# RIPARIAN ZONE EFFECTS ON WATER QUALITY

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## INTRODUCTION

Riparian ecosystems in Georgia are almost exclusively forested wetlands or floodplain forests. Our understanding of the importance of riparian ecosystems in maintaining water quality has been based on a relatively small number of research projects carried out over the last decade. Much of this research has examined effects on runoff and drainage from agricultural land. The Southeast Watershed Research Laboratory of the Agricultural Research Service, in cooperation with the University of Georgia, has made substantial contributions to our understanding of riparian ecosystems. This paper will present a review of research on riparian ecosystems and water quality in the coastal plain and will examine a number of management issues concerning riparian zones.

In the Gulf-Atlantic Coastal Plain of the southeastern U.S., riparian forests often form a natural buffer between row-crop fields in upland areas and the stream channel. This natural buffer was not always in place. When plowing and cultivation were done with horses and mules, it was possible to plow closer to the stream than it is today with large tractors. Aerial photographs from Turner County, GA show clearly that forest buffer strips which are now 30m to 40m wide were not present in the 1930's (Lowrance et al., 1986). Although water quality data for these earlier times are not available, it is likely that the lack of a riparian buffer strip resulted in higher sediment loads and contamination of surface water with the agricultural chemicals used in those days.

## SEDIMENT DEPOSITION

Modern agricultural landscapes contain extensive riparian buffer strips, however their role in water quality maintenance was not well understood. A research project was begun in the late 1970's at the Coastal Plain Experiment Station in Tifton, GA to determine the effects of riparian forests on surface runoff and shallow subsurface flow carrying sediment and nutrients from agricultural areas. Sediment from erosion is the most widespread and most damaging pollutant of surface water in the U. S. and annually causes about $6 billion in off-site damages (Clark, 1985). Nutrients such as nitrogen and phosphorus are major contributors to stream, lake, and coastal eutrophication and can be carried in both surface and subsurface flow.

Examination of long-term trends in erosion, combined with information about present-day sediment delivery ratios and soil morphology, allowed us to estimate the long-term rate of sediment deposition in the riparian zone (Lowrance et al., 1986). This study showed that the average annual rate of sediment deposition ranged from 35 to 52 megagrams per hectare per year. Deposition rates of this magnitude are obviously important in reducing sediment loads in streamflow. Although average annual soil loss was at a maximum in the 1920's, today's very low streamflow sediment concentrations would indicate that these sediments are not being remobilized by present day streamflow.

## NUTRIENT CYCLING

A nutrient budget approach showed that the riparian forest was effective at retaining nitrogen, phosphorus, calcium, and magnesium and kept these nutrients from reaching the stream channel (Lowrance et. al., 1983). Nitrogen moves primarily in subsurface flow from agricultural fields in this part of the coastal plain. Studies of this shallow phreatic flow showed that the total amount of nitrogen was reduced and that an inorganic N output from fields (nitrate and ammonia) was converted to an organic N output to the streams.

In order to manage riparian ecosystems for water quality maintenance, it is necessary to understand the processes responsible for nutrient retention or removal. Nitrate concentrations in shallow phreatic flow decreased as water moved within the riparian forest but chloride concentrations did not (Lowrance et al., 1984a). Nitrate and chloride move at approximately the same rate in water, but nitrate is subject to biological denitrification which converts nitrate to gaseous nitrogen. Chloride does not undergo similar reactions and is biologically inert. Therefore, a decrease in the nitrate/chloride ratio along a flow path is seen as a good indicator of biological removal of nitrate.

A detailed study of denitrification in soil and subsoil of the riparian forest showed that high rates of denitrification took place in these seasonally water-logged, organic rich soils (Hendrickson, 1981). Although rates varied widely in time and space, conservative estimates showed that soil denitrification accounted for about 30 kilograms per hectare per year of nitrogen removal. In addition, a study of vegetation uptake of nitrogen showed that accumulation in woody biomass accounted for about 50 kilograms per hectare per year of nitrogen stored in the riparian forest (Fail et al., 1986).

Other studies on coastal plain riparian forest ecosystems showed similar results to the studies carried out in Georgia. Peterjohn and Correll (1984), working in the Maryland coastal plain near Chesapeake Bay, found the same pattern of nutrient removal from subsurface flow as water moved from agricultural fields to the stream channel. They also found large decreases in sediment, ammonia-N, and total-P in surface runoff as it moved from fields in sheetflow across the forest floor. Vegetation uptake and storage of nitrogen and phosphorus in woody biomass were important sinks in their systems also. Jacobs and Gilliam (1985) found similar nitrate losses from subsurface flow between cropped fields and the stream channel in the North Carolina coastal plain. Sampling of herbaceous vegetation in their study showed that uptake of nitrogen by non-woody vegetation was not an important removal mechanism.

## RIPARIAN ECOSYSTEM MANAGEMENT

Although the above studies, and others, present a convincing argument for the role of forested riparian wetlands as nutrient and sediment sinks, proper management and regulatory guidelines for riparian zones are less well defined. Two important questions related to riparian zone management will be posed here: 1) Can riparian zones be managed for water quality maintenance if the woody vegetation is removed? 2) What farm-directed incentives will be effective in maintaining and restoring riparian wetlands?

Riparian wetlands usually require drainage to be brought into agricultural production. Artificial drainage allows timely equipment operation and avoids damage to plants by water-logged soils. Artificial drainage usually increases nitrate transport in subsurface flow by short-circuiting natural flow paths and decreasing the chance for biological and chemical reactions (Lowrance et al., 1984b, Gambrell et al., 1975).

One means for water quality maintenance without riparian vegetation is called controlled drainage, a system of restricting the flow of subsurface drains by the use of some mechanical structure (Gilliam et al., 1986). Controlled drainage has been shown to decrease nitrate outputs relative to uncontrolled artificial drainage and has achieved nitrate outputs similar to outputs from natural areas of riparian forest. Reductions in nitrate concentrations are achieved by restricting drainage at certain times of the year to promote denitrification and retain water in the soil profile. Two important unanswered questions about replacing riparian vegetation with controlled drainage are: 1) What are the effects on chemicals other than nitrogen? and 2) What are the factors which control denitrification in these drained riparian areas?

A second issue related to riparian zone management is the effect of government incentives to take cropped riparian areas out of production. The Conservation Reserve Program of the Food Security Act of 1985 allows buffer strips, which do not meet erosion requirements, to be put in the reserve. No figures are available to differentiate in-field buffers such as grassed waterways from actual riparian zone buffers. The program is worth noting because of the precedent set for allowing conservation set-asides of land which focus on water quality needs rather than strictly erosion control needs. Given the present level of concern for water quality, expansion of this aspect of the Conservation Reserve Program may be possible in the 1990 Farm Bill. Two improvements which need to be made in the program are to require establishment of the native riparian vegetation and to make provisions for permanent acquisition of cropping rights.

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