

HISTORICAL LAND USE AND ACCELERATED SOIL EROSION IN WATAUGA COUNTY, NORTH CAROLINA (1950-1988)

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Introduction

Accelerated soil erosion is a serious concern in all parts of the world due to the numerous effects it has on the environment and humankind. Activities such as agriculture and construction often increase soil erosion to unacceptable rates (Brown and Wolf, 1984). It has long been known that poor land management practices can result in a loss of topsoil at rates substantially above the rates of replenishment through pedogenesis (Birkeland, 1984). Crop yields and soil productivity are often reduced, and there are clear economic impacts associated with these reductions (Harlin and Berardi, 1987). Population growth and consequent increases in agricultural needs are likely to result in greater soil erosion, decreasing productivity levels, and could contribute to difficulties in feeding human populations. The purpose of this research was to examine historical land use patterns in a southern Appalachian watershed and to utilize Geographic Information System (GIS) techniques to relate those activities to estimated spatial and temporal patterns of soil erosion within the watershed since the implementation of soil conservation programs.

Methods for Estimating Soil Erosion

Researchers have utilized various methods to estimate current or recent rates of soil erosion from local to global scales (Beach, 1994; Phillips, 1990; Trimble, 1973). A few have utilized GIS to accomplish this task (Harden, 1990; Pelletier, 1985; Spanner, et al, 1983).

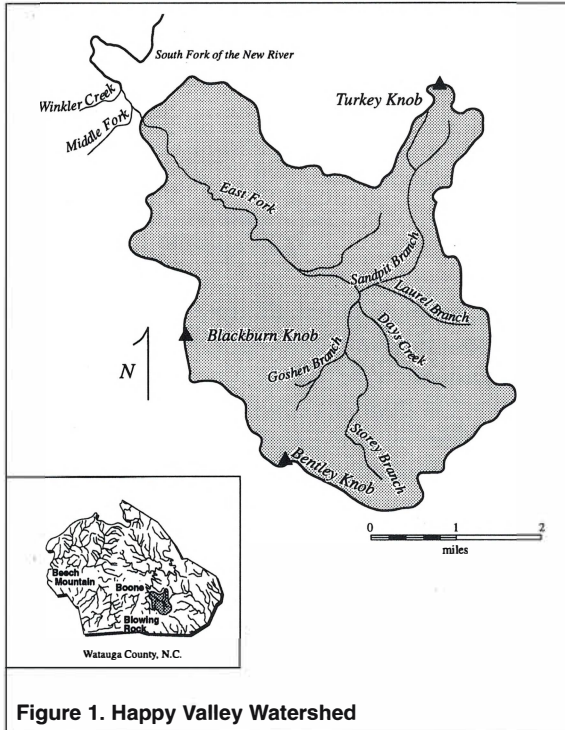
When accurate measurements of soil loss are possible, these impacts can be quantified since a value can generally be placed on both crops and topsoil. The total costs of soil erosion, both monetary and environmental, are unknown and probably can not accurately be calculated (Dunne and Leopold, 1978). Organized soil conservation programs in the United States have been in effect for over 50 years, and hundreds of millions of dollars have been spent in an effort to control the rapid soil loss which has occurred since early European settlement. There has been a notable decrease in

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In southern Appalachia poor land management has resulted in substantial losses of topsoil, a problem recently reduced through soil conservation and land use changes

erosive land use in the southeastern Piedmont region of the United States since the mid-1920s (Trimble, 1973). Based on qualitative historical evidence, it is believed that erosion and sedimentation have been reduced in the Appalachian region as well (Glenn, 1911; Silver, 1990). The watershed of

the East Fork of the South Fork of the New River (subsequently referred to as the East Fork) is within Watauga County, North Carolina (Figure 1). This part of the Blue Ridge is characterized by some of the highest elevations in the Appalachian Highlands and overlooks the Piedmont to the east (Hunt, 1990). The East Fork watershed covers an area of approximately 7.3 square miles (18.9 sq.kms). Within the watershed are numerous agricultural ponds which were constructed primarily for livestock use.



In the Southern Appalachian region, there is a need to assess the effectiveness of soil conservation programs implemented over 50 years ago. Such programs included management practices such as contour plowing and crop rotations, and discouraging row crop agriculture on steeper slopes. In order to accurately assess soil conservation achievements, it is necessary to determine the nature, extent, and intensity of land use through time. The variables associated with most soil erosion models include: precipitation characteristics; the ability of soils to absorb water and their inherent susceptibility to detachment and transport; topographic characteristics such as slope length and gradient; and the local vegetation cover. Geographic information system and remote sensing technologies were jointly utilized to generate a database in a GIS format containing these basic variables.

In choosing a model appropriate for demonstrating the relationships among the relevant variables, the Universal Soil Loss Equation (USLE) was selected. This model is considered to be substantially accurate for predict-

ing long term averages over time. Alternative storm-event driven models require rainfall duration and intensities as input data. Without such data the models are not accurate predictors, nor do they function the way they were intended (Beaseley, phone interview, 1995). And rainfall duration and intensity data do not exist for the Happy Valley catchment.

The USLE was simulated in a raster based GIS and modeled for the Happy Valley basin during the years 1950, 1963, 1976, and 1988. Happy Valley is believed to be representative of numerous upland catchments in the Appalachians. Results were analyzed and compared to patterns of land use change and sediment deposition in the aforementioned agricultural ponds. Sediment cores served as an indicator of the magnitude of watershed stream transported sediment over time by applying sediment delivery ratios (SDRs). These SDRs are derived from volumes of pond sediment representing a percentage of the total gross erosion transported in a watershed over time. Sediment delivery ratios were developed for the thirty-nine year period, but are beyond the scope of this paper.

Agricultural History of the Region

European settlement of the upland southeastern United States began in Virginia about 1700 and ended in Alabama during the 1830s. In the late 17th century, European settlers crossed into Virginia and continued on to North Carolina by 1740 (Trimble, 1973). In North Carolina, much of the settlement was still of the pioneer type with most agricultural activity taking place in the valleys along streams (Hall, 1948, 50). Population growth placed increased pressure on the landscape and colonists often had to adjust their methods of agriculture to correspond with such changes as noted by Silver (1990),

Planters adjusted first by planting corn on the worn tracts and then by allowing them to lie fallow. That worked until the population and labor force grew too large to allow depleted fields adequate time to recover (p. 195).

Land was incessantly and continuously cleared, farmed poorly until perceived to be infertile, and then abandoned (Trimble, 1973, 41). Consequently, farming techniques utilized here could hardly be considered sustainable or conservationist.

European settlement of the Appalachian region lagged behind the rapid migrations into the Piedmont. Happy Valley was one of the wider, larger valleys in Watauga County and was one of the initial sites for settlement in northwestern North Carolina. Although the population was largely agricultural and steadily increasing during the mid 1800s, industries such as

Changes in soil erosion rates for Happy Valley of Watauga County are in this paper assessed by the use of GIS and remote sensing techniques.

Up to and including the Depression years, population increases pressed agriculture onto slopes too steep for rational utilization of the land

lumbering and cattle grazing slowly became more profitable to outsiders. Portions of the region were properly agricultural land, but migration pressures and poor practices brought increasingly more land under cultivation on the steeper slopes. Fields were often worn out and abandoned before the larger girdled trees had fallen. The new fields were then cleared beside the old ones in the same destructive manner, and normally on steeper slopes (Glenn, 1911).

During the 1930s the Depression spawned an increase in the number of farms in the Appalachian region, much of it on land which was ill-suited to cultivation (U.S. Department of Agriculture, 1938). During the period, population densities among farm populations were greater than those of the more productive Mid-west Corn Belt (U.S. Department of Agriculture, 1938). These rapid migrations of people compounded the problem of ignorant farming practices in the region. Despite the concerns of George Washington and Thomas Jefferson with soil erosion, it was not until the 1930s that Congress recognized it as a real problem. This era marked the beginning of conservation efforts in the United States (Harlin and Berardi, 1987).

Even so, by the 1970s, there were growing concerns about the limited acceptance of soil conservation programs among farmers throughout the United States (Dunne and Leopold, 1978).

The temporal pattern of land use change in Happy Valley mirrors regional trends during the same time period. In 1944, the average farm in Watauga County covered approximately 68 acres with 34 acres of cropland, and it produced mainly for the farm household (USDA, 1990). The number of farms in Watauga County declined from 2,553 in 1950 to only 715 in 1987. The acreage of farmland declined by over 60% during the same time period (U.S. Bureau of the Census, 1950; 1987). These figures can be compared to employment figures for agriculture from 1950-1960. In 1950, 665,000 (25.1%) people in North Carolina were reported to be employed in agriculture; the number decreased to 316,000 (11.1%) by 1960 (USDA, 1965).

Estimating Soil Loss in the Happy Valley Watershed

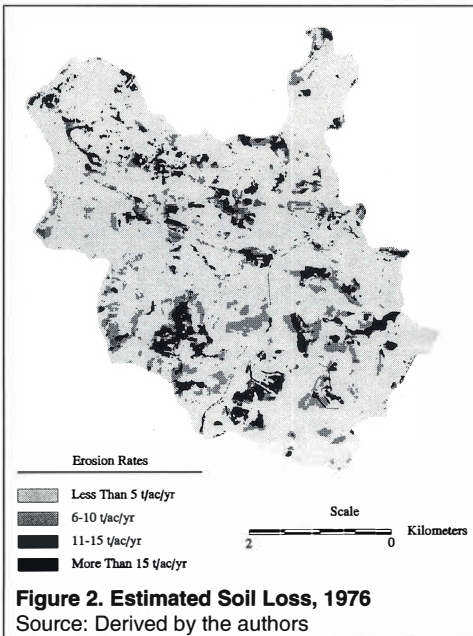
Modeling gross annual erosion for the watershed and determining the extent of erosive land use change over time required the use of available aerial photographs. Individual aerial photograph series for each available year were scanned, rectified (corrected geometric distortions), and merged into mosaics. For a detailed discussion of the steps involved in image processing for earth resource analysis, see Jensen (1996) or Lillesand and Kiefer (1994). The mosaics were imported into a package for processing and mod-

During the 1950s and early 1960s there was a sharp reduction in cultivated areas, and an increase in open pasture land

More recently pasture lands have reverted to forest, and urban usage has extended considerably into the valley

eling. Land use was determined for each scene through an unsupervised classification process. Results of the automated classification were rechecked against the aerial photography and by ground truthing for the 1988 image. The land cover classes from each image mosaic were used as one of the primary variables in order to model soil erosion in tons/acre/year.

Because of the very limited area of other land cover types (water, urban, and specific vegetation groups) and the limited spectral resolution of black and white air photos, only three land cover types were recognized. The land use classes which were used were (1) forest, (2) pasture/open, and (3) cultivated/bare soil. While deciduous trees could be distinguished from coniferous tree stands, there was no reason to make such a differentiation, as the two forest types have similar hydrologic and erosional characteristics. Within each land use class, a cover factor was assigned for USLE input based on a conservative interpretation. For example, the "C" factor values for forest range from 0.0001 to 0.009, indicating two orders of magnitude of variability (U.S.D.A., 1983). In this study, all areas covered by forest were assigned a "C" factor of 0.001. For all variables except slope, a pixel size of 5m x 5m was utilized. Slopes were calculated from a USGS digital elevation model with a spatial resolution of 30 meters.



Patterns of land use change in Happy Valley from 1950-1963 reflect a sharp reduction in cultivated areas and a reversion from agricultural cropland to open pasture; a slight drop in forested areas was also observed (Table 1; Figure 2). The greatest change occurred along the northern boundary of the watershed, an area that revealed very high rates of erosion in 1950. This is an area that experienced substantial reforestation from 1950 to 1963. From 1963-1976, a large portion of pasture reverted to forest. This is seen on the modern landscape in the many stands of white pines found on steeper slopes and ridge lines in the watershed.

This tree species reaches harvest maturity in 20-40 years and is often chosen for woodland conversion for this reason.

	1950	1963	1976	1988
Forest	40.11%	36.77%	47.78%	44.47%
Pasture	36.13%	50.90%	38.82%	45.87%
Cultivated	23.76%	12.33%	13.40%	9.66%
Total Erosion	52,539	34,002	33,110	30,131

Table 1. Temporal land use change and estimated gross basin erosion

Source; Derived by the authors

The beginning of an urban expansion / construction period in the basin is revealed in the 1976 image, with an increase in the cultivated / bare soil class. This trend continued through 1988, with decreased forest area and increased open space. During this period the watershed and county experienced significant population growth. Erosion in Happy Valley was graphically reduced from 1950 to 1963. Much of the agricultural activity taking place on steeper slopes was halted and vegetation reverted predominantly to forest. Erosion figures for the watershed show only slight reductions from 1963-1988. Reductions in agricultural erosion were largely offset by suburban development. In the land cover classifications, these suburban areas show up primarily as forested areas that were cleared and converted to grass. The spectral signature of a lawn is essentially the same as that of pasture. During the construction phase, large amounts of bare soil are exposed, resulting in very high sediment erosion rates (Wolman, 1967). The temporal resolution of aerial photography is not great enough to reveal a large amount of bare soil associated with home construction.

Conclusions

The decline in modeled soil erosion from 1950-1988 appears largely to be a result of the socio-agrarian transitions and not to regional soil conservation programs implemented over the time period studied. Implementation of conservation programs has had little to do with the reductions observed in erosive land use and associated soil loss in Happy Valley. Rates of adoption of conservation programs were low. Changes in land use from an emphasis on row crop agriculture to livestock, forestry, and land subdivision and suburbanization have had a much greater impact on soil erosion in the basin. This marked a decrease in agricultural activity that corresponds to several trends nationwide. As of 1989 only 1,300,000 American farms were family owned and operated, down by nearly 50% from 2,184,000 in 1976 (Hunst and Powers, 1991).

Erosive land use in Happy Valley has been greatly reduced since the period of federal soil conservation program implementation. It is believed that the USLE results provide a reasonable account of the relative rate of soil loss which have occurred in

Though soil erosion rates have been reduced the reason more probably lies within the changing socio-agricultural environment than with the implementation of soil conservation programs

the basin over time. The modeled soil erosion estimates should however not be considered absolute data, but merely a representation of the magnitude of changes in accelerated soil loss and associated erosive land use.

The golden age of family farming in Happy Valley has virtually ended and not due to the implementation of soil conservation programs, but rather to a combination of corporate consolidation farming trends and to a fast-paced socio-economic transition to suburbanization and related expansion of service industries. Subsistence family farms have disappeared, college graduates have proliferated, and a service economy has largely replaced a form of living which used to be essential to clan and family survival in the region (Raitz and Ulack, 1984).

Accelerated soil erosion has not been eradicated in Happy Valley, but it has been reduced significantly and the activities causing it have largely changed. Increases in urban encroachment and development are likely to continue just as population growth shall. Future research should focus on the impacts of continued urban development and construction as the primary contributors to accelerated soil erosion in the Appalachian region.

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