PART IV
LAND USE

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FORMS OF LAND USE

1. Water Supply

Some of the water-supply characteristics of the catchment have been discussed in the introduction, the Hydrology section and in the section on Problems of Stability.

The Broken River has long been recognised as a very variable stream, and the unreliability of its flow has no doubt contributed to the lack of any intensive irrigation development in the valley. The average annual discharge of the river at Goorambat is 257 X 106 m^3. Maximum rates of flow in any one year have ranged from 479.2 m^3 /sec. in June, 1917 down to 7. 1 $m.^3$/sec. in June, 1902. The stream ceased to flow for at least one month during summer or autumn in 23 out of 75 years of records up to 1960. Periods of at least two consecutive months with no river flow have occurred at Goorambat in 17 of these years. The longest dry period was the seven months from the end of November, 1944 to the end of June, 1945. (State Rivers and Water Supply Commission 1964.)

The construction of Lake Nillahcootie to store 37.8 X 106 m^3 was primarily to provide a more reliable water supply for stock, domestic and town requirements in the valley.

Water from Lake Mokoan with a capacity of 370 X 106 m^3 is intended for use in the Goulburn-Murray irrigation system. Because of the large surface area and shallow depth of this storage, evaporation losses would be high. To improve its efficiency, it is planned to release its water into the, Goulburn system early in the irrigation season. This will permit an equivalent volume of water to be held in Lake Eildon where evaporative losses are lower because of its greater depth.

Both Lake Mokoan and Lake Nillahcootie have become popular recreation areas.

A small reservoir on Ryan's Creek, Loombah Weir, provides the water supply of Benalla. Further storage is proposed for the upper reaches of Ryan's Creek.

The catchment of Ryan's Creek above Loombah Weir and the catchment to Lake Nillahcootie have been proclaimed as water supply catchments under the *Soil Conservation and Land Utilization Act*.

2. Agriculture

(a) **Wheat and other Cereals:** Although oats are grown as a fodder crop throughout the pastoral areas cereal crops for grain are grown in the north-west of the catchment only. The length of the ripening season is a limiting factor. The catchment lies on the wetter fringe of the wheat-belt and it is unlikely that the growing of cereal crops will be extended into the wetter land systems. Yields are limited by waterlogging, and gilgai mounds and depressions in "crab-hole," country cause wide variation. The environments most suitable for cereal crops are found only on the north-western extension of the Benalla land system and on the lower slopes of the Lurg land system.

Plate 27. Small orchards have been developed on the lower slopes of the Warby land system. In this photo the water level in Lake Mokoan is near full-supply level.

(b) **Vegetables:** Potatoes have been grown for many years on the Acherton land system, but the industry is at present depressed, mainly because of unfavourable economic conditions and the isolation of the area. This land system has a high potential for a combined industry of vegetable growing and pastoral activities.

The Kilfeera terrace of the Broken River (see the Benalla land system) has good potential for irrigated crops and particularly market gardening in association with high quality pastures. At present this area is virtually undeveloped.

(c) **Tobacco:** Environments suitable for tobacco growing exist along the river, chiefly on the Kilfeera terrace, and to some extent on the Benalla plain close to the river. However, these areas would probably be better used for vegetable production and pastures. At present the area planted to tobacco in north-eastern Victoria is closely controlled to prevent over production and consequent marketing problems.

In summary an environment can be found in the catchment to suit most temperate climate crops. The limiting factors are the steepness of slopes for cultivation from the point of view of erosion hazard, and the economic situation as regards marketing and the distance from major population centres.

3. Horticulture

At present horticulture is mainly confined to the footslopes of the Warby land system (plates 27, 28) but there are also some small areas of orchards in the Lurg and Swanpool land systems. The growing of passionfruit, grapes and hops is included in this section, as well as small fruits such as apples. The Warby land system, although comparatively small in area, is the locality of highest potential within the catchment for this type of industry. Similar sites, but with higher rainfall, are present in the Swanpool land system and these may eventually be developed.

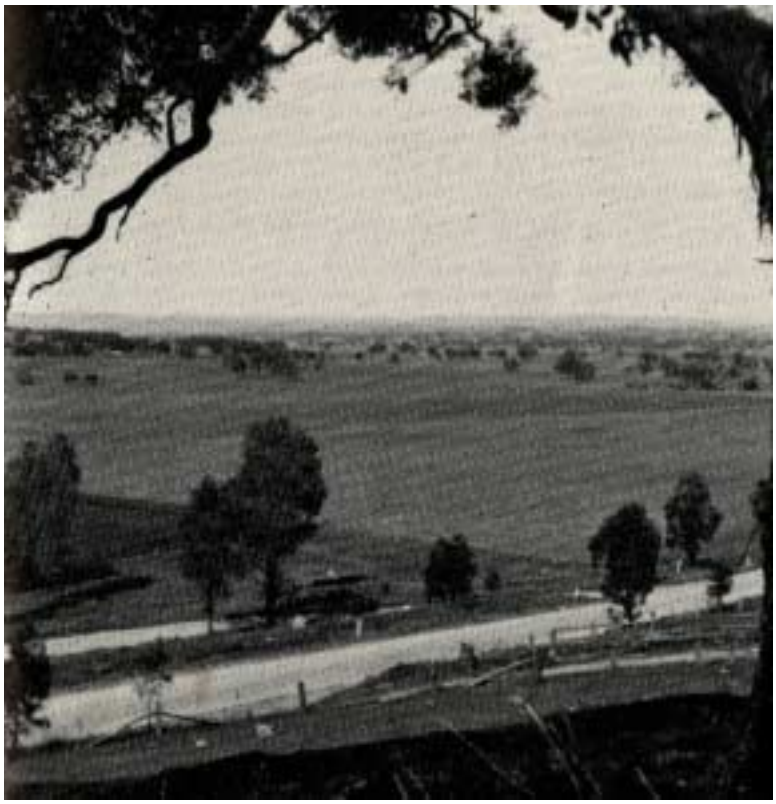

Plate 28. Several commercial vineyards are located on the footslopes of the Warby land system.

The cultivation of hops is limited to the well drained terraces of the upper valleys in the Warrenbayne-Tatong sub-system of the Benalla land system. Possible expansion is limited by the availability of suitable areas. The upper valleys of the Swanpool land system, for example the headwaters of the Moonee-Moonee Creek drainage, are very similar but as yet unused.

The areas which possess the greatest possibility for expansion in horticultural activities are the Tiger Hill land system and some parts of the Loombah land system. Although these areas appear to be suitable for such activities as apple growing, and may be compared favourably with the Stanley area to the cast, isolation and lack of access will limit their development for these purposes. However it is possible that in the future these areas will be opened up for softwood plantations so that eventually a road network will be established and a complementary primary industry may then become desirable.

4. Pastoral Industry

This is the main land use in the majority of the cleared areas.

(a) **Sheep:** In the drier areas, mainly in the north and west, sheep are raised for wool, but there is more emphasis on meat-producing breeds in the wetter climates. However the style of the industry is very mixed and the emphasis depends very much on the local producer and on the state of the markets.

(b) **Beef Cattle:** Beef cattle are grazed in all the cleared areas but are mainly concentrated in the wetter land systems, for example there is much more cattle grazing in the Mansfield land system than in the similar Benalla land system. There is very little forest grazing of cattle within this catchment.

(c) **Dairy Cattle** : The upper valleys and river flats are suitable for dairying, particularly on the Goomalibee and Kilfeera terraces. The Goomalibee terrace could be considerably developed for pasture production particularly if water for irrigation was available to carry pastures through the dry season.

The potential for expansion of the area devoted to the pastoral industry is limited. The areas suitable for sheep grazing have mostly been cleared, and the expansion of the beef cattle industry will depend more on increased carrying capacity on the present areas than on the opening up of any new areas. The only possible exceptions are the Tiger Hill and Loombah plateaux and broad ridge tops. The dairy industry could be expanded, mainly in the Warrenbayne-Tatong sub-system and in the Swanpool land system, but once again the emphasis will be mainly on increasing production from the area already cleared rather than clearing new areas for pasture.

5. Forestry

(a) **Native Hardwoods** : The catchment lacks any extensive areas of ash-type forests. Messmate and peppermint form the basis of the logging industry in the area and there is little chance of permanent expansion except through more intensive utilisation of the enormous quantities of low-grade timber in the peppermint-gum forests. At present these are relatively uneconomic although they could become significant if reconstituted wood were to become economically feasible. However there is no reason to believe that the forests of this particular catchment would be any more valuable than any of the other extensive areas of poor quality peppermint-gum forests in Victoria.

(b) **Exotic Species:** Some areas which would be suitable for plantation establishment, mainly for *Pinus radiata*, exist within the catchment. There are no plantations producing timber within the area at present, although new plantations of pines have been established on the Tiger Hill land system above, Warrenbayne (plate 29) and on the footslopes in the valley of Blue Range Creek. The high rainfall plateau areas are the most suitable for plantation establishment. These include areas in the Tiger Hill, Loombah, Tolmie, Strathbogie and the Archerton land systems. The Tiger Hill land system and the ridge tops of the Loombah land system would appear to be very suitable for plantations as they receive adequate rainfall and have deep, friable, and permeable soils. The soils of the Tolmie land system are not as suitable as they tend to be poorly drained. The Strathbogie area is quite suitable but is already highly developed for agriculture and grazing. The Archerton land system also has potential for pines but this area would be better for agricultural purposes and pastures.

Other exotic timber species are not yet grown commercially in this area. Sites suitable for plantations could readily be found. Feasibility depends on economics. Trees planted along streams in the course of erosion control work could however be harvested. The use of poplars and similar trees for shelter belts in the wetter situations in association with the grazing industries is worth consideration, and if properly managed these belts could be harvested periodically.

(c) **Protection:** Fires may cause serious deterioration of site quality, both to hydrological conditions and timber production, in higher rainfall areas as well as endangering life and property. Fuel reduction burning appears to be an effective means of reducing the hazard of uncontrolled fire and is now generally accepted as a forest management practice. However the long term effects of fire in forested areas are still unknown and it is recommended that the use of fire should be as conservative as possible.

Better access for fire suppression may be desirable in some areas, however this may conflict with some environment preservation or recreation objectives.

Plate 29. Plantations of radiata pine have been established in the Tiger Hill land system south of Warrenbayne.

6. Recreation

The catchment contains a number of areas of value for recreation, but few sites suitable for concentrated development of recreation facilities. Bush scenery, wildlife and space are the most valuable tourist attractions within the area. There are no snow areas. However the catchment area is interesting and diverse and contains some exceedingly attractive country which is still relatively unchanged by man's activities.

On a more local scale the new storage reservoirs should provide major attractions for tourism and recreation. The Lake Mokoan storage will be particularly valuable because of its large area and accessibility. In order that the recreational values of these areas be maintained, particularly as population pressure increases, it will be necessary to control development around the foreshores, and in particular to suppress real estate speculation and the development of fringe or strip urban areas.

7. Wildlife

The forested land of the catchment contains a number of interesting native species. Some portions of the catchment are fairly remote and densely timbered and as these appear to be important as habitat for some of the rarer and more timid animals they should not be disturbed unnecessarily. It is fortunate that the maintenance of suitable habitats for wildlife is usually compatible with management for timber production, and for water production from a largely forested catchment. However, this need not always be so and conscious efforts to develop a knowledge of habitat requirements should be made.

The swamps of the Mokoan sub-system, and in particular Lake Mokoan itself, are important as water fowl habitat. Low earthern banks have been constructed in parts of the enlarged lake boundary to retain water when the water level is lowered. These are intended to maintain some aquatic habitat despite the prime use of the lake for irrigation.

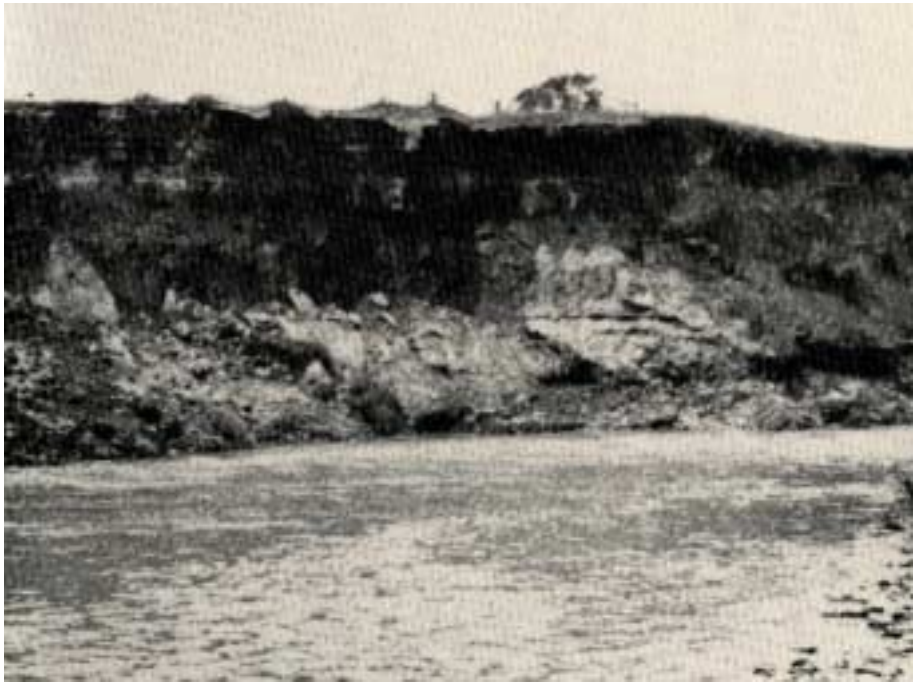

Plate 30. Some of the banks of the major streams are undercut by high flows and soil collapses into the stream. Numerous bands of recent sediments can be seen at the top of the bank.

A scheme of river control combined with small storages, including the farm dams, in the area would also provide an extensive habitat for aquatic life in general and fish in particular. Although most of the fish in the streams are not native they provide a valuable source of recreation and consideration should be given to the fisheries habitat when an improvement programme for the river is planned.

FIG. 36 Mean monthly discharges of the Broken River at Nillahcootie, Lima South and Goorambat

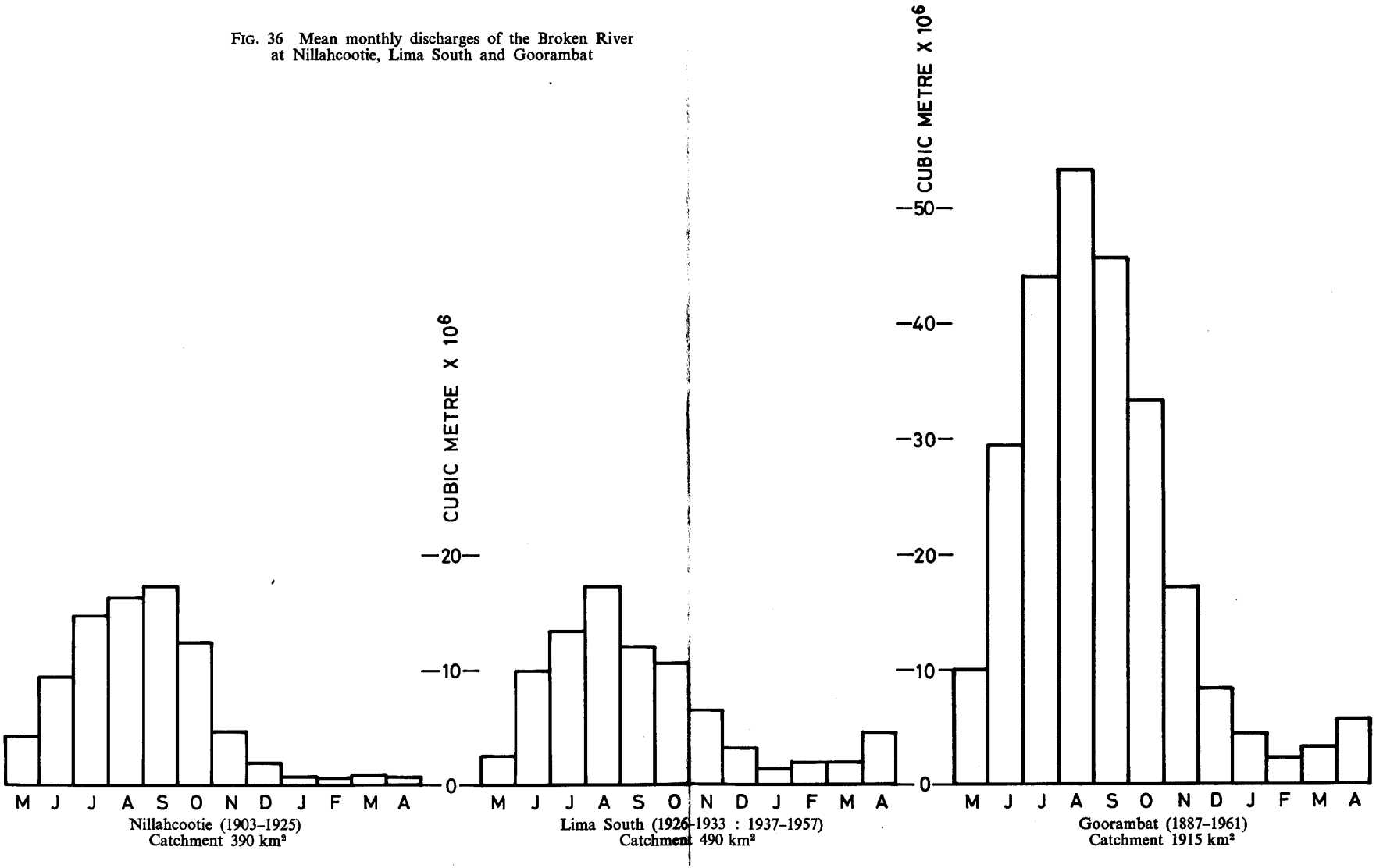

Fig. 36 - Mean monthly discharges of the Broken River at Nillahcootie, Lima South and Goorambat

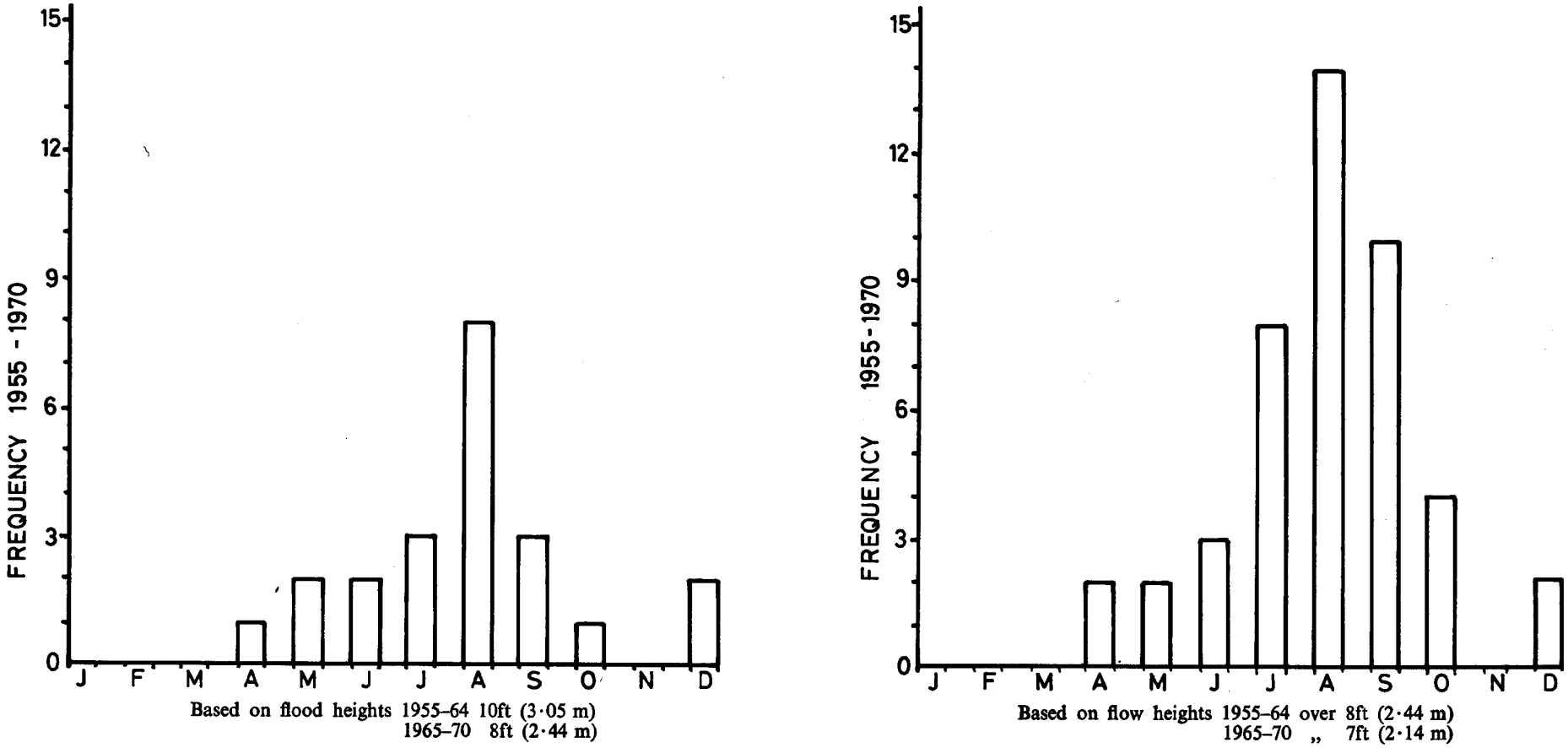

Fig. 37 - Frequency of floods and high flows on the Broken River at Benalla 1955-1970

PROBLEMS OF STABILITY

1. Flooding

The mean monthly discharges of the Broken River at Nillahcootie, Liffia South and Goorambat are presented in Fig. 36. These show that late winter and early spring (July, August) are the times of highest flows, and that the greatest differences between winter-spring flows and summer-autumn flows occur at Goorambat. This may be interpreted as indicating that the lower northern areas contribute a higher proportion of winter flow and a lower proportion of summer flow than do areas in the south of the catchment.

The flood pattern on the Broken River is illustrated in Fig. 37, where August is shown to be the month with the highest frequency of high and flood flows. The flooding problem in this catchment appears to be related to all three of the main phases of flood generation:-

(i) the production of runoff
(ii) concentration of runoff in the main channel.
(iii) channel conditions.

The existence of extensive areas of duplex soils in the lowlands may be a factor in the development of high flows in the river. Because of their heavy clay sub-soil through drainage is very slow, so that once they are wet, heavy or sustained rain will rapidly saturate them and surface runoff will occur. This condition may be expected to exist through much of the normal winter and extend into spring.

The higher country has deeper and generally permeable soils which, even when wet, can absorb more rain and allow it to seep down to streams at a steady rate. Thus runoff from the higher areas though resulting from higher rainfall, may be expected to increase fairly uniformly in early winter and remain high until spring when a steady decline occurs.

It appears that floods occur when heavy or sustained rain falls and causes substantial surface runoff from the lowlands which is then superimposed on the steady high flows derived from the high country. The combined influence of these two sources of runoff reaches its peak most frequently in August.

The production of surface runoff in the lowlands appears to be an inevitable consequence of the type of soil and climate in the area, but the rapidity with which it reaches the streams is probably controllable to some extent. The rapid surface runoff in these areas is facilitated by the generally poor condition of pasture during this time of the year. It is also affected by the condition of the drainage lines which are generally devoid of vegetation which could retard flows. In many instances these are eroded gullies.

A further factor contributing to flood generation on the lower reaches of the Broken River appears to be the differences in channel characteristics between the upper and lower reaches of the stream. To the south of Moorngag the stream channels are broad and deep and they deliver peak flows to the lower areas too rapidly for the channel on the Benalla Plain to handle. There are also indications that the upper part of the valley has steeper gradients. This may have resulted from minor upwarping late in the period of Mt. Kosciusko uplift, so that the drainage system could have been inherently unstable before settlement.

The land systems which are likely to contribute most to flood-flows are as follows :

Mansfield land system: An area of 143 square kilometres in which the soils are likely to become saturated in winter, when most of its runoff occurs. The whole area is partially cleared and grazed and the pastures are typically short and generally unimproved so that surface concentration of water is rapid.

Tolmie land system: Minor surface flows occur because of poorly drained soils in the cleared areas. It is not a very important source at present because a large proportion of it is still forested, but it could be troublesome if a large area was to be cleared without the subsequent establishment of improved pastures.

Table-Top land system: An area of about 100 square kilometres, much of which is steep and in very poor and eroded condition. The soils of the flat areas become saturated in winter and the pastures generally are short and unimproved. Although it is only a small area, and can therefore only have a minor effect, its slopes are amongst those few areas in the catchment which are obviously in poor condition.

These three, land systems are all on the same rock type, the Carboniferous sediments, and are part of a topographic sequence. They are all part of the catchment to Lake Nillahcootie.

Lurg land system: The area of shallow soils and poorly vegetated hills is fairly large and the soils of the flats between the hills are likely to become saturated in winter. The pastures are more highly developed than in the three land systems mentioned above, but generally are still not adequate to retard rapid surface runoff.

Most of the water from this land system enters creeks draining to the swamp system rather than to the main stream.

Warrenbayne-Tatong sub-system : This is about 104 square kilometres of creek valley. It contains minor flood-source areas, mainly on soils which become saturated in winter, but it is fairly well grassed.

Samaria sub-system: This area is a minor flood-source area; hydrologically it is similar to the Mansfield land system, but is less cleared.

Benalla sub-system : This is a large area (249 square kilometres) of poorly drained soils liable to give immediate surface runoff in late winter. It is moderately well grassed as a whole but dense pastures are not common enough to retard rapid water flow. The flat gradients help to prevent unduly rapid concentration.

In summary it appears that the main flood problem originates in about 650 square kilometres out of the 1900 square kilometres in the catchment and is basically caused by soils which become saturated early in winter and thereafter produce surface runoff.

Plate 31. A view south in the Broken River valley at Barjarg in which some erosion of the stream banks on the outside of meanders and recent changes in the course are evident.

2. Erosion

Erosion is not as serious within this catchment as would appear from the condition of the river (Plate 28), and the catchment condition is not as poor as some local opinion indicates. However the standards of land use and condition of the land are unsatisfactory over a fairly large proportion of the area, but the deterioration need not be permanent at this stage. Adjustments of land use practices are needed and these can usually be achieved at comparatively little cost.

Soil erosion occurs in each of the land systems within the catchment and most forms of erosion may be found (Plates 19, 20, 30, 32, 33 and 34) but it is serious in only a few. The chief areas are in the Table-Top land system which is very steep and has only a moderately moist climate and extremely erodible soils.

Plate 32. Tunnel erosion is commonly associated with yellowish duplex soils. In this example the tunnels are in various stages of collapse. They lead into the gully system shown in Plate 33.

Plate 33. A gully system which has formed from collapse and coalescence of numerous erosion tunnels. The water of Lake Mokoan is just beyond the fence in the background.

Mansfield land system has also suffered considerable gully erosion, much of which however is the result of excessive runoff from adjacent areas. These two land systems together are probably the source of a great deal of the sediment which reaches the stream, and probably also the source of substantial proportion of the flood runoff. However mitigation of the erosion within these areas will not solve the problem of flood runoff.

There are areas of serious erosion in the Lurg land system, particularly on the lower slopes, but very little of the sediment reaches the stream. Much of it however is transported into the Mokoan sub-system and may enter Lake Mokoan. Stream erosion is serious in the Benalla land system but this should be tackled in the headwaters as outlined below.

Apart from these specific areas the agricultural lands and the forest land in the catchment are generally in satisfactory condition. Most of the sediment which is a potential hazard to the storages is in fact being generated by stream erosion.

3. Fire

Fire protection is essential for the preservation of catchment values over most of the upper, forested areas. Most of the forested area is at present in sound condition and the flooding and erosion along the streams can be attributed to the surface conditions and the nature of the soils in the lower parts of the catchment. The infiltration capacity of the soils of the higher rainfall land systems is relatively high, and as long as the surface remains rough and does not become sealed infiltration will cope with the heaviest likely rain storms. Repeated fuel reduction burning however may reduce the roughness of the surface and cause a deterioration in vegetative ground cover which could lead to a reduction in infiltration capacity. Conservative use of fire would be wise until the long term effects are better known. If frequent burning is considered necessary as a means of reducing the hazard of wild-fire, such treatment should be restricted to specific locations of very high hazards such as roadsides, or of high strategic value in fire fighting such as ridge tops, in association with mechanically prepared fire trails.

Plate 34. Salting is not a serious problem in the catchment at present, although there are some examples of severe salt damage, such as this area in the Benalla sub-system near Warrenbayne.

4. Treatment of Problems

Both soil erosion and the high runoff aspect of the flooding problem can be tackled through pasture improvement and proper management of grazing. The establishment of deep-rooted perennial pasture

grasses would help to reduce the rate of runoff. If grazing could be carefully controlled so that a continuous cover of grass was maintained, particularly during winter, the rate of surface runoff would be reduced. This could be expected to virtually eliminate soil erosion within areas, and by delaying the concentration of runoff would considerably reduce flood peaks.

The channels of the river and its tributaries also need attention. In order to further delay the concentration of runoff, the minor tributaries and drainage lines should be deliberately choked. This could be done with mechanical structures, but the easiest and cheapest method would be to encourage the growth of vegetation in them. Dense growths of narrow-stemmed vegetation would be ideal; single-stemmed trees could create problems by increasing the turbulence of the flow and so cause scouring. Reeds, grasses and small multi-stemmed trees are suggested, and mint *(Mentha sp.)* is worth particular attention as it seems to grow well in the district and is not attractive to grazing animals. The channels should be fertilized to encourage vegetation, either by aerial or ground spreading. In some cases it might be necessary to construct silt traps before vegetation could be established on the floors of the gullies.

The upper tract of the river delivers water too quickly, and also provides much of the sediment by erosion of its bank and bed. Clearing and straightening of this part of the channel should be kept to a minimum, and the banks should be stabilized with vegetation. The stabilizing vegetation should be small and multi-stemmed so that problems which result from stream turbulence are not created.

Treatment of the plains tract of the river may be difficult. Although some of the stress is relieved by storage in Lake Nillahcootie and the diversion to Lake Mokoan there is still likely to be some flooding. It is impossible to relieve this by making the river channel very much more efficient; the cost of dredging and re-shaping would be prohibitive. Instead it is recommended that land use should be carefully planned so that damage caused by floods is kept to a minimum. The whole of the lowest terrace (the Goomalibee terrace) should be regarded as a floodway, which was its function under natural conditions. The floodwater can be handled without erosion if it is spread on the terrace because of the lower velocities away from the channel. Also some of the water would be used in filling abandoned channels and other depressions. Because the surface of this terrace is very irregular it is mainly used for grazing, and this would seem to be its optimum use. No vulnerable buildings, market gardens, or crops should be established on it, and graziers should be prepared for occasional shallow flooding. Artificial levees are not desirable as confining the flood can only lead to excessive velocities and channel scouring.