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DISCONTINUOUS GULLYING OF THE TEA TREE RIVULET, BUCKLAND, EASTERN TASMANIA

by

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(with two plates and five text figures)

ABSTRACT

The recent development of discontinuous gullying appears to be largely due to clearing of the natural floodplain vegetation in the first half of the 19th century although climatic factors may have contributed in a minor way. Rate of headcut migration is related to the frequency of flood flows which in turn is a function of the frequency of occurrence of large rains. The upward trend in the number of small rains at least since 1915 is thought to have reduced sediment yields through its beneficial influence on the catchment vegetation and may be another factor favouring accelerated erosion of the floodplain.

In future studies of unstable stream channels in alluvial deposits a distinction should be made between continuous trenches and discontinuous gullies. When discussing the effects of vegetation changes on stream behaviour a distinction should always be made between the vegetation of the catchment slopes and that of the floodplain or alluvial fan in which the channel under study is situated since the same change in both may have opposite effects on the behaviour of the stream.

INTRODUCTION

The Tea Tree Rivulet is a permanent stream with a drainage area of 32.5 square miles (Fig. 1). The rivulet joins the Prosser River 4 miles ENE of the township of Buckland and along the last 5 miles of its course where it flows through the Buckland Basin a wide and continuous floodplain has developed. Extensive accelerated channel erosion, active at least since the late 19th century, is taking place with the development of discontinuous gullies.

The area is well suited to detailed study because the catchment of the river is dominated by one lithology and modification of the vegetation cover of the catchment slopes by human interference has been minimal.

A general description of the geomorphology of the Buckland Basin is given in an earlier paper (Goede, 1965). The mean annual rainfall in the basin is approximately 63 cm rising to more than 90 cm in the more elevated headwater region of the rivulet while the mean annual temperature is in the vicinity of 51° F (10.5° C) but the basin experiences moderate frosts in winter due to cold air drainage. Frost action has been observed to play a significant part in making material available for stream erosion.

Much of eastern Tasmania consists of flat lying Permian and Triassic mudstones and sandstones intruded extensively by transgressive sills and dykes of Jurassic dolerite. The catchment under study is underlain almost entirely by dolerite with the exception of a few small patches of Tertiary basalt on the divide near Nugent and a low sandstone ridge to the west of where the rivulet enters the basin.

The vegetation of the catchment is predominantly dry sclerophyll forest with small patches of wet forest along some of the more deeply incised headwater streams. Almost the entire basin is under natural vegetation with the exception of three areas:—

(1) A small area cleared for rough grazing near Nugent on the divide with the Carlton River.

(2) The floodplain of the lower Tea Tree which today is used mainly for rough grazing but shows evidence of more intensive land use in the past.

(3) A limited area of gently sloping hill country, alluvial fans and terraces to the west of the present floodplain.

DESCRIPTION

1. Floodplain Morphology

The term 'floodplain' is used throughout as purely descriptive indicating the lowest continuous depositional surface associated with the stream. It does not imply a surface subject to regular flooding and present day deposition at least not within the area of study. Stratigraphic studies of the floodplain deposits to be published elsewhere indicate that their deposition virtually ceased some 3,000 years ago. Regular overbank flow and active floodplain deposition still occur further downstream in the Gatehouse's Marsh area near the junction with the Prosser River (Goede, 1965).

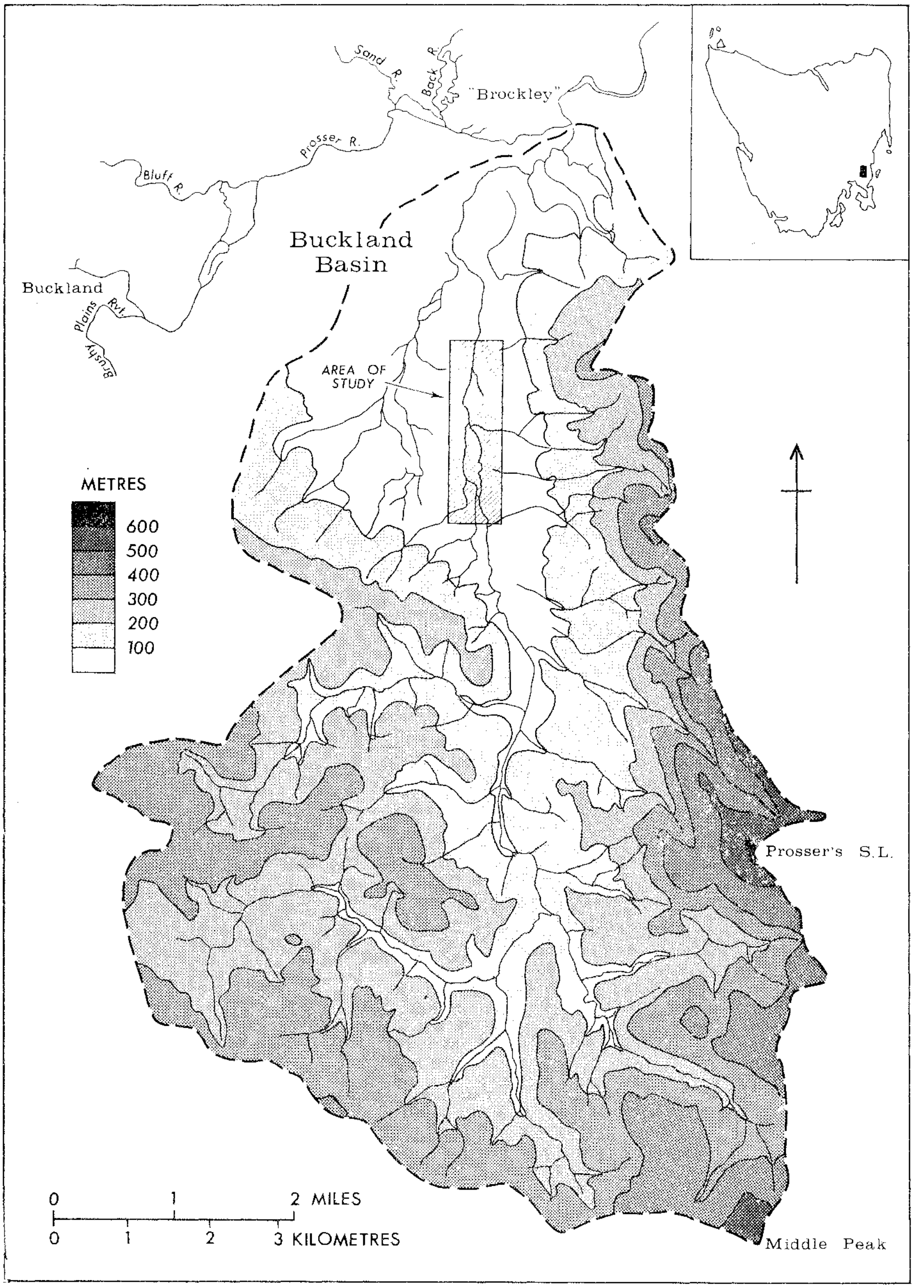

FIG. 1.—Location map, indicating height distribution of basin of Tea Tree Rivulet.

The morphology is that of a typical covered plain (Melton, 1936) with well developed levees grading into a backslope away from the original river channel. The floodplain sediments contain basal dolerite gravels but are for the most part fine-grained with a high percentage of silt and clay. At a point less than 1 mile from its emergence from the hills the average silt and clay content of the alluvium is approximately 60% and increases in the downstream direction.

Accelerated erosion has been active at least since before 1874—the date of the earliest detailed survey available for the area. In part the gullies have developed away from the old channel (Plate II) at or near the outer margin of the floodplain where it is in contact with an older alluvial terrace (Turvey Terrace) overlain by windblown sand. Gullying appears to have been concentrated here by water spilling laterally across the floodplain at times of overbank flow.

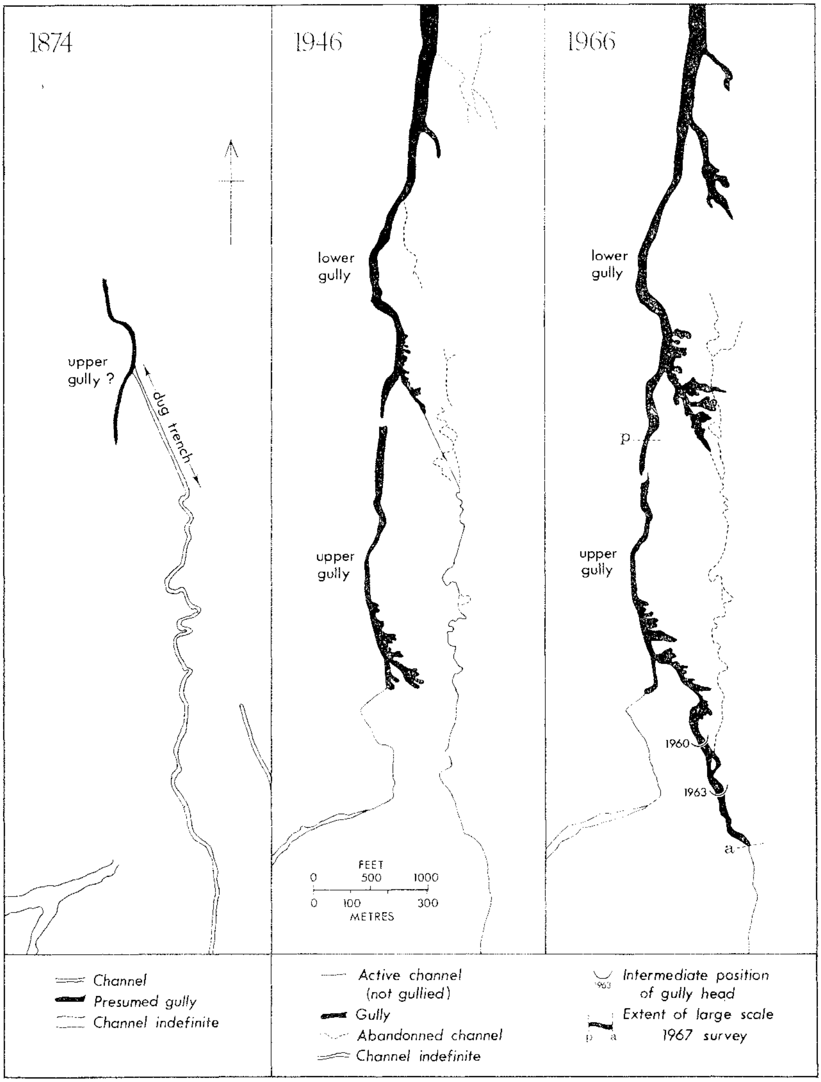

FIG. 2.—Historical map sequence, showing the development of unstable channels.

No doubt another factor in promoting accelerated erosion was the clearing of the floodplain for agricultural purposes in the early days of settlement—probably in the 1830s although the exact date is not known. The original floodplain vegetation was dense scrub dominated by species of tea tree (*Leptospermum* spp.) which can grow to a height of 20 feet and probably played an important part in preventing rapid floodplain erosion.

The floodplain reach of the Tea Tree Rivulet shows two well developed discontinuous gullies migrating upstream with rapid changes in channel morphology in both space and time (Figs. 2 and 3).

All that is known about the onset of discontinuous gullying is based on a survey of the 'Twamley' property carried out by Government District Surveyor Wedge in March 1874. This document is in fact a rather poor record of the extent of gullying at the time (Fig 2). It does however show the earliest effort made to confine gullying to what was then the main river channel. A diversion was dug prior to 1874 (see Fig. 2) from the head of a gully developing along the western outer margin of the floodplain. The diversion did not serve its purpose. Not only did it fail to stop gullying along the floodplain margin but the newly dug channel became itself a focal point for further gullying.

The next source of information is the 1946 aerial photographs which show the development of two distinct gullies. These will be referred to from now on as the upper and the lower gully (Fig. 2). A second set of aerial photographs of the area was taken in 1966 and enabled a detailed analysis to be made of the changes during the intervening twenty-year period. The author made his first visits to the area in 1963

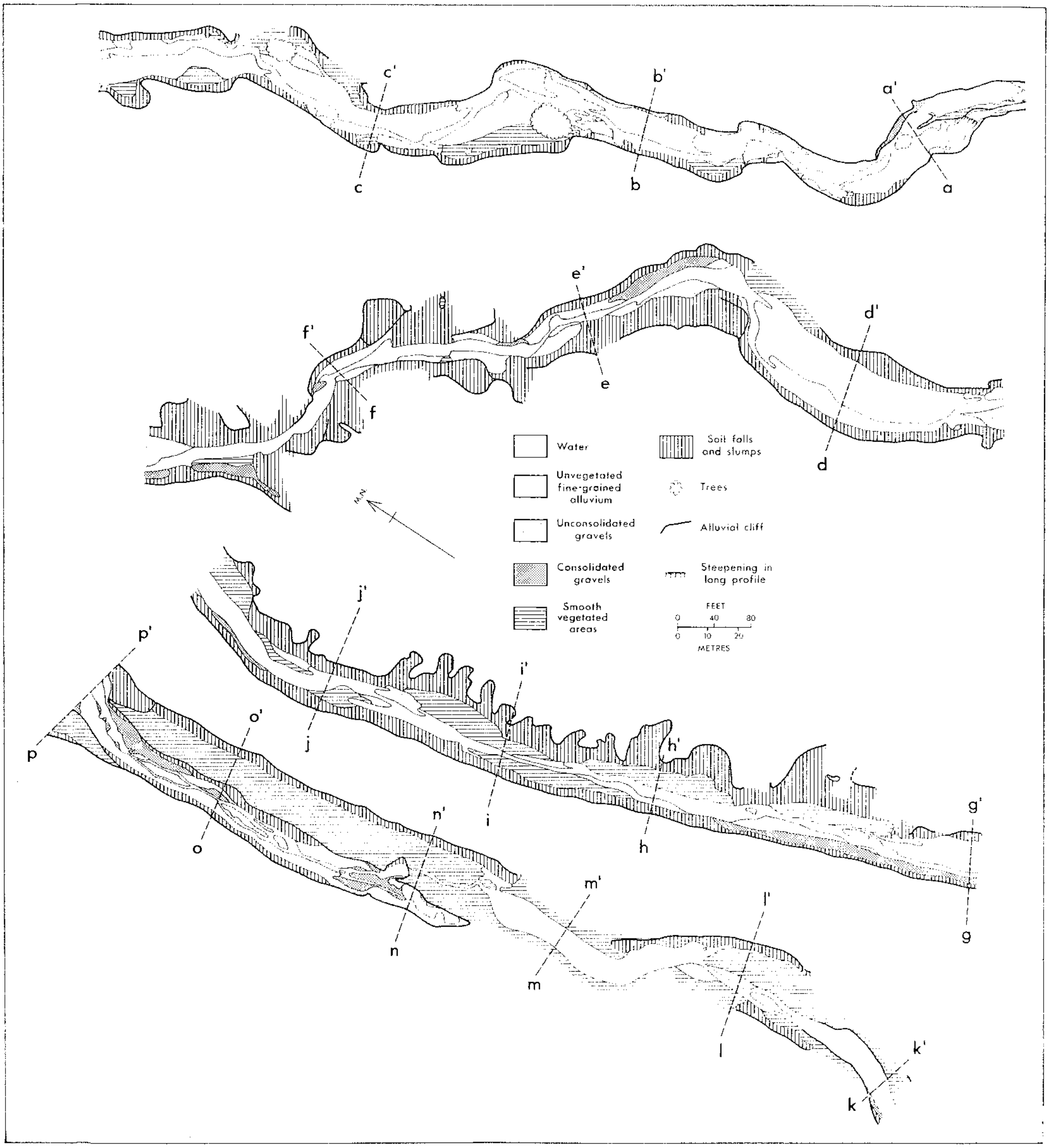

FIG. 3.—Detailed plan survey, showing upper gully and uppermost part of lower gully.

and the gully system has been under intermittent observation since then. In February-March 1967 a survey was made of the upper gully and the uppermost section of the lower gully using a prismatic compass and tape with offsets measured at 20 feet intervals (Fig. 3). In addition sixteen sections were surveyed at intervals of 200 to 300 feet (Fig. 4). The latest information on the area has been obtained from oblique aerial photographs taken in November 1969 (Plate II). The evidence shows that we are dealing with a very rapidly evolving system. The changes with time can be studied in detail for the last twenty-five years and are summarised in figure 2.

2. Morphology and Development of Discontinuous Gullies

The Upper Gully

What appears to be an early stage in the development of the upper gully is shown in the 1874 survey. Comparison with the 1967 survey presented in figure 3 suggests that the head of the upper gully was in the vicinity of cross section *pp'* at a point now approximately 500 feet downstream from the head of the lower gully. The 1946 aerial photographs show the head of the upper gully as having reached a point between sections *ee'* and *ff'* in figure 3. During a major flood in 1960 the gully head came within 50 feet of the river channel and a trench was dug to divert the stream from its original course into the gully, merely hastening an event that would have taken place quite soon in any case. The original channel downstream from the diversion point was abandoned with the head-cut of the upper gully now migrating upstream along the original channel.

This gully when first seen in February 1963 terminated at its upstream end in a vertical head-cut in alluvium some 3 metres high with a deep plunge pool at the base and located approximately 10 metres downstream from section *bb'* in figure 3. By July 1965 the headcut, now degraded as a result of meeting older more compacted alluvial sediments near its base, had migrated to a point at least 13 metres upstream from section *aa'*. The average rate of upstream migration of the headcut between the two dates just mentioned is approximately 53 metres/year.

The discussion of gully morphology is based largely on the detailed survey carried out in February-March 1967 together with field observations made at various times. The upper gully can be divided into three sections. The upper section extends from the headwall upstream from section *aa'* to a point approximately midway between sections *dd'* and *ee'* (Fig. 3). It is floored almost entirely by coarse gravels and there is active bank erosion in the form of soil falls and slumps while the banks are vertical to slightly overhanging with little accumulation of slumped material. Bank erosion occurs mainly at or shortly after periods of high discharge. Where the stream had exposed older alluvial gravels loosening of the pebbles from the matrix due to frost heave was observed one winter morning following a frosty night. This process is probably important in facilitating erosion of the coarse fraction at times of high flow. Frost may also be significant in promoting bank erosion but this has not been observed.

Comparison of 1947 and 1967 aerial photography shows that a distinct meander pattern has developed in the upper section in the last twenty years with an average wavelength of 80 metres.

The middle section extends from midway between sections *dd'* and *ee'* to approximately *jj'* and is much more stable. Bank erosion is less active and for most of its length the stream has developed a remarkably straight channel along the junction with a higher alluvial terrace (Turvey Terrace) made up of more resistant sediments. There is a much greater accumulation of slump material at the foot of the banks and the eastern bank is extremely irregular due to numerous side gullies extending diagonally across the floodplain towards the original stream channel.

In the lower section which extends from *jj'* downstream to the head of the lower gully the stream has more or less re-attained its previous floodplain level by overbank deposition causing a narrowing of the gullied channel. Distinct levees have developed in association with this depositional apron with the channel itself consisting of long deep pools separated by short shallow stretches of vegetated gravel bars. The characteristics of this part of the gully are clearly not those of a channel carrying a significant amount of bedload. In fact there appears to be very little transport of bedload out of the upper gully which has developed largely by the winnowing out of the fine fraction of the alluvium with the coarser gravel concentrated as a lag deposit particularly in the upper section.

The Lower Gully

The first record of the lower gully is found on the 1947 aerial photographs and a comparison of those with the 1967 photographs shows that during the twenty-year period the headcut has migrated upstream a distance of approximately 212 metres giving an average rate of 10.6 metres per year. The migration rate would be quite erratic, not only because of the irregular occurrence of large flows but also because headcut migration would be slow while passing through a bar (Fig. 3). As soon as it reaches the downstream end of the next deep pool immediately upstream the pool will be drained with the sudden displacement of the headcut to the next shallow reach. The latest photographs (Plate I, fig. 2) taken in November 1969 shows that such an occurrence is now imminent. Another peculiarity of the headcut is that at least since 1967 it has consisted of two distinct lobes (Fig. 3), the eastern one taking all the water at times of low flow (Plate I, fig. 1).

Although headcut migration of the lower gully appears to take place at a much slower rate than that of the upper gully a valid comparison cannot really be made as the two rates are calculated over different periods, as well as different lengths of time. No satisfactory rate can be calculated for the upper gully over the period 1947-67 because the breakthrough to the original channel was brought about by human interference.

The lower gully can be divided into the same morphological sections as the upper one but in addition there is a fourth section (immediately downstream from the headcut) which is morphologically distinct and has no counterpart in the upper gully. This is the only section of the lower gully to be included in the detailed survey of 1967 (Fig. 3) and is entirely erosional in character. The floor consists mostly of fine-grained clay-rich alluvium with gravelly patches exposed in places with an anastomosing pattern of low water channels cut into it (Plate I, fig. 2) and locally well developed miniature meanders are present. These meanders with their sharp crested erosional meander cores and incipient scalloping of their sides resemble solution channels in soluble rock rather than classical stream meanders suggesting that colloidal solution of clays may well be a significant factor in shaping their morphology but the presence of potholes containing trapped dolerite pebbles indicates that mechanical erosion is also important. Another characteristic feature of the upper section is the presence of a well developed bench at a level approximately 0.5 metres below the general level of the floodplain. The bench is best preserved on the eastern side of the channel and is well shown in figures 3 and 4, sections *nn'* and *pp'* and less clearly in section *oo'*. It represents the remains of the alluvial apron formed by deposition at the toe of the upper gully and where seen in section these deposits are approximately 1 metre deep and overlie older alluvium. They show well-developed bedding and contain a much higher percentage of sand-size material than the bulk of the older floodplain deposits at this point.

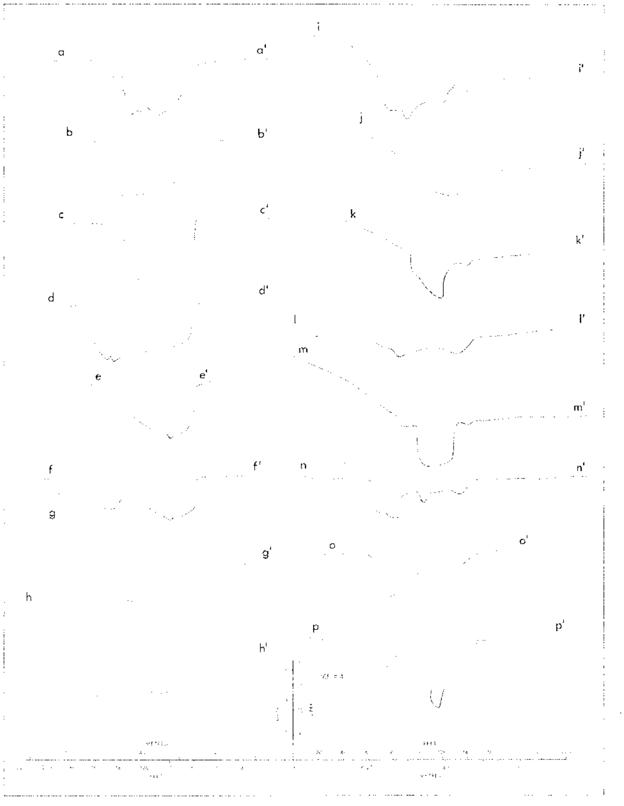

FIG. 4.—Cross-sections of gullies. Positions are indicated in Fig. 3.

The remaining three sections of the lower gully are morphologically similar to those of the upper gully but are longer and the channel width is much greater.

DISCUSSION

1. The Nature of Unstable Stream Channels

In many parts of the world today stream channel patterns can be found which are far from stable. They are usually characterised by rapid changes in channel morphology and are bounded on both sides by vertical banks cut in alluvium or other unconsolidated deposits. Such channels have been described under a variety of names. In the English-speaking world they are generally referred to as gullies or trenches, in the south-west of the United States as arroyos and in the Mediterranean areas as wadis. Unstable channels are not confined to particular climatic regions although some climatic types seem to offer optimum conditions for their development, e.g., Mediterranean and semi-arid climates.

Rather similar channels develop on unconsolidated deposits other than alluvium. They are well known on colluvial deposits but also occur in wind-blown sediments (loess, parna) and deposits resulting from glaciation (till) but for the sake of simplicity it is intended to confine discussion in this paper to unstable channels developed in alluvium.

Few workers in the field of unstable channel morphology have attempted to distinguish between different types of channels. Antevs (1952) proposed a classification into three types: wadis in arid regions, arroyos in semi-arid regions and trenches in humid regions. This classification has not been accepted because it was based on climatic rather than morphological criteria.

It appears to the writer that at least in situations where alluvium is sufficiently cohesive to provide firm banks and to maintain vertical headcuts a useful distinction can be made between two distinct types:—

(1) *Alluvial Trenches.* They are long and continuous stretches of unstable channel bounded by continuously cliffed banks. Although they can be quite deep they show signs of rapid widening and a tendency to evolve a braided channel pattern through the development of midstream bars. Alluvial trenches appear to be the result of a large increase in bedload apparently brought about by environmental changes in the catchment area causing an increased supply of coarse sediment to the stream.

(2) *Discontinuous Gullies.* They are usually developed on a smaller scale than continuous trenches. Their most important characteristic is that they are discontinuous, i.e., stretches along the channel where erosion is dominant are separated by stretches which are either stable or where deposition tends to occur. Rapid channel widening is observed only in the upper parts of individual gullies and changes position with the upstream migration of the valley head. Discontinuous gullying does not appear to be the result of heavy bedload transport since it is unlikely that vertical headcuts in fine-grained alluvium could survive the transport of significant amounts of bedload. The morphology of a stable stream channel upstream of the discontinuous gully system can be used as an indicator of the rate of bedload movement (Schumm, 1968, 1969).

2. The role of Vegetation

The dominant role played by the character and density of the vegetation of the catchment in controlling sediment yield is well known. The vegetation cover in turn is affected by a number of factors which may be climatic, edaphic, topographical or anthropogenic. Langbein and Schumm (1958) established a relationship between effective mean annual precipitation in inches and the sediment yield in tons per square mile for a number of relatively small catchments in the United States. The authors defined effective precipitation as the amount of precipitation required to produce the same amount of run-off as the actual precipitation if the mean annual temperature were 50° F. They also demonstrated the importance of vegetation as the immediate control on sediment yield using bulk density of vegetation as a quantitative parameter. Their use of effective mean annual precipitation largely eliminates temperature as a factor but other aspects of rainfall are not taken into account although their importance is pointed out.

Their graph showing the relationship between annual sediment yield and effective precipitation while admittedly showing a lot of scatter indicates a rapid decline in sediment yield as effective mean precipitation rises from 15 inches to 40 inches. If a similar relationship holds in the case of Tasmanian vegetation as seems likely we can expect considerable changes in sediment yield with relatively small changes in effective precipitation over the range just stated. Since the mean annual temperature in south-eastern Tasmania comes close to 50° F effective precipitation as defined by Langbein and Schumm (1958) can be equated with mean annual precipitation in the area under study. The range of mean annual rainfall of 15 inches to 40 inches coincides approximately with the subhumid province of eastern Tasmania as defined by Davies (1967) on the basis of Thornthwaite's precipitation effectiveness index. A PE value of 64 is accepted as the upper limit of the subhumid province and it is precisely in this province that we find strong evidence of post-glacial valley fills (Davies 1967, Goede 1965).

In the literature the effects of vegetation on stream behaviour have often been confused because most authors have failed to distinguish between the vegetation of the catchment slopes and the vegetation of the floodplain or alluvial fan. It is clear from the literature (e.g., Langbein and Schumm, 1958; Musgrave, 1947) that the vegetation covering the catchment slopes largely determines the amount of load supplied to the stream. Within the range of mean annual rainfall with which we are concerned (15 inches to 40 inches) vegetation density is related inversely to sediment yield. Changes in vegetation density are brought about not only by climatic changes but also by human interference and by catastrophic events, especially fire.

Next the floodplain vegetation should be considered. In the case of a stream which is not entrenched in its floodplain the water table will be close to the surface and a dense natural floodplain vegetation will result even in areas with a dry season and where streams are intermittent. The floodplain vegetation increases the resistance of the channel banks to erosion and at times of overbank flow will also cause a considerable reduction of flow velocities across the floodplain surface tending to cause deposition rather than erosion. The floodplain vegetation in an untrenched floodplain should be relatively insensitive to small changes in climate because of the groundwater supply in the alluvium.

The floodplain vegetation, even more than the catchment vegetation, is subject to change as a result of human interference. Since floodplain soils tend to be fertile and are close to a water supply, the vegetation is often reduced by overgrazing or cleared for agricultural use. Floodplain vegetation is also affected by fires and both human intervention and fires may reduce the floodplain vegetation to such an extent that it no longer provides adequate protection against accelerated floodplain erosion. Once channel trenching starts, there is a rapid drop in the groundwater level of the floodplain (Bryan, 1928) leading to further rapid deterioration of the floodplain vegetation.

In studying past or present changes in stream behaviour, catchment and floodplain vegetation should be considered as separate factors as they may react differently to climatic change and human intervention and also affect stream behaviour in different ways. A reduction in catchment vegetation is likely to increase sediment yield and may be expected to cause a trend towards aggradation while a reduction in floodplain vegetation promotes channel and floodplain erosion through increased flow velocities trending towards accelerated channel erosion.

3. Possible Causes of Changes in Stream Behaviour

It is now appropriate to consider possible causes of changes in stream behaviour in relation to the field evidence obtained from the Tea Tree Rivulet. This evidence is mainly erosional and restricted almost entirely to a period from 1946 to the present. It thus consists of photographic records, surveys and personal observations covering a period of less than twenty-five years. A review of the literature presents confusing and conflicting views on possible conditions favouring the development of unstable channels. Much of this confusion appears to be due firstly to failure to distinguish between continuous trenches and discontinuous gullies and secondly to failure to distinguish between the vegetation of the catchment slopes on the one hand and the floodplain vegetation in the immediate area where the unstable channels are developing on the other.

It was pointed out earlier that a stable stream channel upstream of the discontinuous gully system could be used as an indicator of the rate of bedload movement. Schumm (1968, 1969) found that the width/depth ratio of a stable alluvial channel has a significant relationship to the type of sediment load carried. Bedload channels are characterised by high values for the width/depth ratio. The Tea Tree Rivulet upstream from the upper gully has a stable channel characterised by a low width/depth ratio and does not provide a suitable channel morphology for significant bedload transport. We must conclude that very little bedload is being derived from the catchment area at present.

Possible causes for accelerated channel erosion in unconsolidated sediments are sea level change, recent tectonic movements, a catastrophic event or a sequence of such events, human interference and climatic change. The first two causes need not be considered as it is difficult to see how they could produce discontinuous channel incision in a continuous floodplain tract and as well there is no evidence of recent faulting or tilting. Since there is no historical evidence that initiation of the present phase of discontinuous gullying is the result of a catastrophic event only human interference and climatic change will be considered.

(1) *Human Interference.* This factor has to be considered in relation to both catchment and floodplain vegetation. Its assessment is simplified by the fact that interference with the vegetation of the catchment slopes has been minimal. Apart from limited lumbering activities in the 19th century and the clearing of a few small patches of basalt soils on the divide the vegetation is almost undisturbed. There is no evidence of accelerated soil erosion in the basin. This is in agreement with evidence based on channel morphology at the head of the floodplain tract that bedload transport is very small.

On the other hand, human interference with the floodplain vegetation has been drastic. Clay-rich floodplains such as the one associated with the Tea Tree Rivulet under natural conditions support a very dense vegetation dominated by *Leptospermum* spp. Because of its fertile alluvial soils and the absence of large trees the floodplain was cleared early in the history of settlement. This would have caused increased erodibility of the floodplain and channel banks as well as increased flow velocities close to the floodplain surface at times of overbank flow. It seems very likely that discontinuous gullying began following floodplain clearing in the first half of the 19th century although there is no historical evidence to support this view.

(2) *Climatic Change.* We can make some use of climatic records although it must be pointed out that such records do not go back to the time when discontinuous gullying started. Daily rainfall records have been kept since 1909 at the 'Brockley' homestead located near the confluence of the Tea Tree Rivulet and the Prosser but data are available only from 1915 onwards. They have been analysed for the period 1915-67 using the method first applied by Leopold (1951). The daily rains for each year were grouped into three size classes: 1-49 points, 50-99 points and equal to or greater than 100 points. In figure 5 annual frequency values for each size class are plotted against time in the form of five-year moving averages. For comparison five-year moving averages of annual rainfall are shown on the same graph. Of considerable interest is the marked upward trend of small daily rains over the whole of the period. No such trends are evident in the case of the larger rains or when annual rainfall is examined.

The likely effects of increasing frequencies of small daily rains on the vegetation will be considered only for the catchment vegetation since the floodplain vegetation has been so strongly affected by human interference that the effects of climatic trends are likely to be insignificant by comparison. Leopold (1951) has pointed out that a decrease in the frequency of small rains would adversely affect the vegetation cover and reduce its protective role. Conversely, an increase in small rain frequencies would strengthen the vegetation cover and increase its protective function. The trend towards an increasing frequency of small daily rains in the Tea Tree Valley over the period 1915-67 is likely to have strengthened the vegetation in the absence of significant human interference and this in turn must have reduced the sediment yields. This may well have favoured the further development of discontinuous gullying over the same period. Since records from 'Brockley' are available only from 1915, and discontinuous gullies started to develop before 1874, one cannot say that increasing frequencies of small rains were a factor in initiating their development.

An attempt was made to extend back in time the frequency curve for small rains at 'Brockley' by comparing it with a similar curve for the Hobart station where a much longer record is available. However, when curves for the two stations are compared over the period 1915-67 the Hobart record shows a marked trend in the opposite direction towards decreasing small rainfall frequencies although minor fluctuations at both stations appear to be in phase. This is surprising as the two stations are less than 40 miles apart and their annual rainfall totals are very similar but it is obvious that the Hobart record does not provide a suitable basis for extending the 'Brockley' rainfall frequency curves.

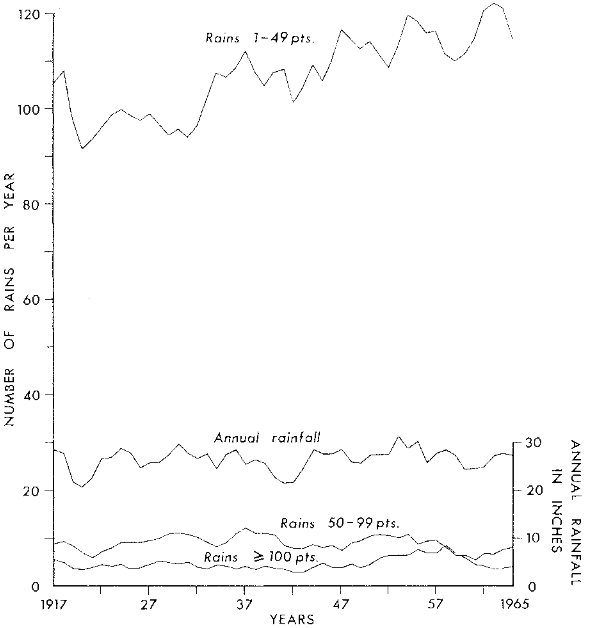

FIG. 5.—Frequency of daily rains at 'Brockley' plotted in three size classes as five-year moving averages against time. For comparison five-year moving averages for annual rainfall are also presented.

Another observation to be made from figure 5 is that the period 1947-67 is marked by above average values for annual rainfall as well as medium and large daily rains no doubt resulting in a high frequency of large discharges. This period represents the time interval between the two sets of vertical aerial photography which show such marked extension of gullying over the period. Field observation confirms that rapid headcut migration coincides with periods of flood discharge.

ACKNOWLEDGMENTS

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REFERENCES

ANTEVS, E. V., 1952.—Arroyo cutting and filling. *J. Geol.*, **60**, 375-385.

BRYAN, K., 1928.—Change in plant associations by change in groundwater level. *Ecology*, **9**, 474-478.

DAVIES, J. L., 1967.—Tasmanian Landforms and Quaternary Climates *in* JENNINGS, J. N. and MABBUTT, J. A. (Eds.). *Landform Studies in Australia and New Guinea*, ANU Press, 1-25.

GOEDE, A., 1965.—Geomorphology of the Buckland Basin, Tasmania. *Pap. Proc. R. Soc. Tasm.*, **99**, 133-154.

LANGBEIN, W. B. and SCHUMM, S. A., 1958.—Yield of sediment in relation to mean annual precipitation. *Trans. Am. geophys. Union*, **39** (6), 1076-1084.

LEOPOLD, L. B., 1951.—Rainfall frequency: an aspect of climatic variation. *Trans. Am. geophys. Union,* **32** (3), 347-357.

MELTON, F. A., 1936.—An empirical classification of floodplain streams. *Geogrl. Rev.,* **26**, 593-609.

MUSGRAVE, G. W., 1947.—The quantitative evaluation of water erosion—a first approximation. *J. Soil Wat. Conserv.,* **2**, 133-138.

SCHUMM, S. A., 1960.—The shape of alluvial channels in relation to sediment type. *Prof. Pap. U.S. geol. Surv.,* **352-B**, 30 pp.

—————, 1968.—River adustment to altered hydrologic regimen—Murrumbidgee River and Paleochannels, Australia. *Prof. Pap. U.S. geol. Surv.,* **598**, 65 pp.

—————, 1969.—River metamorphosis. *J. Hydraul, Div. Am. Soc. Civ. Engrs.,* **95**, 255-273.

PLATE I

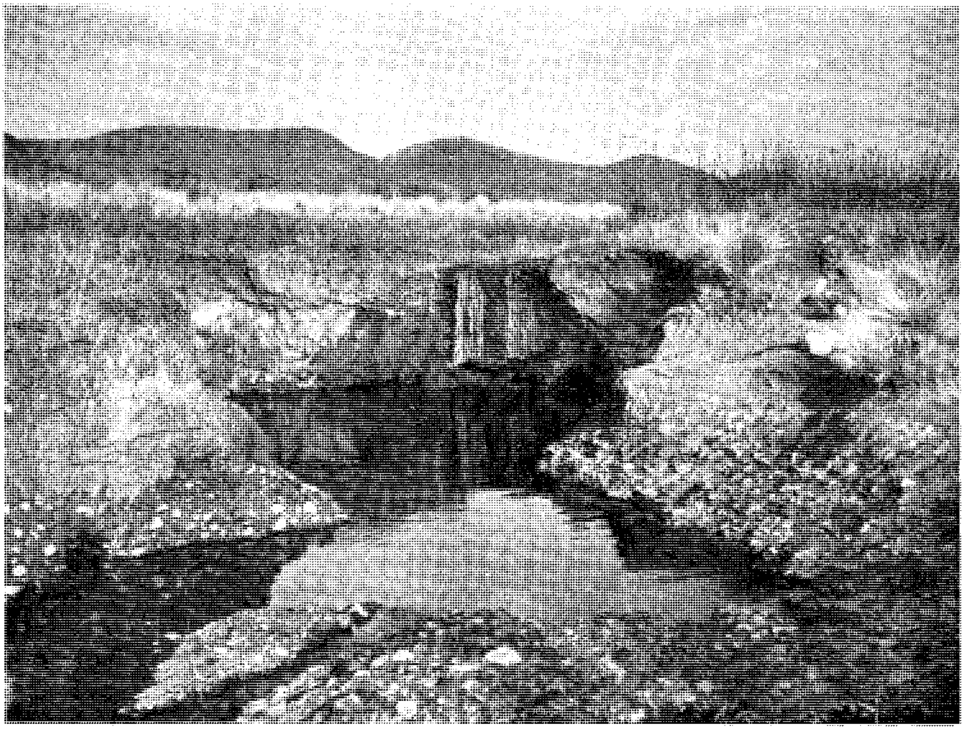

FIG. 1.—Eastern lobe of headcut of lower gully as it appeared in 1967.

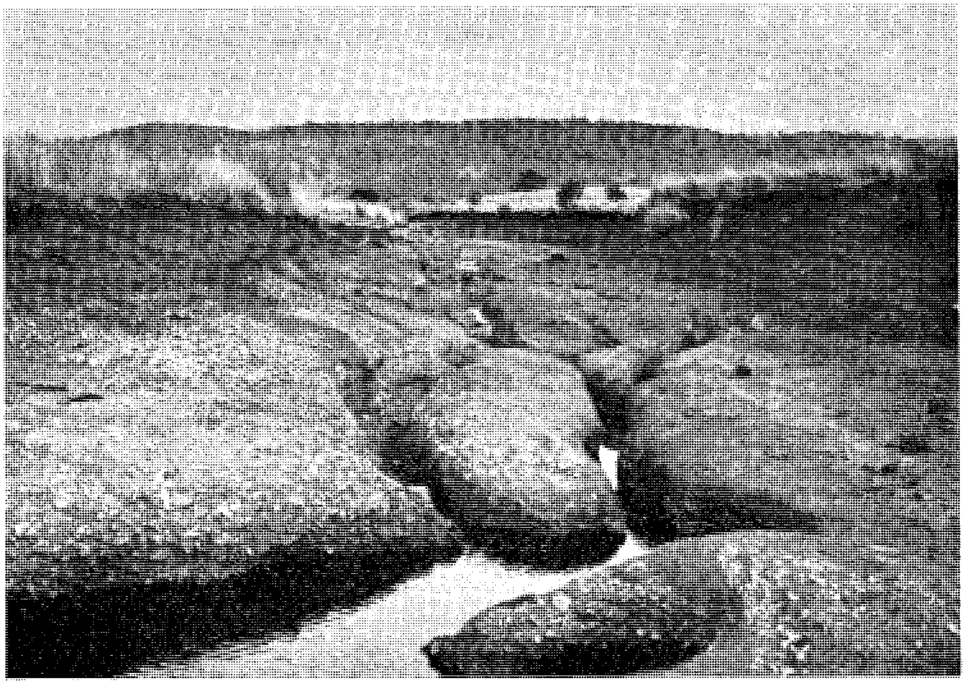

FIG. 2.—Erosional section of lower gully with an anastomosing pattern of low water channels cut into the bed.

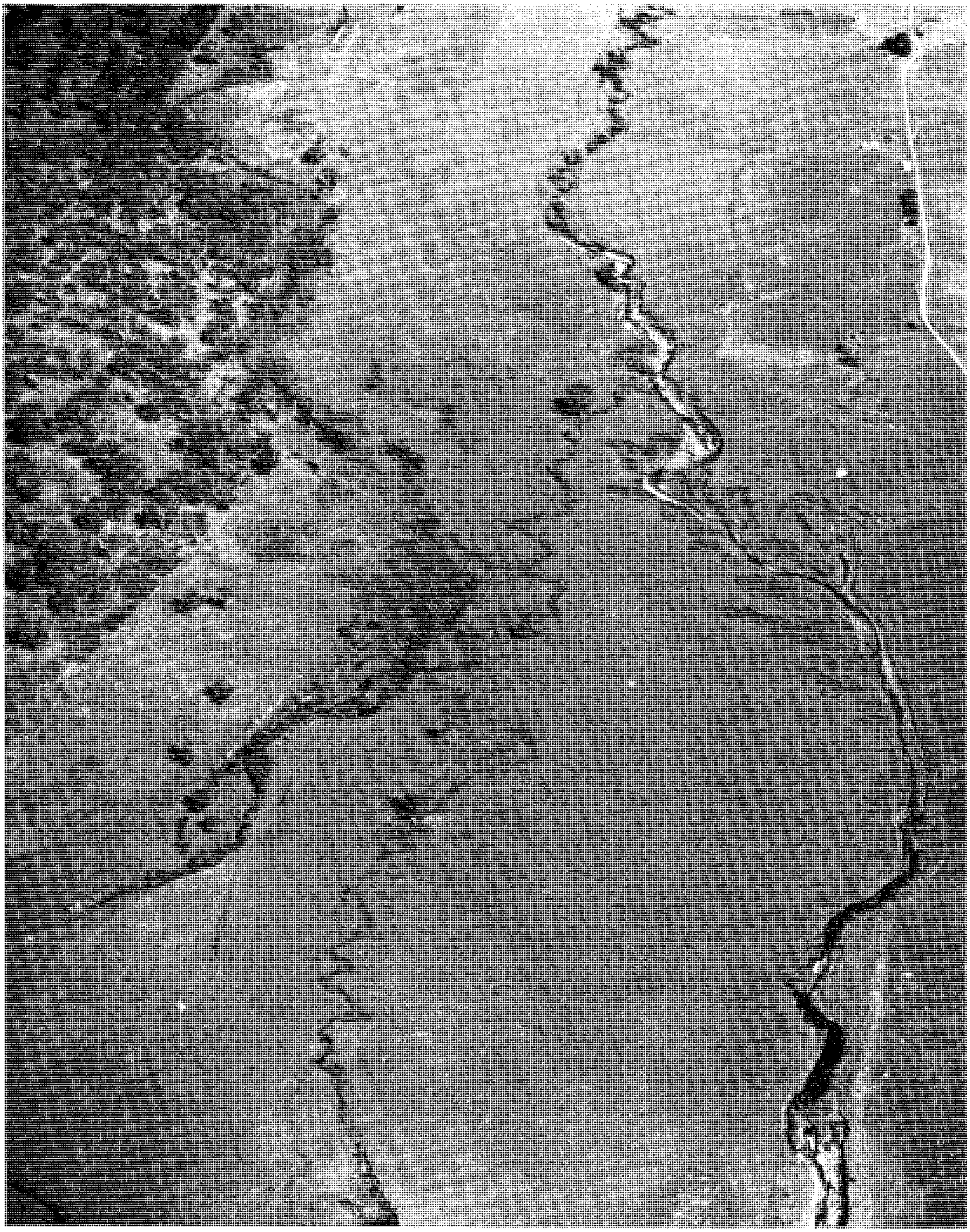

PLATE II.—Oblique aerial view of upper part of floodplain tract of Tea Tree Rivulet showing nature and extent of gullying.

[Photo: Vern Reid