SEDIMENT LOADS IN REELFOOT CREEK WATERSHED, TENNESSEE

Hsiang-te Kung and Jerry Garrett
Department of Geography and Planning
Memphis State University

INTRODUCTION

Reelfoot Lake in Northwestern Tennessee is rapidly filling with sediments mainly supplied from its largest drainage basin–Reelfoot Creek watershed. If measures are not taken to reduce the erosion and sedimentation problems of the soil in the basin, the lake will become a marsh or swamp within fifty years, and Tennessee will have lost one of its most important wildlife habitat and recreational areas. Alternatives for ameliorating the problem have been proposed and most of them have focused on the short-term solution itself, but few of them have looked closely at its causes. An alternative supported by a member of the Reelfoot legislative task force consists of manipulating the lake's water levels to kill aquatic vegetation. Other efforts to deal with the erosion and sedimentation problems have focused on storing sediment after it has already been eroded. Methods for sediment storage consist of construction of sedimentation ponds and dams on bottom land or upland respectively.(1)

Some of the alternatives are incorporated into the Reelfoot Lake Commission Rural Clean Water Project (RL/RCW) and Resource Management System(RMS) to reduce the amount of soil erosion and sedimentation into the lake. (2) Extensive research efforts have concentrated on lake water quality and have found that the lake's water is characterized by relatively high concentrations of nutrients and phytoplankton and low secchi disc visibility. The lake was thus determined to be in an overly rich state of production (eutrophication). (1, 3)

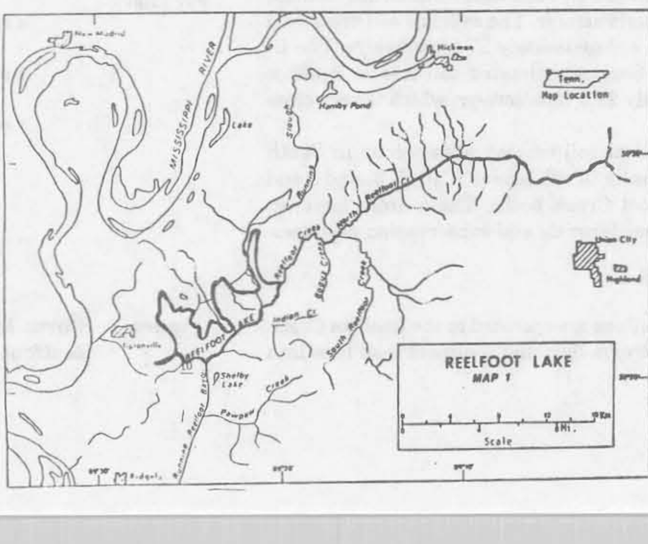
Although sediment loading has been identified as Reelfoot Lake's major problem, a detailed examination is needed to understand the ratio between the amount of soil loss from the critical erosion areas and the amount of sediments actually transported to the streams and lake.

Because of the detrimental effects of sediments on water quality, there is considerable interest in determining the primary sediment sources and percentage of soil loss transported sediments in streams and lakes. The purpose of this study is (1) to calculate the annual soil loss (in tons) from critical erosion areas by subwatersheds in the Reelfoot Creek Basin watershed; and (2) to sample and analyze the stream water sediment load (total suspended solid load). From this ratio (sediment delivery ratio) or percentage between stream sediments and soil erosions can be determined.

STUDY AREA

The Reelfoot Lake drainage basin consists of 153,600 acres in northwestern Tennessee and southwestern Kentucky; it includes 100,000 acres in Obion County, Tennessee, 15,000 acres in Lake County, Tennessee, and 38,000 acres in Fulton County, Kentucky. The lake, located along the eastern edge of the Mississippi River floodplain, had an original surface area of 40,000 acres, but it has been reduced to about 13,000. (3) Its original depth averaged more than 40 feet; today, the average depth is less than 5 feet. Reelfoot Creek drains into Reelfoot Lake from the northeast and is the largest in discharge volume, sediments, and basin size among all the creeks (Running Slough from north and Indian Creek from southeast) flowing into the lake. The creek and its tributaries contribute approximately 40% of the total sediment load of streams and soil loss from critical erosion areas. The creek has two major tributaries, namely, North Reelfoot Creek from northeast and South Reelfoot Creek from south. (Figure 1) Other reasons for selecting the Reelfoot Creek basin as intensive study area are that 1) relatively more water quality data are available from the U. S. Geological Survey Water Resources Division on this drainage basin than the other basins draining into the lake and 2) the easy accessibility of this area allows intensive field work and data collection. Basic information and data such as topographic maps and soil maps are readily available for studying the watershed's physical characteristics and their relationships to erosion and water quality problems.

Figure 1



DATA SOURCES, METHODS AND PROCEDURES

Topographic maps, aerial photographs, and county soil surveys will be used as the primary data sources for studying the watershed characteristics. The U. S. Geological Survey topographic maps of 1:24,000 scale are used to define the stream network (intermittent and perennial streams) and the watershed and subwatersheds of Reelfoot Creek basin. These topographic maps are also used as base maps for transferring information of identified critical erosion areas. The critical erosion areas can be identified through interpretation of the aerial photographs (remote sensing techniques) and can be checked and updated in the field. The erosion potentials (tons/acre) of the study area will be interpreted and calculated by using the Universal Soil Loss Equation (USLE). (4)

A=RKLSCP

Where:

A - Annual Soil losses in tons/acre/year

R - Rainfall intensity factor, (assume to be 260);

K - Soil erodability factor (obtain from soil interpretation);

LS - Length and Slope factor, (assume a slope length of 100 feet and an average slope for each soil mapping unit); and

CP - Cropping and conservation practice factor, (a value of 1.0 is used for the critical erosion areas which assumes no cropping [bare] and no conservation practices [worst management]).

The U. S. G. S. Water Resources Division in March 1984 entered into an agreement with the Tennessee Department of Health and Environment, Division of Water Management to monitor the stream flow and suspended sediment loads flowing into Reelfoot Lake. Actual data collection by U. S. G. S. began on April 3, 1984 at North Reelfoot Creek and Running Slough. Stream flow records were started on May 3 at South Reelfoot Creek. Stream flow and suspended sediment data collection have been completed for one full year, 1984-1985, for North Reelfoot Creek, South Reelfoot Creek, and Running Slough. Data for stream discharge, total suspended sediment loads, and soil losses will be analyzed, and the sediment delivery ratio from total soil loss will be estimated to compare with the Obion-Forked Deer River basin in West Tennessee.

ANALYSIS OF RESULTS

Soil Erosion Estimates

Gross erosion in the Obion-Forked Deer River basin which drains approximately one half on west Tennessee is estimated to be 15,900 tons/mi²/yr (24.8 tons/acre/yr). (5) Suspended sediment yields on the Obion River at Obion is estimated to be 720 tons/mi²/yr (1.12 tons/acre/yr). Hence, the ratio between the suspended sediments and gross soil erosion in Obion Forked Deer River basin is approximately 4.5%.

For the Reelfoot Creek Watershed, 400 systematic random points were used throughout the basin to calculate the total amount of soil loss. (Table 1) A total of 1,608,960 tons/yr of soil erosion has been estimated to have occurred in Reelfoot Creek Basin. North Reelfoot Creek basin averaged 17.7 tons/acre/yr soil loss, while South Reelfoot Creek Basin averaged 36.3 tons/acre/yr. The average soil erosion in the basin is estimated to be approximately 27 tons/acre/yr. The U. S. D. A. Soil Conservation Service estimated soil loss in Reelfoot Creek Basin at approximately 27.5 tons/acre/yr, which is very close to our estimates. (3)

As Table 1 indicates, critical soil erosion areas occur in South Reelfoot Creek Basin, especially in sub-basins 1, 10, 5, 3, and 8 and sub-basin 1 of North Reelfoot Creek basin. These areas have, in general, steep slopes and poor farming and conservation practices.

Measured Sediment Load

Three U. S. G. S. gaging stations are operated in the Reelfoot Creek basin for measuring daily stream flow and sediment load flow into Reelfoot Lake. These records are available from May 1, 1984 to April 30, 1985, for North and South Reelfoot Creeks.

TABLE 1
CALCULATED SOIL LOSS IN REELFOOT CREEK WATERSHED

North Reelfoot Creek ($60\ mi^2 = 38{,}400$ Acres)		South Reelfoot Creek ($40\ mi^2 = 25{,}600$ Acres)	
Sub-basin	Tons/Acre/Yr	Sub-basin	Tons/Acre/Yr
1	41.7	1	75.5
2	20.0	2	9.1
3	10.4	3	36.8
4	22.4	4	14.3
5	19.0	5	51.3
6	8.5	6	24.5
7	1.8	7	12.3
		8	36.3
		9	29.7
		10	73.2
Average	17.7		36.3
Total 679,680 Tons/Yr + 929,280 Tons/Yr = 1,608,960 Tons/Yr			

North Reelfoot Creek gaging station measured 67,848 tons of suspended sediment for the period of May 1, 1984, to April 30, 1985. The highest concentration was 15,600 mg/1; it occurred on June 21, 1984, during a typical summer thunderstorm with a short intense rainfall. This storm produces 1880 tons of sediment load. (Figure 2) The highest precipitation occurred with a storm on May 6-7, 1984, in association with a frontal movement, producing a peak sediment concentration of 8100 mg/1. However, due to the large amount of surface runoff generated by this storm, a total sediment load of 20,576 tons was recorded. The May storm had a much lower peak concentration but involved much more rain over a longer period of time. The sediment transport curve shows distinct differences in summer (dry season) storms and winter (wet season) storms. This curve was developed by plotting mean discharge with tons of sediment delivered for the day. (Figure 3)

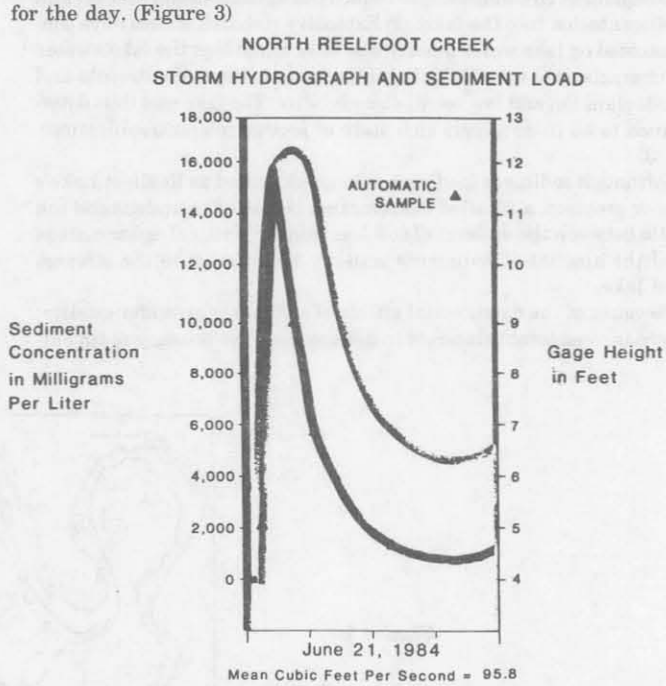


Figure 2: Storm hydrograph and sediment load on North Reelfoot Creek, June 21, 1984.

There are three sedimentation (siltation) ponds in North Reelfoot Creek basin. The exact effect these ponds have on the sediment loads at North Reelfoot Creek is unknown. The effect these ponds have on the discharge can be seen on the hydrograph. (Figure 4) The solid line is a gage height line, and the dotted line is the sediment concentration line. Also shown is the normal stage recession line. This line was drawn to show the effect of the return flow from the sedimentation ponds.

South Reelfoot Creek gaging station measured 85,178 tons of suspended sediment for the period of May 1, 1984, to April 30, 1985. The highest sediment concentration, 29,500 mg/l, occurred on May 27, 1984. The storm had an extremely intense rainfall in a short period of time. The total load for this storm was 19,000 tons. (Figure 5) This was the highest sediment load produced by a single storm during the period of the record. The hydrograph shows the rise and fall in stage along with the rise and fall in sediment concentrations. The hydrograph recessions at South Reelfoot Creek are more natural than those at North Reelfoot Creek due to the lack of control structures (sedimentation ponds) in the basin. (Figure 6) There are no distinct seasonal variations of daily discharge and sediment loads at South Reelfoot Creek. The sediment transport curve shows a good fit when mean discharge for a day is plotted against total tons for that day. (Figure 5) This can also be illustrated in the graph of daily discharge and sediment loads.(Figure 7)

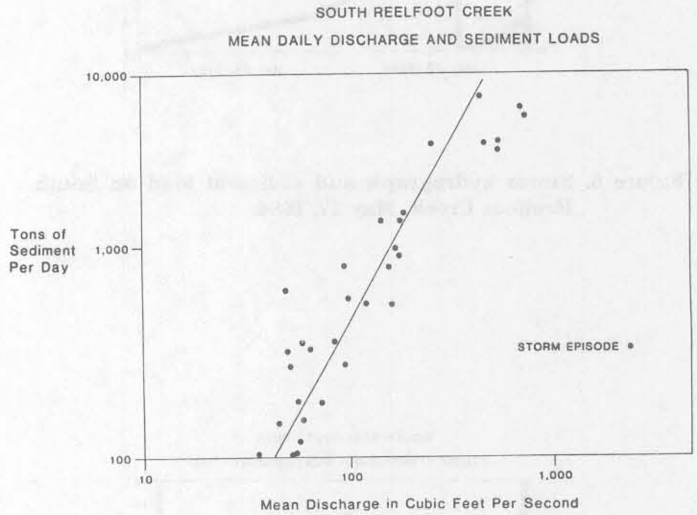


Figure 7. Mean daily discharge and sediment loads in South Reelfoot Creek.

The total sediment loads for Reelfoot Creek by monthly distribution were recorded by U. S. G. S. Water Resources Division. (Table 2) The highest amount of sediment loads occurred in May and December for both creeks, and the lowest occurred in August and September. The high sediment loads are related to heavy precipitation, large surface runoff, and sparse or poor vegetation cover. The low sediment loads are associated with low precipitation, low runoff, and heavy or good vegetation coverage. More sediment loads from soil erosion occurred in winter (wet) season than summer (dry) season.

TABLE 2
TOTAL SUSPENDED SEDIMENT LOADS (TONS) IN NORTH AND SOUTH REELFOOT CREEKS

May 1984	22,869.00	26,207.00	49,076.00
June	2,475.00	37.90	2,512.00
July	769.00	37.80	806.80
August	.32	.62	.94
September	1.12	29.30	30.42
October	7,426.00	2,742.00	10,168.00
November	2,560.00	5,926.00	8,486.00
December	12,175.00	19,799.00	31,974.00
January 1985	2,286.00	5,128.00	7,414.00
February	6,961.00	13,374.00	20,335.00
March	7,024.00	9,184.00	16,208.00
April	3,302.00	2,713.00	6,015.00
Total	67,848.44	85,178.00	153,027.06

Source: Compiled from U. S. G. S. Water Resources Division unpublished record.
Sediment loads for May 1-2, 7-9, 1984, and for October 6-8, 1984 at South Reelfoot Creek were estimated from the sediment transport curve.

Sediment Delivery Ratio (Ratio between Soil Erosion and Sedimentation Loads)

Approximately 4.5% of the eroded material reaches the major rivers in west Tennessee. It is estimated that the unmeasured bedload is 6.1% of the total load for west Tennessee streams. (5) For the purpose of calculating total sediment load, which includes suspended and bed loads, an additional 6.1% of the suspended load will be added. (Table 3) The ratio between soil loss and sediment loads in Reelfoot Creek basin is about 10%. In other words, 10% of the soil losses eventually are transported to Reelfoot Creek and Reelfoot Lake. North Reelfoot Creek basin has a slightly higher sediment delivery ratio than the South Reelfoot Creek basin, but South Reelfoot Creek basin has relatively more soil losses and suspended loads than North Reelfoot Creek basin. (Table 4) This difference may be caused by the topographic factors in the basin wherein South Reelfoot Creek basin has more rough and irregular surfaces than North Reelfoot basin.

TABLE 3
TOTAL SEDIMENT LOADS IN REELFOOT CREEK

	Suspended Load (Tons)	Bedload (%)	Bedload (Tons)	Total
North Reelfoot Creek	67,848	6.1%	4138	71,986
South Reelfoot Creek	85,178	6.1%	5196	90,374
Total	153,026		9334	162,360

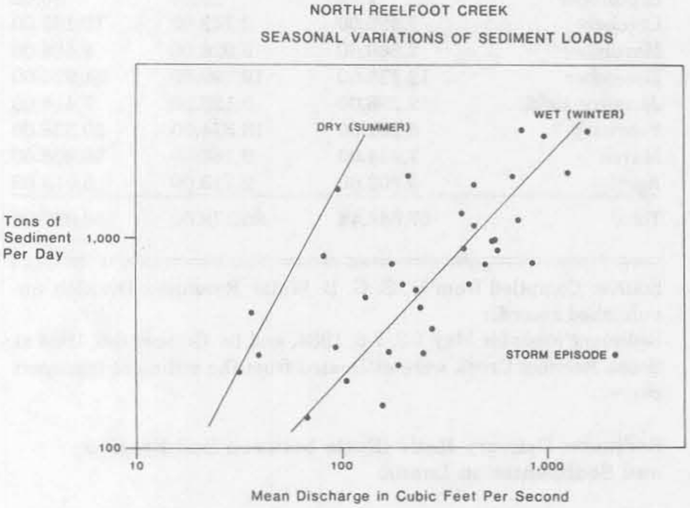


Figure 3. Seasonal variations of sediment loads in North Reelfoot Creek.

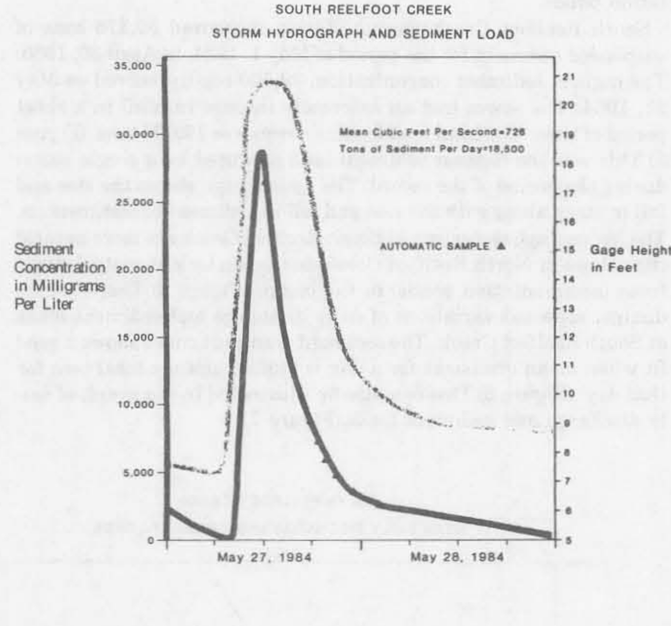


Figure 5. Storm hydrograph and sediment load on South Reelfoot Creek, May 27, 1984.

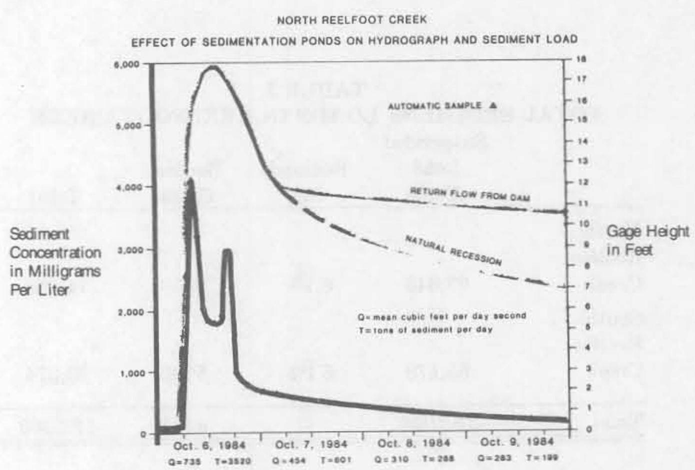


Figure 4. Effects of sedimentation ponds on hydrograph and sediment loads in North Reelfoot Creek.

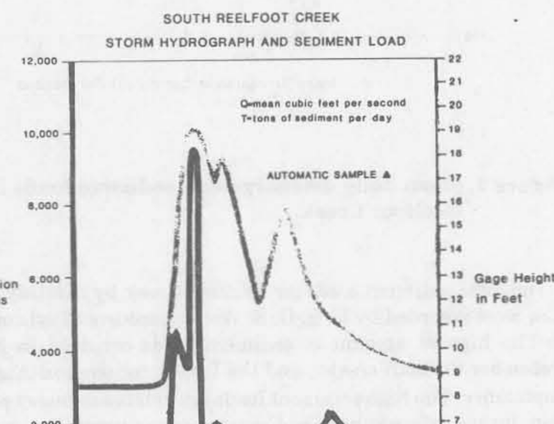


Figure 6. Storm hydrograph and sediment loads on South Reelfoot Creek, December 17-19, 1984.

TABLE 4
SEDIMENT DELIVERY RATIO

	Soil loss (Tons)	Suspended Sediment Loads (Tons)	Ratio (%)	Total Sediment Loads (Tons)	Ratio (%)
North Reelfoot Creek	679,680	67,848	10.0%	71,986	10.6%
South Reelfoot Creek	929,280	85,178	9.2%	90,374	9.7%
Reelfoot Creek	1,608,960	153,026	9.5%	162,360	10.0%

CONCLUSION

An estimated total of 1,608,960 tons of soil erosion occur in Reelfoot Creek basin, and 10% of the eroded soil (162,360 tons) is transported as sediment loads in Reelfoot Creek, eventually ending in Reelfoot Lake.

The purpose of this paper was to provide a basic knowledge of the difference between gross soil erosion and sediment loads in stream and lake. With this understanding one can better see the problems facing Reelfoot Lake. The question of saving Reelfoot Lake must be analyzed from several viewpoints. Whatever viewpoint is taken, the filling of the lake is a natural process. The natural cycle has been accelerated by the lack of conservation practices around the lake. Better land management is a must in the Reelfoot Creek basin, not only because of the lake, but because what little productive land exists in the basin will be gone in years to come.

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