REJUVENATION FEATURES IN THE CADNAM RIVER BASIN IN THE NEW FOREST

By C. G. Tuckfield

Abstract

Severe erosion now affecting many streams in the upper basin of the Cadnam River is caused by a cycle of rejuvenation which apparently post-dates the capture of that river by the River Blackwater at the 75 feet (22 m) stage. Knick points, terraces and floodplain resulting from this rejuvenation are mapped. Measurements of the channel on two first-order tributaries over the 3-year period 1969–72 suggest that the pulse of erosion is migrating headward at approximately 2 m per year. 2.24 m^3 of material per metre of channel were eroded during the 3-year period.

Introduction

The streams of the New Forest may be divided into four groups: I, those flowing south-westward to the River Avon; II, those flowing north-eastward to the River Blackwater; III, those flowing eastward to Southampton Water; IV, those flowing south-eastward to the Solent. The watersheds separating these four groups are drawn in Fig. 1.

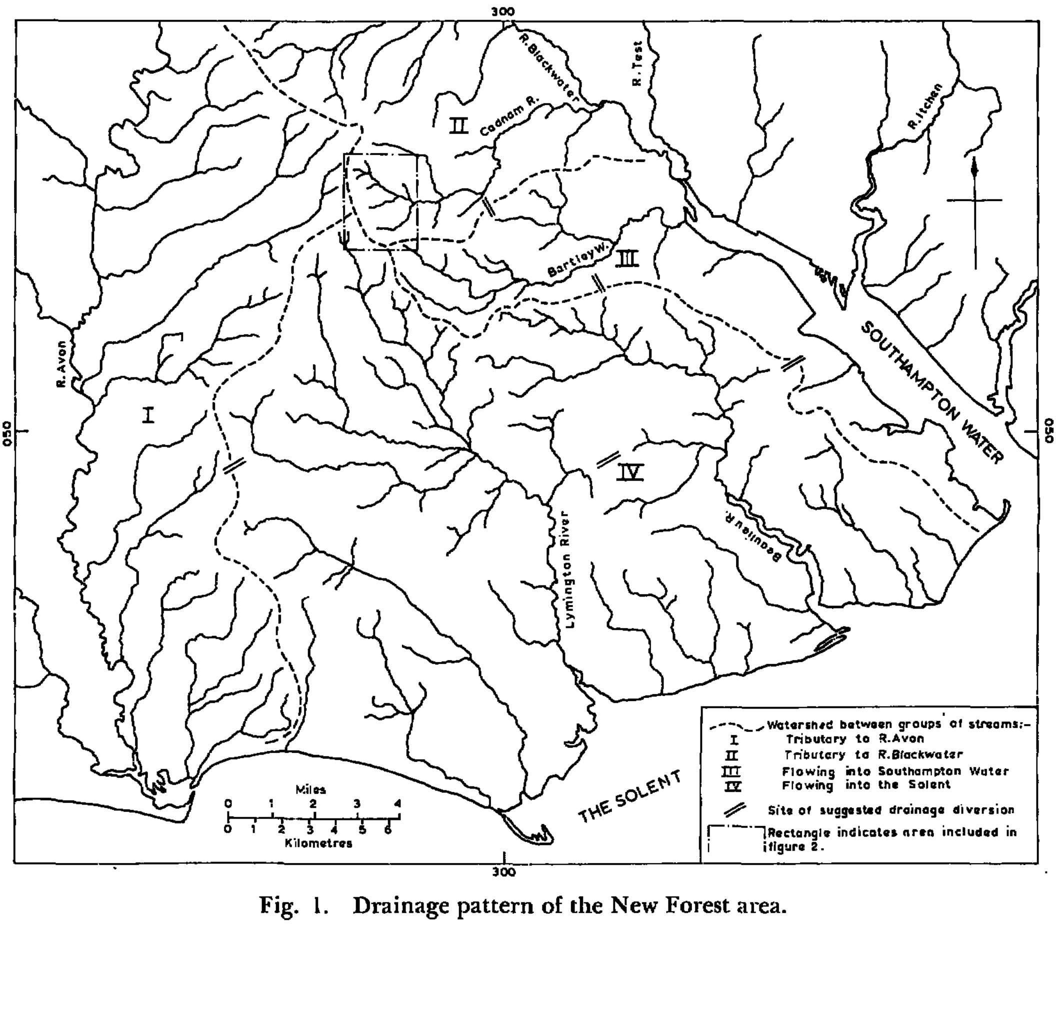

Fig. 1. Drainage pattern of the New Forest area.

But in geological terms the present drainage pattern is quite recent and is the result of many changes which have taken place during the Pleistocene period. As the sea level fell in Southern England and the coastline of southwest Hampshire moved progressively southward, the River Avon maintained its general position and direction, deepening and lengthening its valley as the coastline receded to the south. The main watershed in the west of the Forest has also remained a fairly stable feature, with the southwestward-flowing streams generally maintaining a constant direction of flow, but also slowly gaining in length and deepening their valleys in response to the lowering of the main Avon valley. Everard (1957) gives only one instance of piracy across this watershed when, between the 185 ft (56 m) and 150 ft (46 m) stages, the present Lymington River captured its Ridley and Harvest Slade tributaries from an earlier Bagnum Brook.

By contrast, the north and east of the New Forest appear to have had a much more complicated denudational history, and there the present drainage pattern is the result of a series of river captures extending throughout the greater part of the Pleistocene period and occurring particularly between the 185 ft (56 m) and 35 ft (11 m) stages, by which time Tremlett (1964) suggests the present drainage pattern was broadly established. Perhaps the major change, and one which has had a pronounced effect upon the present fluvial erosion pattern, is that an earlier eastward-flowing drainage system across the central Forest has been replaced by the present mainly southward-flowing one. Tremlett contends that during the 100 ft (30 m) and 75 ft (22 m) stages, the greater part of the present Bartley Water, the Beaulieu River north of, and including, the present Shepton Water (SU 370045), and the Lymington River north of the present Etherise Gutter (SU 324033), formed part of a river system which drained eastward to join the Southampton Water inlet in the vicinity of Applemore Hill (SU 400072). It was not until the 35 ft (11 m) stage that the streams now forming the lower reaches of the Lymington and Beaulieu Rivers had cut back through the extensive 150 ft (46 m) gravels to establish the present south-flowing system.

An early exception to this trend, according to Everard, was when the headwaters of the Cadnam River, which up to the 100 ft (30 m) stage flowed eastward to the present Bartley Water, were, by the 75 ft (22 m) stage, captured by a north-flowing tributary of the River Blackwater, the angle of capture being in the vicinity of Cadnam Roundabout (SU 294137). Another exception is that Bartley Water has gained its most southerly tributaries west of Bucketts Inclosure (SU 330100) at the expense of the present Beaulieu River, but whereas Everard considers that this change had taken place by the 100 ft (30 m) stage, Tremlett postpones the capture until late in the 35 ft (11 m) stage.

From this brief outline of the chronological development of the drainage system, at least four points emerge:

(1) In the south of the Forest, the overall picture is likely to be one of fluvial deposition resulting from the post-glacial rise in sea level.

(2) Across the centre of the Forest is a belt in which the drainage pattern has been drastically modified and where many streams have undergone a reversal in the direction of flow within comparatively recent geological times. This has resulted in areas of indeterminate drainage and, in some places, in considerable deposition in stream reaches.

(3) In the north, at least one drainage diversion appears to have produced increased river erosion.

(4) It is certain that over much of the Forest the drainage pattern must be looked upon as a relict feature which developed under physiographic and climatic conditions very different from those operating at present.

Rejuvenation of the King's Garn Gutter branch of the Cadnam River

Of the sequence of drainage pattern changes briefly described above, based on the work of Everard and Tremlett, the first to occur was apparently the capture of the headwaters of an earlier Bartley Water by the present Cadnam River. Many of the streams tributary to the

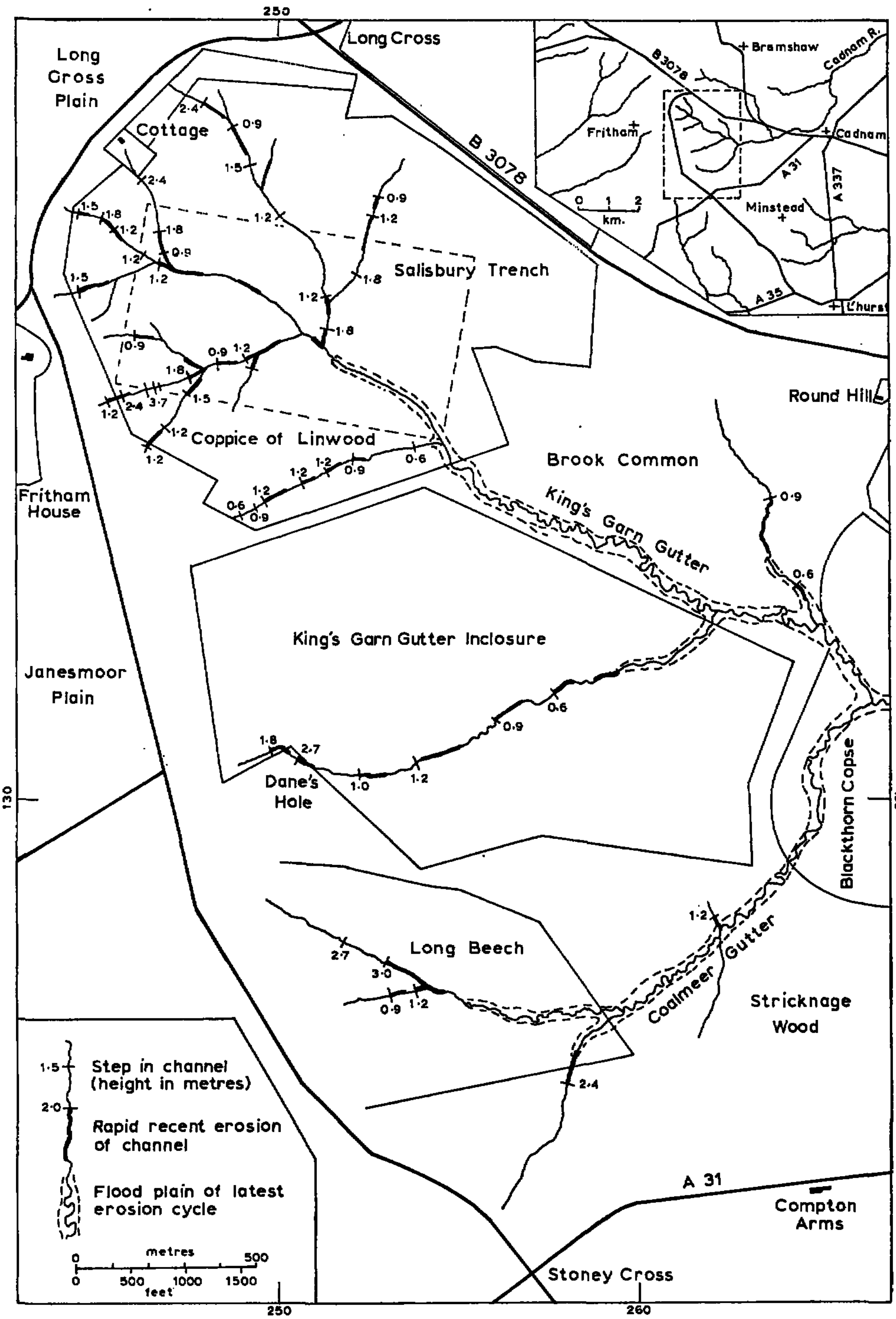

Fig. 2. King's Garn Gutter and Coalmeer Gutter, showing effects of the most recent erosion cycle. The broken-lined rectangle indicates the area included in Fig. 3.

Cadnam River in the north of the New Forest appear to be undergoing a phase of rejuvenation. Almost every first-order tributary of the King's Garn Gutter branch of this river has one or more reaches where rapid erosion is currently occurring, and, downstream of the lowest of these eroding reaches, a new flood plain has developed which is bordered by terraces or terrace remnants. The resultant pattern of erosion is shown in Fig. 2. It can be seen that a similar pattern is common to other tributaries in this part of the Cadnam River basin. The tributaries farther north have not been inspected because many of them flow over private land, but at least the lower part of Shepherd's Gutter (SU 274141) appears to show similar rejuvenation features.

The flood plain of this latest cycle of erosion, indicated in Fig. 2, can be traced continuously from Coppice of Linwood, across Brook Common, through Canterton, to the vicinity of Cadnam Roundabout (SU 293136) where, according to Everard (1957), the capture took place. The new flood plain, here about 100 m wide, and the adjacent terraces, continue down-river to the confluence with the River Blackwater. If Everard's suggested date of the capture is accepted, the new cycle of erosion upstream of Cadnam must presumably date from the 75 ft (22 m) stage at the earliest, which provides an upper limit for the time it has taken the erosion to migrate headward to its present position. As this part of the Cadnam River basin appears to be the area experiencing the most rapid fluvial erosion in the New Forest, it was decided to attempt to obtain some measurements of the present rate of erosion.

Erosion by tributaries of Three Waters Gutter

Measurements were taken on a tributary of Three Waters Gutter in Coppice of Linwood Inclosure, shown in a tracing based on the O.S. 1:2500 maps (Fig. 3). It appears on the Ordnance Survey map as a first-order tributary, but it is found in the field to be a second-order reach fed by three first-order tributaries which have their confluence at SU 247145 in the extreme west of the area shown in Fig. 3. The location of maximum erosion at present on this tributary is in the vicinity of this confluence and it was here that the series of measurements was taken. The limit of rapid erosion, that is the knick point of the latest erosion cycle on this particular tributary, is marked by a series of steps in the channel, some more than a metre in height, which are migrating upstream on each of the feeder tributaries just upstream of the confluence.

At the confluence the stream is deeply incised into a small flood plain of an earlier erosion cycle, and downstream of this point the present deepened channel is bordered by a series of terrace remnants on either side of the stream (Fig. 3). Considerable deposition in the bed of the stream begins about 400 m downstream from the present knick point (marked A in Fig. 3) and the flood plain of the present cycle, sufficiently consolidated to support permanent vegetation, can be recognised about 200 m farther downstream (point B in Fig. 3). The flood plain widens fairly rapidly at first in the downstream direction and 150 m below point B is almost 50 m wide and is supporting oak and beech trees probably over 200 years old.

In June 1969, cross-profiles of the stream channel of the second-order tributary (marked C in Fig. 3) and its two first-order feeder tributaries (D and E) were measured at 10 ft intervals along their lengths, starting at the footbridge (F) and continuing upstream to the limit of rapid erosion, which at that time was approximately 50 m upstream from the footbridge on both tributaries. The channel cross-profiles were remeasured at the same points in June 1970, and again in May 1972. From the measurements the cross-profiles shown in Fig. 4 were drawn and changes in the cross-sectional area of the channel at each point during the two periods June 1969–June 1970 and June 1970–May 1972 were calculated. Pegs were removed by the public from some of the lower sites but data for the three years were obtained for most of the profiles on both tributaries upstream from the 70 ft site (marked (d) in Fig. 4).

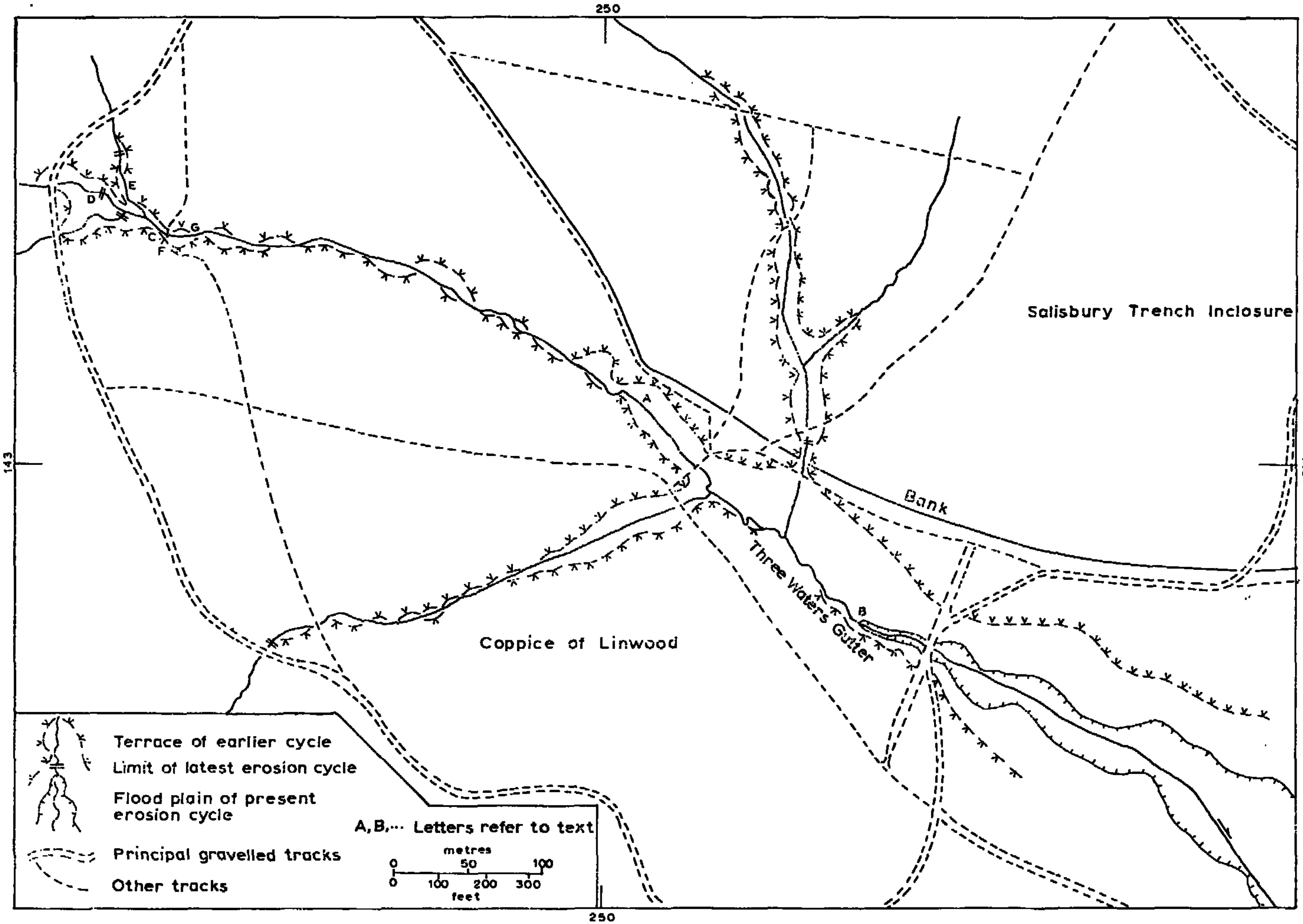

Fig. 3. River terraces and recent flood plain of Three Waters Gutter. For location see Fig. 2.

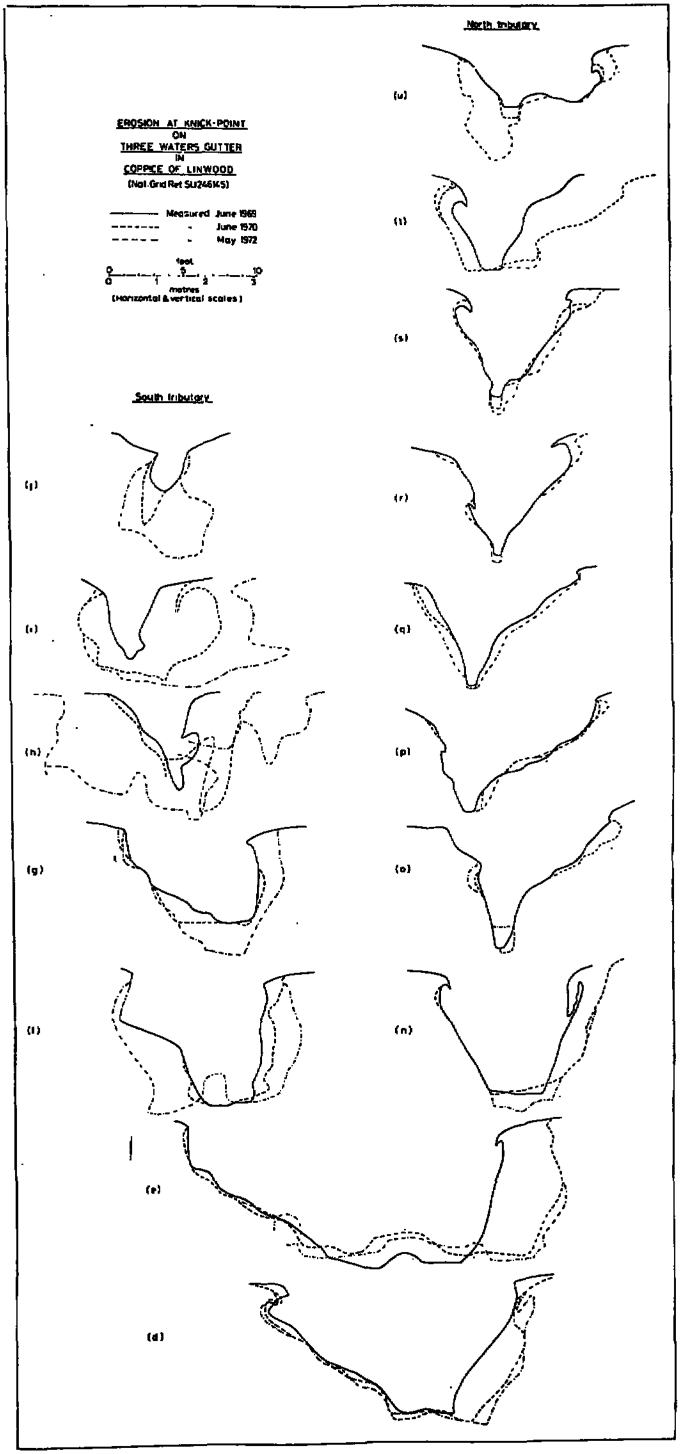

Fig.4. Channel cross-profiles of Three Waters Gutter and two of its first-order tributaries, showing fluvial erosion during the 3-year period 1969–72.

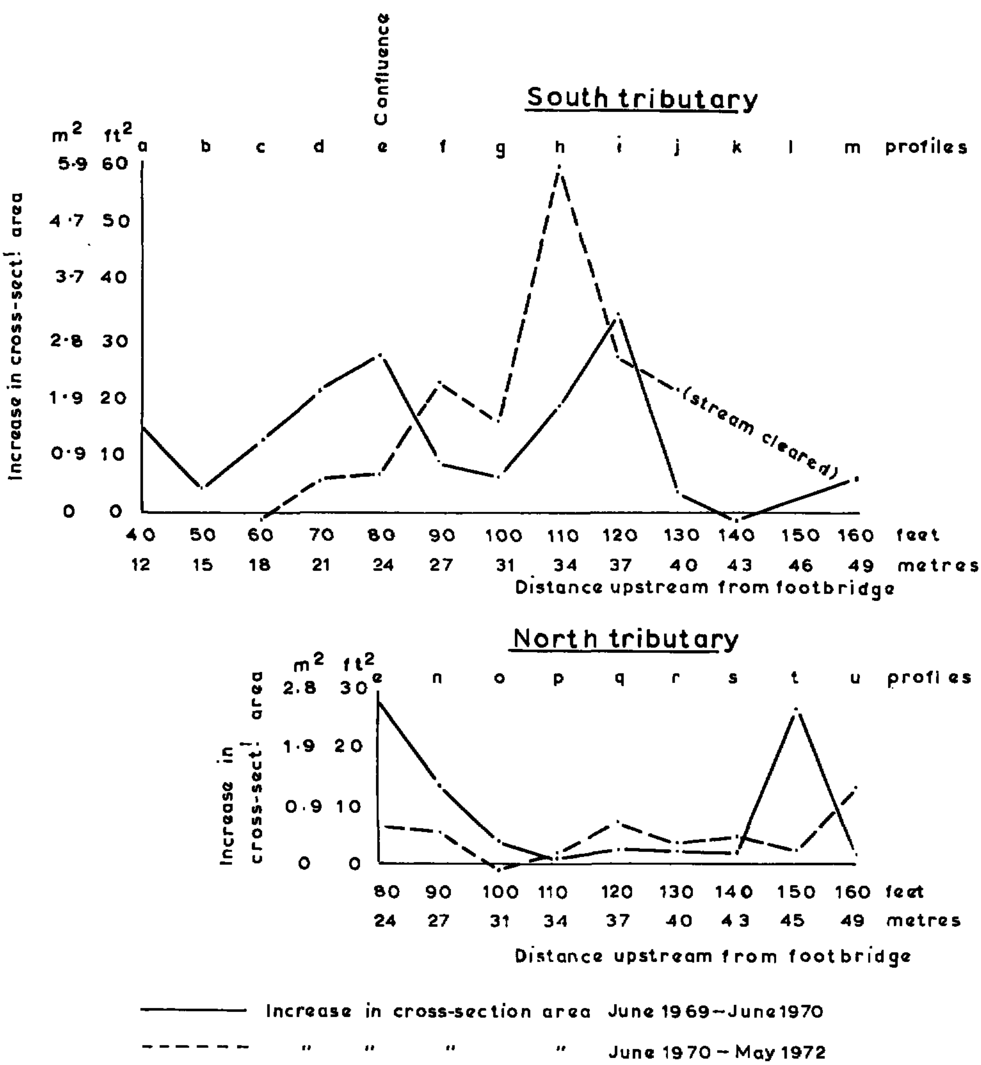

Fig. 5. Changes in cross-sectional area of the channel profiles shown in Fig. 4 during the 3-year period.

The cross-sectional area of the channel in June 1969 and changes in cross-sectional area during the two periods, 1969–70 and 1970–2, for each site were collated. From this data the graphs in Fig. 5 have been drawn. Distance along the channel is plotted on the horizontal axis and the change in cross-sectional area of the channel during each of the two periods is plotted on the vertical axis. The areas included between the lines joining the two sets of coordinates and the horizontal axis thus represent the volume of material removed from the channel by erosion during the two respective periods. These volumes have been computed for each 10 ft section of the channel (i.e. between each pair of consecutive cross-profiles) and the results are shown in Table 1.

TABLE 1. Volume of material eroded from the channel of Three Waters Gutter in Coppice of Linwood (S.U. 246145) between June 1969 and May 1972.

		Volume of material eroded from the channel of Three Waters Gutter												
		Below confluence				South Tributary								Totals
	a	b	c	d	e	f	g	h	i	j	k	l	m	
	ft³	90	83	168	240	177	71	123	261	184	11	6	39	1453
June 1969–June 1970	m³	2.55	2.35	4.75	6.79	5.01	2.01	3.48	7.39	5.21	0.31	0.17	1.10	41.12
	ft³	pegs removed		21	57	140	184	372	431	240	Channel cleaned			1445
June 1970–May 1972	m³	-	-	0.59	1.61	3.96	5.21	10.53	12.20	6.79	-	-	-	40.89
								North Tributary						
						n	o	p	q	r	s	t	u	
	ft³					202	85	20	13	20	18	140	137	635
June 1969–June 1970	m³					5.72	2.41	0.57	0.37	0.57	0.51	3.96	3.88	17.99
	ft³					57	21	1	41	53	40	32	74	319
June 1970–May 1972	m³					1.61	0.59	0.03	1.16	1.50	1.13	0.91	2.09	9.02

From the graphs (*Fig.* 5) and the data in Table 1, the following observations may be made:

(1) From Profile (a) to Profile (e), which is immediately below the confluence, the cross-sectional area of the channel gradually increases in the upstream direction; it reaches its maximum at the confluence, and thereafter decreases generally but irregularly upstream along both tributaries.

(2) Erosion was relatively less in total volume during the 2-year period June 1970–May 1972 than it had been during the one year June 1969–June 1970. The data in Table 2, extracted from Table I, refers to only those portions of the stream for which measurements are available for both periods.

TABLE 2. Volume of material eroded from sections of measured channel.

Portion of stream	Vol. of material removed (m³) 1969–70	1970–2	Total
Second-order stream, profiles (c) to (e)	11.54	2.20	13.74
South tributary, profiles (e) to (j)	23.10	38.69	61.79
North tributary, profiles (e) to (u)	17.99	9.02	27.01
	52.63	49.91	102.54
Rainfall recorded at Southampton Stn. during the relevant period	745 mm	1491 mm	

The total rainfall during the 2-year period is almost exactly double that for the single year, so the relative decrease in erosion during the period 1970–2 cannot be explained in terms of total rainfall. Neither is it related to the number of 'wet' days (i.e. days with 1 mm of rainfall or more), for the number for the 2-year period 1970–2 is 217 days against 110 days for the 1-year period 1969–70.

(3) It can be seen from the data in Table 2 that the greatest decrease in the volume eroded during the second period compared with the first is in the portion of the stream below the confluence, indicating that during the 3 years the location of maximum erosion migrated upstream. During the year 1969–70, a great deal of erosion was still occurring below the confluence but, as can be seen from the profiles (d) and (e) in Fig. 4, by 1970 this had almost ceased; in fact during 1970–2 profile (c) actually showed a decrease in cross-sectional area due to deposition.

If profiles (f) to (j) in the south tributary are studied, it is seen that erosion was already considerable up to profile (i) during the period 1969–70. During the period 1970–2 the rate of erosion was maintained, while the volume of material removed from the section (f) to (i) more than doubled (28 m^3 against 13 m^3), indicating a slight acceleration in the rate of erosion in this section, the highest increase of all being between (g) and (h).

Meanwhile in the north tributary it would seem that the location of maximum erosion had proceeded rather more quickly upstream. In the year 1969–70 the greatest increase in channel cross-sectional area was at profile (t), but in the period 1970–2 it had migrated upstream to profile (u) and the rate of erosion had decreased at all points farther downstream (see Fig. 5).

Conclusion

There seems little doubt that the cycle of erosion now affecting the upper reaches of the Cadnam River postdates the diversion to the River Blackwater which Everard dated to the 75 ft (22 m) stage. The cause of the rejuvenation has not been investigated, but it was probably initiated by one of the periodic falls in sea level during the latter part of the Pleistocene period.

The measurements taken on the Three Waters Gutter tributary of the Cadnam River show that the location of maximum erosion moved some metres upstream during the 3-year period 1969–72. While it would be unwise to extrapolate from data covering such a short period, it suggests that the pulse of erosion is migrating headward on this stream at between 1 and 2 m per year. There is one longer-term observation which confirms at least the approximate accuracy of this conclusion. The present footbridge (F in Fig. 3) replaced an earlier bridge which was situated about 16 m farther downstream at G. The earlier bridge collapsed in the winter of 1948–9 when the location of maximum erosion on the stream was at that point. It has therefore migrated upstream 50 m in 24 years, an average of about 2 m per year.

A little over 100 cubic metres of material were removed from 45 m of channel at this site between June 1969 and May 1972, which is 0.75 m^3 per metre of channel per year. This rate of erosion was confined to a limited length of channel, but even so it is quite exceptional within the New Forest. In a sample study of fluvial erosion covering all the streams within the New Forest perambulation by the present writer (Tuckfield 1973) the next highest rate recorded was 0.064 m^3 per metre per year by Blackensford Brook (SU 231069), a figure much more in accord with the 0.11 m^3 obtained by H. O. Slaymaker (1972) in the upper drainage basin of the River Wye in mid-Wales. King's Garn Gutter is a small stream, even by British standards, with a discharge of only 0.25 m^3/sec in spate conditions, and these figures perhaps indicate how easy it is to underestimate the amount of erosion which such a comparatively insignificant-looking stream can achieve in present climatic conditions.

References

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