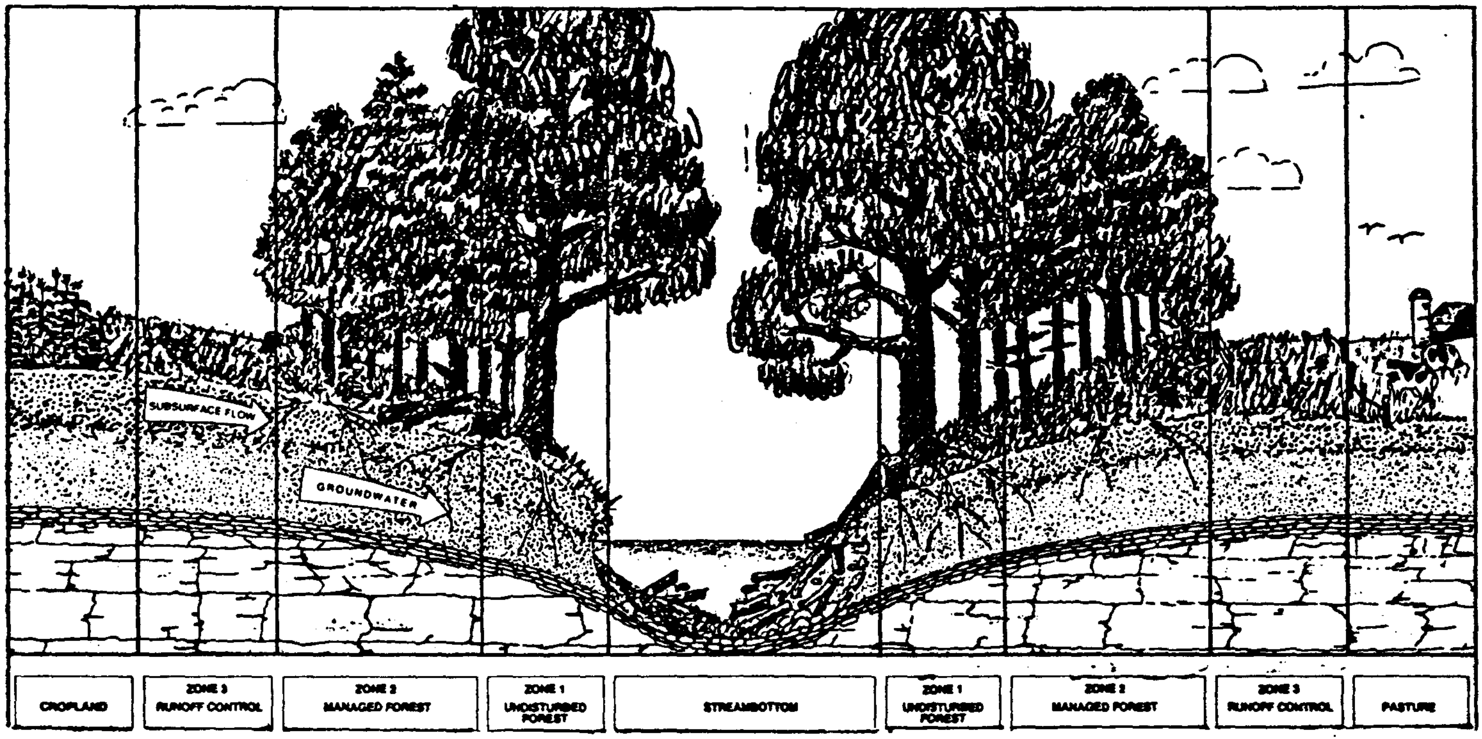
APES Report 93-17

Riparian Buffers for Water Quality Enhancement in the Albemarle-Pamlico Area



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"When streams are isolated from the riparian zone by channelization or vegetation removal, natural biogeochemical functions are impaired and riparian areas no longer function as sinks for nutrients. The development of land management and watershed programs that return sensitive riparian ecosystems to a more natural condition will facilitate an improvement in stream water quality."

Kovacic et al., 1990

EXECUTIVE SUMMARY

Definition and Functions

Riparian buffers are strips of land that intercept surface and subsurface flow from upland sources before it reaches bodies of water. Riparian buffers serve as

- Sinks for nutrients, which may be stored in biomass or soils
- Transformers of inorganic nitrogen in water to atmospheric nitrogen
- Filters for sediment in runoff
- Energy sources for the aquatic food chain
- An important component of aquatic and terrestrial habitat.

Status of Riparian Buffers in the Albemarle/Pamlico Study Area

A new analysis of land use/land cover data for the Tar-Pamlico Basin shows that approximately 75 percent of land within 100 feet of streams is forest or wetland. The percentage of streamside land in forest/wetland varies greatly, from 89 percent in the Fishing Creek watershed to only 40 percent in the Tranters Creek watershed. Riparian corridors have a higher percentage of undeveloped land in the Piedmont relative to the Coastal Plain, probably because of factors such as suitability for agriculture and urban development. Within a given watershed, long corridors can have little or no riparian buffer.

Protection/Restoration of Riparian Buffers

The responsibility for the watershed or basinwide protection and restoration of riparian corridors is currently shared by many public and private entities in North Carolina. State and Federal nonpoint source control programs have generally focused on upland or in-field best management practices rather than riparian corridor preservation. Some programs promote or require the use of streamside buffers in special areas (e.g., along High Quality Waters, in water supply watersheds, and along bodies of water receiving coastal stormwater from new development).

Voluntary incentive and disincentive programs exist, for example, under the Food, Agriculture, Conservation and Trade Act of 1990. While data are limited, it is thought that these programs have historically not been successful in corridor protection or restoration. New incentive programs exist, but funding is uncertain.

Accurate figures about the protected status of riparian corridors are not available. While high-value resources receive better protection, the spatial impact of these programs across the A/P Study area is quite limited. Wetland protection programs probably apply to at least half of the area within 100 feet of streams in the Coastal Plain, although small wetland tracts tend to be at greater risk of conversion than large tracts. More specifically, under Nationwide Permit 26, the Corps of Engineers and the Division of Environmental Management do not regulate wetlands <1 acre and $<1/3$ acre, respectively. Most riparian corridors in the Piedmont are not protected as wetlands. Regulatory programs are limited to filling and draining of wetlands, and do not address the non-mechanized clearing of wetlands.

Examples of riparian corridor restoration and protection from the U.S. Forest Service, Virginia, Maryland, and the Chesapeake Bay Program are provided.

Recommendations

Riparian buffers should be recognized as a key component of watershed management efforts. Immediate steps which could be taken to focus attention on riparian buffers include: holding workshops and convening workgroups; funding riparian corridor studies; including appropriate management actions in the Comprehensive Conservation and Management Plan (CCMP); funding development of educational materials and demonstration projects; updating technical assistance manuals and including a section in river basin plans on riparian buffers. The private sector can help by placing riparian lands in long-term easements and reserve programs.

Much of the recent discussion about buffer specifications has focused on buffer width. While this is certainly an important component, it is proposed herein that the ecological function and integrity of the buffer should serve as the overriding design concept. Specifications from the USDA Forest Service are provided as a potential model. The concept of watershed-wide riparian zone goals is also endorsed. Further recommendations for State and local initiatives are provided.

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RIPARIAN BUFFERS FOR WATER QUALITY ENHANCEMENT IN THE ALBEMARLE-PAMLICO AREA

What are riparian corridors and riparian buffers?

Riparian corridors are strips of land in transitional areas between aquatic and upland ecosystems which follow the course of flowing water. From a water quality management perspective, *riparian buffers* can be defined as areas designed to intercept surface and subsurface flow from upland sources for the purpose of improving water quality. Riparian buffers can also serve to improve the integrity of habitat for both terrestrial and aquatic species.

While this definition results in considerable overlap of buffers with wetlands in their spatial occurrence, it does not require that a buffer be classified as a wetland from a regulatory perspective.

It is important to point out that management of riparian buffers solely for water quality improvement can compromise other values and functions of riparian ecosystems. In other words, buffers should not be viewed as treatment systems. Kuenzler (1990) suggests that "stewardship of our resources requires protection of all values of our landscape units" and dedicating natural wetlands for buffers may result in other wetland values being considered as "strictly secondary and therefore expendable." While this report focuses on water quality values, it does not advocate compromising other resource values to satisfy water quality objectives. Rather, it is proposed that a watershed landscape with a riparian ecosystem designed and managed for water quality improvement can enhance other resource values as well.

How effective are riparian buffers in reducing nonpoint source loading?

The effectiveness of riparian buffers in reducing pollutant loadings depends on many factors, and generalizations can therefore be misleading. Depending on the buffer design and local characteristics, effectiveness can be quite variable. Very high pollutant removal rates have been observed for riparian buffers in North Carolina and elsewhere (Dillaha et al., 1986; Heatwole et al., 1991; Jacobs and Gilliam, 1985; Kovacic et al., 1990; NCASI, 1992). Key characteristics which influence effectiveness are related to topographic, vegetative, hydrologic and soil properties. Even within a relatively small subregion of the Albemarle-Pamlico (A/P) area, these characteristics can vary considerably (Phillips, 1989a, b, c).

While several mechanisms result in assimilation of nutrients in runoff, denitrification, or the biologically mediated process of converting dissolved inorganic nitrogen to elemental gaseous nitrogen, is considered by many to be an especially important process responsible for reducing total nitrogen concentrations in water, particularly in the Coastal Plain. Conditions in the Albemarle-Pamlico region are very conducive to this process when the nitrogen-rich runoff waters are allowed to pass through saturated organic soils (ideally) or through channels with reducing conditions in the sediments. Denitrification is most effective when water is stored in these environments between storm events. Phosphorus removal is a function of different mechanisms. Phosphorus must either be sequestered by the vegetation or attached to particles of sediment and immobilized in the soil. Regardless of the pollutant removal mechanism, removal efficiencies are reduced during storm events because of rapid water conveyance.

The effectiveness of the buffer for pollutant removal also depends on the path water takes through the buffer area. Ideally, uniformly distributed flow allows for maximum interaction of pollutants with soils and plant roots. However, preferential water flow — the movement of a relatively large proportion of the water through a relatively small area of the buffers — can reduce the buffer removal efficiency. A study on 30 farms in Virginia indicated that 60 percent of the flow was "concentrated" (Dillaha et al., 1986).

Artificial drainage involving ditches or drainage tiles and canals is common in the Coastal Plain of North Carolina to lower water tables and prevent the drowning of crops. Since the nature of these systems is to speed up normal infiltration and runoff mechanisms and pass water as rapidly as possible into receiving bodies of water, artificial drainage practices can greatly increase loading to receiving waters. For example, Lowrance et al. (1984) found that nitrate nitrogen loads from drained row crop fields were about 60 times greater than from undrained lands in a 1,568-hectare watershed near Tifton, GA. Jacobs and Gilliam (1985) found nitrate nitrogen concentrations of 10 mg/l in water from tube-drained fields. Drainage practices can therefore significantly reduce the filtering and nutrient transformation capacities of a vegetated buffer area if drainage water is routed directly to receiving streams.

However, even where artificial drainage is widely used in a region, wetlands and buffers may still provide dramatic nutrient reductions in a watershed. Jacobs and Gilliam (1985) sampled a 7,000-hectare watershed (Creeping Swamp; 25 percent cropland) in the Outer Coastal Plain. The downstream mean nitrate nitrogen concentration was <0.1 mg/L over 3 years. This extremely low level was the result of a combination of factors, including denitrification in field-edge ditches and an extensive intact riparian wetland buffer system. Where riparian wetlands are not available (e.g., have been converted to agriculture), a buffer can still provide other functions such as stabilizing streambanks and providing habitat. However, reductions in pollution loadings will, of necessity, rely heavily on upland in-field best management practices (BMPs).

Why are forest ecosystems an important component of riparian buffers?

The term "riparian buffer" refers to the streamside zone without specifying particular ecological characteristics of the buffer. *Forested riparian buffers* (or *streamside forests*), which can be defined as riparian buffers with a functional forest system, are advocated as an important landscape feature in watersheds where upland activities result in elevated pollutant loadings.

Prior to colonization, the Albemarle-Pamlico watershed was almost entirely covered by forested land. Today, it is estimated that a little over half of the Albemarle-Pamlico watershed remains forested (based on LANDSAT data; see Khorram et al., 1991); much of the runoff potentially bypasses forests and their purifying processes. The creation of impervious surfaces and stormwater drainage systems in association with urban and suburban development also reduces the ability of forests to filter contaminants in runoff waters.

The use of forested zones near streams has long been recognized as an appropriate strategy for improving water quality. Depending on the context, such zones have been called buffers, filters, streamside management zones, or greenways.

Forested riparian buffers should be clearly distinguished from vegetative or grassed filter strips (a frequently recommended best management practice to reduce nonpoint source pollution). Forested riparian buffers are generally more effective than grassed filter strips because they

- *Filter sediment and associated pollutants.* Because of the composition of the forest floor (i.e., extensive litter and root system and rigid woody material), forested buffers are usually more efficient sediment traps than grassed filter strips, which can become clogged with sediment over time, and when fertilized, can serve as pollution sources.

- *Transform pollutants to maintain natural biogeochemical balances and reduce toxicity.* The streamside forest can sequester nutrients in plant biomass for long periods of time and can convert inorganic nitrogen in runoff into atmospheric nitrogen (see sidebar). The streamside forest can also convert toxic residues from pesticides into nontoxic compounds.

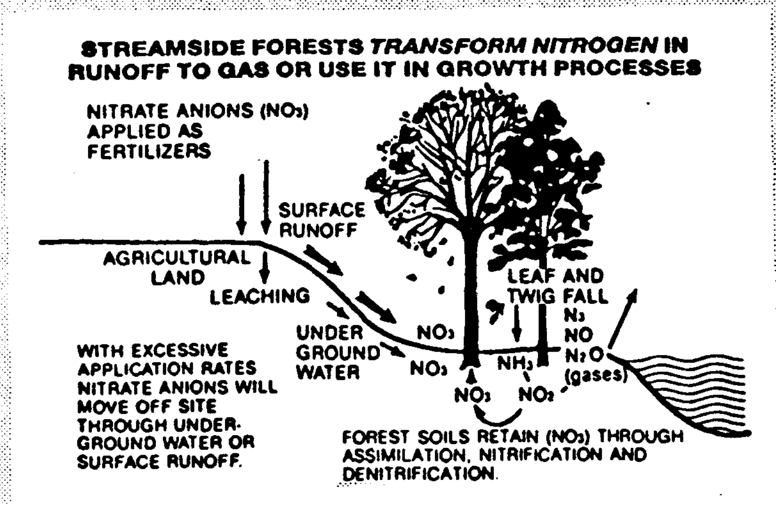
Nature Provides Safe Storage for Nutrients in Biological Cycles

The basic elements that occur in nature move through the environment in a series of naturally occurring chemical and biological states, a process commonly referred to as a cycle. The cycle describes the state, chemical form, and relative abundance of the element at each point along its route through the environment. There is usually a state, chemical form, and location in the cycle in which nature safely stores the bulk of the element. In the case of the nitrogen cycle, the bulk is stored as nitrogen gas in the atmosphere. Pollution occurs when, through societal interference, an element occurs at some point in the cycle in an inappropriate form or amount, thus disrupting the environmental balance.

Nitrogen and phosphorus, elements essential to plant growth, move through the environment in such cycles. Fertilizers and animal wastes both contain nitrogen and phosphorus. When these elements are applied to crop and pasture lands in amounts in excess of plant needs, they can "leak" from the agroecosystem and adversely affect water quality (see figure).

Phosphorus, the less mobile of these two nutrients, is quickly bound to soil particles or taken up by plants. Because about 85% of phosphorus is bound to soil and organic particles, eroding sediments and organic materials borne by runoff are the chief sources of phosphorus in water.

In contrast, nitrogen from fertilizer and animal waste is soluble in water as nitrate, and not held by soil particles. Nitrate ions, which are not taken up by plants or converted to gaseous forms by microbial action, can leach downward through the soil into the groundwater or move laterally with the surface and subsurface flow to contaminate surface waters.



Source: USDA Forest Service, 1992.

- *Improve aquatic habitat and biological integrity.* Streamside forests improve aquatic habitat by stabilizing temperatures, providing structural materials such as large woody debris, providing energy in the form of organic matter (e.g., insects for fish and detritus for aquatic invertebrate), and stabilizing sediment flux.

Forested riparian buffers are a highly cost-effective supplement to traditional BMPs. Runoff from agricultural and developed land in general has higher concentrations of nutrients, sediments, and other pollutants than runoff from forest, regardless of how well the land is managed. This happens because agroecosystems and urban ecosystems characteristically "leak" much higher amounts of nutrients as a result of application of fertilizers and manure, the inefficiency of nutrient uptake in monoculture cropping, and changes in the landscape that decrease the retention time of water.

Finally, it is useful to distinguish between riparian areas with healthy undergrowth and a thick litter cover and park-like woodlands, which may have compacted, low-infiltration capacity soils. Where such woodlands exist, it is important to realize that riparian buffering efficiency may be reduced.

What is the status of forested riparian buffers in the A/P Study Area?

We used geographic information system (GIS) technology and existing data to analyze riparian buffers in the A/P region. Specifically, we

1. Identified surface water features (double line rivers and perennial and intermittent streams in EPA's River Reach File (Version 3) and land use/cover in the watershed from 1987/88 LANDSAT data (Khorram et al., 1991) (LANDSAT data are the only areawide GIS coverage available)

2. Created buffers of 100-1,000 feet (in each direction) along surface waters (a minimum buffer size of 100 feet was chosen based on the resolution of the land use/land cover [LU/LC] data)

3. Overlayed the buffers on LU/LC data, and

4. Calculated the percentage of land within the buffer that is in each LU/LC.

Buffers were created for each subbasin in the Neuse and Tar-Pamlico basins. LU/LC categories were aggregated so that categories for forests and wetlands as defined by Khorram et al. (1992) were considered to be forested buffers (virtually no emergent wetlands occur in the area studied), and categories for agricultural and developed lands were considered to be lands without forested buffers. The resolution and classification of the LANDSAT data prohibited their use for studying grassed filter strips.

A higher percentage of stream miles do not have forested buffers in the lower Tar basin than in the upper basin (Figures 1 and 2 and Table 1). The extent of forested buffers varies widely among watersheds. The Tranters Creek watershed has the poorest natural buffer system (60 percent of land within 100 feet of streams is not classified as forest/wetland), and the Fishing Creek watershed has the best protection (only about 10 percent unbuffered). Topography may explain some of this variation: in the Piedmont, slopes may preclude clearing of streamside forests to the degree found in the flatter Coastal Plain. Higher agricultural productivity of streamside land in the Coastal Plain may also explain this pattern.

It is also important to point out that the amount of the watershed within the 100-foot buffer is only about 5 percent of the total watershed area. One implication is that nonpoint source control programs should be able to more readily geographically focus their efforts in these areas than in large landscapes like river basins or counties.

In addition to studying basinwide patterns, GIS tools also provide an ability to identify individual stream reaches where lack of riparian buffering may warrant special attention. Figure 3 indicates that little or no riparian buffer exists in the western branch of the Conetoe Creek watershed.

Another example of how GIS analyses can be used to study landscape-scale patterns is to compare landscape features (e.g., land use/land cover) across different sized buffers. Figure 4 demonstrates the tendency for land further away from surface waters to be more intensively used. Agricultural, developed, and shrub/scrub land is relatively less abundant for smaller buffer areas that represent lands in closer proximity to linear hydrologic features. Nevertheless, a substantial proportion of area within the smallest buffer (100 feet) is identified as agricultural land. A reverse pattern is observed for forest land and wetlands classifications. These classes are relatively more abundant closer to rivers and streams. There is a clear pattern in all subbasins identifying land use in the 100-foot buffer as the most different from the entire subbasin, with land use in the 1,000-foot buffer as the most similar. Little effect of buffering at the 1,000-foot distance is observed.

A final example of how GIS analyses might be used is in periodic studies of changes in environmental quality within riparian corridors. The net effect of wetlands conservation efforts, development, and changes in agricultural practices are possible topics of interest. This effort would require periodic updates of key data.

Figure 1. Percentage of Land in 100-foot Riparian Corridor Not Classified as Forest or Wetland, Tar-Pamlico Basin

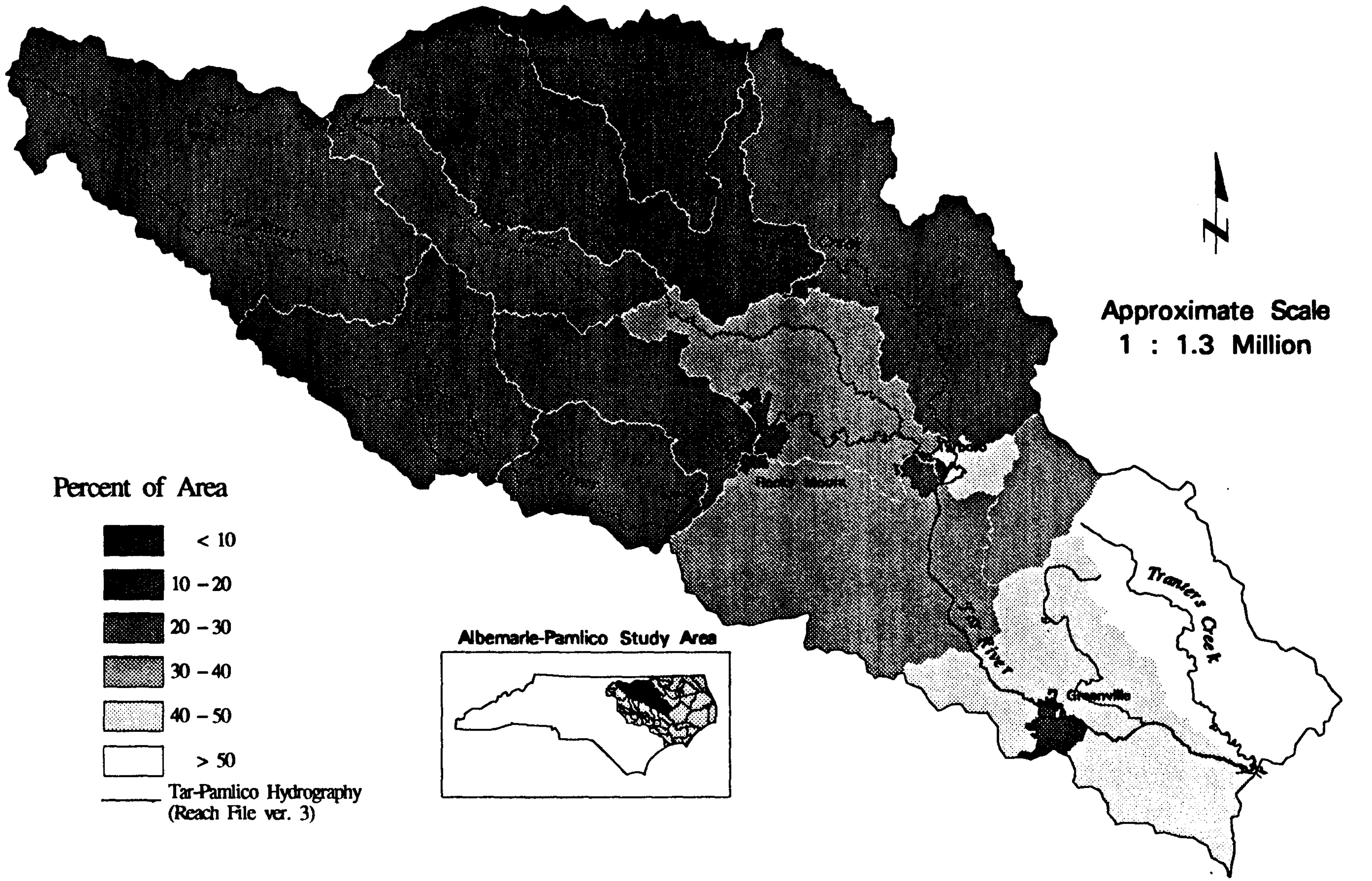


Figure 2. Percentage of Land Within 100 Feet of Streams Categorized as Agricultural or Developed

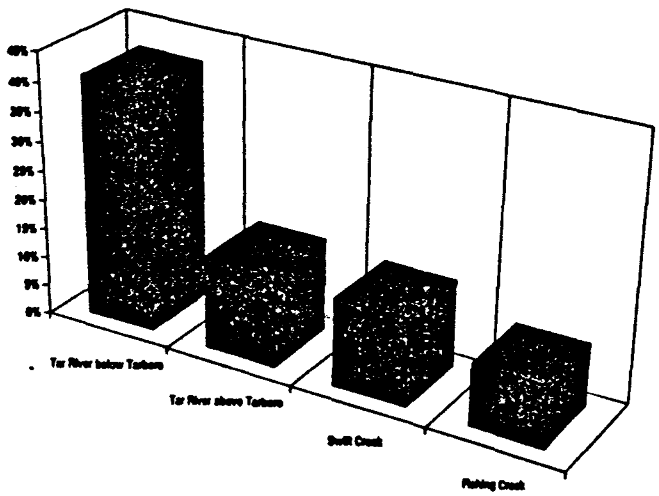
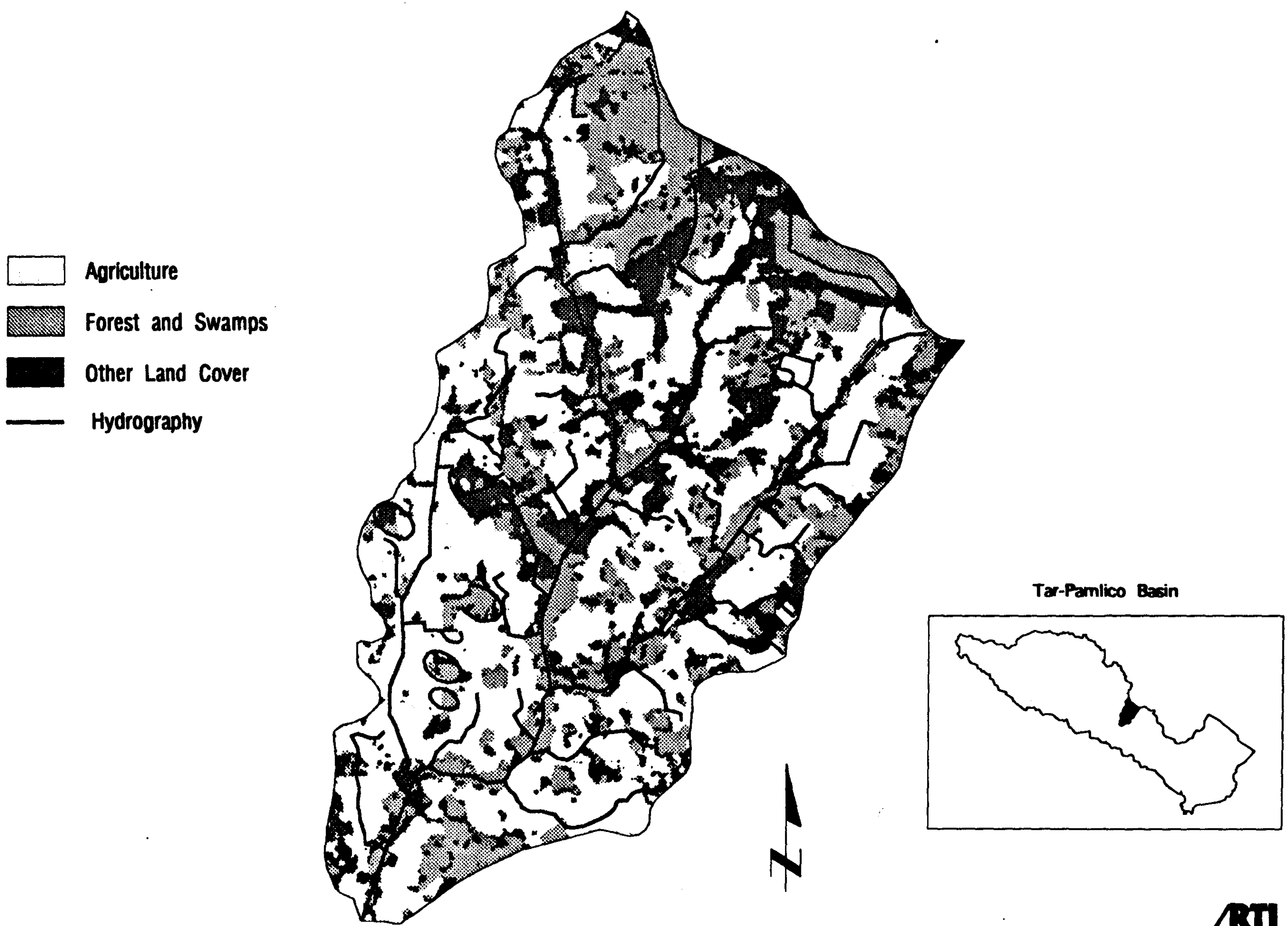


Table 1. Results of Land Cover GIS Buffering Analysis

Polygon	NCDEM Subbasin	Subbasin Name	Total Area (km²)	% total in 100 ft. buffer	% unbuffered
1	030301	Tar River Headwaters	1,123	3%	17%
2	030301	Tar River Headwaters	599	6%	17%
3	030302	Tar River Headwaters/Sapony Creek	532	5%	30%
4	030302	Upper Swift Creek	427	6%	16%
5	030302	Swift Creek	380	6%	15%
6	030302	Stony Creek	313	5%	14%
7	030303	Middle Tar River	61	6%	46%
8	030303	Conetoe Creek	184	3%	30%
9	030303	Middle Tar River	853	5%	27%
10	030304	Fishing Creek	910	5%	9%
11	030304	Fishing Creek	947	3%	17%
12	030304	Little Fishing Creek	461	5%	6%
13	030305	Lower Tar River	767	4%	43%
14	030306	Tranters Creek	631	4%	60%
		Total	8,188	4%	23%

Figure 3. Land Cover in Conetoe Creek Subbasin



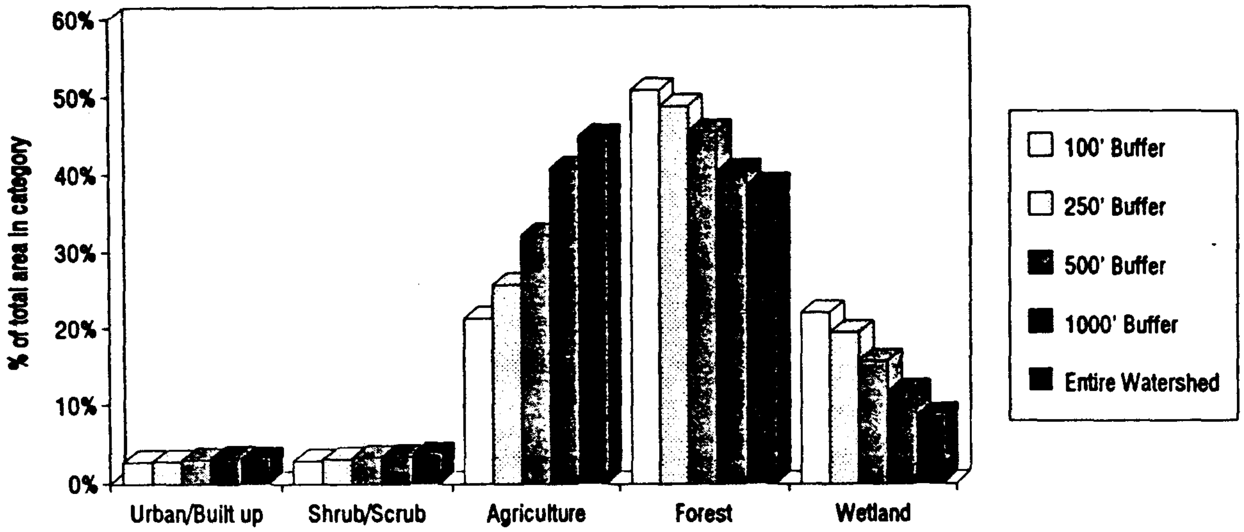


Figure 4. Summary of GIS Hydrologic Buffering Analysis: Neuse and Tar-Pamlico River Basins

How should riparian corridors be managed to enhance water quality?

The USDA Forest Service (1992) has prepared an informative publication entitled *Riparian Forest Buffers*. The document defines separate zones that perform various critical ecological functions. Forest Service specifications for forest buffers are summarized below.

As shown in Figure 5, the Forest Service recommends that buffers consist of three zones: an undisturbed forest, a managed forest, and a zone for runoff control. These zones should be designed to filter surface runoff occurring as sheet flow and downslope subsurface flow which occurs as shallow groundwater. Together, the zones should encourage uniform flow and infiltration while impeding concentrated flow. Uniform flow and infiltration enhance soil/water contact, thus increasing the buffering and filtering capacity of the soil.

Beginning at the streambank is Zone 1, undisturbed forest, which should create a stable ecosystem adjacent to the water's edge and provide soil/water contact areas to enhance pollutant removal. Runoff must enter Zone 1 as sheet flow or subsurface flows. Outflow from ditches and subsurface drains must not be allowed to pass through the riparian forest in pipes as this would circumvent the treatment process.

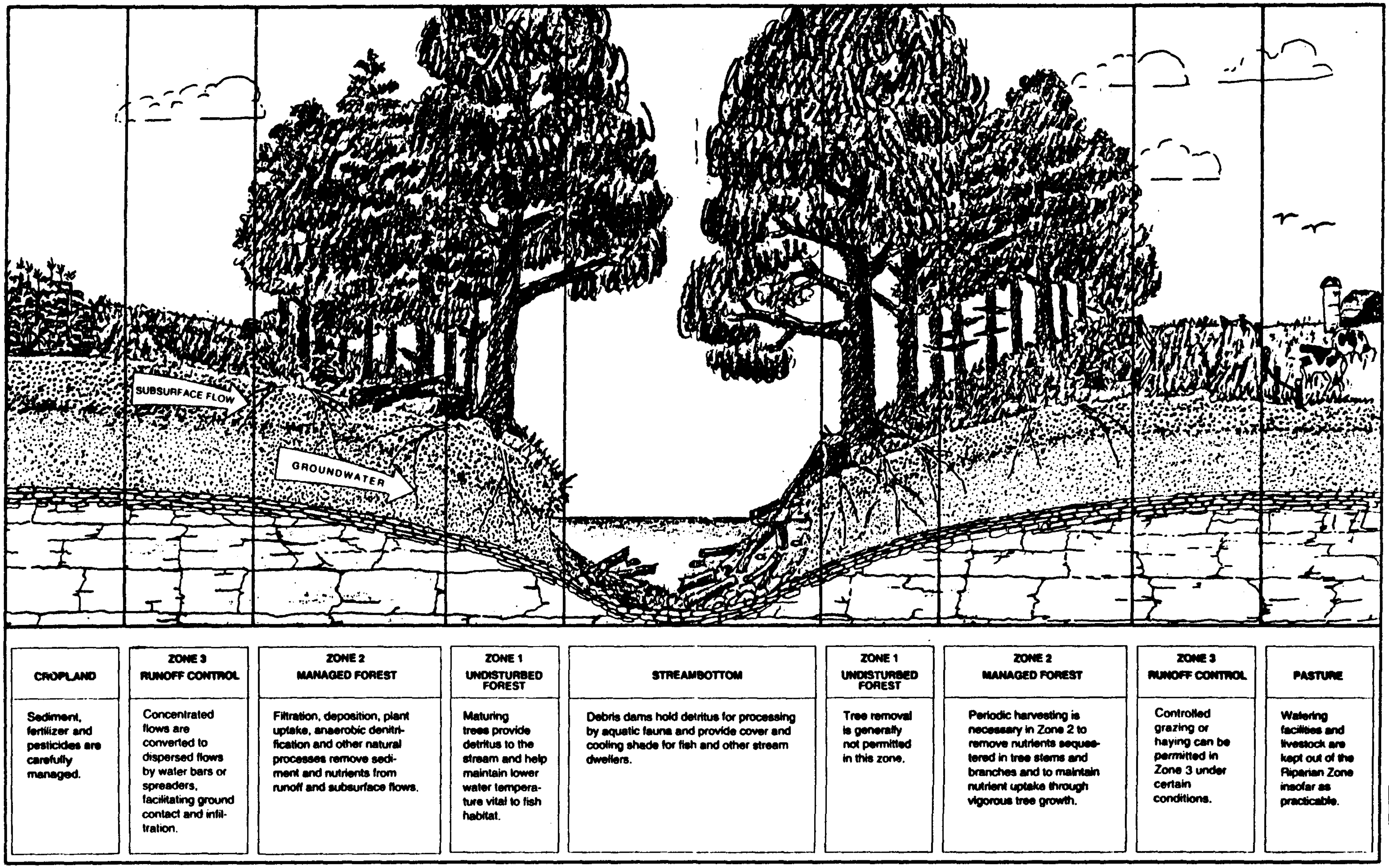


Figure 5. The Streamside Forest Buffer

For best results, Zone 1 should be composed of a variety of native tree and shrub species. A mix of species provides consistent leaf fall necessary to meet the energy and pupation needs of aquatic insects. Large, overmature trees contribute valuable detritus and woody debris and provide shade from sunlight and habitat structure for aquatic species. In addition to filtering and buffering, Zone 1 also provides streambank stabilization. For this reason, livestock, overland equipment, and logging activities should be excluded except in areas where there are specifically designed stream crossings or stabilization maintenance work is required.

Zone 2 should begin at the edge of Zone 1 and provide contact time, a carbon energy source for buffering processes, and long-term storage of nutrients in the form of forest trees. As with Zone 1, runoff and wastewater flows should be converted to sheet or subsurface flow prior to entering Zone 2. To achieve the highest efficiency, Zone 2 should be composed of native riparian trees and shrub species; however, nitrogen-fixing species are discouraged in areas where nitrogen removal or buffering is desired. Management practices should include periodic harvesting and timber stand improvements to maintain vigorous growth and leaf litter replacement. Harvesting also serves to remove nutrients and pollutants stored in the form of wood in tree trunks and large branches. Management for wildlife habitat, aesthetics, and timber is possible. State and Federal forestry agencies should be consulted for selection of appropriate logging equipment if necessary. Except for designated stream crossings, livestock should not be permitted in Zone 2.

Continuing upslope, Zone 3 should provide for sediment filtering, nutrient uptake and enough space for converting concentrated flow to uniform, shallow, sheet flow. Techniques such as grading and shaping or devices which include diversions, basins, and level lip spreaders may be used for flow conversion. For optimal filtering, Zone 3 should consist of dense grasses and herbaceous plants. Mowing and removal of clippings is necessary to recycle sequestered nutrients, promote healthy sod, and control weed growth. Maintaining vigorous growth of vegetation in Zone 3 must take precedence and may not be compatible with wildlife needs. As long as earthen water control structures are not damaged, Zone 3 may be used for controlled intensive grazing.

In addition to maintaining the riparian buffer, it is also important to manage lands adjacent to the buffer zone. Fertilizer and pesticide applications to nearby cropland should be carefully controlled. Erosion control practices should also be used to reduce sediment delivery to the buffer zone. Livestock grazing and watering facilities should be excluded from the riparian zone as much as possible.

How wide should buffers be?

The necessary buffer width for a given environmental goal can be quite variable (NCASI, 1992; Phillips, 1989a, b, c, d). Table 2 indicates the variability of recommendations for buffer strip sizes for different purposes. Phillips (1989a, b) applied models to determine recommended buffer sizes. In Carteret County, a model for solid-phase pollutants indicated that a minimum shoreline setback of 50 feet was warranted for treating sediment. However, a much larger buffer (260-265 feet) was recommended for dissolved pollutants. In another study, Phillips demonstrated that a range of buffer widths of 60 to 860 feet was necessary to achieve 30 percent nitrogen and phosphorus removal, representing the variability in conditions affecting nitrogen removal.

These results suggest that determining the appropriate buffer size or width is highly site specific, and depends not only on environmental factors but on environmental goals and values. These sources and other literature reviewed for this report also suggest that the 25-foot minimum buffer size recommended for the CCMP is smaller than researchers and agencies usually recommend. As pointed out above, the total width is one issue, but strata can also be identified within the total width which distinguish among appropriate ecological functions in different "zones".

As an alternative (or supplement) to specifying a minimum buffer width, which is difficult because of the desired site-specific planning and implementation and land control issues, it is proposed that watershed-wide goals for the establishment of buffers be adopted. For example: a goal in terms of percent cover in forest or wetlands could be established, either on an areawide basis, or on a watershed-specific basis. This approach could be amenable to concepts such as trading, transfer, or purchase of development rights and mitigation banking, and would help focus attention away from parcel-based watershed management to landscape-based watershed management. Some existing programs that could deal with this concept are discussed in the following section.

How is the concept of riparian buffers being applied in the A/P Study area?

Table 3 provides a brief review of existing incentive and regulatory programs. This review suggests the following:

- Riparian management "falls through the cracks" of current government initiatives. There are currently no clear laws, regulations, programmatic guidelines, or technical specifications directed specifically at watershed or basin-scale protection of existing riparian buffers as defined herein.

Table 2. Summary of Literature Recommendations for Buffer Strip Sizes and Streamside Management Zones for Water Quality Protection

Width, m (feet)	Purpose	Source
7-8 (22-26)	Water quality	Doyle et al., 1975, Ultisol in Maryland, 35-40% slope
11 (35)	Water quality (Primary Streamside Management Zone)	Florida Division of Forestry 1990
91 (295)	Water quality (Streamside . discretionary zone--area most influential for surface water quality)	Ibid
23-30 (75-95)	Protection of stream ecosystem	Corbett et al., 1978, as cited in Corbett and Lynch, 1985
8 (26)	Water quality	St. Tammany Parish, LA, 1988 (as cited in Howard and Allan, 1988)
11 (35)	Water quality (small streams)	Scott Paper Co., 1988 (as cited in Howard and Allan, 1988)
12-24 (40-80)	Water quality	South Carolina Forestry Commission, 1988 (as cited in Howard and Allan, 1988)
31 (100)	Water quality (large streams and rivers)	USDA, 1980 (as cited in Howard and Allan, 1988)
8-9 m (26-30 ft) minimum +0.6 for every 1% slope	Sedimentation of stream for general recommendations	Ibid
16-17 m (50-55 ft) minimum +1.2 for every 1% slope	Sedimentation of stream for municipal watersheds	Ibid
7-50 (22-160)	Sedimentation for general forest management	Trimble and Sartz, 1957, dependent on slope
14-100 (45-325)	Sedimentation for municipal watersheds	Ibid
9-103 (30-330)	Sedimentation	Ibid

Width, m (feet)	Purpose	Source
25-125 (80-400)	Sedimentation from developed upland area	Brown et al., 1990, dependent on the nature of the sediment (sand vs. silt)
30 (95)	Aerial application of herbicides; protection of streams, lakes, wetlands, etc. Coastal Plain/Piedmont	USDA Forest Service (1989)
9 (30)	Ground application of herbicides; protection of streams, lakes, wetlands, etc. Coastal Plain/Piedmont	Ibid
30 (95)	Aerial and ground application of herbicides; protection of municipal and domestic water supplies. Coastal Plain/Piedmont	Ibid
91 (295)	Aerial and ground application of herbicides; protection of private residences. Coastal Plain/Piedmont	Ibid
9 (30)	Operation of mechanical equipment; protection of streams, lakes, wetlands, etc. Coastal Plain/Piedmont	Ibid
9 (30)	Construction of firelines; protection of streams, lakes, wetlands, etc. Coastal Plain/Piedmont	Ibid
16 (50)	Water quality. Maryland	Eberling (1992)
15-80 (45-260)	Remove 90% of NO_3 from runoff typical of 50 acres of row crop on poorly drained soils. 50 m recommended as "single figure minimum"	Phillips, 1989
104 (335)	Water quality and wildlife habitat (large streams and rivers)	USFWS, 1988

Table 3. Existing Programs with Potential to Protect or Restore Forest Buffers

Incentive or Regulatory Program	Protected/Potentially Protected Areas	Effect on Riparian Buffers in A/P Study Area
North Carolina Water Supply Watershed Rules	Protects 100-ft buffers along each side of perennial waters for high-density development in water supply watersheds. First 25 ft of buffer left in natural or established vegetation.	Strong, localized protection for selected watersheds (e.g., Falls Lake and Buckhorn Reservoir). Accounts for relatively small percentage of A/P land area.
Coastal Stormwater Rules	Provide setbacks of 25 or 30 ft from surface waters; also, allow use of 30- to 50-ft buffers to treat stormwater from new development. Rules do not specify forested buffers.	Localized protection in coastal areas under development pressure (i.e., new construction). No protection of buffers adjacent to forestry and agriculture.
High Quality Waters (HQWs)	30-ft buffers in natural or established vegetation between built-upon areas and surface waters are one component of protective strategies for HQWs.	Protective of these important bodies of water, but only a small percentage of A/P waters are classified HQWs.
Wetland protection under CWA Sections 401 and 404	Theoretically, protects forest buffers that are classified as wetlands under Section 404. Areas less than 1 acre can be converted to nonwetland uses without a special permit, although projects greater than 1/3 acre are subject to 401 review by NCDEM. Conversions of 1 to 10 acres fall under a nationwide permit; those greater than 10 acres receive intense Federal review and are often not granted the required individual permit.'	No analysis has been done; wetland maps are still under preparation for much of A/P area. For discussion purposes: minimal protection of 100-ft forest buffers in the Piedmont because perhaps only one-fourth of land within 100-ft buffers is Section 404 wetlands. In Inner Coastal Plain, perhaps half of the forested land within 100 ft of bodies of water is 404 wetlands; in Outer Coastal Plain, perhaps 75 percent.

Incentive or Regulatory Program	Protected/Potentially Protected Areas	Effect on Riparian Buffers in A/P Study Area
USDA Conservation Reserve Program (CRP)	Agricultural land adjacent to bodies of water from 66 to 99 ft wide can qualify for 50 percent cost share plus rental payments to establish permanent vegetative buffer. However, program emphasis has been on retiring highly erodible fields and not streamside land.	Minimal impact to date due to low landowner participation, especially for streamside land; as of 2/91, only 104 acres in NC were devoted to buffers through CRP. Future potential could be significant.
USDA Wetlands Reserve Program	Provides payments to landowners for returning agricultural land to wetlands. Upland buffer areas, natural wetlands, and riparian areas along bodies of water may also be eligible if they link restored wetlands.	NC was a pilot State in 1992. Only 4,713 acres accepted on 6 farms. Future potential for protection and restoration of forest buffers not clear.
USDA Environmental Conservation Acreage Reserve Program (ECARP)	Provides funding to help establish the Wetlands Reserve Program (WRP) using 15 to 30-year easements. Could be used in forest buffers that have wetland features.	Program has not received full congressional funding. Considerable potential and with far greater applicability to A/P area than the Farm Bill's CRP program for highly erodible soils.
NC Forest Practice Guidelines	Streamside management zone along each side of intermittent and perennial streams and perennial bodies of water. Widths are from 50 to 200 ft depending on waterbody type. Logging is allowed but certain practices are restricted.	Does not prevent conversion of forest buffer to other uses such as agriculture or urban. However, as long as forestry remains the buffer's use, offers voluntary protection against certain practices that affect the buffer's functions.
Greenways or Stream Corridors	Forest buffer is generally protected or restored; size of buffer varies according to local ordinance or amount of land purchased or under easement.	More than 40 communities in NC have programs (e.g., Raleigh Greenway system; Eno River corridor). Impact on A/P estuaries likely is low because of small number of stream miles protected or restored.

Incentive or Regulatory Program	Protected/Potentially Protected Areas	Effect on Riparian Buffers in A/P Study Area
1990 Coastal Zone Management Act Reauthorization	Coastal counties	Requires implementation of management measures to control nonpoint sources. Riparian protection is among the measures in recent guidance.
Basinwide Planning/Total Maximum Daily Load Process Under CWA Section 303(d) TMDL Process	No explicit provisions for forest buffer protection. Emphasis is on point source controls and onsite or upland BMPs to achieve water quality standards. Some States are using the TMDL process to restore degraded aquatic habitat.	Minimal at present, but protection or restoration of forest buffers could become important to the TMDL process. Under the EPA's phased TMDL approach further actions could be required if BMPs prove inadequate to achieve water quality standards. Aquatic habitat protection, a value provided by forest buffers, may also receive increased emphasis.
Sale, donation or easement by private landowner	Area protected or restored depends on the wishes of old and new landowners.	A few large donations and sales have protected forested buffers in the A/P study area (e.g. Roanoke River floodplain; Alligator River National Wildlife Refuge). Otherwise, relatively small acreage protected in this way.
CWA Section 319 Nonpoint Source Program	Forested buffers are a potential BMP in 319 watersheds, but are not widely encouraged or funded.	Minimal. Section 319 watershed projects are intensive but cover only a small percentage of the A/P Study area.

Source: NCDEM, 1991; J. Dorney, 1993; USDA, 1993; USEPA, 1993.

Most of the remaining riparian forest has probably been spared conversion because of physical and economic factors such as topography and soil suitability for crops.

- The Section 404 and 401 wetlands protection programs probably offer *protection* of the largest amount of riparian buffer acreage against conversion or development. This protection is thought to be very limited in A/P watersheds in the Piedmont and somewhat limited even in the Coastal Plain.

- Selected highly valued ecosystems (e.g., Alligator River, Roanoke River) are being protected through both public and private initiatives.

- There appears to be limited movement toward *restoring* riparian buffers. Incentives under the Farm Bill may offer the best governmentally-supported opportunities for the future, but restoring buffers does not appear to be a high priority, and funding is uncertain.

How are other nearby States addressing protection and restoration of buffers for water quality enhancement?

The concept of forested riparian buffers for water quality protection is beginning to be adopted in several mid-Atlantic States. Examples from Virginia, Maryland, and the Chesapeake Bay Program are provided.

In 1988, the Virginia General Assembly passed a set of regulations that require local governments within the Tidewater region to establish a minimum buffer area adjacent to Resource Protection Areas and their tributary streams. The standard minimum width is set at 100 feet, which assumes a reduction of 40 percent of the nutrients and 75 percent of the sediment entering the protected area. If this minimum width cannot be met, then BMPs must be used to achieve an equivalent level of water quality as that produced by the 100-foot buffer. The Virginia Agricultural BMP Cost Share Program helps finance buffer establishment. The program will pay 10¢ per linear foot of grassed buffer length, provided the buffer averages 20 feet in width with a minimum width at any point of 10 feet. For a wooded buffer area, which must be maintained for at least 10 years, the state will pay $100 per acre. Depending on the soil and slope conditions, the widths of these buffers may range from 50 to 150 feet.

In a review of the Virginia regulation, Heatwole et al. (1991) point out that "due to the lack of specific design criteria and the site-specific nature of vegetative filter strip effectiveness it is unlikely that [the regulations] will result in significant improvements in water quality." The authors further state that "most surface runoff will collect in ephemeral drainageways", greatly reducing the effectiveness of the regulation. Another problem pointed out is that the regulation assumes that technical methods exist to estimate the effectiveness of 100 foot buffers.

The State of Maryland established buffer width requirements as part of a statewide nontidal wetland program. Buffers adjacent to these wetlands can range anywhere from 25 to 100 feet, depending on soil type and slope gradient. Some forestry and agricultural activities are exempt from this regulation, while those that are not exempt must have approved pollutant control plans. Like Virginia, Maryland has instituted a cost-share program which will pay a farmer up to 87.5 percent of the cost to implement a filter strip. The USDA Soil Conservation Service takes part in this program by providing technical assistance in designing the filter strip. Maryland has also enacted water quality protection programs specific for the Chesapeake Bay. The Critical Area Law requires special water quality protection efforts within a 1,000-foot strip of land around the Chesapeake and its tidal areas. In 1988, the Maryland Forest, Park, and Wildlife Service created the Green Shores Program to establish forest buffers of at least 50 feet around the Chesapeake Bay and its tributaries.

Special water quality protection recommendations for the Chesapeake Bay have also been provided by the Forestry Work Group of the Non-Point Source Subcommittee, Chesapeake Bay Program (1992). This group promotes the integration of forest buffers into residential and commercial development as well as farm planning, operation and management. In order to accomplish this goal, the Forestry Work Group advises the review of land use ordinances to ensure that forest buffers are retained or restored during residential and commercial development. The group also stresses the importance of coordination between Federal and state agencies to establish a forest buffer system throughout the Chesapeake Bay watershed.

What are the major policy issues associated with the use of riparian buffers in the A/P area?

1. *Incentive and disincentive programs exist, but need to be carefully coordinated to bring diverse resources and interests to bear to establish and protect riparian buffers*

The fullest possible use of existing incentive programs to protect or restore riparian buffers is important. These can involve Federal or State cost-share programs or incentives such as tax writeoffs. For instance, cost-share money to provide alternative watering supplies for livestock may overcome objections to fencing off an area. Reductions in property taxes for land used as a buffer (e.g., linked to conservation easement provisions) can also be a helpful incentive.

Such programs are often easier to organize where rural areas are close to urbanized or rapidly urbanizing areas. The recreational and open space values of the rural countryside creates incentives for greater land and water quality stewardship. Linear parks and greenways can easily be adapted to such regions (e.g., the Eno River State Park corridor). The proximity of urban and rural areas also creates the potential for successful pollution trading systems, as in the Tar-Pamlico Basin.

Perhaps the greatest challenges involve regions that are predominantly rural and also lack obvious core areas of public lands or parks. If State programs are not well equipped to provide tax writeoffs or cost-share incentives to preserve or establish riparian buffers, then the burden falls on Federal programs, mainly those promoted by agencies in the USDA. The 1985 Farm Bill created a series of economic disincentives for converting wetlands to farmland. Revisions added under the Food, Agriculture, Conservation, and Trade Act of 1990 created a much broader range of potential water quality incentives. The Environmental Conservation Acreage Reserve Program (ECARP), the Wetlands Reserve Program, and the Conservation Environmental Easement Program (CEEP) allow payments to farmers willing to place riparian areas or other sensitive areas under easement agreements for periods of 15 to 30 years. The concept is similar to the CRP established under the 1985 Farm Bill, but seeks to provide special mechanisms to promote water quality objectives and encourage the establishment of permanent wooded land covers.

Full funding for these new Farm Bill programs has not yet materialized. Another major problem in using such programs for establishing a geographically targeted set of forested buffers is that the Farm Bill's conservation thrust is on crops and land uses falling under commodity support programs. (For instance, there are commodity programs for corn or wheat but not for sweet potatoes. Supports are provided for dairy operations but are absent for most confined animal feeding operations.) The possibility of losing other USDA support benefits (e.g., FmHA loans) is often an inducement for farmers to set up general purpose conservation plans, but, in areas lacking highly erodible soils or where major commodity crops are uncommon it may be hard to make the USDA programs the backbone of an incentive system for forested buffers.

2. *Buffer protection/restoration will conflict with landowners desires to pursue intensive uses*

For a buffer zone to provide an optimal level of ecological services, the buffer cannot be subjected to intensive uses. This should be understood and carefully explained to landowners. Access should be carefully controlled to minimize traffic from heavy equipment and from frequent movement of pedestrians or livestock. Frequent traffic creates ruts, footpaths, or other surface alterations that act in a manner similar to ephemeral watercourses under wet weather conditions. To prevent this sort of short-circuiting effect, forested buffers must generally be fenced off to livestock, and frequent use of heavy machinery and traffic must be limited. Timber can be harvested (using thinning techniques for mature trees -- not large area clear-cuts), and a limited number of mowings of meadow forbs and grasses can be carried out each growing season. The buffer zone can also be used for hunting and as access for bank-fishing.

Phillips (1989d) completed a modeling analysis with important implications for establishing buffer specifications. The study concluded that

> *"Implementing riparian vegetative buffers would likely affect land use only on a very local spatial scale, with limited influence on the broad-scale patterns of land use. Any significant changes in riparian land use dictated by buffer establishment are consistent with existing land-use incentives and disincentives in U.S. Department of Agriculture programs."*

3. *How much will riparian buffer protection/restoration cost?*

The cost of *protecting* the remaining forest buffers in the A/P Study area is not known. For discussion purposes, a crude estimate for the Tar-Pamlico Basin can be made using Virginia's payment of $100 per acre for 10 years and assuming that half of the forestland in the 100-foot corridor is protected by existing programs.

Total forested area in 100-foot buffer in basin above Washington x % of area not protected by current programs x cost for protection per unit = total cost for protecting 100-foot corridor.

68,447 acres x 0.5 x $100/acre = $3.4 million

The cost of *restoring* nonforested rural land can also be calculated. Assuming the same cost per acre:

20,200 acres x $100/acre = $2.03 million.

However, it is important to realize that this level of incentive may be insufficient for many landowners and that incentive programs for retiring cropland have not been accepted in the past and, barring major shifts in landowner values, may not be accepted in the future.

In any discussion of economic impacts of initiatives, it is important to consider the impact of no action. In other words, there is certainly an economic impact associated with the loss of riparian forests. The impact, while difficult to quantify, can conceptually be thought of in terms of both market-based values, such as timber or fish harvest, and nonmarket values, such as decreases in biodiversity.

4. *A unified vision for riparian corridor protection, as articulated by legislation, regulations, ordinances, policies, and specifications currently does not exist.*

While a number of governmental initiatives currently indirectly affect riparian corridor management, a clear recognition of riparian corridors as landscape units with intrinsic ecological value does not currently exist. In order for riparian areas to receive additional and more focused protection, new partnerships between currently fragmented programs and interests are needed. These partnerships will have to transcend jurisdictional boundaries, and involve all levels of government.

Recommendations

The principal recommendation of this report is that the A/P Management Conference adopt and implement the concept of a riparian buffer as a functional ecological entity with significant environmental benefits and a high priority management measure.

Maintenance and establishment of buffers should immediately be accelerated and prioritized through an array of available vehicles, including conservation reserve enrollments, public land acquisition, "swampbuster" enforcement, conservation easements, and tax incentives.

More specifically, the following ecological guidelines (taken from the U.S. Forest Service, 1992) should be considered to help establish riparian buffers and to ensure that the integrity of the buffer will be maintained.

- Streamside forests should be used in conjunction with sound land management systems that include nutrient management and sediment and erosion control.

- The streamside forest should be wide enough to filter sediment from surface runoff. Maximal effectiveness depends on uniform shallow overland flow.

- Trees can be removed periodically to remove nutrients sequestered in woody biomass and to maintain system efficiency.

- Periodic minor ground shaping may be necessary to encourage dispersed flow and prevent concentrated flow.

- A portion of the riparian forest immediately adjacent to the stream should be managed to maintain a stable streamside ecosystem and to provide detritus and large stable debris to the stream.

- Crown cover should be managed to minimize fluctuations in stream temperature and to maintain stream temperatures within the range necessary for instream aquatic habitat.

- Instream slash and debris removal practices should be revised to conserve existing large stable debris by retaining useful stable portions of jams whenever possible. Unstable tops and smaller debris with potential to form problem jams should be removed a sufficient distance to prevent re-entry during storm events.

Based on our literature review, we feel that limiting watershed management policy to a general requirement for a minimum buffer size of 25 feet will (1) not be sufficient for establishing the ecological functions described in this report; (2) not account for site-specific factors such as local slopes, soils, land use, land cover, preferential water flow, and receiving water goals; and (3) focus efforts on land control issues rather than landscape stewardship/trusteeship issues. One suggestion is to develop watershed-wide riparian corridor goals as an alternative or supplement to establishing a minimum buffer width. Another possibility is to identify a wider minimum width which can be revised downward where a demonstration can be made that upland pollution is being controlled or favorable conditions exist to allow for a smaller size.

The following are recommendations for near-future steps the management conference could take:

<u>State Initiatives</u>

- Convene a workshop to discuss riparian corridor protection and restoration in the A/P Study area. Include researchers and technical and policy experts from Soil Conservation Service, Agricultural Stabilization and Conservation Service, North Carolina Division of Soil and Water, North Carolina Division of Environmental Management, North Carolina Department of Agriculture, universities, and other organizations. Possible agenda topics could include:

  - the current extent of forested buffers
  - strengthening incentives and disincentives
  - tracking the effectiveness of efforts to protect and restore buffers
  - review of other riparian area protection initiatives

- Update technical assistance handbooks, manuals, and specifications to include technical guidance on forested riparian buffers.

- Recognize forested riparian buffers as a primary management measure in the CCMP
- Riparian buffer restoration should be a focus of wetlands mitigation projects
- Integrate buffers into State basin plans and watershed plans
- Establish and publicize demonstration projects
- Create intergovernmental funding mechanisms that link buffer acquisition to water quality benefits; coordinate land acquisition efforts with private, nonprofit organizations
- Fund multiagency river corridor studies, and generally encourage the establishment of river corridor partnerships
- Develop educational and training materials.

Local Initiatives

- Local land use plans should establish minimum setbacks for all development from surface waters
- Local governments should enact zoning/subdivision ordinances which require riparian buffers between built-upon areas and shorelines or stream banks and establish preferred land uses in riparian areas (e.g., highest priority — open space; lowest priority — low density residential; certain intensive land uses prohibited).

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