A TROPICAL EXAMPLE OF TOPSOIL ENRICHMENT BY FLOOD SILT

S. G. Reynolds*

ABSTRACT

The sediments deposited during a flash flood estimated to have had a peak discharge of the order of 2000 cusecs are demonstrated to have considerably enriched the topsoil of several acres of productive valley alluvium. The probability that this is a recurring rejuvenation process is discussed.

INTRODUCTION

All rivers transport sediment as bed or suspended load. In times of flood their erosive energy and carrying capacity are greatly increased, resulting in changes in channel profile and the transport of large quantities of sediment (Leopold *et al.* 1964). Considerable damage is often caused by flood water, and by the sediments deposited when river velocity slackens (Stallings, 1957; Bleasdale and Douglas, 1952). However, the deposition of sediments on agricultural land is not necessarily detrimental, and may be beneficial, depending upon the texture and fertility of the sediment and upon the rate of its deposition (Kohnke and Bertrand, 1959). Farmers living on the flood plains of such rivers as the Hwang-Ho, Po and Nile for centuries relied upon the annual silt deposition by flood water to enrich their soils.

The process of soil enrichment by flood silt is by no means limited to the large rivers of the world. This paper considers the small-scale example of a flash flood and its effects on several acres of productive land in Western Samoa.

DESCRIPTION OF THE AREA

Part of the 77-acre area of the South Pacific Regional College of Tropical Agriculture is a steep-sided, flat-bottomed valley in the middle of which is the meandering course of the Papase'ea Stream which flows for only several months of the year, usually towards the end of the wet season. The soils on the valley bottom are the richest of the whole farm area with a deep, well drained profile and a topsoil adequately supplied with most plant nutrients. In places

* South Pacific Regional College of Tropical Agriculture, Alafua, Western Samoa.

the soil becomes rather stony where coarser fragments have been deposited.

The soil profile shows several obvious stages of fluvial deposition of sand and pebbles, with an admixture of soil washed (or resulting from mass movement) from the valley-side slopes. At the time of the flood reported in this paper the major part of the area was down to vegetables, including a large sprinkler irrigation trial. The remainder of the cultivable area was being fallowed, or was under passionfruit.

DETAILS OF THE FLOOD

Following a week of not excessive rainfall (in the dry season) the bed of the stream remained dry. Rainfall totals of 10–19 July were 1.70, 0.00, 0.10, 0.48, 0.04, 0.98, 0.25, 0.99, 0.07 and 0.00 inches respectively. On the night of 17–18 July, following a heavy fall of almost an inch of rain between 1.30 a.m. and 7.15 a.m., the stream began to flow and rose rapidly. The fall of rain registered by the college meteorological station was too small to have accounted for the rapid rate of rise and the maximum height attained by the river. Unfortunately, no rain gauges are located in the upper catchment area of approximately one square mile, but rainfall there must have been greater than 0.99 inches.

The river rose in several hours to an estimated peak discharge of about 2000 cusecs (assessed from depth of flood water indicated by silt and debris, and flow velocity at 7.00 a.m. on 18 July). Overnight the irrigation layout was badly damaged; the electric pump mounted on a 10-cwt concrete base was moved 30 feet and large quantities of debris including 1-cwt logs were deposited 50–60 yards from the main stream course. By 7.00 a.m. on the morning of 18 July, the flood had considerably subsided; discharge was estimated at only 500 cusecs. Within two days the stream had completely dried up again.

RESULTS OF THE FLOOD

Although damage was caused to the irrigation plant and several vegetable trials by the flood, there were benefits which are difficult

TABLE 1 — Chemical analysis of topsoil and flood sediments.

		Topsoil	*Flood sediments*
pH		6.20	6.28
Percentage organic C		2.89	11.96
Percentage total N		0.36	0.76
Ratio C/N		8.1	15.8
Percentage 1% citric soluble P_2O_5		0.1300	0.1550
Exchangeable cations (m.e./100 g):			
	K	0.69	1.18
	Mg	10.73	20.23
	Na	0.34	0.56
	Ca	16.84	27.91
Cation exchange capacity		28.20	56.10
Total exchangeable bases (by addition)		28.60	49.88
Percentage base saturation		100	89

to express in monetary terms. As the flood subsided on the morning of 18 July, it was noted that a thin layer of fresh river silt had been deposited over much of the valley bottom. In small local depressions this was 4–5 cm deep. As this layer dried out it developed the polygonal cracks typical of material with a high clay-silt content.

Representative samples were taken from the fresh sediments and from the topsoil, and a detailed chemical analysis of both carried out. Details of the test methods are described by Reynolds (1970). The results of the analyses are set out in Table 1. The flood sediment is demonstrated to be much richer than the topsoil. In particular it has a higher level of organic carbon and total nitrogen — in fact, some of the sediments had a thin black skin of organic matter on drying out. The individual exchangeable cations and cation-exchange capacity are twice as high in the flood sediment as in the topsoil. These richer sediments were deposited over much of the area occupied by the various vegetable trials.

DISCUSSION

As deposition by streams is very varied, it was fortunate that little of the coarse bed load reached the college area, only the richer sediments being deposited. It is well established that soil removed by erosive processes is usually much richer than the soil remaining (Stallings, 1957; Walker and Wadleigh, 1968), because organic carbon and clay particles are usually washed away leaving the coarser particles behind. Also, plant nutrients like nitrogen, phosphorus, potassium, magnesium and calcium are removed. The fresh river sediments deposited by the Papase'ea Stream have been shown to be more fertile than the topsoil of the valley alluvium, which itself is much richer than nearby sedentary soils.

Although the soil profile shows obvious sand-pebble and some clay deposition stages, evidence of recent periodic clay-silt depositions does not stand out. This is possibly because of the thinness of the individual layers, which could have been broken up by subsequent ploughing. Local evidence suggests that the stream periodically floods this area, therefore it is probable that the process of topsoil enrichment described above is a regularly recurring feature which from time to time enriches and rejuvenates the valley topsoil. Thus the fertility of the valley alluvium is maintained, whereas most of the farm soils are undergoing steady impoverishment through leaching and other processes.

This beneficial process would probably continue as long as there are no climatic or major land-use changes in the catchment area. However, tentative plans to straighten the stream course to make more land available for cultivation could reduce the risk of future floods and bring an end to the deposition of river sediments.

CONCLUSIONS

Although some damage was caused by the flood, river sedimentation was in this case beneficial, because the rich sediments were deposited in thin layers which could easily be incorporated into the topsoil by ploughing.

ACKNOWLEDGMENTS

I am indebted to Mr M. Mata'afa and Mr L. Isaako who assisted with the sediment collection and the chemical analyses of the samples.

REFERENCES

Bleasdale, A.; Douglas, C. K. M. 1952: The storm over Exmoor on 15th August, 1952. *Met. Mag. 81.*

Kohnke, H.; Bertrand, A. R. 1959: *Soil conservation.* New York, McGraw-Hill.

Leopold, L. B.; Wolman, M. G.; Miller, J. P. 1964: *Fluvial processes in geomorphology.* San Francisco, Freeman.

Reynolds, S. G. 1970: *A manual of introductory soil science and simple soil analysis methods.* South Pacific Regional College of Tropical Agriculture Monograph Series, 1.

Stallings, J. H. 1957: *Soil conservation.* Englewood Cliffs, Prentice-Hall.

Walker, K. C.; Wadleigh, C. H. 1968: Water pollution from land runoff. *Plant Food Review 14* (1) : 2–4.