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STATUS OF GULLY REHABILITATION: A CASE STUDY FROM WEST TENNESSEE

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ABSTRACT

Gully reclamation efforts in Meeman-Shelby State Park in 1936 may not have survived more than a few months due to the record rainfall of over 400 mm in January, 1937. The regraded hillslopes and gully bottoms were subjected to intense sheetwash by rainsplash and saturated slopes failed by slumping. The log check dams constructed in the upper portions of the gullies to entrap sediment were inundated and either destroyed or buried. Recently, three of these log dams were exposed by renewed gully incision, only to be partially reburied during the 250 mm of rainfall that occurred over 36 hours in December, 1987. This modern event suggests that similar processes occurred fifty years ago and may have played a significant role in initiating the current phase of gully development within the park. In addition, poor management of surface drainage from roadways and compacted playing fields is assisting erosion by supplying sediment-free water to gully headcuts. Current efforts to control this problem appear to be uncoordinated and are unsuccessful due to lack of knowledge of the geomorphic processes involved and the spatial and temporal relationships between sediment storage and transfer within the gully system.

INTRODUCTION

The loess-covered landscape of West Tennessee has been a favorite area for cultivation and forestry since the early 1800s. The extensive clearing of forests to service the growing hardwood furniture industry and to provide farmland seriously affected the geomorphic stability of many small streams and ephemeral channels draining this region. In the bluff area of Shelby County, Tennessee, the land use changes initiated a phase of gully reactivation and network expansion that has produced both extensive downcutting, as well as widespread deposition of sediment within the gully channels and along bluff footslopes and bottomland forests. Much of this sediment originated from fields that were finally abandoned between 1920 and 1935 (Barnhardt, 1988a, 1988b). The encroaching gullies, a loss of productivity, and the purchase of the land by the federal government to establish a Recreation Demonstration Project eventually set the stage for the rehabilitation of these gullies and their reforestation with hardwoods in 1936-37.

This area, now the Meeman-Shelby State Park, was rehabilitated differently than areas such as Natchez Trace State Park in that native hardwoods were planted instead of the more commonly used pines. The resulting tree density and initial ground protection afforded by the tree cover may be one of the reasons for the continuing gully erosion throughout Meeman-Shelby State Park. This paper will examine the status of gully rehabilitation efforts in one gully located in an area where extensive regrading, replanting, and engineering structures (log and debris dams) were employed to stabilize the gullies and promote sedimentation.

GEOMORPHIC IMPLICATIONS OF LANDSCAPE REHABILITATION

Many large-scale reclamation projects were initiated across the United States in the early 1930s, as there was a sense of urgency due to the tremendous soil damage that was occurring on farmland and pasture. Even though the best procedures and materials were used in these efforts, little was known of the effects that these projects would have on the fluvial systems acting on the hillslopes and gully bottoms. Hillslope angles were regraded to 1:1 or flatter and channel bottoms were leveled to 1:5 slopes where log and debris dams were emplaced (Ayres, 1936). The loess deposits upon which these reclamation techniques were being applied are known for their erodability by surface runoff and wind (Grissinger and Murphey, 1982, 1983) The regrading and leveling served to work the surface sediment into a very friable, absorbant unit that initially had little, if any, vegetative protection. Since broadleaf species were planted and some slopes were left for natural revegetation, it is reasonable to assume that many slopes were barren or sparsely covered for several years. Several archival photographs from early 1936 that are displayed in the interpretative museum at the park provide visual evidence for this assumption.

Within the park, the bottoms of larger valley-floor gullies, once farmed, are now experiencing rapid incision that exceeds two meters in many areas (Barnhardt, 1988b). The initial incisions were most likely caused by the increased runoff originating on the reclaimed slopes. Since much of the sediment was being trapped behind control structures constructed in the upper reaches of the gullies, the sediment-free runoff continued downstream and began to erode sediment previously stored along the channel and floodplain. The current phase of incision is most intense in the upper portions of the gullies and appears to be related to the excess roadside runoff that is diverted into gully headcuts. However, much smaller gullies are also exhibiting valley floor incision unrelated to runoff from roadways but originates on playing fields that have lost their permeability due to excessive compaction from human traffic (White, 1988).

The current phase of incision is eroding sediment that was initially trapped behind log and debris dams constructed along many small tributary gullies in 1936. These small gullies represent a part of the gully network where large amounts of sediment have been stored for over fifty years. The energy provided by the increased runoff from these playing fields is readjusting the channel and hillslope geometry. The debris and log dams were intended to function for only three to five years during which sediment would accumulate behind them and trees could be planted to stabilize the sediment.

The dams were very successful in trapping sediment temporarily. But sediment stored in stream channels behind small obstructions is subject to removal once the obstruction is breached or buried. There are many instances in the study area where small trees have dammed the channel only to have the sediment overtop the natural obstruction creating a small knickpoint which then migrates upstream excavating most of the sediment. However, McDowell (1987) cites several instances where large organic debris dams have acted to modify the sediment transfer and storage in small streams by buffering the effects of mass movements that introduce large sediment volumes into the small streams. Some of these natural organic dams may remain relatively stable for 100 years or longer and may affect the morphological development of the stream channel.

The interesting point concerning the small reclamation dams studied at Meeman-Shelby State Park is that the dams themselves were completely buried by the sediment. These dams were designed to trap sediment only until their spillway was reached. For them to be buried, a large amount of sediment would have to be delivered to the channel during a short period of time, otherwise the excess sediment would be carried over the notched spillway downchannel to the main tributary. The log dams in the study area are about two meters wide, one meter high at the top, and one-half meter high at their notched spillway. The sediment appears to have been delivered by slope processes such as slumping and high volume sheetwash rather than downchannel deposition by flowing water. Evidence supporting this is the presence of thick, non-laminated silt accumulations behind each of the dams. Since these colluvial deposits would have been more viscous than fluvial deposits, they could easily have overwhelmed the dams and essentially buried them with a plug of sediment. The barren, regraded gully hillslopes would have been prime sources for this sediment.

FATE OF RECLAMATION DAMS

Slumping is common on the steep, loess slopes in the park. In December, 1987, a 250 mm rainfall over a 36-hour period triggered three large slumps in the study area which buried almost completely the three dams that were only then being reexposed from their burial 50 years ago. Two of the slumps were initiated by or accompanied large treefalls. Figures 1 and 2 illustrate the effects of treefalls on hillslope morphology.

Figure 1. Gully hillslope in July, 1987. Note base of tree in uppermost right.

The dense seasonal canopy has little effect on raindrop impact during the winter. The intense rainfall in late December fell upon soil already saturated from previous rains in early December. Much of the sediment and organic debris was deposited on the gully bottom only a few meters downsteam of its point of origin. The method of deposition is very similar to that which I believe was involved with the initial burial of the log dams in January, 1937 when over 400 mm of rain was recorded. Neitzel (1981) found similar colluvial deposits at an archaeological site near Natchez, MS that he believed were related to forest clearing by Indians.

Figure 2. Gully hillslope in January, 1988. Tree from upper right has fallen. The thickness of the slump is closely related to the depth to a clay-rich soil horizon.

In a similar fashion, the hillslopes in Meeman-Shelby State Park had just recently been reworked by WPA/CCC workers as part of the reclamation project. These unprotected slopes could not have withstood the record rainfall of January, 1937 without yielding significant amounts of sediment. Further, the steep angles to which the hillslopes and gully channels were graded suggest that these slopes were unlikely to remain stable for any length of time, regardless of the protection afforded by vegetation. Potential geomorphic instability was already present at the moment the reclamation project was completed. Unfortunately, a record rainfall only a few months after the completion of the project probably negated any positive effects of the reclamation on the gully channels themselves. Even though park personnel commented in future years about the reduction in sediment yields, it is likely that the reduction was due mainly to the conversion of farmfields to an increasingly mature forest and the fact that the sediment was being stored temporarily along the channels. Trimble and Lund (1982) noted that many areas in the southern Piedmont had experienced similar reductions in erosion due to cropland being converted to forest and pasture. However, unlike many reclaimed areas, Meeman-Shelby State Park continues to exhibit severe gully entrenchment and extension that threatens park and county roads.

Future Problems

As many researchers have stated, it is far easier and cheaper to prevent erosion than to correct the problem once it is established. Aside from the funding problems faced by all public agencies, the control of soil erosion and gully development in this park area lies in the realization that a short-term solution may not be available. In fact, many of the attempts to control gully activity near the headcut where it abuts roadways are detrimental to the cause. The large quantities of sediment-free water that drain into gullies from roadways undermine the headcut causing block falls and slumps. The high-energy water continually removes this sediment exposing the base of the cut to renewed undermining. Since the sediment is not allowed to slump and settle into the channel creating a lower angle of repose, vegetation can not establish itself and stabilize the sediment. Additional problems are created along the expanding upper reaches of the gully network where mature trees are being undercut. Remnants of the pre-settlement forest, these large trees frequently dislodge many cubic meters of sediment during treefall (see Figures 1 and 2).

Abandoning major access roads and recreational facilities is obviously not a logical alternative to controlling gully problems. However, if a coherent, long-term (on–going) plan to control drainage is not effected soon, the list of alternatives will be drastically shortened. The initial cost of 1) resurfacing selected road sections, 2) creating water and sediment retention basins, 3) improving infiltration rates and soil moisture retention, and 4) controlling sediment transfer by a combination of structural and vegetation controls is unlikely to be more than the ineffectual piecemeal approach that seems to be currently employed.

Reconstructing Past Events

The geomorphology of the gullies is a function of the processes that have operated over long periods. The sedimentation record assists in interpreting the frequency, magnitude, and spatial extent of past events. Occasionally, modern analogs are available for study which help reconstruct these events. Such is the case here where treefalls, slumps, and record rainfall joined in December, 1987 to clarify the scenario that is most likely to have occurred in 1937. Buried wood from forests ranging in age from 900 to 4000 radiocarbon years is exposed in Meeman-Shelby State Park (Barnhardt, 1988b). The stratigraphic occurrence of the wood provides strong evidence that pre-settlement sedimentation and erosion was much less than at present. While erosion is a natural process, the current accelerated rates in many areas are artificially high due to human activities. An appreciation of how geomorphic processes function is essential to successfully managing the gully problems in western Tennessee. To ignore the realities of these physical processes is to lose the battle before it is begun.

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