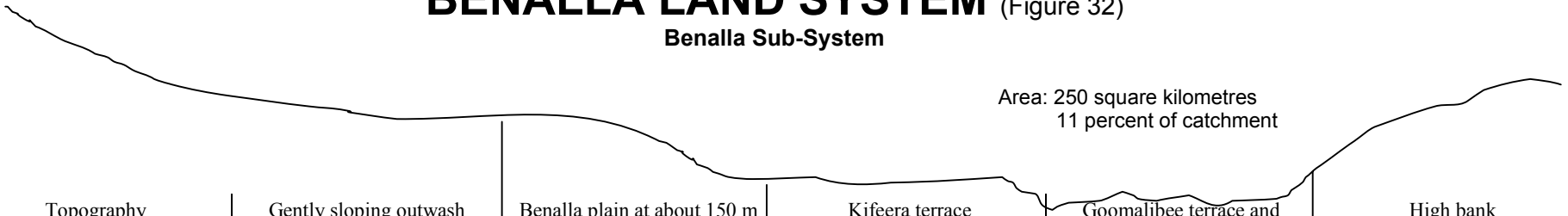
BENALLA LAND SYSTEM (Figure 32)

Benalla Sub-System



Topography	Gently sloping outwash slopes and fans	Benalla plain at about 150 m elevation	Kifeera terrace	Goomalibee terrace and stream channel	High bank
Climate	Average annual rainfall about 630 mm with dry summers. Growing season: March – May and September – November. Average temperatures: Jan 23°C; July 8°C; Year 16°C. Estimated evapotranspiration: Jan 125 mm; July 23 mm; Year 800 mm.				
Parent Materials	Hill-wash and alluvial fan deposits over older alluvium of the flood plain	Old flood plain deposits, alluvium	Alluvium	Alluvium	Old alluvium and hill-wash mantle.
Soils	Reddish gradational soil and weakly bleached gradation soils over yellowish or reddish clays at depth on slopes; gilgaied yellowish solodic soils on flat areas with pale gradational soils along drainage lines.	Yellowish duplex soils; some with gilgai features; reddish gradational soils on low ridges (prior stream ridges)	Reddish gradational soil on well drained areas; non-calcareous dark clays and gleyed gradational soils in wet areas.	Brown and grey loams, some gleyed; undifferentiated sands and loams.	Gilgaied yellowish duplex soils.
Vegetation	Woodland of grey box and white box, some yellow box and apple box; red gum in drainage lined.	Woodland of grey box and red gum with apple box and yellow box.	Woodland of red gum.	Woodland to open-forest of red gum.	Woodland to open-forest of yellow box, grey box and red gum.
Land Use	Mainly grazing sheep and cattle; some cereal crops.	Grazing and cereal crops; parts are water-logged in winter.	Grazing; low level of development.	Grazing or used	Grazing.
Erosion Hazard	Low to moderate where close to hilly areas.	Low	Low	High stream-bank erosion hazard	Moderate to low
Erosion Status	Generally sound but gully erosion extends down from adjoining hilly areas	Generally sound	Sound	Active stream-bank erosion; flooding and sedimentation.	Generally sound
Potential Land Use	The present use is sound but the area is capable of more intensive development.	Drainage would benefit some areas; improvement of pastures.	Suitable for intensive agriculture.	Subject to flooding; grazing of specialised pasture species which can utilise deep ground-water in summer and tolerate winter flooding.	Grazing of improved pastures.

BENALLA LAND SYSTEM

The plains have been mapped as the Benalla land system and have been separated into four sub-systems, Benalla, Warrenbayne-Tatong, Mokoan and Samaria sub-systems. They are all plains, or valley areas contiguous with the plains, and have generally low relief. However they differ from one another in climate and in drainage, and therefore in soils and vegetation.

Benalla Sub-system (See Fig. 32)

The extensive alluvial plains, including the river-terrace tract, have been defined as the Benalla sub-system. It occupies 250 square kilometres (11 per cent) within the catchment and similar areas may be found in the broad, lower valleys of many north-eastern streams.

The topography is simple and of low relief. It consists mainly of a broad plain, the Benalla plain (Plate 24), at about 150 m elevation but also includes gently sloping outwash fans from small hilly catchments adjacent to the plains, and the terraces associated with the trunk streams. The Benalla plain is regarded as being the third and highest terrace. The second terrace, which is referred to as the Kilfeera terrace in this study, is more extensive than the lowest terrace, the Goomalibee terrace.

Plate 24. The Benalla Plain is a major component of the Benalla sub-system. Grazing is the dominant form of land-use and scattered red gums provide shade for stock.

The whole sub-system consists of alluvium of various ages, most of it directly associated with the stream systems, but some having soils with some reddish gradational soils on low sandy ridges. On the Kilfeera terrace there are reddish gradational soils and non-calcareous dark clays, with pale gradational soils in wet sites, and some gleyed loams. The Goomalibee terrace, which is confined to a belt immediately adjacent to the river, contains meander scars and billabongs. It is characterised by undifferentiated sands and loams, brown loams and gleyed loams.

The present land uses are based mainly on the grazing of sheep and cattle. There is some cereal cropping but this is not usually a satisfactory enterprise, partly because of the prevalence of winter water logging and partly because of the uneven development over the gilgaied areas. The area is at the higher rainfall limit of satisfactory cereal-crop growing. With that exception, the present land uses are suitable for the environment but the area is capable of more intensive development, particularly by the general improvement of pastures. The lower terrace areas are largely neglected but the soils are suitable for intensive agriculture. The availability of reliable irrigation water from Lake Nillahcootie could encourage the development of irrigated pastures. The Goomalibee terrace is subject to flooding but has compensating features ; the water-table would probably be within reach of the deeper plant roots through most of the summer, and the area could support intensive grazing on specialised improved pastures without irrigation.

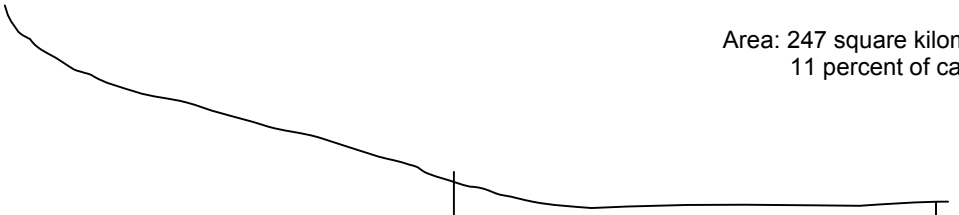
The erosion hazard is generally low and the area is sound overall except for gullies which extend from catchments in the hills. Stream bank erosion however has been very active and the deposition of sediment on the Goomalibee terrace has been a serious problem in places.

Most of the water yield from this area is by overland flow which occurs mainly when the soils have become saturated. Runoff can be expected in most years from June through to the end of September and thus contributes to the flood hazard while providing little useful water. Land use practices will not have much effect on this because of the low potential water use at that time of the year and the lack of adequate water storage in the soils.

Where possible artificial drainage would help reduce water logging but may accentuate the flooding problems. The larger drains may scour unless properly designed and constructed.

BENALLA LAND SYSTEM (Figure 33)

Mokoan Sub-System



Area: 247 square kilometres
11 percent of catchment

Topography	Gently sloping outwash areas	Swampy plain at about 200 m elevation	Swamp
Climate	Average annual rainfall about 630mm, with dry summers. Growing season: March-May and September-November. Average temperature: Jan 23°C; July 8°C; Year 16°C. Estimated evapotranspiration: Jan 125 mm; July 23 mm; Year 800 mm.		
Parent Material	Alluvial sheets and fans, overlying older alluvial plain deposits.	Lacustrine sediments.	Lacustrine sediments.
Soils	Weakly bleached gradational soils and reddish gradational soils on slopes; yellowish duplex soils some gilgaied, and pale gradational soils.	Gilgaied calcareous dark clays, and pale gradational soils; often flooded.	Slightly saline calcareous dark clays; usually flooded.
Vegetation	Woodland of red gum, grey box and white box; some yellow box and apple box.	Woodland of red gum.	Woodland of red gum in shallow water; reeds in deeper areas and free water.
Land Use	Grazing, mainly sheep; some cereal cropping.	Grazing; water-fowl refuge and breeding areas.	Unused; water-fowl refuge and breeding area
Erosion Hazard	Low to moderate near hilly areas	Low	Nil
Erosion Status	Generally sound, except for gully erosion extending from adjacent hills.	Sound	Sound
Potential Land Use	The present uses are well suited to the environment, but the area is capable of further development.	Much is now inundated by Lake Mokoan; the remainder is sound agricultural and pastoral land capable of further development. Drainage may improve productivity in some areas.	Inundated by Lake Mokoan; irrigation storage; recreation; water-fowl breeding and refuge area

Mokoan Sub-system (See Fig. 33)

The Mokoan sub-system of the Benalla land system consists of flat plains which contain swamps and areas of internal drainage. It does not include all of the swampy areas but by far the largest are in this sub-system. There are similar areas further to the west where they have been mapped by Downes (1949) as the Upotipotpon soil association. The topography is very subdued and consists of gently sloping outwash areas at the foot of the hills, and swampy plains which terminate in swamps (Plate 25). Not all of the swamps contain free water throughout the year, but the land system includes the extensive Mokoan swamp system. The area is developed on alluvium and dark coloured stream sediments derived from catchments of both granitic and sedimentary rock. It occupies about 247 square kilometres which is about 11 per cent of the catchment.

The climate is similar to that of the Benalla sub-system. Rainfall is about 630 mm per annum, a little less on the western fringe, with a summer drought. The growing season is approximately through September to the end of November and from March to late May. Evaporation is high during summer and exceeds the rainfall by 170 mm or more. Plant growth is limited by lack of water in summer and by low temperatures in winter, and, particularly within this sub-system, by waterlogging during winter.

The vegetation on the better drained fringes consists of a woodland of red gum, grey box, with some yellow box and apple box. The swampy plains carry a woodland of red gum and the swamps carry tall woodland of red gum on the fringes, with open water and reeds in the centres of the deeper depressions.

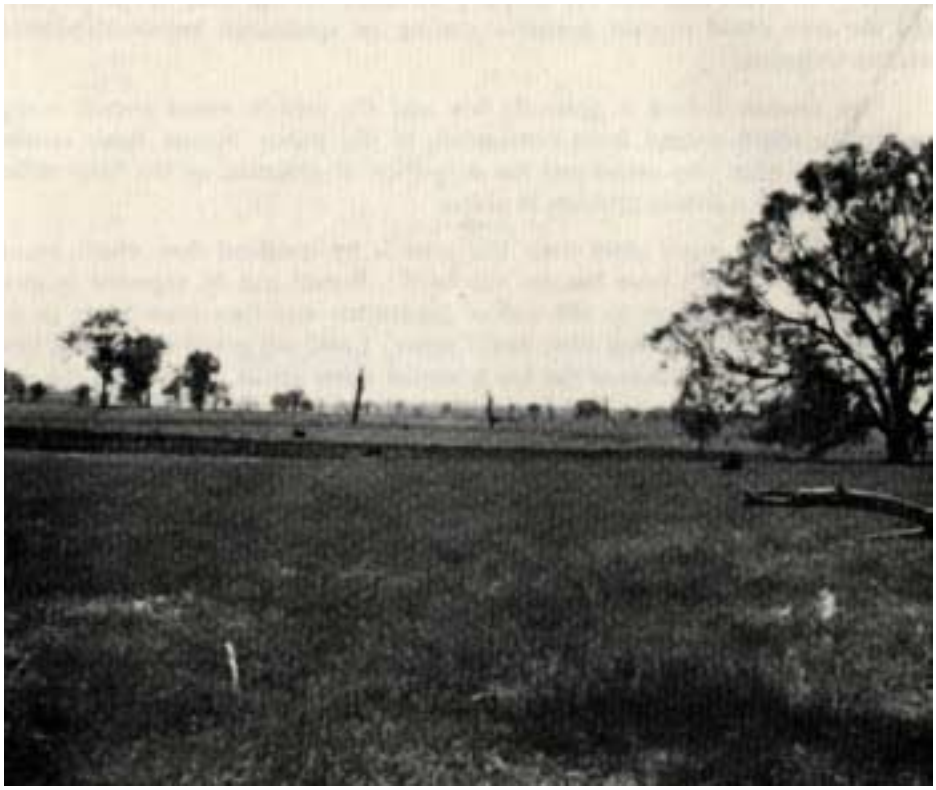
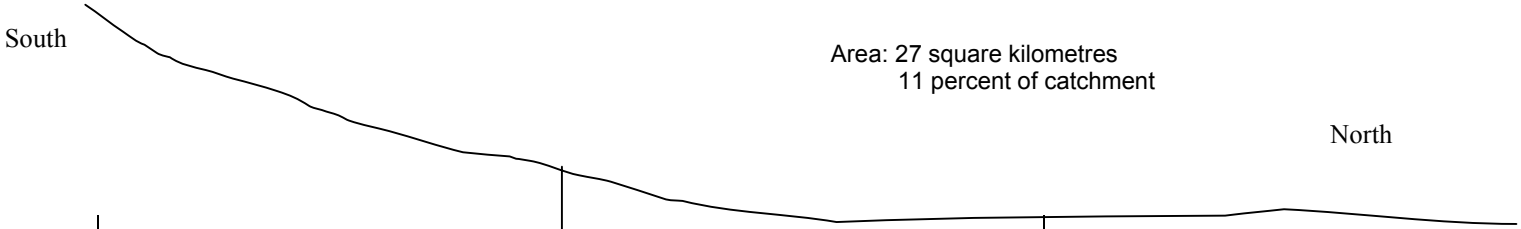


Plate 25. The Mokoan sub-system, although similar to the Benalla sub-system, is distinguished by the presence of swamps, many of which retain water throughout the year.

The soil pattern follows a similar sequence, which is mainly influenced by the drainage. The slopes have weakly-bleached gradational soils and reddish gradational soils, often overlying yellowish or reddish clays. The well drained flats have yellowish duplex soils and near the drainage lines deep, pale gradational soils are usual. The swampy plains are occupied by gilgaied calcareous dark clays and by pale gradational soils in the outwash areas of the creeks. The swamps have a floor of slightly saline, calcareous, grey cracking clays, and are normally. flooded each winter. The situation as described applied particularly to the area surrounding Winton Swamp which is now regularly flooded by the waters of Lake Mokoan.

BENALLA LAND SYSTEM (Figure 33)

Samaria Sub-System



Topography	Valley-head slopes up to about 300 m elevation.	Mid-valley.	Poorly drained lower flats at about 210 m elevation.
Climate	Average rainfall from 760 mm to 890 mm. Growing season: March-May and September-December. Estimated average temperatures: Jan 22^{o}C; July 8^{o}C; Year 15^{o}C. Estimated evapotranspiration: Jan 125 mm; July 20 mm; Year 760 mm.		
Parent Materials	A range of sedimentary and acid igneous rocks.	Valley-fill sediments; hill-wash and alluvium.	Alluvium and redeposited soil material
Soils	Yellowish duplex soils; some friable reddish gradational soils with poorly structured subsoil.	Yellowish duplex soils tending in some areas to be gilgaied; some weakly bleached gradational soils.	Gilgaied yellowish duplex soils with deep A horizon; pale gradational soils.
Vegetation	Open forest t woodland of long-leaf box, red stringybark, red box and broad-leaf peppermint.	Open forest to woodland of candlebark gum and apple box, with red gum and yellow box in lower areas.	Woodland to open forest of red gum, yellow box and apple box with grey box on drier sites. Red stringybark and red box on rises.
Land Use	Partly cleared and grazed.	Mostly cleared; grazing of sheep and cattle and some dairying.	Mostly cleared but some reverting to forest; grazing of sheep and cattle.
Erosion Hazard	Moderate	Moderate to low	Low except for moderate hazard in stream lines
Erosion Status	Generally sound	Generally sound; some gully erosion.	Stream-bank erosion
Potential Land Use	The present uses are well suited to the environment; Capable of further development		

The sub-system includes the swampy areas of effluent drainage in the Baddaginnie and Upotipotpon areas. The tract around Winton Swamp occupied about 180 square kilometres and the other two areas together occupy about 67 square kilometres. Before construction of the retaining embankment the Mokoan swamp system had about 17.5 square kilometres of open water, and 25.6 square kilometres of permanent swamp including the vegetated Green Swamp. In addition to this there was a little over 2.5 square kilometres of small swamps distributed about the land system and having more-or-less permanent water.

The soils of the Baddaginnie and Upotipotpon areas are intermediate in development to the gilgaied, calcareous, dark clays and the yellowish duplex soils. They are often brown to grey and gleyed, and are normally gilgaied. The sub-system boundary has largely been interpreted from the gilgaied soil patterns and the effluent drainage patterns evident on aerial photographs. The remaining boundaries are topographic, mainly where the sub-system adjoins the Lurg and the Warby land systems.

At present the area is used mainly for grazing. There is some cereal cropping but in general the soils are too wet in winter. However these soils have a fairly high potential for pasture production and they are improved by cultivation, which mixes the heavy clay from the rises with the deep, loamy materials of the hollows in the gilgaied pattern.

The erosion hazard is low because of the gentle slopes, but large drainage ditches may scour if they are constructed on too steep a grade. Gully heads and stream-bank scouring are fairly common in the minor drainage lines which dissect the area, mainly because of flood runoff originating outside the sub-system.

The area has little value as a source of useful water, but sediment from local erosion could be detrimental to Lake Mokoan. Because Lake Mokoan is large but shallow it has a high potential evaporation loss. For this reason discharges from the lake are made early in the irrigation season, enabling water to be retained in the more efficient Lake Eildon. The Winton Swamp was one of the more important waterfowl habitats in Victoria, and special provision for retaining water for this purpose has been made in the development of the lake as an irrigation storage.

Present uses are sound but the area is capable of further development. Drainage of the wet flats would be beneficial but attempts to drain the more permanent swamps are apparently not desirable. The irrigation storage will be valuable for recreation and also for the maintenance of waterfowl populations.

Samaria Sub-system (See Fig. 34)

This is a fairly small valley area, contiguous with the plains. The catchments with which it is associated consist mainly of sedimentary rock and rhyodacite. It occupies 27 square kilometres, about one per cent of the catchment.

The topography consists of swampy low flats, well drained mid-valley slopes and steep valley head-slopes which give way to the Moorngag and Tiger Hill land systems.

There is a climatic gradient up the valley and this gradient steepens appreciably before the topographic break in slope. Average annual rainfall is generally between 760 mm and 890 mm and the growing season extends from March to May and September to December.

The vegetation is an open forest to woodland of long-leaf box, red stringybark, red box and broad-leaf peppermint at the head of the valley, with candlebark gum and apple box in the mid-valley sections. The lower valley areas have much more in common with the plains to the north and carry red gum, yellow box and apple box, with grey box on drier sites. Red stringybark and red box occur on the slopes and valley sides.

The soil pattern follows a similar trend to the climatic pattern. The lower areas have deeply gilgaied yellowish duplex soils with very deep A-horizons, and pale, weakly-bleached gradational soils. These soils are similar to those developed on the Mansfield Plain. The mid-valley sections have yellowish duplex soils which give way to the gilgaied forms down the valley. The upper valley sections also have yellowish duplex soils which give way to friable yellowish gradational soils higher up the slopes.

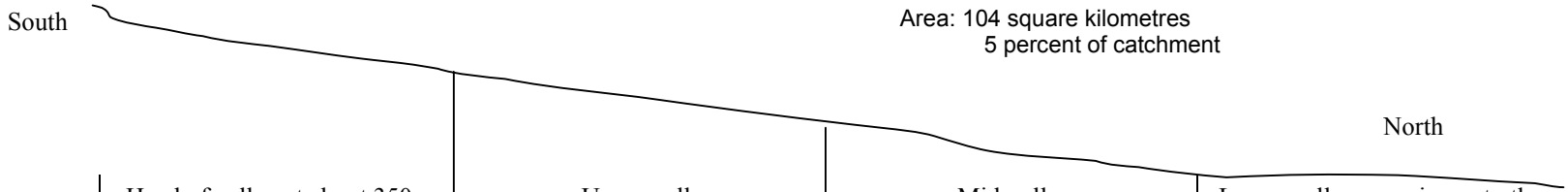
The present land uses are mainly the grazing of sheep and fat cattle, with some dairying. Part of the land system is uncleared or has reverted to forest. Although these uses are well suited to the environment the area is capable of much more agricultural development. The climate is more favourable than that of the open plains, but parts of the valley suffer from waterlogging and the soils are also subject to scouring. The area does not contribute much water to the stream system except for winter runoff from saturated soils, and this merely contributes to the flood problem. If the winter runoff could be retained within the area it would provide valuable summer irrigation.

There is scope for pasture improvement and drainage, as well as on-farm water conservation for summer use and conservation of fodder for use in the winter.

For the maintenance of catchment values it will be necessary to control erosion, including stream bank scouring, and to encourage the development and management of pastures to reduce the rate of overland flow.

BENALLA LAND SYSTEM (Figure 33)

Warrenbayne-Tatong Sub-System



Topography	Head of valley at about 350 m elevation	Upper valley	Mid-valley	Lower valley, opening onto the plain at about 210 m elevation.
Climate	Average annual rainfall from about 760 mm in north to about 1 150 mm in south. Growing season: March-May and September-December. Estimated average temperatures: Jan 21°C-22°C; July 7°C-8°C; Year 13°C-15°C. Estimated evapotranspiration: Jan 125 mm; Year 760 mm.			
Parent Materials	Some acid lavas; mainly alluvium	Alluvium	Alluvium	Alluvium
Soils	Friable reddish brown soils with weakly structured subsoils; friable brownish gradation soils; gleyed grey loams on wet flats.	Friable brownish gradational soils and friable reddish gradational soils with weakly structured subsoils; gleyed grey loams on wet flats.	Weakly bleached gradational soils; yellowish duplex soils.	Weakly bleached gradational soils; reddish and yellowish duplex soils; the terrace sequence as in *Benalla* sub-system.
Vegetation	Open forest of narrow-leaf peppermint and candlebark gum on side slopes; manna gum on well drained areas; swamp gum on wet flats.	Transition zone; narrow-leaf peppermint in south to broad-leaf peppermint in north, both with candlebark gum; swamp gum along wet flats.	Open forest of red stringybark and broad-leaf peppermint on sides of valley; candlebark gum along valley bottoms.	Open forest to woodland of red box and red stringybark on slopes; red gum dominant along valley bottom and other flat areas.
Land Use	Some cleared areas, used for dairying.	Mostly cleared and used for dairying, cattle grazing; hopes on well drained flats.	Mostly cleared; mixed farming, dairying, fat cattle, sheep.	Predominantly grazing of cattle and sheep.
Erosion Hazard	Moderate to low	Low	Low	Low except for moderate hazard on streams.
Erosion Status	Mainly sound	Sound	Sound	Some stream erosion
Potential Land use	The present uses are well suited to the environment; Capable of much more development.			

Warrenbayne-Tatong Sub-system (See Fig. 35)

This sub-system of the Benalla land system consists of alluviated valley bottoms contiguous with the Benalla Plain. The alluvium has mainly been derived from the acid lavas, and this has influenced the soils developed within the sub-system. This sub-system includes the lower valleys of the Five Mile Creek and Holland's Creek, (Plate 26) and the valleys of Sam's and Ryan's Creeks plus part of the Broken River Valley near Swanpool. The area of the sub-system is about 104 square kilometres which is about 5 per cent of the catchment.

Topography consists of narrow valleys with gradually steepening gradients toward their heads. Because the valleys are narrow the alluvial-colluvial foot-slope deposits from the valley sides make up a major part of the landscape. Some of the valleys are winding but there are many straight sections on most of them and the general trend is south to north.

The rainfall increases from 760 mm in the north to approximately 1150 mm per annum at the southern end of the sub-system. The growing season is approximately from March to May and from September to December, but varies with position in the valley. The valleys continue well on into the highlands past the alluvial flats, and drainage of cold air from the highlands results in the valley bottoms being frosty during the cooler months.

The changes in vegetation up the valley follow the pattern of climatic change. In the lower sections, adjacent to the plain, woodland of red gum which is typical of the stream lines on the plain, is still present, and red box and red stringybark occur on the side-slopes. A little further up the valley, candlebark gum replaces red gum along the stream, and the open forests on the slopes are of red stringybark and broad-leaf peppermint. Toward the heads of the valleys, narrow-leaf peppermint replaces broad-leaf peppermint, and swamp gum appears along the wet stream lines and on poorly drained flats. The side-slopes carry open forest of narrow-leaf peppermint and candlebark gum.

Plate 26. In the valley of the Holland's Creek near Tatong, the steep slopes of the Loombah land system merge with the gentle valley-slopes and plains of the Warrenbayne-Tatong sub-system.

The soils follow a similar trend. Near the northern ends of the valleys they are weakly-bleached gradational soils and reddish or yellow duplex soils, together with the terrace sequence as in the Benalla sub-system. Further up the valleys yellowish duplex soils are more characteristic and these give way gradually to friable brownish gradational soils. Friable reddish gradational soils are typical of the southern slopes. Gleyed loams occur on the wet flats where swamp gum is the dominant vegetation.

The land use changes with position in the valley. These valleys contain some specialised sites which have usefulness out of proportion to their area. Near the mouth of the valleys the main land use is grazing of sheep and cattle on permanent pastures, as on the plains. As the rainfall increases mixed farming becomes more common, and includes dairying, but there is still a fairly large proportion of fat cattle and sheep. Still further up the valley dairying becomes dominant with fat cattle as an important sideline. The growing of hops is a significant local industry and is confined virtually to valley heads. At the extreme head of the land system the valleys narrow very rapidly and there is little agricultural development. A number of these areas have been cleared and many are reverting to forest, apparently mainly because of their isolation. This land system represents a very useful environment with much more reliable growing conditions than the open plains, and in particular, less moisture stress. Most of it is capable of a high level of development.

The present uses are well suited to the environment and development should be continued along the established lines, principally by pasture improvement and the more intensive utilization of this excellent environment.

Although it represents about 5 per cent of the catchment this sub-system is composed of a number of small separate areas and thus has little direct effect on the hydrology of the catchment as a whole. It is mainly free of serious erosion but the streams tend to deliver their water too quickly, and there is minor stream erosion at the lower ends of the valleys. These scoured out stream channels may require attention in a flood mitigation programme.