

GIS Analysis Determines Erosion Potential At Buffalo National River Basin

By Tim Stephenson and David Mott

Land use activities in the hilly terrain of the Ozark Plateaus have resulted in widespread erosion at least since the mid 1800s. The principal endeavors here in the late 19th and early 20th centuries were logging, open grazing of hogs, and row cropping in flood plains. More recently, conversion of forest to pasture is the

dominant activity.

Because the Ozark region is dominated by limestone and dolomitic rock types, which typically produce poor soils with a high proportion of gravel sized chert, the dominant land derived sediment resulting from this erosion is soil and gravel. As a result of the gravel's size and mass, it has a relatively long residence time in the surface hydrologic system. Accord-

ing to Jacobson and others (1990), erosion and transportation of sediments has caused Ozark streams to exhibit gravel aggradation and resultant channel instability. By comparing recent and prehistoric periods of aggradation, these authors have concluded that the recent episodes appear to be much more severe.

Aggradation of channel sediments and clearing of

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Gravel aggradation and streambank erosion in a tributary to the Buffalo National River result from upland clearing and removal of riparian vegetation.

riparian vegetation for agriculture have caused increased channel instability, anastomosing (dividing and reuniting), shallowing and widening (Jacobson and Pugh, 1992). As a result, there is evidence that significant changes are occurring in the physical habitats that influence aquatic ecosystems. This study uses a GIS to define the land use change in relation to slope in a portion of the Buffalo National River Basin and to interpret the potential for upland erosion and gravel transport.

The Watershed

Buffalo National River (BUFF) was established as the nation's first National River in 1972 for "preserving as a free-flowing stream an important segment of the Buffalo River in Arkansas . . ." (P.L. 92-237). In reality, BUFF is a narrow corridor straddling the river and averaging 2 miles in width. It comprises only 11 percent (95,730 acres) of the total watershed area (840,000 acres). The park is extremely susceptible to water resource degradation from external sources and lies downstream from all the diverse land use activities and pollution sources within the watershed.

As with many Ozark streams, the Buffalo River is in a state of disequilibrium. Because of its relatively steeper topography, greater magnitude of peak flood events, and gravel inputs from three different plateau systems, the Buffalo River may be among the most impacted streams from current and past land use changes. Gravel aggradation and clearing of riparian vegetation have resulted in widespread erosion affecting from 10 to 15 percent of the river corridor.

Methodology

The study unit encompasses 4,170 acres of private property in the Springfield Plateau region of the drainage basin. The area is sparsely populated and characterized by sharply defined valleys containing small streams separating flat topped ridges. Land use data from 1965, 1974, and 1979 were analyzed by Nyquist (1982), to an accuracy of 0.09 percent of the total acreage. The land use data for 1983 were digitized at the University of Central Arkansas (UCA) from aerial photography provided by the Arkansas Highway and Transportation Department. The slope characteristics were derived from elevation data digitized at UCA from USGS 7.5 minute quadrangle maps.

Studies by El-Swaify and others (1985), indicate

that on slopes greater than 7 degrees, overland flow is the major causal factor in the detachment of soil components. Clearing of forests and conversion to pasture greatly increase the overland flow component of a given precipitation event. A GIS analysis was employed, based on these physical processes, to determine the relative rate of conversion on 3 different slope regimes over 4 discrete time intervals.

Results

Nyquist (1982) studied the land use changes occurring in the entire Buffalo River watershed from 1965 to 1979 and determined that "the rate of conversion (from forest to agriculture) was nearly halved in the years 1974 - 1979." A summary of the data generated by this study is given in Table 1 and indicates the amount of cleared land increased by 126 percent from 1965 to 1983. Although this study corroborates Nyquist's findings of a decrease in the rate of conversion from 1974 to 1979 in the smaller study area, this appears to represent only a temporary slowdown in the conversion rate as opposed to any long-lasting trend.

As of 1965, 770 acres of the study area were in pasture, with 39 percent of this area on slopes greater than 7 degrees. An additional 962 acres had been cleared by 1983, with 50 percent of the conversion taking place on slopes greater than 7 degrees.

During the 18-year study period, the amount of land cleared for pasture on slopes less than 7 degrees increased by 103 percent, while conversion on slopes of greater than 7 degrees increased by 160 percent. Given the erodible characteristics of the areas being

cleared on the steeper slopes, plus the fact that these areas are being cleared at an increased rate, significant potential exists for further loading of gravel from highland areas and associated degradation of stream geomorphology.

The increased conversion on steeper slopes apparently results from several factors, among which are a lack of available level land and an upswing in the cattle market. While results of this analysis are not intended to be conclusive, due to the limited size of the study area, they are consistent with general field observations. Because of the importance of land use trends to BUFF's water resources, further research covering more of the watershed and using more current data is warranted.

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References

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Poor soils and steep slopes combine to produce large volumes of gravel, which are transported by heavy rains to the surface hydrologic system at Buffalo River.

Table 1. Summary of land use and slope data.

Time Period	Acres Converted			
	All Slopes	0 to 7 Degrees	7 to 14 Degrees	14 to 35 Degrees
1965	769	467	202	97
1965-1974	438	237	118	82
1974-1979	151	62	51	38
1979-1983	373	182	104	87
1965-1983	962	481	273	207