stock. A tree planting programme designed to afford, in due course, shade and shelter in each paddock has been followed, a number of trees being planted each year. As well as providing shade and shelter these woodlots will be a source of timber for farm use when the trees mature.

As well as having a purely practical value, the presence of trees in the vicinity of a farm dwelling adds much to the pleasure of living therein. A woodlot has been established to the west of the Station residence resulting in very great improvement in appearance and providing shelter from the wind. It is interesting to note the increase in bird life in the vicinity of these woodlots; fifteen different species of birds have been seen in the homestead enclosure and the adjacent woodlot (Fig. 6).

## CONCLUSION.

Starting with a severely eroded farm in 1944 it has been possible in a comparatively short space of time to reclaim the area and to ensure that production at a high level

can be continued without further damage by erosion and with steady improvement in soil fertility.

The extent to which these results are due to altered farm practice is evident when it is mentioned that on 240 acres there are no earthworks whatsoever. On another 61 acres mechanical control measures consist only of pasture furrows, while 150 acres are protected by graded banks discharging into grassed waterways.

Much of the success achieved has been due to the inclusion of lucerne in both the permanent sown pastures and the pasture leyland. This plant, by reason of its deep rooting habit, has been able to withstand several periods of unfavourable rainfall. Because of its quick response to summer rains, a great bulk of feed, with consequent protection against erosion, is produced at times when no growth can be expected from the indigenous fodder plants.



# SOME WESTERN PASTURE SPECIES—BLUEBUSH, COTTONBUSH AND OTHER PERENNIAL CHENOPODS

BY

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IN a previous article in this journal (Vol. 7, No. 2) the perennial saltbush (*Atriplex vesicarium*) was discussed in some detail. In this article it is intended to discuss a number of other plant species in the same family (Chenopodiaceae) as the perennial saltbush, which plays such a prominent part in the composition of western pastures.

Second in importance only to the perennial or bladder saltbush are the plants falling into the genus of *Kochia*. To this genus belongs the bluebushes and cotton bush, and it is characterised by the presence of a horizontal membranous disc or wing on the fruiting body. According to Black there are twenty-four species of *Kochia*, but not all of these are familiar to the grazier.

Other plants to be discussed are those belonging to the genus *Bassia* (roly poly), *Rhagodia* and *Enchylaena* (berry saltbushes), *Malacocera* (woolly saltbush), *Chenopodium* (goosefoot) and *Salsola* (prickly saltwort).

## I. THE BLUEBUSHES.

Perhaps the most important species of the genus of the *Kochia* are those which are known as the Bluebushes. This term includes four main species and several less important species, but only those four will be discussed; these are *Kochia pyramidata* (black bluebush), the seed of which characteristically turns black when ripe, *Kochia planifolia* (low bluebush), *Kochia sedifolia* (bluebush or pearl bush) and *Kochia Georgei* (George's bluebush).

All these bluebushes occur in association with one another and with perennial saltbush, though perhaps the most important communities are:—

(*a*) *K. pyramidata—K. sedifolia;*

(*b*) *K. pyramidata—K. planifolia;* and

(*c*) *K. sedifolia—Atriplex vesicarium.*

It is not uncommon to find pure stands of any of these bluebushes.

### Occurrence, Longevity, Drought Resistance.

The bluebushes occur west of the 13 inches isohyet and on red-brown sandy soils overlying limestone nodules at various depths, this depth governing the type of community. They are to be found over fairly extensive areas throughout the Western Division, scattered throughout the perennial saltbush association on the undulating country surrounding the Barrier and Grey Ranges, and throughout the far south-west of the State, west of a line from Hay to Ivanhoe.

The soils supporting the bluebush association are invariably very sandy, and are highly susceptible to wind erosion once the protective cover of vegetation has been removed; some of the worst examples of drift are to be found on such soils. As bluebush country is often undulating, severe water erosion is also a common feature. As a whole the community may be described as a low scrub, the bushes being separated by a distance equal to or slightly less than the diameter of the bush.

Of these four bluebushes, *K. sedifolia* is by far the most drought-resistant and long-lived. It will even survive complete defoliation by stock. Unlike the perennial saltbush the bluebushes are deep rooters, but in common with this species produce deciduous feeding roots following good rains and these are shed when the ground is no longer moist.

*Table of comparison between (a)* K. pyramidata, *(b)* K. sedifolia, *(c)* K. planifolia *and (d)* K. Georgei.

| —— | *Kochia pyramidata.* | *Kochia sedifolia.* | *Kochia planifolia.* | *Kochia Georgei.* |
|---|---|---|---|---|
| COMMON NAME ... | Black Bluebush. | Bluebush or Pearl Bush. | Low Bluebush. | George's Bluebush. |
| HEIGHT ... ... | 2–4 feet ... ... | Up to 3 feet ... | Up to 2 feet ... | Up to 2 feet. |
| COLOUR AND APPEARANCE. | Greenish-grey or bluish-grey. | Branches and leaves are covered with minute white hairs which give a very pale blue almost white colour. | Similar to *K. sedifolia* but the whitish colour not as pronounced. | As for *K. sedifolia*, but hairier and dull greenish grey. |
| LEAVES ... ... | Cylindrical fleshy, less than ¼ inch length. | Cylindrical, fleshy, in less than ½ inch in length; no leaf stalk. | Club-shaped, fleshy, about ½ inch in length; definite leaf stalk. | Slender-cylindrical, fleshy, about ½ inch in length; woolly. |
| LONGEVITY ... | Perennial — very long lived possibly 50 years. | Perennial — very long lived, possibly 50 years. | Perennial — probably intermediate between *K. sedifolia* and *K. Georgei.* | Perennial—about 12 years. |
| SOIL TYPE ... | On sandy soils, where the limestone layer is 4 feet or more below the surface. | Red-brown soils of medium to light texture which are rich in lime. | As for *K. sedifolia.* Limestone within 4 feet of surface. | As for *K. sedifolia.* Limestone within 4 feet of surface. |
| PALATABILITY ... | Palatable, but may be considered as valueless as fodder. Can be poisonous on an empty stomach. | Palatable, but not as much as *K. Planifolia.* | Very palatable ... | Palatable. |

Perhaps the most remarkable feature of the bluebushes is the fact that seed will germinate over a wide temperature range. This gives it an advantage over the saltbushes in that germination can take place at almost any time of the year following sufficient rains. However, unlike saltbush, whose seeds may be viable up to six years, the seeds of bluebush are viable for only a few months.

The bluebushes are not grazed heavily, as the herbage grasses which form the ground cover throughout the communities form the most important supply of fodder. Its great resistance to drought means that the bush provides both a supply of fodder during drought when all other feed is lacking, and provides permanent protective cover for the soil.

**Regeneration.**

The occurrence of seedlings of *K. sedifolia* is extremely rare. Unfortunately, its great drought resistance and longevity do not necessitate regeneration from seed, and consequently the bush is very capricious in its seeding. The other three species, however, seed freely following good rains. The bushes flower in late winter, the seeds falling in spring or early summer. On denuded or eroded areas the possibility of natural revegetation is somewhat limited by the fact that the light, winged fruit of the bluebushes may fail to find a hold on the bare surface. Thus a cover of herbage is necessary to catch the seed, but under normal circumstances the natural process of recolonization is very slow.



**Reaction to Grazing.**

The first species to disappear from the bluebush pasture are the palatable grasses which form the basis of the ground cover between the bushes. These are chiefly *Stipa sp.* (spear grass), *Eragrostis sp.* (Love grass) and *Enneopogon sp.* (niggerheads). The latter two species are capable of replacing themselves from year to year and consequently a heavily-grazed area suffers firstly by the loss of *Stipa.*

Once the palatable grasses and herbaceous annuals are removed, the sheep are forced to revert to the bluebush; though in outward appearances the community does not seem to have suffered much, the lack of herbaceous cover renders the soil susceptible to drift or water erosion. Further heavy grazing leads to the removal of the bluebushes and the community degenerates, following which, scalding and soil drift take place.

The rabbit is very fond of the bluebush, and in addition the sandy soils supporting the bluebush are very favourable for burrowing so that bluebush country is usually heavily rabbit-infested. Perhaps it is the rabbit rather than the sheep that is responsible for the total destruction of bluebush in some areas.

**II. COTTONBUSH (Kochia aphylla).**

Throughout the perennial saltbush association there appear many communities in which the cottonbush is the dominant species. These areas may be only small in dimension, but in many cases there are extensive pure stands. The cottonbush association is the result of a heavy grazing policy which brings about the replacement of the perennial saltbush. Whether the *Kochia sp.* is less palatable than the *Atriplex sp.* that it replaces is a debatable point. Some graziers claim that the stock do better on the *Kochia* pasture; nevertheless the degeneration into the cottonbush pasture is the least serious of all the changes which can be brought about by the overstocking of the perennial saltbush pasture. Apart from

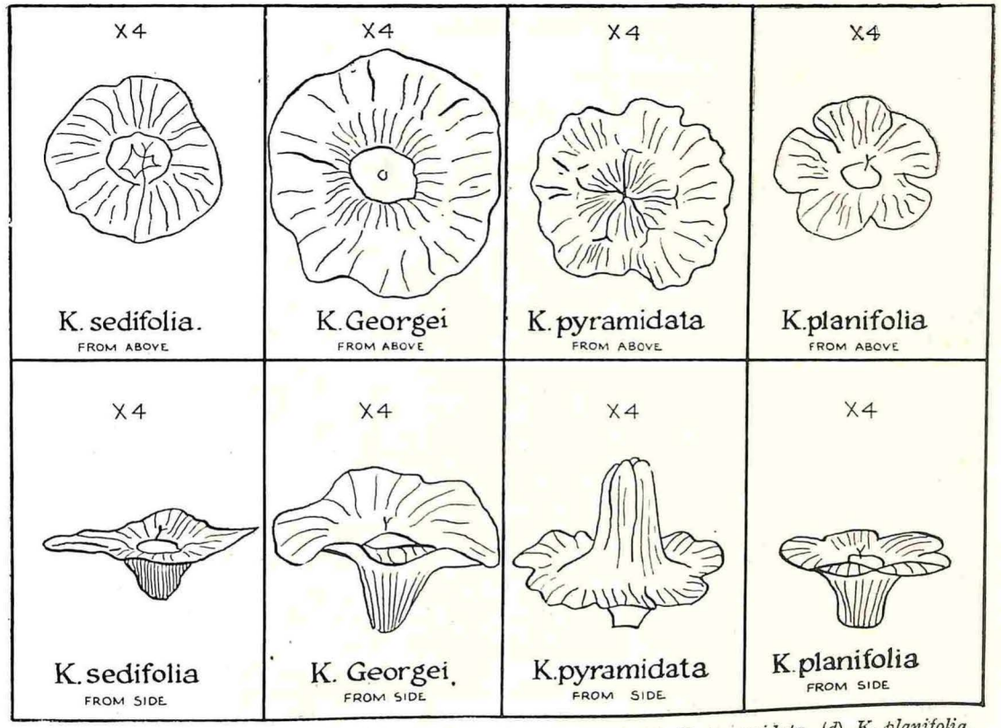


*Fig.* 1.—Comparison of fruits of—*(a) K. sedifolia, (b) K. Georgei, (c) K. pyramidata, (d) K. planifolia.*

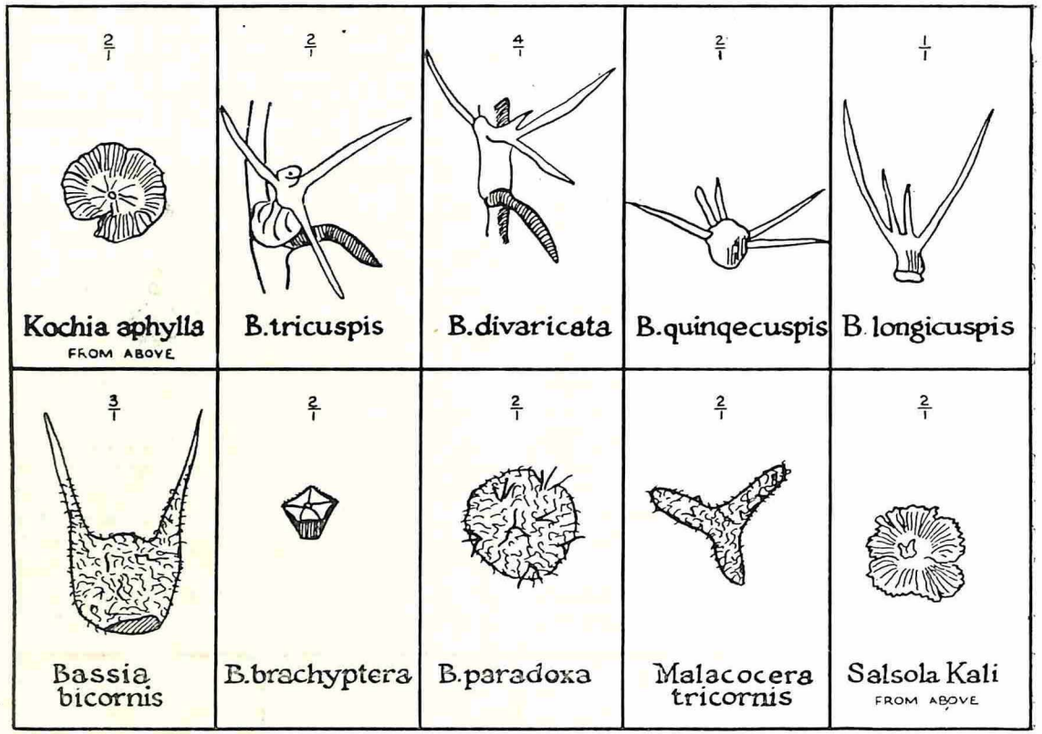


*Fig.* 2.—Fruits of species of *Kochia, Bassia, Malacocera and Salsola.*

the change in the shrub dominant layer there is little or no change in the herbaceous flora.

**Description.**

It is a greenish-grey shrub, up to 3 feet in height but more generally it is seen at about 2 feet, with slender, stiff spreading branches which are striate. The leaves are small and crowded on the stems, the barren branchlets becoming rigid and pointed. The winged fruit is up to ¼ inch in diameter. The bush is often covered with small white, woolly balls which look like cotton balls, and this is probably where the plant derived its common name. However, these balls are due to a small grub (which can be seen quite plainly on dissection), the plant probably throwing out a protective covering in response to the stimulus, or it may be the product of the grub itself.

**Occurrence.**

The shrub occurs throughout those areas where the perennial saltbush is found but it is confined to the soils of heavier texture. It is frequently found in depressions, crab-holes and along water courses.

**Reaction to Grazing.**

With heavy stocking, the cottonbush community shows further degeneration and is invaded by *Bassias* (roly poly), annual saltbushes and unpalatable annuals. It is not common to find eroded areas in this community, as when the soil is bared it is too heavy to be affected; after sufficient rains and spelling from stock recovery is quite rapid.

## III. COPPERBURRS, POVERTY BUSHES, ETC. (*Bassia spp.*).

Throughout the west, the *Bassias* form a very important portion of the floristic composition of any community. This group of plants is characterised by possessing a woody seed covering, bearing 2-12 spines, which may be only a fraction of an inch long or well over an inch. The leaves are always



narrow and in most cases quite succulent. A pasture which has a high percentage of *Bassias* is regarded as one which has been heavily stocked, the more palatable species having been eliminated by selective grazing. While young, the *Bassias* are quite palatable, but once the spines begin to harden their attraction is lost. The rapid growth of *Bassias* in a pasture is due to a number of factors:—

(1) The spiny fruits make them easily spread by sheep;
(2) the rapid germination of the seed;
(3) the production of seed at a very early stage in the plants growth;
(4) their comparative freedom from grazing once the spines become well developed.

In pure stands of *Bassia spp.* movement of sheep becomes quite restricted due to the spiny nature of the bushes. Conversely, by restricting the numbers of stock the more palatable and desirable species successfully complete with the *Bassia spp.* These are very closely allied to the *Kochias*, and there are certain features common to both which encourage drought resistance; for example, the similar type of fleshy cylindrical leaf, and a deeply penetrating root system. Under suitable conditions they have a life span of 2-3 years. Black records thirty-one species of *Bassia* which could be considered as common to Western New South Wales.

The replacement of the perennial saltbush by various species of *Bassia* is very evident in every district where the saltbush was once dominant. In the gibber country of the West Darling the copperburrs are regarded very favourably as fodder plants and, apart from scattered grasses, may be the only kind of fodder available.

Many communities of *Bassia* can be recognised, these communities being a stage in the redevelopment of the climax community, the perennial saltbush. However, this is dependent on supplies of seed of saltbush and where the bush has been absent for a few years it may be said quite definitely that it will never return unless seed is introduced to the area.

Only the most important species of *Bassia* will be considered. These are:—

(a) *Bassia tricuspis.* This is known locally as either roly poly, burr or

*Fig.* 3.—Cottonbush (*Kochia aphylla*) in the Hay district. There is a good growth of grasses between bushes.

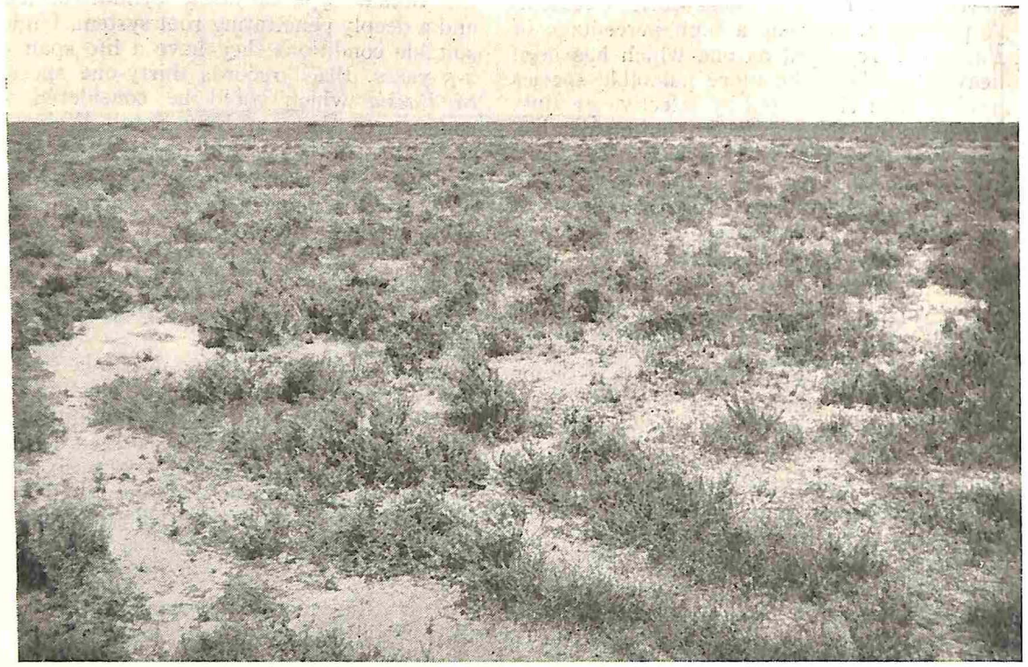

*Fig.* 4.—Copperburr (*Bassia divaricata*) and annual saltbush on former perennial saltbush in the Booligal district.

poverty bush; it is a small undershrub about 12-18 inches high. The seed covering has a broad base and has three spines, with very rarely a fourth. The stems and branches are tinged with red, and the leaves are dark green.

(b) *Bassia divaricata.* This bush is about 12 inches high and it is known locally by the same common names as the preceding, and also as copperburr. The fruit has four spines, three of which are long (up to ½ inch), the fourth being much reduced in size. The seed covering is closely appressed to the stem. The stem and branches are yellowish and the leaves bright green. This is the most widespread of the degenerate species, being found in every district where there was originally perennial saltbush. This is due to its impalatability because of sharp-spined fruits, and the fact that it germinates rapidly after rain. In its young stages it forms a low grade fodder.

(c) *Bassia longicuspis.* An undershrub up to 18 inches in height with a very characteristic fruit with four, rarely three, spines, which are often over an inch in length. This is also known as copperburr or roly poly, but also as bindy-eye, which is probably a corruption of a native name. It is confined in its distribution to the gibber plains north of Broken Hill, and in general appearance is very much like *Bassia tricuspis.*

(d) *Bassia quinquecuspis.* This is a shrub up to three feet in height, which has a dark green appearance and which occurs usually on the heavier soil types. In the west, together with *Salsola kali* (prickly saltwort), it invades any cultivation land. The fruit has five spines, two of which are small and united near the base. This is the true roly poly and it is so called because of the older plants becoming detached from the roots and rolling along in a mass, thereby spreading its seeds.



(e) *Bassia bicornis.* Known locally as goat head, it is a small shrub which is tomentose in its early stages. The fruit is up to ¼ inch in diameter and has two stout, rigid spines which are woolly for the most part, and give the plant a distinctive white appearance, the leaves being grey-green.

(f) *Bassia paradoxa.* This is a low densely woolly shrub about 6-9 inches high and grey-green in colour. The fruit is the result of the union of 6-10 fruits, each with two to five spines, giving a woolly, globular whitish mass; hence its local name of cannon ball.

(g) *Bassia brachyptera* (short-winged saltbush). A low growing perennial which is covered with soft white hairs. Each plant forms a mat; it is capable of colonising scalds and, under favourable conditions, may form a complete cover. The small seed is blown about and falls into the cracks of the scalded areas where it germinates and the process is repeated. It is a relatively good feed, which is enhanced by the fact that the spines are almost lacking in this species.

(h) *Bassia ventricosa.* This is a low brownish-grey bush, with a barrel shaped fruit from the top of which two short spines protrude, with a very short third spine. In the West Darling country it is probably the most widespread of all species of the *Bassia,* being common on both heavy and light soils.

(i) *Bassia uniflora.* A low creeping bush, with dark green leaves, being light grey under the more arid conditions of the West Darling. The fruit is short and broad with two short almost parallel spines. Being very succulent and with a relatively small proportion of fruit, it is quite palatable. It is common as a primary colonizer on scalds, associated with *Salsola kali,* forming small islands of vegetation.

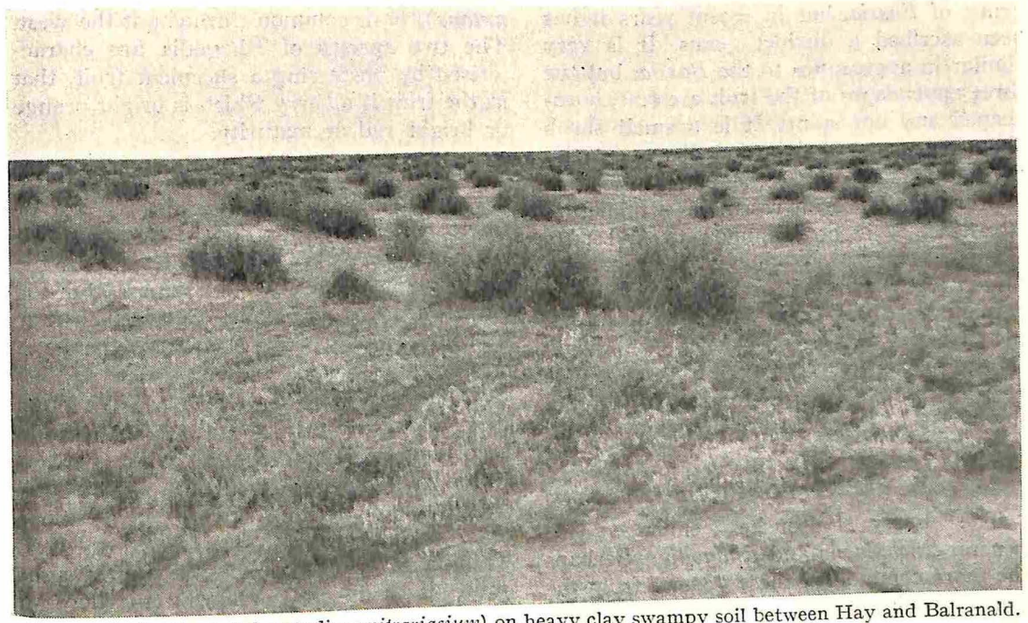

*Fig.* 5.—Indigo bush (*Chenopodium nitrariacium*) on heavy clay swampy soil between Hay and Balranald.

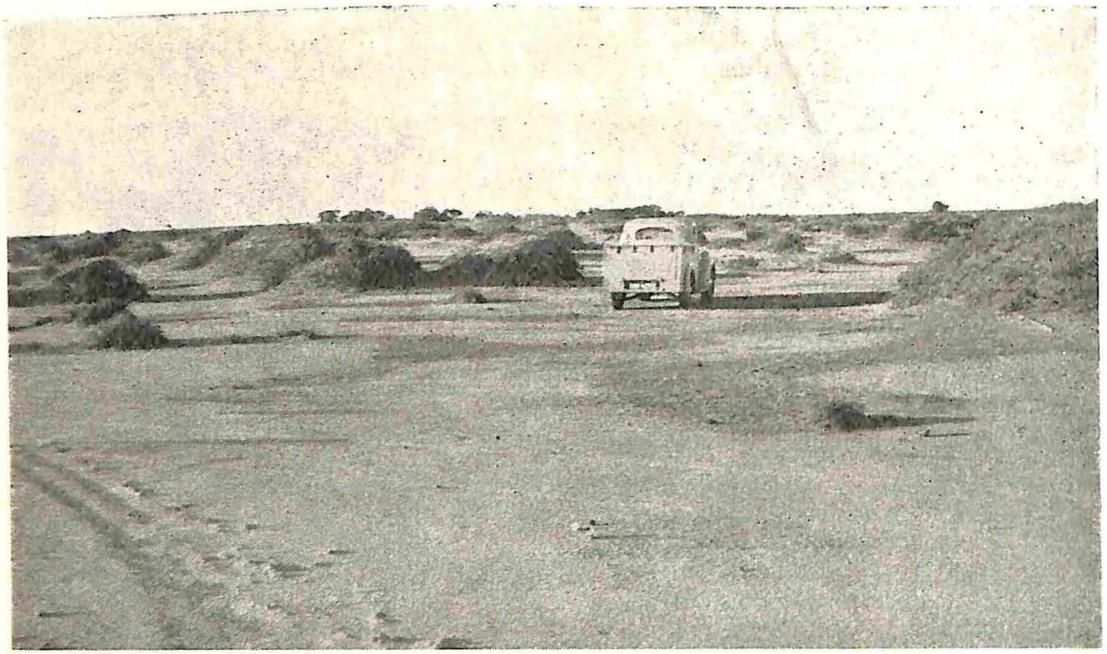

*Fig.* 6.—Nitre bush (*Nitraria Schoberi*) accumulates hummocks of sand. Note the young plants colonising bare scald.

It would be worthwhile mentioning here another species, viz., *Malacocera tricornis.* This plant was formerly placed in the genus of *Bassia,* but in recent years it has been ascribed a distinct genus. It is very similar in appearance to the *Bassia,* but the three appendages of the fruit are soft, horn-shaped and not spiny. It is a small shrub about one foot in height and diameter, with hairy branches giving the plant a whitish appearance. The fruit resembles a miniature star-fish. It is not common to find pure stands of this species, but it is common to find it growing in association with the perennial saltbush and with the roly polys, the latter showing evidence of being choked out by *Malacocera.* The shrub is perennial and of good fodder value and, therefore, a useful pasture plant.

## IV. BERRY SALTBUSHES.

The Berry Saltbushes embrace two genera, *Enchylaena* and *Rhagodia.* Perhaps the more common of these genera, from the graziers' point of view, is *Rhagodia.* Within this genus falls two dwarf shrubs known locally as Dillon bush (*Rhagodia spinescens*) and climbing saltbush (*Rhagodia nutans*), both common throughout the west. The two species of Rhagodia are characterised by possessing a succulent fruit, that is, the fruit is a berry which is bright orange or bright red at maturity.

(*a*) *Rhagodia spinescens.* This is a shrub varying in height and may be quite low or up to three and four feet high, and about the same diameter. The branchlets on the older plants often end in spines, and the leaves, up to ½ inch long, are greenish grey in colour and usually hastate at the base. The fruit is bright red when ripe and up to ¼ inch in diameter. The scrub is found most commonly on the saltbush plains, and according to Beadle occurs in every plant community except the mallee. It is very commonly found in the black box clumps and depressions throughout the west. Though it shows preference for alkaline soils, it will grow almost anywhere if planted. The species is quite edible.



(*b*) *Rhagodia nutans.* A small herb or shrub up to one foot in height, though it may exceed this when climbing. The stems of the plant are weak so that the plant is normally prostrate, but where possible the plant will climb, *e.g.,* in box clumps where it will be seen to ascend the timber. The leaves are longer and narrower than those of *R. spinescens* and are dark green and flaccid. The fruit when ripe is bright red but smaller than in the preceding species. It is quite palatable to stock.

(*c*) *Enchylaena tomentosa.* This is the remaining berry saltbush and is often called Barrier saltbush or ruby saltbush. This is a perennial bush, usually prostrate, but is up to 18 inches high. The leaves are tomentose and succulent and up to ½ inch in length. The plant occurs throughout the west and shows no preference for soil. The succulent fruit is bright orange, or bright red in colour and up to ¼ inch in diameter. This species is also quite palatable.

## V. CHENOPODS.

In this group, the genus Chenopodium, there are several herbs which are found in the west and which are generally regarded as weed plants (goosefoots and fat hen), but the species which is most important is the shrub known locally as indigo bush (*Chenopodium nitrariaceum*). This is a shrub three to six feet in height and about the same diameter, though in both cases these measurements may be exceeded. The shrub presents a mealy-grey appearance and it often has spiny branchlets. The flowers are in rather dense terminal spikes. It occurs on the heavy grey self-mulching river flats and swamps in association with lignum. Vast areas of country support it near Maude, Balranald, and along the Lachlan River between Booligal and Oxley, where there is periodic inundation of the land adjacent to the river and where many swamps, lakes and watercourses are consequently filled. It is an edible shrub.

## VI. SALTWORT (Salsola).

The last species of the family Chenopodiaceae to be discussed is *Salsola kali.* Known alternatively as prickly saltwort, roly poly or buckbush, it is an annual, generally about two feet high, with bright green leaves, from ¼ inch to 1 inch long, ending in a sharp point. As the name implies, some species of *Salsola* grow in salty ground and contain alkaline salts. It is undoubtedly a primary coloniser. It is one of the first species to make an appearance in a psammosere (succession on a sand dune) and it is also one of the first plants to appear in the natural regeneration of scald and also where scalds have been mechanically treated. When young the plant is quite edible, but when it becomes older and spiny it is shunned by stock; when it is dead it breaks off above the ground and forms a typical roly poly which is carried about by the wind and builds up against fences.

## VII. NITRE BUSH (Nitraria).

There now remains one species which belongs to the family *Zygophyllaceae* and which is common throughout the west, viz., *Nitraria Schoberi* or nitre bush. A few remarks will prevent its being confused with either *Rhagodia spinescens* or *Chenopodium nitrariaceum.* It is a rigid, spreading shrub up to six feet high but usually three feet, the leaves being thick and green, usually in clusters and about an inch long. The fruit is succulent and up to an inch long, purple, red or golden when ripe.

It is found mainly in the perennial saltbush association, though it does occur in other communities. It probably occurred in small quantities originally, and has spread through degeneration of the surrounding pasture. It is particularly common on the Hay plain, mainly west of Hay, but it does occur both south and north of this area.

An unpalatable species, it is shunned by stock under all conditions though the fruit is edible. Its most important characteristic is its drought resistance, and it will remain quite green during periods of drought when all else has succumbed. It is very rare for it ever to be killed by drought. The shrub serves as a break for wind and arrests drift sand which in some cases completely covers the bush. This does not kill it and when rain falls it produces a green bush on the top of the sand, with the formation of a hummock. It is not uncommon to see vast areas dominated by these hummocks, particularly along the road from Hay to Balranald.

## CONCLUSION.

Preservation of existing pastures, whether they be saltbush, bluebush, copperburrs or grasses, is essential in preventing the deterioration by erosion of arid and semi-arid country of Western New South Wales. Pasture degeneration means also a reduction in carrying capacity, which means lower returns, greater production costs and a smaller margin of safety in drought or times of low prices. The productivity of the Western Division, as in the case of any other tract of country, is vitally dependent upon the soil, and the stability of the soil is in turn vitally dependent upon its plant cover. The prevention of soil erosion lies in the maintenance of a permanent pasture cover, by means of judicious stock and pasture management. Where possible, stock management should be designed to improve the condition of the pastures.

There is still one group of plants in the family Chenopodiaceae which remains to be discussed, namely, the annual saltbushes, and these will be examined in a following article.

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# SOIL CONSERVATION IN THE COOTAMUNDRA DISTRICT


BY

J. H. Warburton, H.D.A., Soil Conservationist.


At Cootamundra, on the south-western slopes, erosion in all its many stages can be seen—sheet erosion in grazing paddocks and rilling and gullying in cultivation paddocks. This change from a well grassed countryside to an area showing erosion can be attributed to man.

Cootamundra is one of our most favoured sheep and wheat growing districts and has all the natural resources that should lead to good farming and in turn a prosperous community.

## RAINFALL.

The average annual rainfall is approximately 23 inches. There is an influential rainfall period of seven months, April to October inclusive. From May to September it is particularly reliable, while in April and October the chances of effective falls are better than one year in two. During the months November to March effective falls are received about one year in four. The average winter rainfall, April to September, is between 12 inches and 14 inches, average summer rainfall 10 inches to 12 inches. High intensity storms are fairly frequent, occurring mainly during the summer.

## TOPOGRAPHY AND SOILS.

The topography is gently undulating to hilly with isolated areas of alluvial flats suitable for lucerne. The contour will permit occasional cultivation of the major portion of the area. Considerable areas are suitable for topdressing and the sowing of subterranean clover and Wimmera rye.

Except for isolated alluvium along watercourses the soils are loams of granite origin with occasional areas of slate origin. The latter soils are of less depth and "gravel" hills occur.

The steeper hills have rocky outcrops and soils are mostly red sand loams.

Except for the red gravel hills and rocky hills, the soils and general lay of the country are suitable for intense mixed farming operations, including improved pastures in long rotations with wheat and oats, and lucerne as summer pasture and hay. Fat lambs from crossbred sheep are produced very successsfully.

## VEGETATION.

Under judicious stocking and controlled rabbit population, this district is capable of growing and maintaining a good cover of natural herbages and grasses.

The main grasses are corkscrew (*Stipa sp.*), red grass (*Bothriochloa decipens*), star grass (*Chloris truncata*), barley grass (*Hordeum* sp.) and soft brome (*Bromus mollis*).

Mention should be made of white top or wallaby grass (*Danthonia sp.*), but due mainly to overstocking and rabbits this succulent grass has nearly disappeared; however, during 1950 when 46 inches of rain were recorded some paddocks have again produced white top.

The main legumes are ball clover (*Trifolium glomeratum*), haresfoot clover (*Trifolium arvense*) and burr trefoil (*Medicago denticulata*); these respond well to topdressing.

The natural timber is fairly uniform, being mainly savannah woodland formation, with yellow box (*E. melliodora*), white box (*E. albens*), red gum (*E. blakelyi*). The steeper hills carry brittle gums and black pine. Red gravel hills are usually associated with stringy bark (*E. macrorrhyncha*) and ironbark (*E. sideroxylon*), with an occasional yellow box in the water courses.

Introduced pasture plants are lucerne, subterranean clover and Wimmera rye. Sub. clover seeds freely and is becoming widespread, particularly on the lighter soil types. Wimmera rye, which is an annual but will withstand drier conditions than sub. clover, is more suited to the red soils but, in conjunction, both have made great progress, not only from a grazing point of view, but also as soil improvers.

## LAND USE IN THE PAST.

Cootamundra, being in a fairly reliable rainfall area, has always been looked upon as being a very safe district for cereal cropping; land values are relatively high. This high price of land, and unsuitability of some of the land used for crops, has resulted in some cases in too much pressure on the land and consequent serious erosion.

The better type land is generally undulating to hilly; cropping on gentle slopes was quite in order, but many cases have been found where the country rises to steep hills and right at the base of the hill the land has been and still is being cropped. Many instances of unwise land use and farming can be found and much land that should be reserved for grazing only has been continuously cultivated.

Up till recently no provision was made for run-off from adjacent hills by leaving the natural watercourses in their virgin state; this error has led to many paddocks being discarded as useless for cultivation because gullies have formed along the drainage lines and have now divided the paddocks into small islands.

The waterways or natural depressions, which should have been retained only as waterways, were looked upon as the best soil in the paddock; these were cultivated and consequently this best soil has now been lost to the farmer forever.

Ploughing was carried out according to the shape of the paddock and as a rule the land was ploughed up and down the slope and the usual headlands ploughed from corner to corner diagonally across the paddock; the results on undulating lands were inevitable and considerable erosion took place. Unfortunately, many farmers still continue to plough up and down slopes.

The practice of growing crop after crop on the same land year after year has been largely discontinued, mainly because yields

*Fig.* 1.—Gullying on gently sloping grazing land.



*Fig.* 2.—Long fallow. The soil is compacted and rilling occurs on finish out.

have decreased through loss of fertility and the increase of weed growth, such as skeleton weed. Landholders are now adopting a mixed farming system with crop rotations, pastures and stock raising, that not only helps maintain the fertility of their land, but will build it up as years go by and help to prevent or control further erosion.

## SOIL CONSERVATION MEASURES.

Successful measures depend on the landholder and the topography of his farm. Excellent results are being obtained by adoption of the following.

### Revegetation.

This can be achieved by the introduction of subterranean clover and Wimmera rye either direct or by sowing with a cover crop of wheat or oats, stripping the grain, then light grazing of the stubble and the following autumn top-dressing the stubble with 90-112 lbs. superphosphate. The amount of grazing this first year will depend on the season and growth of clover and rye, but it should be restricted so that the clover will not be eaten right off and trampled too much. Annual top-dressing will increase grazing benefits.

In an area that has completely lost or partially lost its fertility the clover should be left for grazing for from five to eight years before it is again cropped.

When a paddock is sown to clover the fertility and texture of the soil is improved by the addition year after year of dry matter which increases the organic content of the soil. This also builds up the water holding capacity of the soil.

The practice of using a long fallow period should be discontinued; if a paddock is laid down to pasture for a period, short fallowing will produce a successful crop and also allow a good germination of clover seed which will produce a good grazing paddock the following year in place of a bare stubble paddock.

Long fallowing has a disadvantage in that the continual working of the seed-bed produces a very fine surface which, when exposed to the rigours of nature, is badly washed and/or the top soil blown away.

Pasture top-dressing with superphosphate is increasing, more so on properties where sub. clover and Wimmera rye have been sown. Top-dressing natural pastures is beneficial, as it increases the growth of annual

clovers and stimulates the better types of perennial grasses, such as white top or wallaby grass, which over the past years has been mostly eaten out, due to overstocking by both rabbits and sheep. This has allowed the spear grass (Corkscrew) to dominate the pasture sward.

Spear grass, as the name implies, has an awned seed which may cause death, particularly of lambs. Its feeding value is not high but it will sustain stock. Wallaby grass, on the other hand, produces, if allowed to, a great bulk of highly nutritious grazing.

### Making Better Use of the Land.

To make better use of the land available, the landholder must work with his eye to the future, not only the immediate present. The landholder must work with nature and not submit his land to a utilisation resulting in degeneration instead of improvement.

A broad plan for a working basis is as follows:—

(*a*) On level to slightly undulating land the proper land use is rotational cropping to wheat and oats, sowing down to pastures or lucerne, whether for hay or grazing;

(*b*) Moderately undulating land may be used for occasional crops, grown more or less as a cover crop for the establishment of sub. clover and Wimmera rye grass;

(*c*) The steeper parts of the farm should be used for natural pasture grazing only and top-dressed with superphosphates where possible.

The planting of trees where they will do most good for wind-breaks and erosion control should always be considered. On the management of the steeper country will depend the welfare of the holding. Overstocking, the cause of most of our erosion on the hills, must be avoided and rabbits kept to a minimum or, better still, eradicated completely.

Fencing, if possible, should be designed so that these hilly areas may be grazed judiciously and a good grass cover maintained to help reduce run-off. It is on the steeper country that erosion problems originate, and these should be controlled at the source.

### Mechanical Control Measures Where Necessary.

The use of mechanical methods to control erosion are not in all cases necessary, but

*Fig.* 3.—Pasture furrows on hilly grazing land in the Cootamundra district.



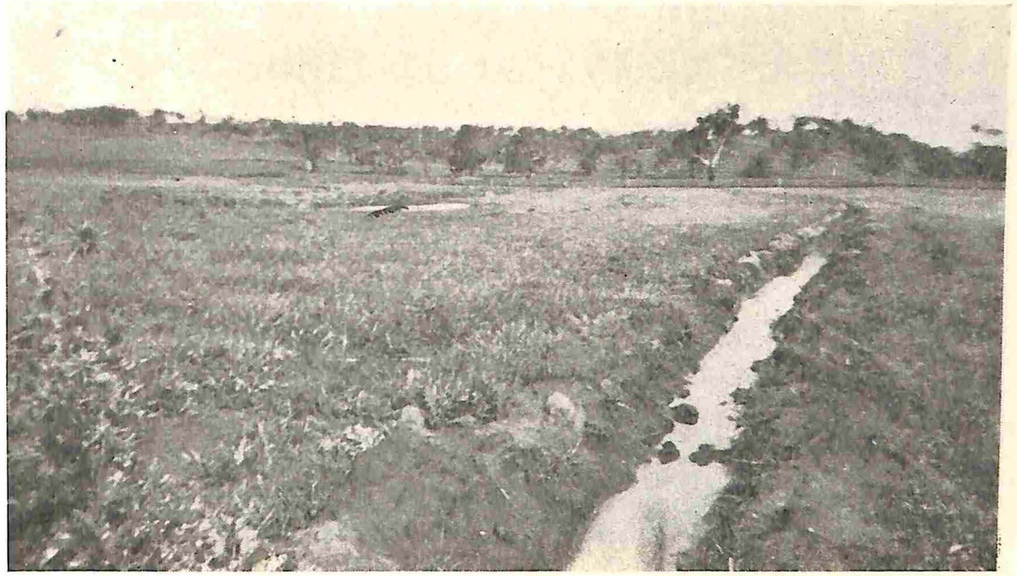

*Fig.* 4.—Pasture furrows retain water on the land.

*Fig.* 5.—Diversion bank protecting gully head.

*Fig.* 6.—Well grassed natural drainage line in cultivation land.

may be looked upon as a means towards an end.

Mechanical means of control, if put in with a lot of thought to the future management of the farm, can be the farm's backbone. Even on country where no visible signs of erosion are in evidence, a system, say, of contour furrows, graded and absorption banks and waterways can save a lot of future trouble.

Instances have been found where mechanical work has been carried out and the work has not been maintained. Failure to maintain work can cause trouble.

Contour or pasture furrows, as the name implies, are put in on grass land, usually on the undulating country or the steeper country, the plan being to keep the rainfall on the hillside, allowing no run-off to the paddocks below. A system of contour furrows and contour farming may be used, that is, the top country furrowed and the farming land worked on the contour. Contour farming is farming around hillsides to fit the lay of the land at right angles to the natural slope rather than up and down the slope. Working on the contour increases the effect of rainfall and so produces more growth, each contour acting as a small reservoir, which prevents rainfall running down the slope. By this method installation of graded banks on gently sloping arable land can often be avoided and successful erosion control still be achieved.

In this district, if run-off from the high country is controlled by pasture furrows, which hold the rainfall more or less where it falls, so increasing the retention of the water and, in turn, increasing growth of the pasture, and the cultivation is done on the contour, and provision is made to allow the natural waterway to function in its natural state, most erosion troubles can be avoided.

## CONCLUSION.

Although soil erosion is widespread in the Cootamundra district, climate, soils and topography are all favourable for the installation of wise land use methods and, where necessary, mechanical soil conservation works. Striking results are achieved rapidly, not only in positive erosion control but also in improved productivity of holdings.

There are few districts in the State where efficient rural planning will return such major benefits. The experience and advice of the Soil Conservation Service are available to all landholders in the district.



# HALL'S CREEK SECTOR KEEPIT CATCHMENT AREA

BY

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

HALL'S Creek catchment lies along the central southern border of Keepit catchment area. On the southern side its boundary is marked by a spur range running west from Mt. Gulligal, on the Moonbi Ranges. To the east around the headwaters, the boundary is formed by the Moonbi Range. The northern boundary is not so clearly defined, being a line of hills which form a watershed between Hall's Creek and its tributaries and the Namoi River which runs in a westerly direction farther to the north.

In extent Hall's Creek catchment comprises approximately 100,000 acres, which represents about 1/14th of the Keepit catchment.

In previous numbers of this Journal Mau (Vol. 5, No. 3) and Sterelny (Vol. 6, No. 4) have described the overall nature of the soil conservation activity in progress in the foreshore and Spring Creek sectors. It is here proposed to outline the position within the Hall's Creek valley.

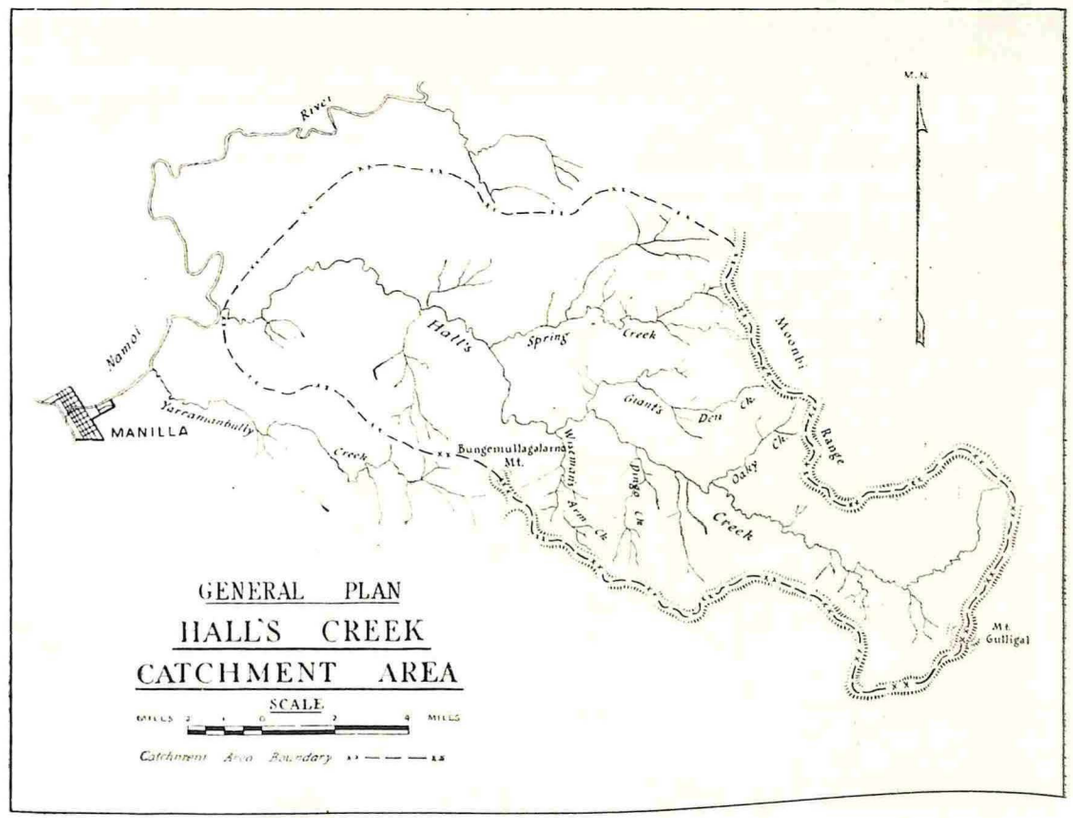


*Fig.* 1.

*Fig.* 2.—A general view of Hall's creek watershed.

## TOPOGRAPHY AND EROSION.

The topography is mainly mountainous with only a small portion of the area suitable for cultivation. These areas of cultivation are usually in the form of small pockets among the hills and each of them have large catchments with a resultant high degree of erosion, both sheet and gully. These areas, because of their smallness and infrequence in individual properties, have in the past been over-cultivated, another factor which has contributed to the serious degree of erosion.

The hilly country, which comprises perhaps 95 per cent. of the area, shows evidence of indiscriminate clearing and in many cases is practically denuded of trees.

These watersheds now exhibit an alarming state of erosion, particularly in the form of gullies; during the past twelve months of high rainfall landslides have been frequent; their occurrence no doubt has been greatly accelerated by the lack of vegetation to hold the soil in place.

## SOILS.

A detailed soil survey of the Hall's Creek area has not been carried out, but the general position is as follows:—

In the extreme eastern areas around the headwaters of Hall's Creek, soil types are mainly derivatives of igneous intrusives in the form of granites and pegmatites. Soils derived from these parent materials are of the expected light ashen colour, highly podsolised as a rule, and showing little accumulation of organic matter in the surface layer.

Moving westward from the Moonbi Range area, rock types are Devonian in nature and comprise shales, mudstones, tuffs and interbedded volcanics. This class of country is colloquially known as "trap," carrying stone on the surface and through the "A" and "B" horizons.

To the west of Bungemullagalarno Mountain a definite line of serpentine is found stretching in a roughly south-east, north-west direction. This ridge shows up in many areas right through Keepit catchment



from Hall's Creek to the Barraba district. Soils derived from this material are usually grey-brown in colour and stand out in contrast to the red soils derived from shales close by.

Along the creek proper and more especially in the western areas close to Manilla, good alluvial flats of dark red to chocolate clay loam soils occur, these soils forming the bulk of the better class arable land in the area.

## VEGETATION.

Tree species occurring in Hall's Creek valley are those typical of the North-Western Slopes. Yellow box (*E. melliodora*) and apple (*Angophora intermedia*) are found on the creek flats and silty soils of the lower valley. The hills of the lower and middle valley are mainly timbered with grey box (*E. hemiphloia*) and white box (*E. albens*), the latter species predominating on the drier sites and more exposed situations. On the granitic soils in the upper parts of the valley red gums (*E. Blakelyi* and *E. dealbata*) are prominent.

On the better soils of the lower country Queensland blue grass (*Dicanthium sericium*) and wallaby grass (*Danthonia spp.*) occur, together with the star grasses (*Chloris spp.*). On much of the uplands red grass (*Bothriochloa decipiens*) is now the dominant pasture, and wire grass (*Aristida spp.*) is prevalent on the lighter soil types.

## LAND USE.

For the purpose of describing utilisation, the area can be conveniently divided into two parts:—

Firstly, the eastern portion consists of upper slopes and intermediate tablelands which comprise approximately one-half of the area. Because of its mountainous terrain this portion has largely been used for the grazing of wethers for wool, a purpose for which this type of country is well suited. Small pockets of cultivation in the folds of the hills are used for the growing of crops for grazing and fodder conservation, while on the fertile creek banks lucerne is the main fodder crop grown.

Secondly, the western portion consists of intermediate slopes situated closer to the town of Manilla. Wool production is still the most important pastoral pursuit carried

*Fig.* 3.—Most of the catchment comprises hilly grazing lands. Arable country is limited.

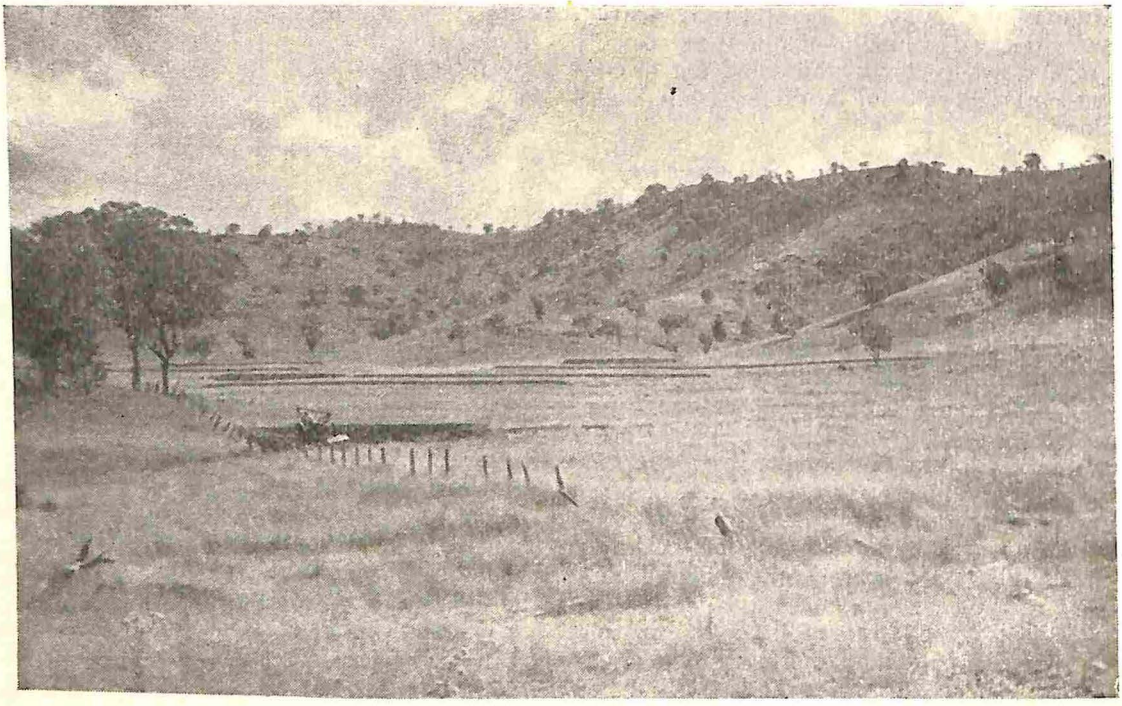

*Fig.* 4.—A Minor Demonstration area within Hall's creek catchment.

on, while the raising of fat lambs becomes increasingly important. The area suited to cultivation is often extended to slopes with excessive gradient. Run-off after storms dissects the arable land by rill and gully formation which carry large quantities of soil to the creek.

## SILTATION.

Under normal seasonal conditions Hall's Creek does not carry a large volume of water and is usually clear. Its rise following a storm is often rapid, and although its colour suggests that it is carrying a large volume of silt, analysis of samples over a period of years has indicated that, although heavily contaminated, the quantity carried is not so high as that of other tributary streams.

## EROSION CONTROL.

To date mechanical soil conservation work has been carried out on six properties in this area with many in the design stage. The areas treated have been small but in most cases have been the only portions suitable for cultivation on the property. Fig. 4 shows a typical area treated as a minor demonstration.

Mechanical measures include the use of absorption banks and graded banks, silt traps and waterways.

## CONCLUSION.

Because of the high proportion of hilly country to cultivation, control of erosion necessarily involves the adoption of wise land use principles on an extensive scale. Regeneration of timber on the steeper lands is necessary, frequently with exclusion of stock from steep hazardous parts. In other steep areas the densest pasture cover is necessary, achieved by carefully controlled grazing and rabbit control. On the lower lands much mechanical work is required.

As in other creek valleys within Keepit catchment excellent co-operation between landholders and the Service has been achieved and a promising start has been made in the application of both wise land usage and mechanical soil conservation measures on the individual holdings within the Hall's Creek valley.