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Riparian Forest Buffer Panel Report: Technical Support Document

Prepared by the
Riparian Forest Buffer Panel
Technical Team

Chesapeake Bay Program

March 1997

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Prepared October 1996
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Technical Team

Chesapeake Bay Program

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SECTION 1:
RIPARIAN FOREST BUFFER POLICY

Chesapeake Bay Program

CHESAPEAKE EXECUTIVE COUNCIL

DIRECTIVE NO. 94-1

RIPARIAN FOREST BUFFERS

The restoration of water quality and living resources are the principal goals of the 1987 Chesapeake Bay Agreement. To achieve these goals, we agreed to reduce nutrients in the main stem of Chesapeake Bay 40 percent by the year 2000 and to sustain this level thereafter. In 1992, we reaffirmed these goals and also recognized the importance of the tributaries to the Bay ecosystem. We thus began to develop tributary-specific nutrient reduction strategies to achieve water quality requirements necessary to restore living resources in the tributaries as well as the mainstem of the Chesapeake Bay. In 1993, we furthered our commitment to these living resources by agreeing to construct migratory fish passages and remove stream blockages in the tributaries to restore hundreds of miles of historic spawning areas. We now recognize that forests along waterways, also known as "riparian forests," are an important resource that protects water quality and provides habitat and food necessary to support fish survival and reproduction. Used as buffers, riparian forests provide a means of helping us achieve our restoration goals in the tributaries.

~

BASED ON SCIENTIFIC RESEARCH INTO THE ENVIRONMENTAL BENEFITS OF RIPARIAN FOREST BUFFERS, WE HAVE FOUND THAT:

- ✧ Forests have the ability to absorb and denitrify nitrogen in surface and groundwater, and to trap phosphorus-laden sediment and other pollutants resulting from adjacent land uses, thereby protecting water quality.
- ✧ Riparian forests provide shade, organic matter, and often control stream bank stability, which in turn provide a range of living resource habitat benefits, including the moderation of stream temperature, support of the food web, protection of fish habitat, and sediment and erosion control.
- ✧ Riparian forest buffers deliver the greatest range of environmental benefits of any type of stream buffer.

THE ENVIRONMENTAL BENEFITS OF RIPARIAN FOREST BUFFERS AND THEIR POTENTIAL IN HELPING US MEET OUR NUTRIENT REDUCTION GOALS REPRESENT A UNIQUE OPPORTUNITY TO DEVELOP A COMPREHENSIVE BASINWIDE POLICY TO MAINTAIN AND RESTORE THIS VITAL RESOURCE. A POLICY IS TIMELY FOR THE FOLLOWING REASONS:

- ✧ Since much has been done by state and federal agencies, private landowners, and industry to improve water quality through the protection of riparian forests, it is now appropriate for the Chesapeake Executive Council to adopt a comprehensive policy addressing riparian forest buffers in the Chesapeake tributaries.
- ✧ Much of the inventory of riparian forests has been conducted or is underway, and as we learn more about the extent and condition of these forests, a policy is needed to guide management actions.

- ✧ The tributary strategies to date have identified riparian forest buffers as an important best management practice in controlling nutrient loading to streams.
- ✧ As we provide for migratory fish passage, it becomes even more important to ensure favorable water quality and habitat in those streams and rivers.
- ✧ Maintaining long-term caps on nutrients in the tributaries will require approaches that maintain ecosystem or watershed-scale functions, like those provided by healthy riparian forests.

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THEREFORE, TO FURTHER OUR COMMITMENTS MADE IN THE 1987 CHESAPEAKE BAY AGREEMENT, WE WILL:

- ✧ Recognize the value of riparian areas in the Chesapeake Bay watershed and commit to develop a policy which will enhance the maintenance, restoration and stewardship of this valuable resource.
- ✧ Convene a panel or task force to recommend a Chesapeake Bay Program policy on riparian forest buffers. To ensure broad public input, the panel will conduct a series of workshops or roundtables involving landowners, federal, state and local governments, non-profit organizations, business, industry, scientists, and citizens.
- ✧ Request the panel to consider and make recommendations, where appropriate, for:
  - accepted definitions of forest buffers which address the ecologically beneficial characteristics and functions of riparian forests while accommodating resource management activities appropriate within the riparian zone;
  - a quantifiable goal or goals, measured in acres, stream miles or other appropriate terms, to serve as a long-term target for the maintenance and restoration of riparian forests, as well as a timetable for achieving this goal;
  - ways to strengthen communication and partnerships while recognizing the rights and responsibilities of federal, state and local governments, private landowners, and the public, so as to better coordinate policy and program actions regarding riparian forest buffers;
  - ways to support other stream protection efforts where landowners or land managers are unable to implement riparian forest buffers.
- ✧ Request the panel to submit an interim report to the Executive Council in 1995, outlining the major policy findings and any appropriate recommendations, and to submit final recommendations for a riparian forest buffer policy in 1996 for consideration by the Executive Council.

~

By this DIRECTIVE, we reaffirm our commitments made in the Chesapeake Bay Agreement to restore and protect the ecological integrity, productivity and beneficial uses of the Chesapeake Bay. In recognition of our commitments, we the undersigned agree to further our efforts through this directive which is hereby incorporated into the overall Chesapeake Bay Program.

DATE October 14, 1994

FOR THE COMMONWEALTH OF VIRGINIA George F. Allen

FOR THE STATE OF MARYLAND William Donald Schaefer

FOR THE COMMONWEALTH OF PENNSYLVANIA Robert P. Casey

FOR THE DISTRICT OF COLUMBIA Sharon Pratt Kelly

FOR THE UNITED STATES OF AMERICA Carol M. Browner

FOR THE CHESAPEAKE BAY COMMISSION Elmo G. Cross, Jr.

Chesapeake Bay Program

CHESAPEAKE EXECUTIVE COUNCIL

ADOPTION STATEMENT ON RIPARIAN FOREST BUFFERS

In past commitments, we agreed to reduce nutrients, to restore habitat, to improve access to thousands of miles of habitat for migratory fish, and to enhance watershed management by developing and implementing tributary-specific pollution reduction strategies. All of these are part of the effort to achieve our goals for improved water quality and living resources in the Chesapeake Bay. Building on these past commitments, we now highlight the role that conservation, restoration, and stewardship of our riparian areas, and in particular riparian forests, play in reaching our long-term goals for restoration of the Chesapeake Bay.

BASED ON RECOGNITION THAT RIPARIAN FOREST BUFFERS CAN PROVIDE A RANGE OF WATER QUALITY, LIVING RESOURCE, AND WATERSHED BENEFITS:

- In October of 1994, the Chesapeake Executive Council adopted Directive 94-1 which called upon the Chesapeake Bay Program to develop a policy which would enhance riparian stewardship and efforts to conserve and restore riparian forest buffers.

- The Executive Council appointed and convened a 31-member Riparian Forest Buffer Panel composed of federal, state, and local government, scientists, land managers, and citizen, farming, development, forest industry, and environmental interests. The Panel represented a wide range of viewpoints and experience and conducted an extensive stakeholder involvement process.

- The Panel was guided by a commitment to develop goals based on sound science, to recommend flexible strategies, to focus on voluntary incentive-based approaches, to increase private and non-profit partnerships, to enhance, streamline, and coordinate existing government programs, to respect private property rights, to be responsive to landowner needs, and to ensure stakeholder involvement.

- The Panel has provided a set of overall goals, recommendations, suggested actions, and technical information that will help guide the conservation and restoration of riparian buffers in the watershed.

THEREFORE, TO SUPPORT AN INTEGRATED AND COMPREHENSIVE APPROACH TO THE CONSERVATION OF RIPARIAN AREAS, WE:

- Accept the report of the Riparian Forest Buffer Panel.
- Adopt the proposed definition of "riparian forest buffer".
- Adopt the following additional Chesapeake Bay Program goals for states and federal agencies:
  - *To assure, to the extent feasible, that all streams and shorelines will be protected by a forested or other riparian buffer.*
  - *To conserve existing forests along all streams and shorelines.*
  - *To increase the use of all riparian buffers and restore riparian forests on 2,010 miles of stream and shoreline in the watershed by 2010, targeting efforts where they will be of greatest value to water quality and living resources.*
- Adopt the five Policy recommendations of the Panel.
- Direct each state and the federal government to establish a riparian buffer implementation plan with conservation and restoration benchmarks addressing the Policy recommendations of the Panel by June 30, 1998.

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Maintaining and restoring buffers along all streams and shorelines will not be an easily-achieved goal. Furthermore, reaching these goals will require engaging new partners, energizing the public to plant trees and restore streams, working with farmers, other landowners and local governments, building new relationships with industry and business, and continuing to develop new and innovative approaches and incentives.

By these actions, we reaffirm our commitments made in the Chesapeake Bay Agreement to restore and protect the ecological integrity, productivity and beneficial uses of the Chesapeake Bay. In recognition of our commitments, we the undersigned agree to further our efforts through the encouragement of voluntary effort to conserve and restore riparian forest buffers throughout the Chesapeake Bay watershed.

Date OCTOBER 10, 1996

CHESAPEAKE EXECUTIVE COUNCIL

FOR THE UNITED STATES OF AMERICA

FOR THE STATE OF MARYLAND

FOR THE COMMONWEALTH OF PENNSYLVANIA

FOR THE COMMONWEALTH OF VIRGINIA

FOR THE DISTRICT OF COLUMBIA

FOR THE CHESAPEAKE BAY COMMISSION

Final Report of the Riparian Forest Buffer Panel

INTRODUCTION

In October 1994, the Chesapeake Executive Council adopted Directive 94-1 which called upon the Chesapeake Bay Program to develop a set of goals and actions to increase the focus on riparian stewardship and enhance efforts to conserve and restore riparian forest buffers. The Council recognized that forests along waterways are an important resource that protects water quality and provides habitat and food necessary to support fish and wildlife survival and reproduction. The Council appointed a panel to recommend a set of policies, recommend an accepted definition of forest buffers, and suggest quantifiable goals. The Panel was a diverse group of thirty-one members, comprised of federal, state, and local government representatives, scientists, land managers, citizens, and farming, development, forest industry, and environmental interests. This report contains our principal findings and recommendations. Background material which describes in more detail the technical basis for the recommendations and elaborates on the implementation options is available as a Technical Support document.

The Panel adopted a set of principles to guide its deliberations. These principles formed the basis of the Panel's work and are reflected in its recommendations:

✦ *Develop goals based on sound science*
✦ *Recommend flexible strategies*
✦ *Focus on voluntary incentive-based approaches*
✦ *Increase private and non-profit partnerships*
✦ *Enhance, streamline, and coordinate existing government programs*
✦ *Be responsive to landowner needs and ensure stakeholder involvement*
✦ *Respect private property rights*

FINDINGS

Based on stakeholder input and an extensive review of the science, programs, experience, and opportunities related to riparian forest management, the Panel found that:

✦ Streams and rivers in the Chesapeake Bay watershed offer a great diversity of form and function. Changes in the landscape have altered many streams and shorelines from their natural condition. There are an estimated 111,000 miles of perennial and intermittent streams in the watershed. Small first and second order streams are often the most critical in terms of downstream water quality and living resources. As a result of aerial surveys, it is estimated that more than 50 percent of the Bay's waterways are bordered with 100 feet or more of forest on each side.

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✦ A stream and its riparian area function as one. The condition of the riparian area helps determine the quality and integrity of stream channels and habitat available for fish and other wildlife. Riparian areas interact with the flow of surface and groundwater from upland areas and play an important role in water quality.

✦ A sound scientific foundation exists to support the nutrient reduction and ecological values and functions of riparian forest buffers and to promote their use as a management tool.

✦ Riparian forest buffers will contribute to accomplishing Chesapeake Bay Program goals for nutrient reduction (especially the year 2000 cap), tributary strategies, submerged aquatic vegetation restoration, fish passage, and habitat restoration.

✦ While many approaches to stream protection and riparian buffers exist, few have targeted the conservation and restoration of riparian forests.

✦ Landowners see riparian forest buffers as more permanent than other stream protection alternatives. They consequently need additional incentives and/or more inducement to establish this type of buffer on productive land that is generating or has significant potential to generate non-forest income.

✦ Existing programs are not adequately funded, integrated, or coordinated to effectively target riparian forest buffers and track accomplishments.

✦ Although streamside vegetation of any kind is desirable, forests provide the greatest number of benefits and highest potential for meeting both water quality and habitat restoration objectives. There are situations throughout the watershed where it will not be possible to provide forest buffers. In these instances, other buffers will provide some of the desired benefits.

LAND USE-SPECIFIC FINDINGS FROM STAKEHOLDER MEETINGS

The Panel also recognizes that existing land uses affect the approach to buffers. Related to these major land uses, the Panel found that:

✧ *On Agricultural land*

Riparian forest buffers are currently used as a management practice on some farm fields and pastures and as a component of some conservation management plans. With increased effort, the promotion of riparian forest buffers can become a part of routine farm conservation planning efforts. A discussion of standards for their use can be found in the Technical Support document to this report.

Site-specific conservation plans must incorporate landowner objectives and the range of practices necessary to achieve healthy and functional riparian systems. Restoration of degraded conditions and long-term success will depend on a flexible riparian system conservation approach that examines a farm in relation to its adjacent properties and the stream's relationship to its watershed. Implementing successful riparian system conservation includes 1) encouraging practical management measures that limit soil disturbance and reduce potential water quality impacts, 2) increasing shade, habitat, and food for fish and riparian-dependent wildlife, and 3) maintaining economic viability of farming operations.

Teams such as the USDA State Technical Committees can assist in targeting, coordinating, and tracking implementation of federal, state, and local programs for riparian forest buffers and riparian system conservation on agricultural land.

The Panel found that successful implementation of buffers on agricultural land will require 1) enhanced educational programs for landowners, 2) technical support and financial incentives aimed at agriculture, and 3) public recognition of the value and importance of farm land in this rapidly urbanizing watershed.

✧ *On Forested Land*

Riparian forest buffers in the context of forest management raise different issues than other land uses. Because the land is already forested, efforts are focused on retaining forest land and on techniques for its future management. On lands where forests are managed for silviculture, clearly accepted guidelines already exist for "streamside management zones" and are widely practiced on public lands, by industry, and by private landowners.

Forest management, which includes timber harvesting, is compatible with maintaining functioning riparian forest buffers. Deriving income from management of riparian forests should be integrated with a wider range of management objectives.

The success of a riparian forest buffer retention strategy relies in part on creating a favorable climate for continued forest land ownership. Actions which will contribute to this climate include: 1) education and voluntary participation by landowners and forestry professionals with riparian forest buffer criteria, 2) recognition by the public that managed forests are a beneficial land use for water quality and habitat, and 3) appropriate technical support and financial incentives for riparian forest retention and recommended management.

The Panel found that the work underway in the forest industry, especially the Sustainable Forestry Initiative, could and should serve as a model.

✧ *On Developed and Developing Lands*

Implementation of riparian forest buffers in developed areas is different from agricultural or forestry settings. First, the changes resulting from impervious cover of buildings, streets, and other infrastructure are permanent and typically result in cumulative changes in the hydrological regime. In contrast, the changes resulting from farming and forestry can be reversed. Secondly, the per-unit value of developed land is significantly greater than the per-unit value of farm or forest land.

A strategy to implement riparian forest buffers on developed lands must include a recognition of these unique considerations. For high-density urban environments, the focus should rely primarily on education, citizen involvement, and general awareness of the importance of natural systems and people's connection to them. Restoration should be promoted where feasible, and through local outreach with grassroots and civic organizations. Recommendations for urban and suburban alternatives to a riparian forest buffer must be developed for those areas where development has already precluded the maintenance or establishment of a forest buffer.

In developing areas, there is a greater opportunity to conserve environmental benefits. Maintaining structural, hydrological, and functional integrity of riparian systems is an essential objective of development planning and construction.

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A key component to successful implementation of riparian forest buffers in developed and developing areas is to support existing federal, state, and county laws and local ordinances. In addition, local zoning and subdivision ordinances, comprehensive land use plans, regional or watershed-specific stormwater management plans, and riparian system conservation plans are appropriate mechanisms. Effective implementation of riparian forest buffers on developed and developing lands can result from a set of guidelines that ensure consistency and clarity, but remain flexible to site-specific needs. Specifically the Panel was impressed with approaches which: 1) allow flexibility for expansion, contraction, and averaging with respect to buffer width criteria so as to account for the 100-year flood plain, steepness of slope, adjacent wetlands, limited lot size, stormwater ponds, etc., 2) provide for flexible uses within the riparian forest buffer, including freedom to harvest timber for firewood or commercial use, consistent with state forestry harvesting guidelines, 3) promote riparian forest buffers as part of stormwater management planning, and allow pollution removal effectiveness of buffers to be credited in stormwater management plans and calculations, and 4) provide flexibility for development density compensation where forest buffers are required or proposed so that developers can establish the same number of lots on the parcel outside the riparian forest buffer as would be allowed without a riparian forest buffer.

These findings, which are supported by background information included in the Technical Support document, formed the basis for the recommendations which follow.

RECOMMENDATIONS

The Executive Council asked the Panel to consider and make recommendations, where appropriate, for 1) accepted definitions of forest buffers which address ecologically beneficial characteristics and functions of riparian forests while accommodating resource management activities appropriate within the riparian zone, 2) a quantifiable goal or goals to serve as a long-term target for the maintenance and restoration of riparian forests, as well as a timetable, 3) ways to strengthen communication and partnerships to better coordinate policy and program actions, and 4) ways to support other stream protection efforts.

DEFINITION

Clarity of definition is important, perhaps more so than consistency from one jurisdiction to the next. The Panel recommends that the Executive Council adopt the following definition of riparian forest buffers, to be applied throughout the Bay watershed:

> ***Riparian Forest Buffer**: An area of trees, usually accompanied by shrubs and other vegetation, that is adjacent to a body of water which is managed to maintain the integrity of stream channels and shorelines, to reduce the impact of upland sources of pollution by trapping, filtering, and converting sediments, nutrients, and other chemicals, and to supply food, cover, and thermal protection to fish and other wildlife.*

Width is an important consideration in the overall effectiveness of forest buffers. The appropriate width of the forested buffer will vary depending on site conditions, topography, adjacent land use, and the benefits one is trying to gain by installing a buffer. Technical guidance on buffer width can be found in the Technical Support document as well as various other sources.

GOALS

The Panel recommends that the Council adopt one long-term and two immediate goals:

- ✦ ***Assure that every stream in the watershed is protected by a riparian forest or other buffer.***
- ✦ ***Conserve existing forests along streams and shorelines.***
- ✦ ***Increase basin-wide riparian forest buffers through restoration benchmarks to be established by each signatory in 1998 with the aim of accelerating the present rate of reforestation in the riparian area. Priorities should be focused on those areas that will provide the greatest benefit.***

POLICIES

Maintaining existing buffers along all streams and shorelines will not be an easily-achieved goal. Restoring forest buffers in areas where they are most needed will also be difficult. However, the present level of effort is inadequate, and the Executive Council is urged to enable the realization of these goals by making adequate staff resources, technical assistance, tax relief, financial incentives, and education programs available.

The Panel believes that adoption of five policy recommendations will help enable the signatories to establish and develop implementation strategies. These five recommendations address the remainder of the Panel's charge.

✦ Recommendation 1: Enhance Program Coordination and Accountability

> *"Establish mechanisms to streamline, enhance, and coordinate existing programs related to buffers and riparian system conservation."*

Suggested actions include:

✧ Establish coordinating teams to address how riparian forest buffer retention and restoration goals are being achieved. These teams should report annually to the Chesapeake Bay Program Implementation Committee.

✧ Use federal, state, or other sources of funding to establish personnel in each jurisdiction capable of specializing in landowner outreach and education and local program assistance for riparian forest buffer design, establishment, management, and education.

✧ Encourage public land managers to review current practices and policies (e.g. mowing, wildlife management, encroachment, disturbance, and practices on leased land) and to develop plans and goals for riparian system and riparian forest buffer protection and restoration.

✧ Evaluate and modify existing federal and state cost-share and assistance programs to simplify the process, streamline implementation, and ensure that they support a wide range of riparian system conservation practices, including planting trees and shrubs, maintenance of plantings until successfully established, use of temporary fencing, and development of off-stream water sources.

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✦ Recommendation 2: Promote Private Sector Involvement

"Build partnerships with the private sector to help support the promotion and implementation of riparian forest buffer retention and restoration activities."

Suggested actions include:

✧ Establish a recognition program in each state to reward and recognize developers, farmers, and forest landowners for riparian forest buffer accomplishments and proper riparian system conservation.

✧ Establish demonstration projects which enlist industrial/corporate landowners to establish riparian forest buffer restoration/retention on their lands.

✧ Convene a workshop to explore ways to facilitate and encourage land trusts to increase the conservation of riparian forests and riparian systems, to include provisions in existing easement agreements for riparian forest buffer establishment and stream enhancement activities, and to track lands protected by permanent easements.

✧ Improve the ability of non-governmental partners such as private, nonprofit, and watershed organizations to assist in landowner outreach, education, and buffer restoration efforts by establishing grants through public/private endowments supported by multiple funding sources. Ensure an adequate and inexpensive supply of native riparian planting materials.

✧ Continuously work to involve citizen groups and volunteers in riparian forest buffer planting and management efforts in rural and urban areas and build a cadre of private individuals who can assist government agencies to design, organize, and implement stream improvement and riparian restoration projects.

✦ Recommendation 3: Enhance Incentives

"Develop and promote an adequate array of incentives for landowners and developers to encourage voluntary riparian buffer retention and restoration".

Suggested actions include:

✧ Compile a list of existing federal and state tax advantages, tax relief provisions, conservation easement tax benefits, tree planting credits, and other tax options that currently exist and market these tools to landowners.

✧ Deliver to Congress an Executive Council proposal to amend inheritance tax law and provisions that unintentionally result in conversion of forests and agricultural land to other land uses, making opportunities for riparian forest retention difficult.

✧ Create flexible state income tax incentives (such as tax credits for tree planting, retention, or easement expenses in buffers) to promote riparian forest buffers.

✧ Enable, encourage, and, where necessary, amend legislation to ensure that local governments have the authority to promote preferential property tax strategies.

✧ Implement, within existing state land trust or conservation easement programs, mechanisms which emphasize riparian forest buffers and riparian systems.

✧ Develop strategies and tools to promote local implementation of flexible land development practices which enhance riparian forest buffer retention, such as density compensations, pollution removal credits for riparian forests in stormwater management plans and calculations, more flexible use of buffer resources, and off-site mitigation or buffer trading within existing regulatory programs.

✧ Encourage agencies to evaluate their regulatory and conservation programs and develop approaches that will not penalize landowners who restore buffers.

✦ Recommendation 4: Support Research, Monitoring, and Technology Transfer

> *"Increase the level of scientific and technical knowledge of the function and management of riparian forest and other buffers, as well as their economic, social, ecological, and water quality values."*

Suggested actions include:

✧ Update state and federal technical assistance handbooks, manuals, and specifications and provide a field handbook providing guidance on the benefits, functions, design, establishment, and management of riparian forest buffers.

✧ Develop a research agenda that addresses information needs regarding riparian forest buffers, such as landowner concerns, economic analysis of costs and benefits, and ecological and physical relationships.

✧ Conduct an analysis of riparian forest and other buffer effectiveness and targeting for nutrient removal and living resource habitat enhancement.

✧ Commit to repeating the inventory of riparian forests in the Chesapeake Bay watershed at periodic intervals, continually refining the technological capabilities and resolution of the inventory, in order to accurately measure progress and program accomplishments against the baseline findings of the inventory completed in 1996.

✦ Recommendation 5: Promote Education and Information

> *"Encourage Bay signatories to implement education and outreach programs about the benefits of riparian forest buffers and other stream protection measures."*

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Suggested actions include:

✧ Publish state directories for riparian forest buffer and stream protection and restoration assistance programs for use by landowners, citizens, and local governments.

✧ Coordinate the development of educational materials and tools (such as public service announcements, videos, posters, fact sheets, displays, brochures, field tours; Internet homepage, etc.) and implement a basin-wide public outreach and education program about the benefits of healthy streams and riparian areas.

✧ Initiate ongoing training and education programs as appropriate for developers, loggers, the forest industry, consultants, and citizen groups as well as other resource professionals and decision-makers to communicate the importance of riparian forest buffer and riparian system conservation, methods of protection and establishment, and the use of watershed and stream assessments.

✧ Ensure coordination among agencies providing landowner assistance to develop and implement a strategy for enhanced outreach, technical assistance, and education related to stream restoration and riparian forest buffers on private and public lands.

✧ Establish and publicize riparian forest buffer and riparian system conservation demonstration sites in each jurisdiction which are representative of all physiographic regions and land uses.

CONCLUSION

The environmental benefits of riparian forest buffers presents the Executive Council with a unique opportunity to develop a Bay-wide policy that will help in meeting the Bay Program's goals to reduce nutrients and restore habitat for living resources. The Panel urges the Executive Council to adopt these recommendations and will call upon their respective staffs to implement a comprehensive riparian system conservation policy which includes forest buffers as an important component. Revisiting the goals of the policy, evaluating programs, and redirecting actions as necessary will be important as the Chesapeake Bay Program monitors progress in adding forest buffers and improving riparian system conservation. The adoption and implementation of a riparian system conservation policy will assure that the huge effort mounted by the Executive Council over the past decade continues to advance, while simultaneously respecting the partnerships that have been forged, the legal responsibilities of the various levels of government, and the evolving knowledge base which forms the foundation of this work.

SECTION 2:
DEFINITIONS

DEFINITIONS

Definitions of riparian areas and buffers vary depending on the perspectives of managers and scientists, the various land use settings in which they are found, as well as the activities carried out in the riparian landscape. The word "riparian" is derived from the Latin word for bank or shore and simply refers to land adjacent to a body of water. Most agree that riparian areas do not have fixed, linear boundaries but vary in width, shape, and character. When we use the term riparian, we are referring to streamsides, river banks and floodplains of perennial and intermittent streams and the shorelines of the Chesapeake Bay.

The concept of a buffer is to provide a transitional environment capable of reducing or eliminating the potential impacts of land uses on the adjacent body of water; e.g. impacts on the physical, chemical and biological aspects of that environment. Buffers are especially valuable in providing "a last line of defense" for water quality impacts that may occur on a short and long term basis. Using riparian areas in this context means putting naturally occurring or enhanced riparian functions to work for a specific set of management objectives.

STREAM: A perennial or intermittent watercourse having a defined natural channel (excluding man-made ditches) which contains flow from surface and groundwater sources during at least 50% of an average rainfall year.

> *Streams and rivers in the Chesapeake watershed offer great diversity of form and function. A long history of changing land use means that many stream channels and shorelines have been altered from their natural condition. This definition describes those streams which would benefit from riparian forest buffers.*

RIPARIAN AREA: The area of land adjacent to streams, rivers and other bodies of water that serves as a transition between aquatic and terrestrial environments and directly affects or is affected by that body of water.

> *A stream and its riparian area function as one. The condition of the riparian area helps determine the quality, health, and integrity of the stream and the habitat available for fish and other wildlife. Because of their position in the landscape, riparian areas interact with the flow of surface and groundwater from upland areas and play an important role in water quality.*

RIPARIAN FOREST BUFFER: An area of trees, shrubs, and other vegetation situated between a land use and adjacent body of water which is managed to maintain the integrity of stream channels and shorelines, to reduce the impact of upland sources of pollution by trapping, filtering and converting sediments, nutrients, and other chemicals, and to supply food, cover and thermal protection to fish and other wildlife.

> *Riparian buffers are one of the most effective practices for pollution prevention. Forests provide the greatest number of environmental benefits of any buffer vegetation and have proven most successful in bringing overall water quality improvements.*

FOREST BUFFER WIDTH: A fixed or variable distance measured from the edge of the streambank or shoreline within which the vegetation and land is retained and managed for the purpose of sustaining specific or multiple buffer functions.

It is difficult to define an "ideal" buffer width suitable for all applications. Buffer widths are determined through consideration of actual watershed and site conditions (stream sensitivity, steep slopes, stream size , floodplains, etc.), landowner objectives (forest management, recreation, grazing system, etc.), desired buffer functions (remove groundwater nutrients, filter sediment, provide bird or fish habitat, etc.),and the potential for land use impact (cropland, urban, roads). A primary advantage of fixed widths is ease of administration; variable-width approaches may require extensive site investigation.

FOREST BUFFER RESTORATION: The re-establishment of a sustainable community of native trees, shrubs and other vegetation adjacent to a body of water where forest cover had been converted to other uses and which is capable of providing multiple buffer functions.

Replanting cultivated fields, pastures, turf lawns, or areas disturbed by construction or development requires technical and financial investment. Restoration also provides opportunity for public involvement. Once planted, a new buffer will begin providing some benefits immediately. Within 10-15 years, riparian forest buffers provide a full range of water quality and habitat values with little long-term maintenance.

FOREST BUFFER CONSERVATION: Retaining and managing existing riparian forests so that they continue to provide the benefits of a forest buffer.

Retaining a corridor of natural forest vegetation along streams and shorelines in rural and developing areas is a valuable aspect of local planning. Riparian forest buffers or corridors should be designed to provide as many benefits as possible; expanding or contracting to incorporate important ecological and physical site needs, integrate regulatory or economic constraints, and include public use where suitable. Linking forest buffers within a watershed is desirable.

STREAM CORRIDOR CONSERVATION: An approach to management that encourages the protection of a stream and a continuous vegetated buffer zone from a stream's headwaters to its mouth and integrates riparian buffers with other needed stream protection and restoration actions.

Stream valleys or "corridors" are important assets of a landowner, a community, and the public. They contain wetlands and vegetated areas that help filter runoff and groundwater, protect water quality, and provide critical habitat for plants, animals and fish. They also contain cultural and historic resources, and provide prime recreational and scenic values worthy of conservation for people. Forests represent a target vegetation for stream corridors.

WATERSHED-BASED PLANNING: An approach to resource, land use and development planning that utilizes natural watershed instead of geopolitical boundaries in order to sustain natural stream functions while accommodating a reasonable level of land development.

Changes in a watershed such as conversion of forest to other land uses, increasing impervious area, channelizing streams, and ditching and draining fields, and roads and subdivisions can all have dramatic effects on stream function as well as water quality. Sustaining the long-term functions of a watershed and healthy, productive streams means incorporating essential "green" infrastructure like natural stream corridors with traditional development needs.

DEFINITIONS: Background Information

"Even though they may be physiographically distinct, most riparian zones cannot be dealt with as separate functional entities ... rather riparian habitats are best evaluated and managed as part of larger landscape units such as watersheds".

-Eugene Odum, 1971

Riparian areas are a resource with high economic and ecological values. In their natural forested state they provide crucial fish and wildlife habitat, and help control stream stability, flow and water quality. In addition, riparian areas are used for recreation or timber production. Many acres of riparian area have been converted to other land uses such as cultivated agriculture, pasture, grass filter strips, lawns, or residential, commercial, and industrial development and infrastructure. Recognizing these multiple values and uses is essential in developing effective management and restoration strategies.

Perspectives on Terminology

understanding any concept requires knowledge of the terminology used to describe it. The definitions of a riparian area sometimes vary depending on the perspectives of managers and scientists. The word *"riparian"* is derived from the Latin word for bank or shore, and simply refers to land adjacent to a body of water. Plant ecologists define riparian areas based on soil moisture conditions and unique plant communities associated with wet and mesic soils. Others may define riparian areas in terms of soil characteristics, hydrology, or landscape features. Law or policy often defines it in terms of its uses. Consequently, riparian areas do not stop at an arbitrary, uniform distance away from a stream or watercourse, but vary in width and shape.

Ecosystem perspectives of riparian areas incorporate concepts of geomorphology, terrestrial plant succession, and aquatic ecology. Here, riparian areas are defined as three-dimensional zones of influence between terrestrial and aquatic ecosystems. The boundaries of the riparian area extend out from the streambed or tidal shoreline and upward into the canopy of streamside vegetation. Likewise, the functioning riparian zone may be considered to extend into the soil to the water table and incorporate underlying hydrogeologic conditions.

With the exception of tidal marshes and emergent wetlands, nearly all riparian ecosystems of the Chesapeake Bay watershed in their natural state were dominated by forested plant communities. Relative to other land types, riparian areas are characterized by a combination of high species diversity, high species density and high bio-productivity (Hunter, 1990). Natural and man-caused factors have greatly altered riparian character and condition over time, and landscape differences, such as physiographic region, result in differences in form and function of riparian systems.

These and other definitions identify several aspects of a riparian area held in common. They are: 1) an adjacent body of water, 2) a lack of clearly defined boundaries, and 3) the role as a transition between aquatic and upland environments. In the Chesapeake Bay Watershed, forests are the natural vegetation which comprises the riparian zone or streamside and shoreline areas.

What is a filter strip and a buffer?

When adjoining land uses are significantly different, or where potential for conflict is serious, it is common practice to create a buffer between them. Thus we have buffers between highways and houses, around recreation sites, airports and bombing ranges. Generally as the density or magnitude of the activity or the potential for conflict increases, the width of the buffer necessary to contain the negative effects increases proportionally. In terms of a riparian area, the differences between developed or disturbed lands and the stream or aquatic environment are significant; the more intensely disturbed or developed, the more the difference. Likewise the size or importance of the buffer increases as the potential conflict created by increased yields of nutrients, chemicals, and sediment from land use increases. Riparian buffers have been described as 'one of the most effective tools for coping with nonpoint source pollution' (Phillips 1989).

"Filter strips" are vegetated sections of land designed to accept runoff for pollutant removal. They are not designed for high velocity flows, but rather low volume dispersed flows and groundwater. Filter strips differ from *"natural buffers"* in that strips are not 'natural" but rather designed and managed specifically for the purpose of pollutant removal. *"Enhanced natural buffers"* are where the removal capacity of a natural buffer is improved through land grading, water spreaders, planting or other measures.

Riparian buffer strips should be designed to fulfill one or more of the following basic roles (Belt, et.al, 1992):

- ✦ to protect fish and wildlife by supplying food, cover, and thermal protection.
- ✦ to help prevent upland sources of pollution from reaching surface waters by trapping, filtering and converting sediments, nutrients, and chemicals.
- ✦ to maintain the hydrologic, hydraulic, and ecological integrity of the stream channel and associated soil and vegetation (i.e. maintaining stream bank stability and channel capacity)

Streamside Forests

Naturally forested riparian areas have also been called "streamside forests", "'river woods", and "wet woods", to name a few. When thinking of these areas as part of a landscape rather than in a role as buffer, people also routinely think of stream corridors, greenways, and river parks. In each case, the riparian area is the same resource, but its dimensions and management are defined by its desired use or individual value to people rather than by its ecological significance.

What is a riparian forest buffer?

Buffers or filter strips may utilize a variety of vegetation types. Forested riparian buffers (or streamside forests) are riparian buffers with a functional forest ecosystem. The use of forested zones near streams has long been recognized as an important strategy for improving water quality while also restoring the ecosystem. In this way, forested riparian buffers should be clearly distinguished from vegetative or

grassed filter strips (commonly recommended as a BMP) because of their ability to accomplish both water quality and ecological roles.

The riparian forest buffer may vary in size, shape, mix of vegetation, and management objectives, however, it maintains trees over the long term as the dominant part of its plant community. Welsch recognized the value of riparian forests in providing ecological benefits and provides a three-zone forest buffer concept as a recommendation designed for water quality treatment and control of the stream environment. These linear strips of forest and grass are designed as a last line of defense for the stream from the activities we undertake on adjacent lands. The three-zone concept allows customizing with site and landowner objectives. Benefits of the riparian forest buffer also accrue both on-site and downstream.

Describing riparian forest buffers in different landscapes

To increase general understanding, it is sometimes useful to characterize riparian forest buffers by their use in each of the unique land use settings in which the practice is applied.

In the Forested Landscape

This is a riparian forest buffer on forested lands. Where the landscape is managed for wood products, the riparian forest buffer is referred to as a "streamside management zone (SMZ)" or "streamside management area". In a forest landscape, management objectives for the forested areas closest to the water are oriented away from timber production, toward water quality protection and habitat concerns. Forest composition in the SMZ commonly represents a more natural diversity, rather than favoring commercial species. SMZ widths are usually fixed but may vary from 25' to over 300', primarily controlled by slope or biological considerations.

> *Streamside Management Zone - a designated forest area varying in width where management practices are modified by water quality or aquatic resources.*

In the Agricultural landscape

Forests which have remained as part of agricultural areas may be managed as woodlots or family forests, but many are limited to fragmented patches confined to wet soils or steep slopes and hilltops which proved difficult to cultivate. Riparian forests have usually been cleared on farms managed for livestock. These areas present the classic definition of riparian forest buffer as a water quality and habitat enhancement BMP. Because of potentially high levels of sediments, nutrients and other chemicals leaving the crop or pasture fields in surface or groundwater, RFBs are may be designed to serve as a zone to buffer water quality impacts of this land use from a streams, river or bay. In addition, streams have often been highly altered in these areas and the forest buffer supports the restoration of aquatic habitat. Existing riparian forests are usually very narrow bands (10-25') of intermittent trees along the bank of a river or stream. Groundwater may be drained by tiles.

Agricultural applications of forest buffers sometimes require the conversion of active cropland , but most often are a combination of pasture, grass filter strip, and/or cultivated field. Establishing riparian forest buffers will involve the difficult task of wholesale conversion of grass to forest where no forest has existed for 50-250 years or the expansion of narrow existing forest strips.

Agricultural Riparian Forest Buffer - an area of trees and other vegetation separating cropland or pasture from a s or other surface waters which is designed and managed to provide shade and stream habitat and to trap and remove nutrients, sediments, pesticides and other chemicals from surface runoff and subsurface/groundwater flows. RFBs are retained, enhanced or planted.

In the suburban/developing landscape

Describing riparian forests and forests in general in the suburban or developing landscape is one of change. Retaining existing riparian forests and planning for sustaining them over the long term is the challenge. As forests are cleared for development and runoff, temperature, edge effect, exotic plants and pests all increase, the focus is on retaining functional riparian forest corridors. Like agricultural areas, the potential benefits of retaining these riparian forests is equally high for future water quality and aquatic resources. Increased nutrients from road runoff and lawn fertilizers are effectively treated by the riparian forest buffer if stormwater designs allow watershed infiltration. Riparian forest buffers in these areas often contribute to higher property values.

In developing areas, many communities already have subdivision or zoning rules that impose mandatory building setbacks from lot lines. Some communities require a specific setback from the shoreline (such as mean high tide) or streambank. Maintaining vegetated buffers that function in ways that provide environmental benefits generally means preserving or establishing a zone of woody vegetation where disturbance and building can be limited. To accomplish this, other lot line setbacks may need to be reduced or a subdivision may need to alter lot size.

One key principle of modem land use planning promotes concentrating intense development in areas where supporting infrastructure already exists. This principle focusses on infil development and redevelopment. In many communities, these intensely developed areas may include s banks and the shorelines or larger bodies of water. These shorelines may already have high land values and tax burdens, creating a desire to maximize the economic return on such properties. This may precludes giving such valuable land over to environmental uses such as a buffer.

Suburban Riparian Forest Buffer - corridors of forest bordered by parks, ballfields, roadways and residential/commercial lawns and landscaping which are retained and managed to provide the natural functions and values of sediment filtering, enhanced infiltration, nutrient uptake and processing, temperature moderation, noise control, screening, aesthetics, and diverse habitat.

In the urban landscape

Forests in the urbanized landscape are highly fragmented and often dysfunctional ecosystems. Of all the various types of urban forests, including trees in parks, along streets, and on private lots, forests bordering streams and rivers, are probably the most valuable forests from a water quality and habitat perspective. The fragments of riparian forest that have been protected from development often represent the largest contiguous forests within urban areas. Refuges for songbirds and other wildlife, they can be unique areas for appreciation of nature. From a human perspective, they provide much needed recreational areas for urban residents through the accommodation of streamside trails.

Interest and activity in reforestation and tree planting has greatly increased over the past decade. Most projects involve augmenting or connecting fragmented riparian forest buffers. The ability of riparian forest buffers in urban areas to significantly improve water quality alone is somewhat limited due to the volume and velocity of stormwater runoff. However, merging aesthetic and habitat improvement

objectives with open space, vacant lot and parkland management has yielded many excellent examples of riparian forest restoration and natural buffer creation. Riparian forest buffers have also found a place in stormwater management in conjunction with wet ponds, wetland detention, and stream erosion control.

Urban Riparian Forest Buffer - Corridors or strips of forest, often narrow or highly irregular in extent or linear distance, which are protected, managed, and/or enhanced for aesthetic, habitat, recreational, climatic, or water quality benefits within a highly impervious setting.

SECTION 3:
SCIENCE

SCIENCE

Our knowledge of the values and functions of riparian forests has been rapidly growing over the last 15-20 years. Scientists agree on the body of knowledge indicating the critical habitat functions provided by riparian forests. Substantial research is continuing to advance technical knowledge about the water quality functions of riparian forests gained over the last decade. However, it is only very recently that detailed scientific research on the water quality and ecological functions of forests have been put to use in management.

Under natural conditions, riparian forests provide a dynamic yet stable buffering system along most shorelines, rivers, and streams in the Bay watershed. The scientific foundation of the Riparian Forest Buffer System is based on studies of naturally-occurring riparian forests and experimental-scale grass filter strips. Although few studies have documented the specific changes in water quality during the establishment period of a restored riparian forest, even newly planted forest buffers are expected to sustain water quality functions over the long term in a manner similar to the natural system.

The Consensus Report

A report just released by the Chesapeake Bay Program, serves as a research synthesis and scientific consensus. *"Water Quality Functions of Riparian Forest Buffer Systems in the Chesapeake Bay Watershed"*, by Lowrance, et.al., contains a review of riparian forest and vegetated filter strip literature and helps determine the applicability of riparian forest buffer systems as a water quality enhancement practice. The report acknowledges that scientific questions remain and that there is some uncertainty in predicting generalized nutrient reductions over time due to variations in loading rates, management, site conditions, and hydrology on individual field sites. However, the Report firmly supports the use of forest buffers as a pollution prevention tool, describes and quantifies the ecological and water quality functions of riparian forests, and discusses the level of effectiveness predicted.

Water Quality Functions*

- Maintains the ecological integrity and stability of the stream environment
- Removes sediment and sediment-borne nutrients and other chemicals
- Removes nitrogen from surface and groundwater
- Controls dissolved phosphorus

**Listed from most common to least common function in all riparian forests*

Priority Considerations

Based on current scientific knowledge, establishing and managing buffer for multiple water quality and habitat objectives may be subject to a variety considerations useful in tageting efforts in the field.

Habitat- Riparian forests are essential habitat for fish and upland species of wildlife. Targeting for habitat enhancement will be different than for water quality.

Geographic Setting - Differing hydrology and soils will affect the level of pollutant removal of riparian forest buffers. In general terms, environmental settings where a higher percentage of the water budget moves to streams as subsurface flow and not deep groundwater or surface runoff, will provide ideal conditions for nutrient reduction processes. This is especially true for dissolved nitrogen, a praticularly difficult pollutant to

retain on the land. Shallow aquicludes, highly dissected landscapes, and the presence of well-developed floodplains all indicate high potential for dissolved nutrient removal. In optimum areas, removal may be as high as 98% declining to 0 in hydrologic systems with deep groundwater percolation or extreme runoff efficiency. Surface runoff treatment is affected more by slope and degree of soil permeability. In the Bay watershed, water quality benefits of riparian forest establishment and retention may be highest in the Coastal Plain. Piedmont, and specific areas of the Valley and Ridge hydrologic provinces

Stream Size - Small streams (order 1-3) constitute the greatest number of stream miles and may be the highest priority areas to reduce nutrients. Small streams also experience higher nutrient loads in relation to their flow volume. Buffers here are expected to be highly effective for water quality.

Contiguous Buffers - Achieving continuity of forest buffers on the landscape could be given higher priority than potentially larger fragmented buffers and may be considered as a specific goal.

Width - Buffer width is most affected by slope of adjacent lands, degrees of water quality or habitat benefit desired, soils and hydrologic setting and landowner constraints. Flexible buffer widths based on these criteria are most desired, with minimums provided to ensure adequate control of the stream environment.

Degree of Degradation - the severity of degradation is directly related to the benefits expected from riparian forest buffers. Streams in areas without forests, such as pastures, may benefit the most while highly urbanized streams affected by altered hydrology may provide high wildlife and aesthetic benefits but may not be able to provide high levels of pollution control.

Loading rates -Where nutrient loading is highest, pollutant removal efficiency may also be highest.

Research Gaps and Information Needs

There are many aspects of forest buffer retention and establishment which will require additional study. Some have their resolution in monitoring management choices, not in scientific study. Specific questions include: What are the specific environmental variables that control water quality effectiveness of buffers and how are they quantified? How quickly do newly planted trees begin to function as a forest? What species provide the greatest return to water quality? What is the most efficient planting and maintenance method in agricultural areas? How do buffers function in highly developed areas? How should buffers be integrated with stormwater planning? A listing of potential future research areas was developed by the panel and is provided.

RESEARCH NEEDS

- What is the time required for buffers to achieve maximum effectiveness?
- There is a need for information that is equivalent to the data in the piedmont, in order to accurately determine priorities between provinces (coastal vs. ridge and valley).
- Since most data currently available is limited to relatively small plots within a watershed, there is a need for information that encompasses all the land uses in the entire subwatershed.
- At present, there is little information on the relative benefits of the various tree species that could constitute a forested buffer. The role of root structure and the rate of denitrification of the various species is important to establish the balance of species in a buffer. The effectiveness of various grasses on sites of varying characteristics, is needed to provide planning information to achieve specific goals.
- Establish minimal requirements for reliable site indicators of hydrological conditions..
- Determine the benefits of including multiple tree species in a forested buffer versus a monoculture. What is the optimal number of species under a variety of conditions such as soil types, hydrological conditions and physiographical provence?
- Develop data on sheet runoff and the relative effectiveness of the various types of vegetated and engineered (level lip contouring) that can be combined with the forested buffers to increase controls.
- Develop a nitrogen budget to determine the fate of nitrogen in these areas.
- The hyperbaric zone surrounding the root structure is known to play an important role in controlling the movement of nutrients through soils to the stream channel. The precise role and mechanics of this zone should be determined.
- The role of storm events on the stream systems or any aquatic system, has long been minimally understood. The role of buffer strips during these events in influencing the discharge of nitrogen and/or phosphorous is not understood.
- Are there seasonal differences in the effectiveness of buffers? Experience at one site in Pennsylvania suggests that there is little variation. Data from Georgia supports this observation.
- There is a need to develop information on the load reduction of nutrients exporting various types of buffers into the stream. This would apply to grasses, forested and any combination of the two.
- In order to assess the benefits accrued to the stream life from the shading by the forested buffers some effort in developing thermal models, that include various miles of riparian buffers and the diversity of aquatic life, would provide a relative simple and reliable cost - benefit for that measure.

FACT SHEET

Riparian Forest Buffers in the Chesapeake Bay Watershed

Background

When colonists first arrived on the shores of the Chesapeake Bay, over 95% of the landscape was forested. Captain John Smith wrote in 1608, "the country is overgrown with trees...and affords no grass but that which grows in the marshes." This vast forest was an important regulator of the Bay's environment - a "living filter" that protected the land, filtered pollutants and sediment from rainfall, regulated stream and air temperatures, controlled runoff, and provided wildlife habitat.

The last 300 years have brought dramatic changes to the Bay's forests. Agricultural expansion, deforestation, and the growth of cities removed almost 70% of the watershed's forests by the mid-1800's. These changes in land use resulted in a fragmented forest landscape that adversely impacted the Bay and its streams and rivers, as well as its wildlife and fish. While many forests have returned or have been replanted, less than 60% of the Bay's original forested areas remain. With over 13 million people living in the Bay's watershed, urban growth now results in the permanent loss of almost 100 acres of forests every day.

What is a riparian area?

Riparian refers to the area of land adjacent to a body of water, stream, river, marsh, or shoreline. Riparian areas form the transition between the aquatic and the terrestrial environment.

Linking the landscape to the Bay, close to 100,000 miles of interconnected streams, rivers, wetlands and their riparian area serve as a "circulatory system" for the Chesapeake Bay. Forests are the natural riparian vegetation in the Bay region. Although they comprise only about 5-10% of the land in the watershed, riparian areas play an extremely important role in maintaining the health of the Bay. However, 50% or more of these streamside and shoreline forests are now disturbed or degraded, and more continue to be lost. Protecting and replanting riparian forests is one of the goals of the Bay restoration effort.

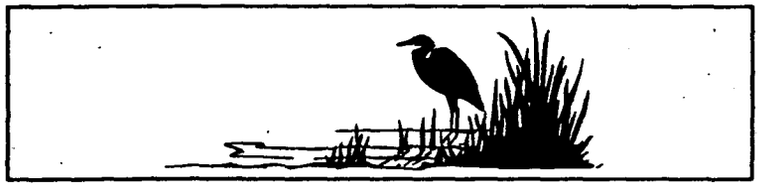
Functions and Values

Riparian forests are integral to the health of the Bay and its rivers for many reasons. Their position in the landscape makes these forests excellent buffers between upland areas and waters that eventually enter the Bay. Studies have shown dramatic reductions of 30 to 98% in nutrients (nitrogen and phosphorus), sediment, pesticides, and other pollutants in surface and groundwater after passing through a riparian forest. In addition, trees provide deep root systems which hold soil in place, thereby stabilizing streambanks and reducing erosion.

Cool stream temperatures maintained by riparian vegetation are essential to the health of aquatic species. Shading moderates water temperatures and protects against rapid fluctuations that can harm stream health and reduce fish spawning and survival. Elevated temperatures also accelerate algae growth and reduce dissolved oxygen, further degrading water quality. In a small stream, temperatures may rise 1.5 degrees in just 100' of exposure without trees.

Riparian forests offer a tremendous diversity of habitat. The layers of habitat provided by trees, shrubs, and grasses and the transition of habitats from aquatic to upland make these areas critical in the life stages of over one-half of all native Bay species. Forest corridors provide crucial migratory habitat for neotropical songbirds, some of which are now threatened due to loss of habitat. Also, many ecologically important species such as herons, wood ducks, black ducks, as well as amphibians, turtles, foxes and eagles utilize the riparian forest.

Riparian forests also offer many benefits to migratory fish. Forested streams and rivers provide suitable spawning habitat for shad, herring, alewife, perch, and striped bass. The decline of these species is partly due to destruction of habitat, which for some, like shad and herring, extends well into small streams. Trees and woody debris provide valuable cover for crabs, small fish and other aquatic organisms along the Bay's shoreline as well. Degradation of any portion of a stream can have profound effects on living resources downstream. While the overall impact of these riparian forest corridors may be greatest in headwaters and smaller order streams, there is a clear linkage all the way to the Bay.



The Benefits of Riparian Forests

1. Filtering Runoff

Rain that runs off the land can be slowed and infiltrated in the forest, settling out sediment, nutrients and pesticides before they reach streams. Infiltration rates 10-15 times higher than grass turf and 40 times higher than a plowed field are common in forested areas.

2. Nutrient Uptake

Fertilizers and other pollutants that originate on the land are taken up by tree roots. Nutrients are stored in leaves, limbs and roots instead of reaching the stream. Through a process called "denitrification," bacteria in the forest floor convert harmful nitrate to nitrogen gas, which is released into the air.

3. Canopy and Shade

The leaf canopy provides shade that keeps the water cool, retaining more dissolved oxygen, and encourages the growth of diatoms, nutritious algae and aquatic insects. The canopy improves air quality by filtering dust from wind erosion, construction or farm machinery.

4. Leaf Food

Leaves fall into a stream and are trapped on woody debris (fallen trees and limbs) and rocks where they provide food and habitat for small bottom-dwelling creatures (i.e crustaceans, amphibians, insects and small fish), organisms that are critical to the aquatic food chain.

5. Stream and Habitat

Streams that travel through woodlands provide more habitat for fish and wildlife. Woody debris serves as cover for fish while stabilizing stream bottoms, thereby preserving habitat over time.

The Forest Buffer Concept

The concept behind a riparian buffer is to put the natural benefits and functions of riparian areas to work in non-point pollution control. When considering the range of benefits provided and potential effectiveness, forests are the most effective type of riparian buffer available. These linear strips of forest serve as a stream's last line of defense against the activities we undertake in managing the land, such as agriculture, grazing, and urban development. Unlike most best management practices, the high value of forests to wildlife and fish helps these buffers accomplish habitat benefits at the same time they improve water quality.

Definition of a Riparian Forest Buffer:

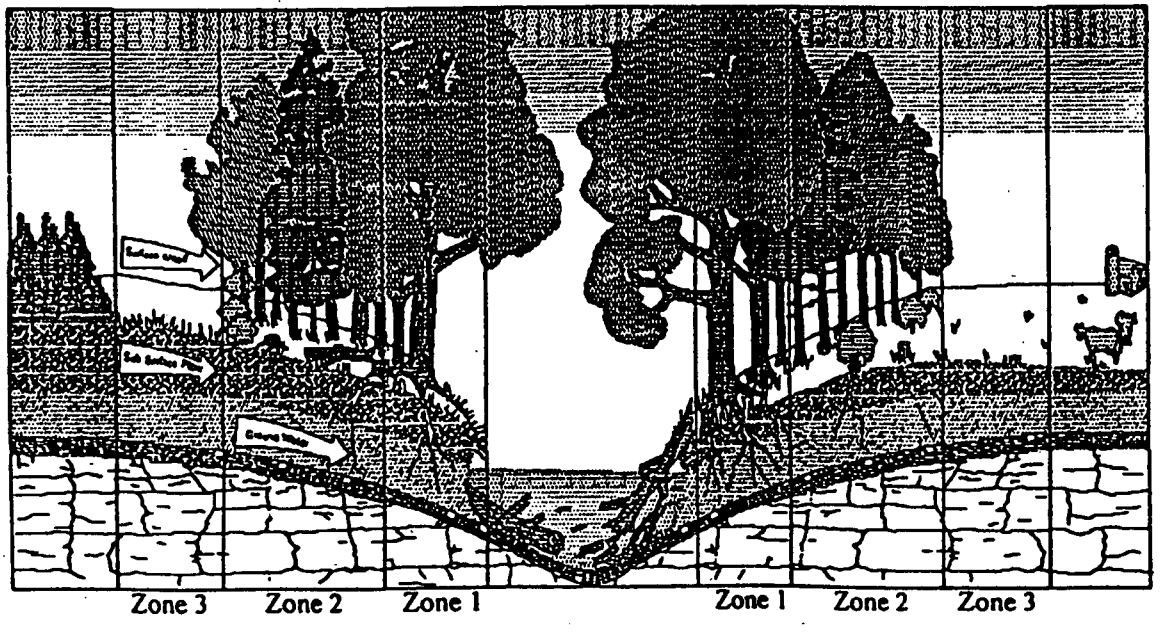
An area of trees, usually accompanied by shrubs and other vegetation, that is adjacent to a body of water which is managed to maintain the integrity of stream channels and shorelines, to reduce the impact of upland sources of pollution by trapping, filtering, and converting sediments, nutrients, and other chemicals, and to supply food, cover, and thermal protection to fish and other wildlife.

Riparian buffers will vary in character, effectiveness and size based on the environmental setting, proposed management, level of protection desired and landowner objectives. A three-zone buffer concept has been proposed to assist technical professionals and landowners with the planning and design of riparian forest buffers. The width of each zone is determined by site conditions and landowner objectives.

ZONE 1 - The mature forest along the edge of the water maintains habitat, food, and water temperature and helps stabilize streambanks, reduce flood impact and remove nutrients.

ZONE 2 - This zone contains a managed forest. The primary function of Zone 2 is to remove sediment, nutrients and other pollutants from surface and groundwater. It also provides wildlife habitat and accommodates other desired buffer objectives, including economic benefits to the landowner from management of the forest resource.

ZONE 3 - Zone 3 may contain grass filter strips, level spreaders or other features useful in slowing runoff, infiltrating water and helping to filter sediment and its associated chemicals.



Chesapeake Bay Riparian Forest Buffer Initiative

There are a number of existing federal, state and local programs that can help protect and restore riparian forest buffers. These programs include the use of tools such as agricultural and wetland reserve programs, cost-share practices, conservation easements, zoning and stormwater provisions, and tax incentives. The Chesapeake Bay Program has recognized the need for better coordination among these programs and, in October 1996, adopted a comprehensive policy calling for more aggressive action in conserving and restoring forests along the Bay's tributaries and shorelines. The Chesapeake Bay Program adopted three goals and five specific policy recommendations:

Goals:

✧ *To assure, to the extent feasible, that all streams and shorelines will be protected by a forested or other riparian buffer.*

✧ *To conserve existing forests along all streams and shorelines.*

✧ *To increase the use of all riparian buffers and restore riparian forests on 2,010 miles of stream and shoreline in the watershed by 2010, targeting efforts where they will be of greatest value to water quality and living resources.*

Policy recommendations:

✧ *Establish mechanisms to streamline, enhance, and coordinate existing programs related to buffers and riparian system conservation.*

✧ *Build partnerships with the private sector to help support the promotion and implementation of riparian forest buffer retention and restoration activities.*

✧ *Develop and promote an adequate array of incentives for landowners and developers to encourage voluntary riparian buffer retention and restoration.*

✧ *Increase the level of scientific and technical knowledge of the function and management of riparian forest and other buffers, as well as their economic, social, ecological, and water quality values.*

✧ *Encourage Bay signatories to implement education and outreach programs about the benefits of riparian forest buffers and other stream protection measures.*

Each of the states and the federal government will develop an implementation strategy for the riparian forest buffer initiative by June 30, 1998. Working together, efforts by landowners, communities, citizens and federal, state and local government to conserve and restore riparian forest buffers in the Bay watershed will help to improve the health of our streams and rivers as well as the Chesapeake Bay itself.

For more information contact:

Chesapeake Regional Information Service
(800) 662-CRIS

OR

Chesapeake Bay Program
410 Severn Ave, Suite 109
Annapolis, MD 21403
(410) 267-5700 or (800) YOUR BAY

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January 1996

Riparian Forest Buffers

Prologue:

A Watershed Dependent on Trees

Since the glaciers withdrew from Pennsylvania about 10,000 years ago, forests have dominated the land which today makes up the 64,000-square-mile Chesapeake Bay drainage basin. Prior to the Colonial era, it has been said, the forest blanket was so complete that a squirrel could have traveled from the Atlantic Coast to the Mississippi River without touching the ground. That may not be much of an overstatement, though forest fires and Native Americans certainly cleared openings in that blanket from time to time.

As the dominant vegetation, trees exerted important environmental controls over the flow of water and nutrients from the headwaters of the region's rivers to the Chesapeake Bay. A complex food web evolved, intimately connected to the forest. Leaves and twigs that fell into the streams provided food for algae species that thrived in the shaded waterways. Many insects, in turn, became adapted to feeding on those types of algae. The forest canopy moderated temperatures, allowing many sensitive species, such as trout, to survive. But in a relatively short time after colonial settlement, massive forest clearing would dramatically change the conditions to which many living things had adapted over thousands of years.

Introduction:

Four Centuries of Landscape Change

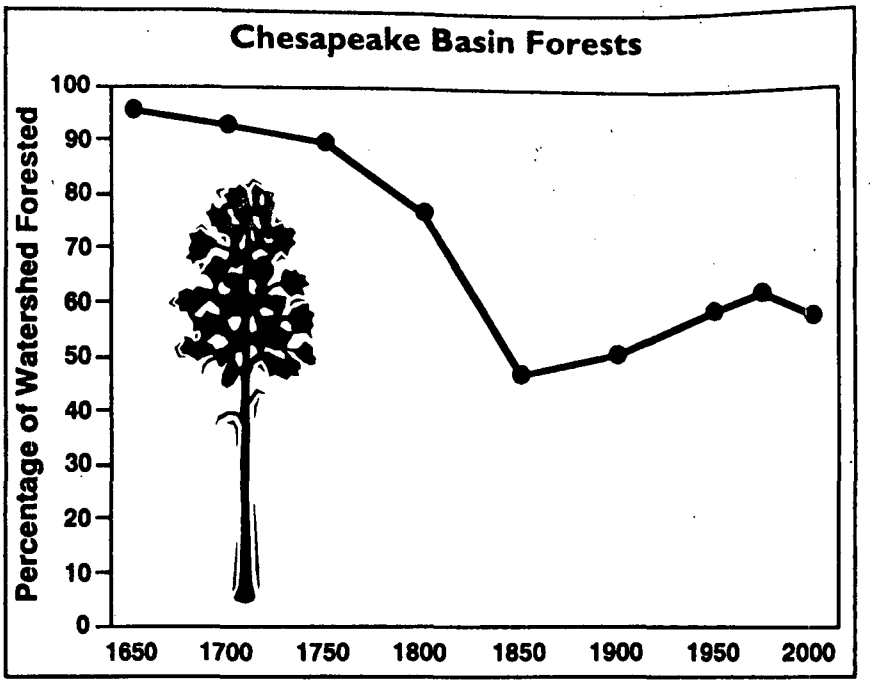
In the early 1600s, William Strachey, secretary of the Jamestown colony, observed, "the land we see around us is overgrown with trees and woods, being a plain wilderness, as God first ordained it." It is no wonder that the region seemed so strange to Europeans who had cleared most of their large forests centuries before. Also, Europe had only about 25 prominent tree species, while the New World had more than 500.

Lumber quickly became one of the first exports from the colony; the first ship returning to England carried a cargo of oak and cedar. Soon, the colony became an important supplier of ship masts and hardwood lumber. Land was quickly cleared for farming, settlements and fuel.

The rate of land clearing increased rapidly through the 1800s as demand for wood — primarily as fuel for industry — grew. By the early 1900s, only about 30-40 percent of the watershed was still covered by forest. After the early part of the century, forests gradually reclaimed some land, particularly as previously harvested areas

regrew and farmland was allowed to return to forest. By the late 1970s, forest land made up 60 percent of the Chesapeake Bay watershed. Since then, the amount has declined, largely because of development and suburban sprawl.

As a result, today's forests are not evenly distributed in the watershed. Much of the remaining forest land is far inland, covering the mountains of Pennsylvania, Maryland and Virginia. By contrast, most of the forests have vanished in agricultural areas and rapidly developing urban centers nearest the Bay, where deforestation in some counties approaches 80 percent.



For the Chesapeake Bay, that change has major ramifications. Acre for acre, forests contribute less sediment and nutrient runoff pollution than any other land use; its ability to filter water is comparable to wetlands. The loss of forests is therefore correlated with declining water quality in both the Bay and the rivers and streams that supply it with fresh water. In recent years, studies have suggested that streamside forests can serve as highly effective filters that control both surface runoff and — in many landscapes — groundwater flow into streams. In addition, they provide shade, temperature control and food required by many aquatic species.

Streamside forests, as a result, are being viewed as a way to partially mitigate the loss of forests over much of the remaining landscape. This recognition has come after many streamside forests were cleared for other uses. The Chesapeake Basin has roughly 100,000 miles of rivers and streams, but it has been estimated that as much as 50 percent of the streamside forests have been removed or severely impaired.

Bay Restoration Goals

Responding to widespread concern that the Bay's water quality was dramatically worsening, the Environmental Protection Agency financed a seven-year study of the estuary which concluded, in 1983, that excess nutrients were a key problem in the Bay. That same year, the Chesapeake Bay Program was created as a cooperative, consensus-based effort to restore the nation's largest estuary. Policy is set by the Chesapeake Executive Council, consisting of the governors of Maryland, Virginia and Pennsylvania; the mayor of the District of Columbia; the administrator of the EPA; and the chairman of the Chesapeake Bay Commission, which represents the legislatures of the three states.

The Executive Council set the direction for the cleanup effort in the 1987 Chesapeake Bay Agreement. It set restoration of the Bay's "living resources" — its fish, shellfish, waterfowl and other water-dependent species — as the primary goal of the cleanup. To achieve that goal, it called for a number of actions to improve water quality. The cornerstone was a commitment to reduce the amount of the nutrients nitrogen and phosphorus entering the Bay 40 percent by the turn of the century.

That goal was based on research and computer modeling that indicated such a reduction would result in a significant water quality improvement. Excessive amounts of nutrients spur algae blooms which cloud the Bay's water. This prevents sunlight from reaching grass beds that provide important habitat for fish, blue crabs and other species. When the algae dies, it sinks to the bottom of the Bay and decomposes in a process that depletes the water of the oxygen needed by most aquatic dwellers. During the summer, large amounts of the Bay's water becomes totally, or largely, depleted of oxygen, forcing species to move elsewhere. Many of those that cannot move die.

Into the Tributaries

After a multiyear review that verified the need for a 40 percent nutrient reduction, the Executive Council in 1992 determined that the goal should be met by setting specific nutrient reduction targets for each of the Bay's major tributaries. That led to the development of "tributary strategies" by each of the Bay states to offer details of how those reductions will be achieved.

Generally, it is thought that achieving the goal will push the envelope of technology for many nutrient control practices, both for controlling "nonpoint source" runoff from fields, lawns and streets, as well as for "point source" discharges, primarily from sewage treatment plants.

As a result, the past few years have seen a surge in interest for the use of "riparian forest buffers" to control runoff. Though not viewed as a pollution control technique until recently, research indicates that in many landscapes, forest buffers can be highly effective in controlling phosphorus and nitrogen. And because forests are the natural landscape for the Bay watershed, forest buffers also help to re-create the water quality conditions needed for native aquatic species to thrive — from the algae at the bottom of the food chain to the fish at the top.

Recognizing that riparian forests "deliver the greatest range of environmental benefits of any type of stream buffer," the Executive Council in 1994 called for the creation of a policy to guide the maintenance and restoration of forested riparian buffers in the Bay watershed. Not only would forest buffers help improve water quality, the Council said, but they would help fulfill other goals, such as creating the water quality conditions in river and streams that will be needed to support migrating shad, herring and striped bass as fish passages are constructed.

Forested riparian buffers will also play a key role in the Bay Program's long-range goal of capping nutrient inputs at the 40 percent reduction levels after the turn of the century despite the increased growth and development expected in the watershed. "Maintaining long-term caps on nutrients in the tributaries will require approaches that maintain ecosystem or watershed-scale functions, like those provided by healthy riparian forests," the Council said in its directive.

Forested Riparian Buffers

Exactly what constitutes a riparian forest buffer will vary from landscape to landscape. The term itself is still evolving, but it is based on two definitions. The phrase "riparian area" refers to the land adjacent to streams, rivers or water bodies that directly affects — or is affected by — the water. The area serves as a transition between aquatic and upland environments. A "buffer," meanwhile, is an area managed to reduce the impacts of an adjacent land use.

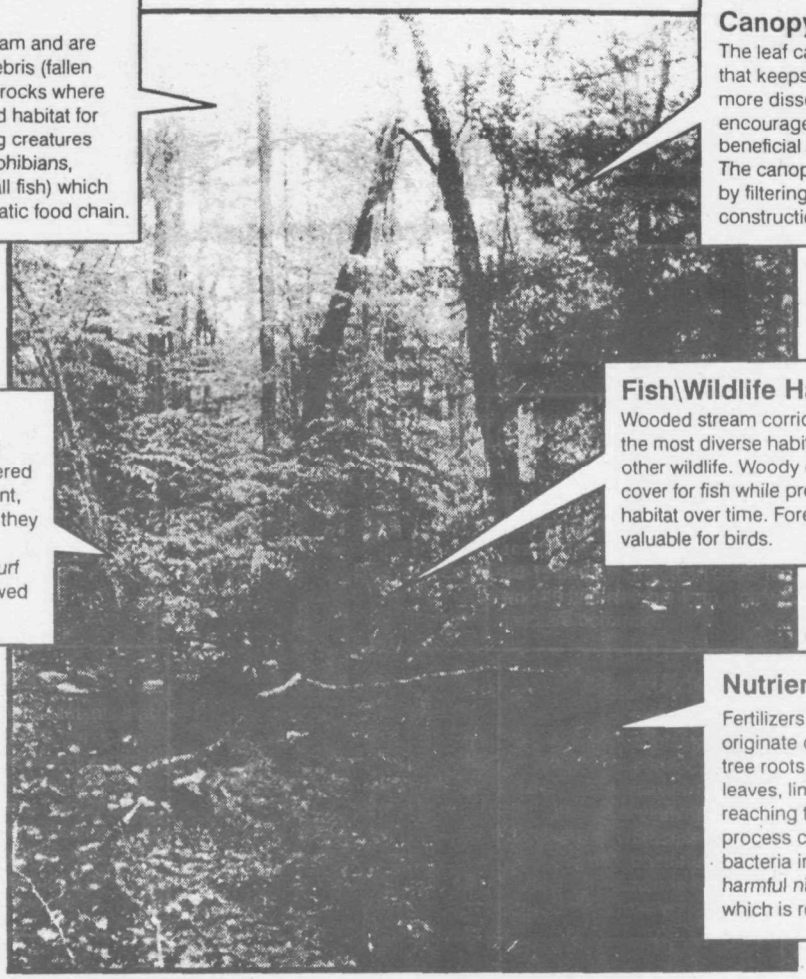
"We now recognize that forests along waterways, also known as 'riparian forests,' are an important resource that protects water quality and provides habitat and food necessary to support fish survival and reproduction. Used as buffers, riparian forests provide a means of helping us achieve our restoration goals in the tributaries."

— from the 1993 Chesapeake Executive Council directive on Riparian Forest Buffers

A "forest riparian buffer" is a combination of the two. It refers to a forested area situated between a stream and the adjacent land use which is managed to help maintain the hydrologic and ecological integrity of stream channels and shorelines; prevent upland sources of pollution from reaching surface waters by trapping, filtering and converting sediments, nutrients and chemicals; and protect fish and other wildlife by supplying food, cover and temperature control.

With more than 100,000 miles of widely differing streams winding through the Bay watershed, there is

Benefits of Riparian Forest Buffers



Leaf Food
Leaves fall into a stream and are trapped on woody debris (fallen trees and limbs) and rocks where they provide food and habitat for small bottom dwelling creatures (such as insects, amphibians, crustaceans and small fish) which are critical to the aquatic food chain.

Canopy and Shade
The leaf canopy provides shade that keeps the water cool, retains more dissolved oxygen and encourages the growth of diatoms, beneficial algae and aquatic insects. The canopy improves air quality by filtering dust from wind erosion, construction or farm machinery.

Filtering Runoff
Rain and sediment that runs off the land can be slowed and filtered in the forest settling out sediment, nutrients and pesticides before they reach streams. Infiltration rates *10-15 times higher than grass turf* and 40 times higher than a plowed field are common.

Fish\Wildlife Habitat
Wooded stream corridors provide the most diverse habitats for fish and other wildlife. Woody debris provides cover for fish while preserving stream habitat over time. Forest diversity is valuable for birds.

Nutrient Uptake
Fertilizers and other pollutants that originate on land are taken up by tree roots. Nutrients are stored in leaves, limbs and roots instead of reaching the stream. Through a process called "denitrification", bacteria in the forest floor convert *harmful nitrate to nitrogen gas*, which is released into the air.

no "one size fits all" description of an ideal riparian forest buffer. Instead, a three-zone buffer concept has been developed to help technical professionals and landowners customize buffer planning for widely varying landscapes. The three-zone buffer provides a framework in which water quality, habitat and landowner objectives can be accomplished. The three zones consist of:

❑ Zone 1, a permanent tree buffer immediately adjacent to the stream bank which exerts the most control over the stream environment.

❑ Zone 2, a managed forest immediately upslope from Zone 1 which is the primary area for the removal of pollutants carried in surface runoff and shallow groundwater.

❑ Zone 3, a herbaceous or grass filter strip, or other control measure, upslope from Zone 2 which helps to protect the forested buffer and slow runoff to improve the sediment trapping ability in Zone 2.

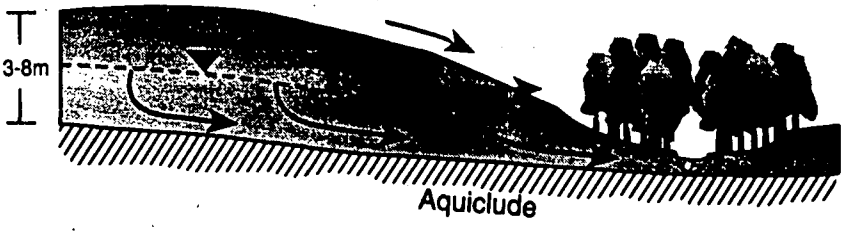
This highly flexible system can be adapted to maximize environmental benefits for a wide variety of geologic and geographic conditions while taking landowner objectives into account. Zone 3, for example, is compatible with uses that range from suburban lawns to stormwater management to pasture. Zone 2 may shrink or expand to reduce pollution runoff and to meet landowner objectives such as improving wildlife habitat or providing recreational opportunities such as bike paths. Managed timber harvests could take place in Zone 2, and may even be desirable as growing trees will uptake more nutrients than mature ones.

This mix of techniques helps compress a number of

Inner Coastal Plain

Of all physiographic regions, the inner coastal plain probably represents the maximum potential for nonpoint source control in riparian forest buffer systems. Most excess rainfall enters streams through subsurface runoff or shallow groundwater and therefore moves in or near the forest buffer root zone where nutrient removal is very high. Forest buffers will be highly effective in controlling most particulate surface runoff as well, though dissolved phosphorus removal takes place at a lower rate. Because this region is often flat, many agricultural areas have drainage systems. For forest buffers to be effective, those systems must be modified to encourage flow through the buffer.

INNER COASTAL PLAIN

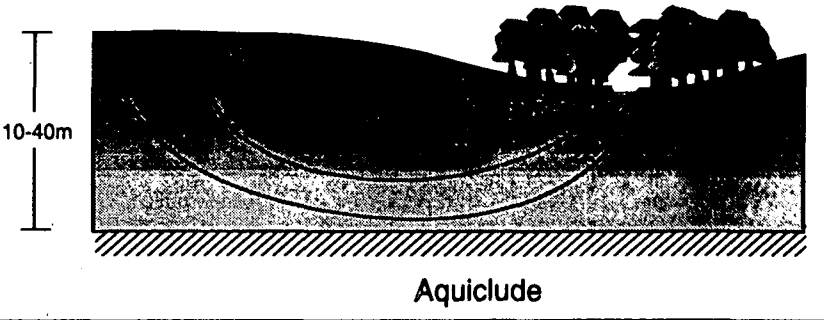


Water Quality Function	Expected Level	Critical Constraints	Restoration/ Enhancement
Removal of nitrate *from groundwater*	High, most water *moves in or near* root zone.	Bypass due to artificial *subsurface drains.* Organics in Zone 2.	Important on all streams. Rapid *restoration of dentrification* function. Ground cover in Zone 3.
Removal of sediment and sediment-borne pollutants	High/Medium	Convert concentrated flow to sheet flow.	Restore in all areas. Enhance existing forest with Zone 3 speaders.
Removal of dissolved phosphorus	Medium/Low	Control of dissolved P in surface runoff and groundwater is limited.	Restore in areas with major P load in surface runoff. Enhance existing forest with Zone 3.

Outer Coastal Plain

Well drained upland: Aside from lands immediately adjacent to streams, excess rainfall sinks farther into the ground and therefore enters the streams through their bottoms, never coming into contact with the root zone. As a result, there is little nitrate removal from groundwater. In this area, Zone 1 vegetation is particularly important because trees immediately adjacent to small streams offer the most potential for root systems to intercept the deeper groundwater before entering small streams. Management actions in this area might include the selection of trees that would have roots most likely to make that connection. If the roots can reach the groundwater, ni-

OUTER COASTAL PLAIN FLOW SYSTEM
Well-Drained Upland



Water Quality Function	Expected Level	Critical Constraints	Restoration/ Enhancement
Removal of nitrate from groundwater	Low, primarily removal from shorter flow paths.	Bypass flow due to deeper aquifers. Long flow paths surface in stream channels.	Concentration on headwater areas. Zone 1 important for nitrate removal.
Removal of sediment and sediment-borne pollutants	High/Medium	Concentrated flow must be converted to sheet flow.	On larger streams, focus on filtering eroded sediment. Enhance functions of Zones 2 & 3.
Removal of dissolved phosphorus	Medium/Low	Dissolved P control is limited. Focus on P load in surface runoff.	Increase vegetation uptake and accretion. Enhance existing forest and grass strips.

Continued on page 11

habitat and pollution-control functions into a relatively narrow strip of land. Conceptually, planners generally consider a buffer width of 75 to 100 feet on each side of the stream adequate to achieve all of those functions. The width of each zone may vary from landscape to landscape. In general, wider buffers will help increase runoff control, particularly on steep slopes. In areas where wide buffers are not practical, even narrow wooded buffers — perhaps only 25 feet — can provide some habitat benefits such as streambank stabilization, food supply for aquatic organisms, and shading. On the narrowest headwater streams, the overall buffer width needed for water quality may also be narrower.

Applying the System

To help assess the effectiveness of riparian forest buffers in various settings, the Chesapeake Bay Program formed a special team of scientists in 1994 to review available research about forest buffers and their impact on habitat and water quality. In August 1995, their work resulted in a consensus document, "Water Quality Functions of Riparian Forest Buffer Systems in the Chesapeake Bay Watershed."

The team concluded that in almost all settings, the forest buffer system will help control the stream environment and substantially improve habitat for aquatic species. In most places, buffers will prove to be an effective means to control surface runoff and many types of runoff-borne pollutants as well, though effectiveness will vary from landscape to landscape. Controlling groundwater pollutants varies widely, depending on the geologic setting.

The scientists rated the four major functions performed by riparian forest buffers from their most common and widespread role, to their least effective function. Those were, in descending order of effectiveness:

❑ Control of the stream environment. This includes controlling stream temperatures and the amount of light reaching the stream; expanding habitat diversity; stabilizing the streambank against the effects of erosion; and enhancing the food web.

❑ Control of sediment and sediment-borne pollutants. Forests are highly effective at trapping and filtering sediments and any accompanying pollutants (such as particulate phosphorus or nitrate) that are contained in the runoff. Debris on the forest floor slows the water, allowing sediment to settle. Slope and soil permeability are the greatest factor in determining effectiveness of sediment trapping; areas with steep slopes may require wider buffers. Buffers can trap 80-90 percent of the sediment as long as management actions are taken to disperse concentrated runoff flowing into the forested area.

❑ Control of nitrate in shallow groundwater. In areas where groundwater moves in short, shallow paths to the stream, passing through the root zone of the riparian forest buffer system, nitrate removal can be extremely high, on the order of 90 percent. In areas where groundwater flows in longer, deeper paths to larger streams, the root zone will be bypassed and nitrate removal may be minimal. Of all the forest buffer functions, this one is most sensitive to the geographic, geologic and land use settings.

❑ Control of dissolved phosphorus. While buffers are effective at controlling particulate phosphorus linked to the sediment, they are less effective at controlling dissolved phosphorus. Most dissolved phosphorus is immediately available to organisms when it reaches the water. To increase dissolved phosphorus retention, efforts to trap fine sediments need to be coupled with the use of vegetation that increases phosphorus uptake into plant tissue. Fortunately, dissolved phosphorus makes up a very small portion of the Bay's pollution problem.

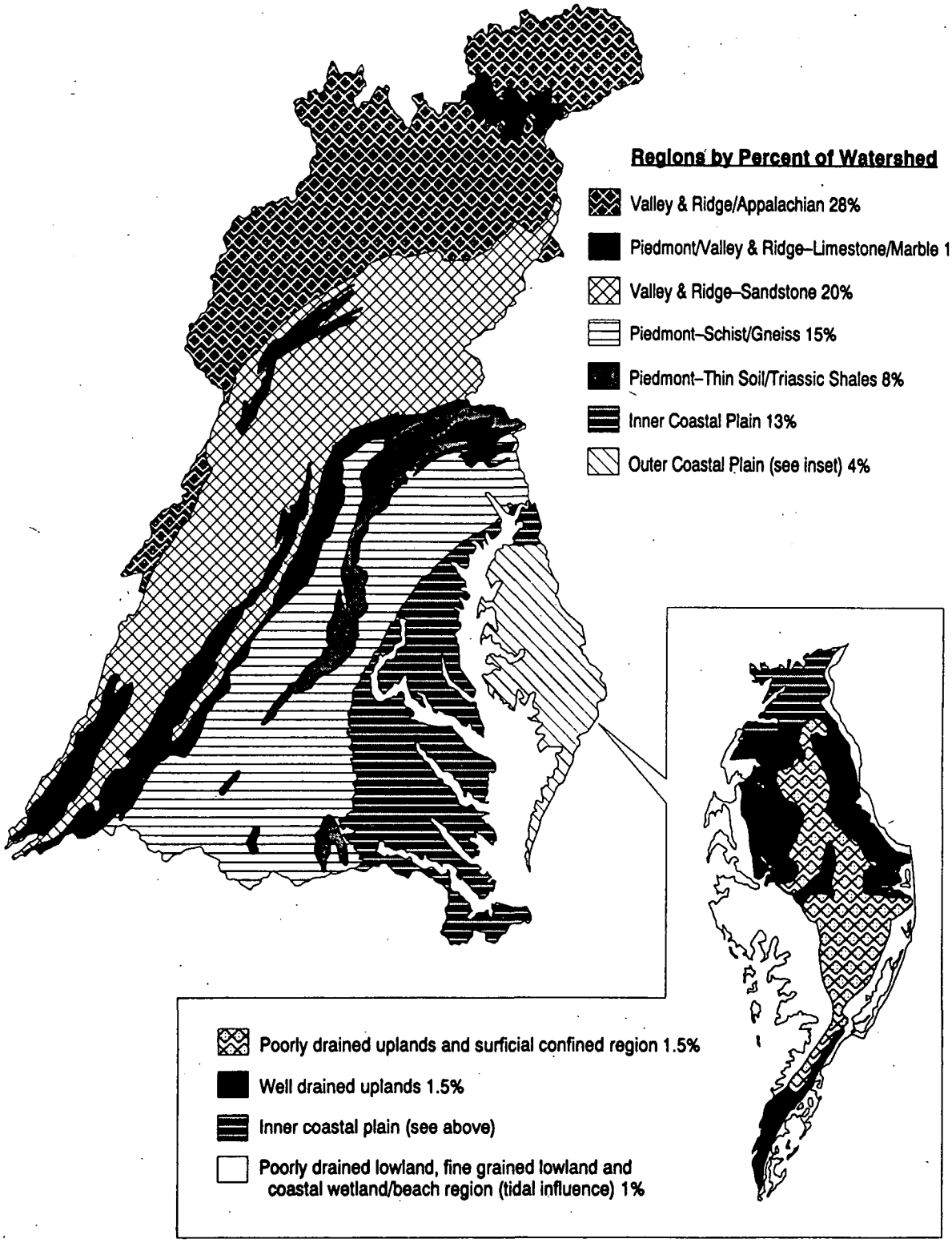
The scientists reviewed forest buffer effectiveness for pollution control within each of the major physiographic regions found in the Chesapeake Bay watershed, and offered their best professional judgments of how riparian forest buffer systems would perform.

Riparian Forest Buffers:
% Reduction of Nutrients and Sediment*

Level	Sediment	Nitrogen	Phosphorus
High	85-95	68-92	70-81
Medium	65-85	45-68	50-70
Low	40-65	15-45	24-50

* General approximations for 100-foot forest buffer system. Actual levels will vary by land use and site conditions. Based on loadings from agricultural lands, performance in field studies rated as high removed total N in the range of 23-66 #/acre/year and total P in the range of 1-3 #/acre/year from adjacent fields. Expected level of function is based on mature forest in Zone 1 & 2.

Major Hydro-Physiographic Regions in the Chesapeake Watershed



Riparian Forest Buffers

The Three-Zone Concept: A Tool to Guide Forest Buffer Planning

A three-zone system has been developed to help plan riparian forest buffers. This three-zone concept is intended to be highly flexible in order to achieve both water quality and landowner objectives.

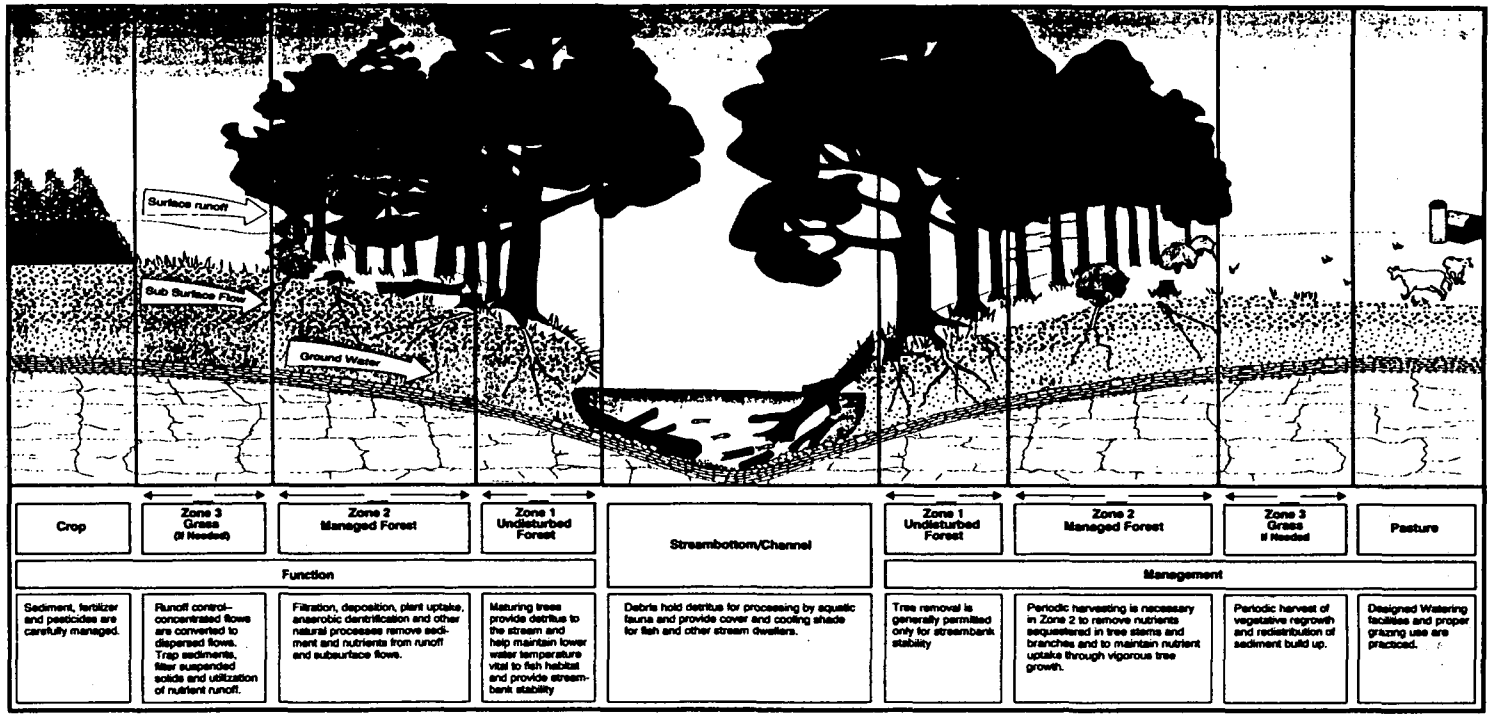
Zone 1: This represents the inner core of the buffer, stretching upland from the edge of the stream. Its primary purpose is to stabilize the streambank and provide habitat for aquatic organisms. The roots of trees in Zone 1 hold together the soil to resist the erosive force of flowing water. This also keeps sediment, and any nutrients bound to it, out of the stream.

Roots and fallen logs slow stream flow. This not only provides additional protection against erosion, but also creates pools that form unique "microenvironments." Pools support species of macroinvertebrates different from those in riffles only a few feet away. As a result, the presence of trees is directly related to greater biodiversity in the stream ecosystem.

Roots and submerged tree limbs also provide important habitats for macroinvertebrates, supporting even greater densities of the insects than can be found on the rocky stream bottom. This fallen debris also traps leaves, twigs, fruit seeds and other material in the stream, allowing it to decay and be used by stream-dwelling organisms. As the canopy is removed, there is not only less material, but the litter that remains breaks down more rapidly. Litter seems to be trapped and consumed in a relatively small area, so an upstream forested area does little to "subsidize" an unforested area downstream. This supports the need for a continuous streamside forest where possible.

The leafy canopy of the trees provides shade that helps to control water temperature. Maximum summer temperatures in a deforested stream may be 10-20 degrees warmer than in a forested stream. That is significant as temperature changes of only 4-10 degrees usually alter the life-history characteristics of macroinvertebrates that form an important part of the food web.

In addition, shaded streams support algae communities dominated by diatoms — a type of algae favored by many species — throughout the year while areas getting more direct sunlight are dominated by filamentous algae. This change, at the very bottom of the food web, is critically important. While crayfish and a few insect species will consume filamentous algae, most macroinvertebrate species cannot because they have evolved as specialists for scraping diatoms from the bottom.



While Zone 1 will improve habitat along all streams, its greatest impact will be along smaller streams where the canopy completely covers the water surface, providing maximum control over light and temperature conditions. Trees in Zone 1 will aid in filtering surface runoff and, in some landscapes, can help remove nutrients carried in the groundwater.

Zone 2: Located immediately upslope from Zone 1, the primary function of Zone 2 is to remove, transform, or store nutrients, sediments and other pollutants flowing over the surface and through the groundwater. Widths of Zone 2 can vary.

In areas where shallow groundwater flows through the root zones of trees, large amounts of nitrate can be removed before the water enters a stream. This results primarily from plant uptake and denitrification in the soils. Nitrate removal in these areas can be high — on the order of 90 percent. In areas where the groundwater flows deeper, much of this benefit will be lost as most of the water bypasses the root zone and enters the stream directly through the sediment.

Regardless of whether shallow groundwater flows through the root zones, all Zone 2 forest buffers will remove surface-borne pollutants. Debris from the trees slows and traps sediments in the runoff, giving the nutrients they carry time to infiltrate into the ground where they may be stored or removed through natural processes. Studies have found that Zone 2 can remove 50-80 percent of the sediment in runoff from upland fields. Generally, the upland edge of the Zone

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2 forest traps the largest share of coarse sediments while finer sediments will drop out as the water flows through the remainder of the buffer. Fine sediments carry larger amounts of nutrients and pollutants, so their concentrations are distributed over a wider area. This makes the width of Zone 2 critical.

Whether they are pulled from shallow groundwater or infiltrate into the soils from surface runoff, nutrients are removed in zone 2 through a variety of mechanisms. The most obvious process is plant uptake, as all plants must absorb nutrients to grow. In addition, forests provide large amount of decaying organic material that is necessary to fuel the microbial processes in Zone 2 soils that remove nutrients. There are three main ways those processes work:

- Microbes in the soil can take up nutrients and store them until they die, at which time the nutrients are released in a mineralized form that is less biologically available to other organisms and more readily stored in the soil. If managed to foster accumulation of this material, Zone 2 may support significant long-term nutrient storage.
- Denitrification takes place under the proper conditions when certain denitrifying bacteria convert nitrate to nitrogen gases. Denitrification is carried out by anaerobic microbes, organisms which survive in water or soils — usually wetlands — without oxygen. The large amount of decaying organic material on the ground in forested buffers depletes oxygen in the soils, and there is usually enough moisture in riparian areas to support the microbes needed for denitrification. Even drier forest soils commonly have small pockets which support these bacteria. Denitrification rates will vary depending on site conditions.
- Microbes use organic compounds as food and, though various reactions, change them so they are degraded to simpler compounds or synthesized into microbial biomass. Riparian forests appear to support a variety of microbial degradation mechanisms, though the management strategies that would promote them are not understood at this point.

Several factors will affect Zone 2 effectiveness at controlling surface runoff. Runoff must be managed to encourage "sheet" flows across the buffer. Buffers must also be wide enough to trap and hold sediments coming from adjacent land uses; if the buffer becomes overloaded with sediment, the excess will no longer be trapped and will simply wash into the stream. And the ability of Zone 2 forests to remove nutrients in groundwater will vary dramatically from landscape to landscape, depending on whether the groundwater comes into contact with the root zone.

Most Zone 2 studies have been made in existing or "natural" riparian forests. Scientists believe that even greater nutrient removal can be achieved in riparian buffers that are specifically managed for this function. Such management could include planting trees, such as bottomland hardwoods, which grow well in "well-watered" conditions and absorb large amounts of nutrients, or, through management techniques that promote soil conditions conducive to microbes that promote denitrification or nutrient storage.

Zone 3: Located immediately upslope of Zone 2, Zone 3 contains grass filter strips or other control measures which help slow runoff, filter sediment and its associated chemicals, and allow water to infiltrate into the ground. Grass filter strips help to protect the wooded areas and sets the stage so the forest buffer can perform at its maximum potential. Effective sediment trapping in Zone 2 requires that runoff entering that portion of the buffer be in the form of sheet flow. Zone 3, therefore, acts to spread out the flow and prevent runoff from adjacent land uses from eroding channels into the buffer.

Several studies show that grass filter strips are highly effective at reducing sediment runoff, with removal rates of 50 percent or more. Also, the filter strips are highly effective at removing sediment-bound nutrients such as phosphorus, but less effective at removing dissolved nutrients. Over time, the removal efficiency decreases as grass is smothered by deposited sediment. Generally, the narrower the filter strip, the shorter its effective life. As a result, grass filter strips require periodic maintenance which includes the removal of sediment, reestablishment of vegetation, and removal of channels. In urban areas, infiltration trenches and stormwater control measures may be common in Zone 3.

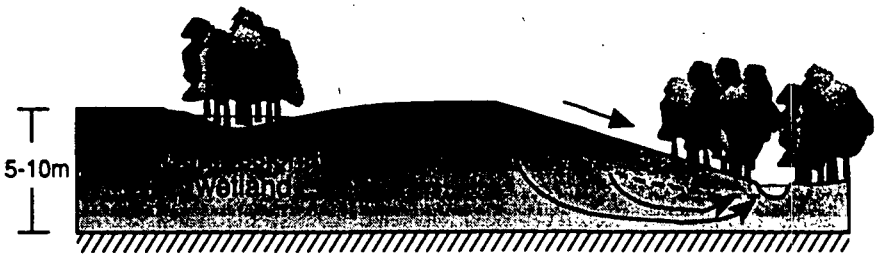
Continued from page 6

trate removal could be about as effective as buffer systems in other landscapes. Regardless of the groundwater situation, buffer systems in this area would still provide sediment control capacity similar to the Inner Coastal Plain. Because of the lower water tables, well-drained uplands may have more capacity to store dissolved chemicals in groundwater.

Poorly drained upland/ surficial confined: Groundwater is slightly higher here than in the well-drained upland but lower than the inner coastal plain. As a result, the effectiveness of nitrate removal from the groundwater is between those two extremes. Surface runoff control would still be effective, but removal of dissolved chemicals would probably be less than in the well-drained upland because the higher groundwater level limits storage. Agriculture in this region is commonly associated with artificial drainage, which requires integration into the buffer system.

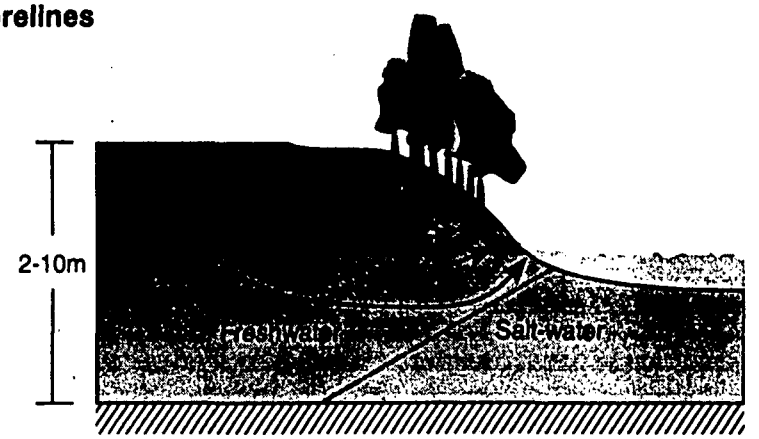
Shorelines: Tidally influenced areas are unique because groundwater discharges are affected by tidal movements. Also, unlike most of the Bay watershed, marshes are the natural shore vegetation in many of these areas. At sites where marshes are not the natural shoreline, forest buffers can help stabilize the banks. Shorelines and cliffs are unique areas where special management may be needed. In most areas, the water table will be completely under the root zone, minimizing its influ-

OUTER COASTAL PLAIN FLOW SYSTEM
Poorly Drained Upland/Surficial Confined



Water Quality Function	Expected Level	Critical Constraints	Restoration/ Enhancement
Removal of nitrate from groundwater	Medium/High	Lower loadings. Lower rates of removal in head-water areas.	Restore first in headwaters then larger streams. Rapid restoration of dentrification function.
Removal of sediment and sediment-borne pollutants	High/Medium	Less surface runoff but similiar efficiencies as in other C P systems.	Enhance vegetation in broad existing areas. Restore in headwaters.
Removal of dissolved phosphorus	Medium/Low	Dissolved P control is limited. Focus on P load in surface runoff.	Increase vegetation uptake and accretion. Enhance existing forest and grass strips.

OUTER COASTAL PLAIN FLOW SYSTEM
Shorelines



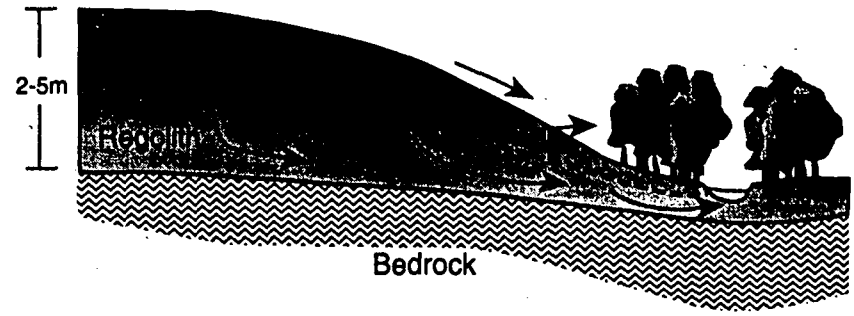
Water Quality Function	Expected Level	Critical Constraints	Restoration/ Enhancement
Removal of nitrate from groundwater	Low/Medium	Depth to water-tables. Bank erosion due to unstable soils.	Limit practice to areas without marsh wetlands down slope. Enhance vegetation uptake.
Removal of sediment and sediment-borne pollutants	High/Medium	Convert concentrated flow to sheet flow. Bank stability limits usefulness in some areas.	Restore/enhance in all areas. Limit to wider Zone 3 in some areas. Enhance Zone 3.
Removal of dissolved phosphorus	Medium/Low	Dissolved P control is limited. Focus on P load in surface runoff.	Increase vegetation uptake and accretion. Enhance existing forest and grass strips.

Piedmont

The Piedmont contains rich soils which can be quite deep. The effectiveness of a riparian forest buffer's ability to remove nitrate from the groundwater hinges on the depth of those soils and the underlying bedrock. In areas with thin or finely textured soils and short flow paths to streams through shallow groundwater or surface seepage — characteristics common in the Virginia Piedmont — nitrate removal would be high, as in the inner coastal plain.

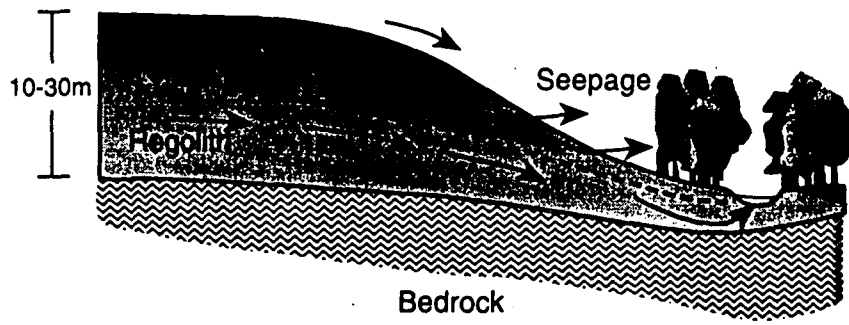
Piedmont areas with deeper soils are likely to have longer flow paths which allow water to sink deeper into the ground before entering the stream, in some cases bypassing the forest buffer. These areas are characterized by two different types of bedrock: gneiss/shist and marble. Areas with primarily shist bedrock would achieve moderate nitrate removal as groundwater would be forced to move laterally toward small streams. Some groundwater would either seep up toward the surface before reaching the stream or would pass through the root zone of the buffer, while some flowing more deeply would bypass the buffer. In areas with deep soils underlaid by marble, nitrate removal would be minimal as much of the groundwater would move through the porous marble layer and into regional aquifers. Riparian forests are most valuable here in floodplains and valley bottoms.

PIEDMONT FLOW SYSTEM
Thin Soils/Triassic Shales



Water Quality Function	Expected Level	Critical Constraints	Restoration/ Enhancement
Removal of nitrate from groundwater	High	Lower loadings than ICP Valley shapes control local flow paths.	Select deeply rooted vegetation, restore small and large streams, seepage areas.
Removal of sediment and sediment-borne pollutants	High/Medium	Slope of non-floodplain areas. Volumes of surface runoff.	Restore in areas. Function dependent on Zone 3 in first few years. Enhance Zone 3.
Removal of dissolved phosphorus	Medium/Low	Control of dissolved P in surface runoff.	Restore in areas with large surface runoff P loads. Increase infiltration.

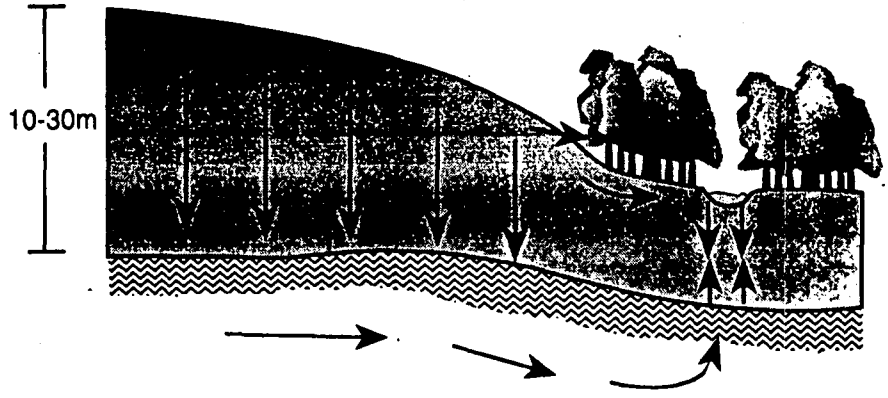
PIEDMONT FLOW SYSTEM
Schist/Gneiss Bedrock



Water Quality Function	Expected Level	Critical Constraints	Restoration/ Enhancement
Removal of nitrate from groundwater	Medium	More flow into regional aquifers, bypassing riparian zone.	Select deeply rooted vegetation. Restore in seepage areas.
Removal of sediment and sediment-borne pollutants	High/Medium	Slope of non-floodplain areas. Sediment loads in stream flow from valley sides.	Restore in areas with erosion impacting streams. Enhance existing forests with Zone 3.
Removal of dissolved phosphorus	Medium/Low	Control of dissolved P in surface runoff.	Restore in areas with large surface runoff P loads. Increase infiltration.

Sediment control in areas characterized by thin soils and flatter terrain would be similar to that of the inner coastal plain, with the removal of sediment and particulate nutrients being fairly high, while control of dissolved phosphorus would be fairly low. In hillier areas of the Piedmont, sediment control will depend on how effectively Zone 3 is managed to spread out the runoff and prevent it from cutting channels into the forest, allowing water to pass rapidly through the buffer. Steeper slopes in riparian areas may limit both the sediment filtering capacity and the retention time of water, possibly requiring expansion of Zone 3 and/ or Zone 2.

PIEDMONT/VALLEY & RIDGE FLOW SYSTEM
Marble/Limestone Bedrock



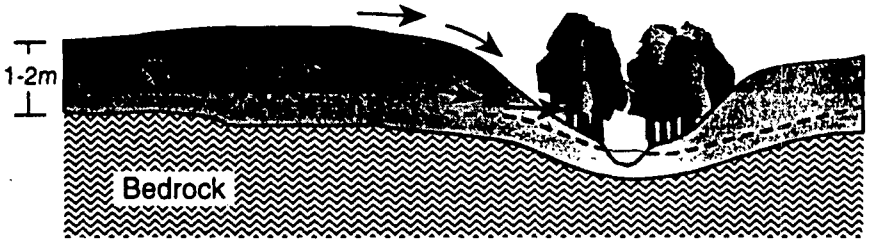
Water Quality Function	Expected Level	Critical Constraints	Restoration/ Enhancement
Removal of nitrate from groundwater	Low	Most flow into regional aquifers and into large rivers.	Dentrification focus. Select deeply rooted vegetation. Restore in seepage areas.
Removal of sediment and sediment-borne pollutants	High/Medium	Slope of non-floodplain areas. Sediment loads in stream flow from valley sides.	Restore in all areas with erosion impacting streams. Enhance existing forests with Zone 3.
Removal of dissolved phosphorus	Medium/Low	Control of dissolved P in surface runoff.	Restore in areas with large surface runoff P loads. Increase infiltration and fine sediment filter.

Valley and Ridge/Appalachian

The Valley and Ridge province is characterized by folds in topography. Ridges of harder, more resistant rock lie parallel to softer rock worn down over time to form the lowlands. Streams are intimately connected to this topography, flowing on belts of soft rock which rarely cross mountain ridges. Where they do, they cross at right angles, forming a distinctive "trellised" drainage pattern. Springs and seepage areas are common and the water table is often close to the surface in near-stream areas.

This area is characterized by larger streams that drain the main valleys, with smaller, and often steeper, streams draining the ridges. Forested riparian buffers have proven highly effective in controlling water

VALLEY & RIDGE FLOW SYSTEM
Sandstone/Shale Bedrock



Water Quality Function	Expected Level	Critical Constraints	Restoration/ Enhancement
Removal of nitrate from groundwater	Medium/High	Presence of seeps and floodplains. Valley configurations.	Select for vegetation uptake especially early in growing season. Deeply rooted.
Removal of sediment and sediment-borne pollutants	High/Medium	Sediment loads in stream flow from valley walls. Slopes of non-floodplains.	Restore in all areas with stream erosion. Enhance Zone 3 to control sediment.
Removal of dissolved phosphorus	Medium/Low	Control of dissolved P in surface runoff.	Restore in areas with large surface runoff P loads. Increase infiltration.

temperature and sediment delivery to streams in forest and agricultural settings in the Valley and Ridge, but knowledge of the removal of nutrients from groundwater is less certain. This is primarily because of differences in geology. Water flow in Valley and Ridge areas with limestone bedrock is complicated and quite variable over time. There is often little potential for removing nitrate from groundwater as water will flow through cavernous openings in the rock to deep aquifers. From there, groundwater will eventually flow into the bottom of larger streams or rivers, bypassing riparian buffer zones altogether. Valley and Ridge areas with sandstone/shale bedrock have greater potential for groundwater nitrate removal as the hard bedrock keeps water moving laterally in the shallow soils toward the streams. Seepage and near-stream areas provide opportunities for substantial nitrate removal, while valley floodplains where groundwater discharge occurs will likely be areas for forest buffers to influence water quality. Surface runoff control would face the same issues as in hilly portions of the Piedmont.

VALLEY & RIDGE/APPALACHIAN FLOW SYSTEM
Low Order Streams

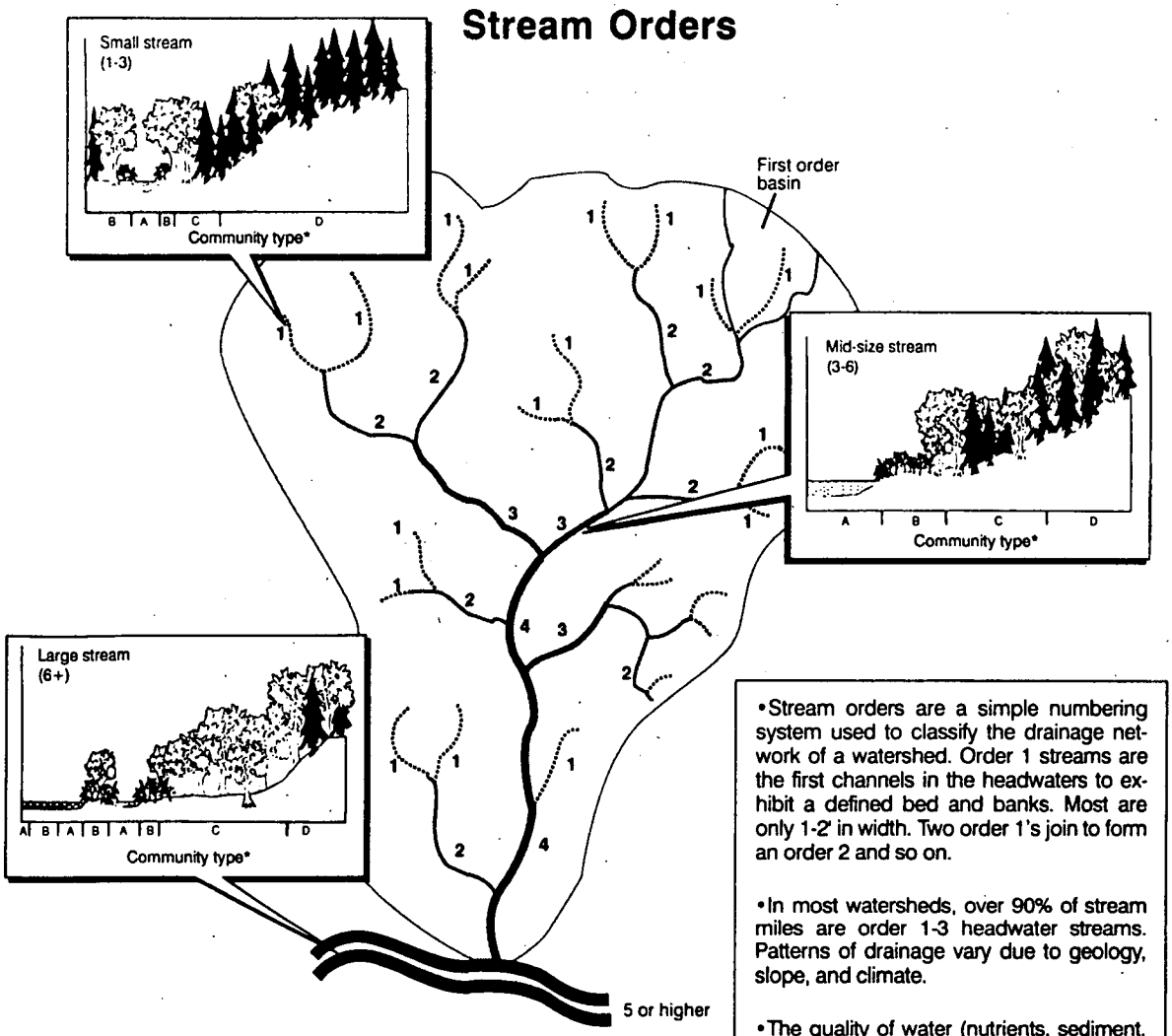
Water Quality Function	Expected Level	Critical Constraints	Restoration/ Enhancement
Removal of nitrate from groundwater	Medium/High	Residence time of water. Presence of seeps and floodplains.	Select deeply rooted vegetation for uptake. Zone 1 is important for removal.
Removal of sediment and sediment-borne pollutants	High/Medium	Sediment loads in stream flow from valley walls. Slopes of non-floodplains.	Restore in all areas with stream erosion. Enhance Zone 3 to control sediment.
Removal of dissolved phosphorus	Medium/Low	Control of dissolved P in surface runoff.	Restore in areas with large surface runoff P loads. Increase infiltration.

Management considerations

To be most effective, riparian forest buffers need to be planned and implemented on a watershed scale. This allows for a continuous forested buffer linking the headwaters with downstream areas. Protecting headwaters is particularly important because forest buffers affect water quality primarily as water moves *toward* the stream; downstream buffers will have proportionally less impact on polluted water already in the stream. Watersheds that have the highest stream densities — the number of streams relative to the size of the watershed — will get the greatest water quality benefits as most surface and groundwater will flow through the buffer before reaching the stream.

Riparian forest buffers exert the greatest control over small streams (Order 1-3). Not only will much of the water entering the stream pass through the buffer, but the tree canopy also covers the entire waterway, providing shade and litter inputs. As the stream widens and the canopy no longer shades the entire surface, the buffer can still filter nutrients flowing toward the stream. Forest buffers along wider streams will also provide such benefits as streambank stabilization; mitigation of flood damage; provision of coarse

Stream Orders



***Key**

A–Active channel or water body
B–Stream banks and adjacent area flooded on an annual basis
C–Riparian zone of influence-zone of vegetation directing affecting or affected by the stream or water body
D–Uplands

(Note that A, B and C make up the complete riparian zone. In some cases, portions of D may be included in a ripanan buffer.)

- Stream orders are a simple numbering system used to classify the drainage network of a watershed. Order 1 streams are the first channels in the headwaters to exhibit a defined bed and banks. Most are only 1-2' in width. Two order 1's join to form an order 2 and so on.

- In most watersheds, over 90% of stream miles are order 1-3 headwater streams. Patterns of drainage vary due to geology, slope, and climate.

- The quality of water (nutrients, sediment, and temperature) is affected most by the condition of headwater streams (order 1-4). Riparian forest buffers may exert their greatest influence here as the majority of water flows through the shaded riparian zone.

- Riparian forests may provide the greatest opportunities to enhance fish habitat on mid-order streams (3-6) and shorelines where there is sufficient large woody debris, stream structure and flow to support fish and other aquatic life.

- Larger streams and rivers (order 6+) are often characterized by well-defined floodplains or adjacent wetlands. Wider buffers may be needed here to allow meandering, as well as improve channel stability, water quality, and wildlife corridors.

woody debris and leaf detritus, habitat and stream structure; and shading to cool a portion of the channel and the groundwater recharging the streams. These functions will occur regardless of stream size. Providing a continuous stream corridor is therefore desirable.

It's unclear how quickly newly established riparian forest buffers impact water quality. Based on the coastal plain, which has received the most intensive research, newly planted buffers would have a substantial impact within 5 to 10 years in areas where wetland soils existed in the past. Within 15 to 20 years, buffer systems would provide their full range of benefits.

Once established, a forest buffer should provide water quality and habitat benefits indefinitely but may require maintenance. In areas — particularly on steep slopes — actions will be needed to assure that runoff does not carve gullies that allow water to rapidly flow through the buffer. In some areas, primarily buffers with older trees, periodic selective harvesting may be required as growing trees will absorb more nutrients than mature ones. Efforts may also be needed to control invasive plants, particularly nonnative species, which can limit tree growth and diminish the habitat quality for aquatic species.

For best results, the three zones should be integrated. The width of the buffer will vary depending on the site conditions and landowner objectives. As a minimum, establishing contiguous forest buffers of even narrow (Zone 1) width to link existing forested areas or buffers should be considered a high priority to provide continuous streamside habitat. If only a minimal forest buffer is possible, efforts should be made to ensure it is wide enough to sustain a forest community and forest soil conditions over the long term.

Conclusion

In the Chesapeake Bay watershed, riparian forest buffers will enhance or restore stream habitat in any setting, and will improve water quality in the vast majority of areas. For fish, wildlife and people, they are one of the most valuable investments landowners, and the public, can make for the Bay.

In recognition of their significant role in Bay restoration efforts, the Chesapeake Executive Council asked that recommendations for a riparian forest buffer policy be developed for its 1996 meeting. The policy, developed with input from government agencies, landowners, scientists, nonprofit organizations, business, and others, ensures that the improvements in riparian forest protection, restoration and stewardship take place by setting quantifiable goals for riparian forest restoration in the watershed and a timetable for reaching that goal. To promote forest buffer protection and restoration, the policy explores ways to improve communication and build partnerships among federal, state and local government agencies, as well as with private landowners and the public to coordinate existing programs and provide additional incentives.

Ultimately, success in enhancing riparian forests and buffers will depend as much on cultivating a stewardship ethic among landowners and other "stakeholders" as it will on planting trees. Determining how policies that will promote riparian forest buffers should be incorporated into local government land use plans, how to integrate economic values of buffers into decision-making, and the development of incentive and educational programs needed to promote riparian forest buffer maintenance and restoration throughout the watershed will be the challenge. With such cooperation, the tributaries will carry cleaner water into the Chesapeake — and provide an avenue for many of the Bay's fish species to travel upstream and thrive — for generations to come.

ALLIANCE for the CHESAPEAKE BAY

Production of this White Paper was funded by the Chesapeake Bay Program as a public education service. Technical assistance was provided by USDA's Forest Service and Agricultural Research Service.

For more information about riparian forest buffers in the Bay watershed, contact: 1-800-YOUR-BAY

The Alliance for the Chesapeake Bay is a nonpartisan, nonprofit group of citizens, scientists, corporations, trade groups, environmental groups and others from throughout the Chesapeake Bay watershed: from Owego, N.Y., through Lancaster, Pa., to Williamsburg, Va., and from Harpers Ferry, W.Va., beyond Washington, D.C., to the Eastern Shore of Maryland.

The Alliance does not lobby. It is committed to hands-on restoration, public policy research, and education and information services. It puts the collective talents and resources of its diverse membership to work directly on watershed restoration.

For more information about the Alliance, call the Chesapeake Regional Information Service, 1-800-662-CRIS.

Determining the Width of Riparian Buffers

There is substantial agreement in the scientific community about the value of using vegetation to buffer valuable aquatic resources from the potential impacts of adjacent human use of the land. There is also general agreement that the greatest range of buffer benefits are provided when natural vegetation, like forests, are the target vegetation (Lowrance, et.al., 1985; Lowrance, et.al, 1995; Schueler, 1995; Fail, et. al., 1986; Karr and Schlosser, 1978; Desbonnet, et.al, 1994; Correll, Jordan and Weller, 1994; Peterjohn and Correll, 1984). However, there is often little agreement and much continuing research and debate over how to best achieve the level of protection needed and how to best delineate and manage a buffer. Of all questions related to practical use of riparian buffers, determining of the appropriate width of a buffer is certainly the most frequently discussed.

One of the important factors which determines the effectiveness of a buffer is its size or effective width. Buffers which are too small may still place water quality or aquatic resources at risk. They may also present problems with sustainability over the long term. Buffers that are larger than needed, may unnecessarily restrict use of a portion of the land. Therefore, the need to determine "minimum" widths has been a primary focus of resource agencies and local governments for many years. Complicating the picture further, buffer size requirements are typically established by political acceptability and compromise rather than on scientific merit. It is likely that these debates will continue.

DISCUSSION OF BUFFER WIDTH CRITERIA

Various approaches and formulas have been devised to determine and evaluate the needed width of a riparian buffer. Establishing criteria that are scientifically based should be the goal of resource and conservation agencies. Four criteria are generally discussed for determining the adequate width of riparian buffers for protection of streams. They are:

1) the existing or potential value of the resource to be protected,
2) site, watershed and buffer characteristics,
3) the intensity of adjacent land use, and
4) the specific water quality and/or habitat functions desired.

If necessary, these scientific criteria can then be modified by the management objectives or constraints of a given landowner or land management agency. In this way, scientific criteria guide width decisions but are modified by socioeconomic variables where the risk and benefits of the decisions can be identified and discussed.

For example, when a 75' wide buffer is determined appropriate but is reduced to 25' by constraints imposed by land use, the risk of reduced water quality functions and potential sustainability should be identified. Likewise, when a decision is made to choose warm-season grasses over forest as the target buffer vegetation, reductions in stream stability, flood mitigation, groundwater nutrient removal and aquatic/terrestrial habitat should be identified. In simple terms, smaller buffers may be adequate when the buffer is in good condition, the resource values may be low, site conditions are

ideal, the adjacent land use has a low potential for impact, and/or the desired buffer functions are few. Conversely, larger buffers are necessary for high value water resources that are adjacent to intense land uses with poor quality buffer condition and/or a high level of multiple buffer functions is desired (Castelle, et. al., 1994).

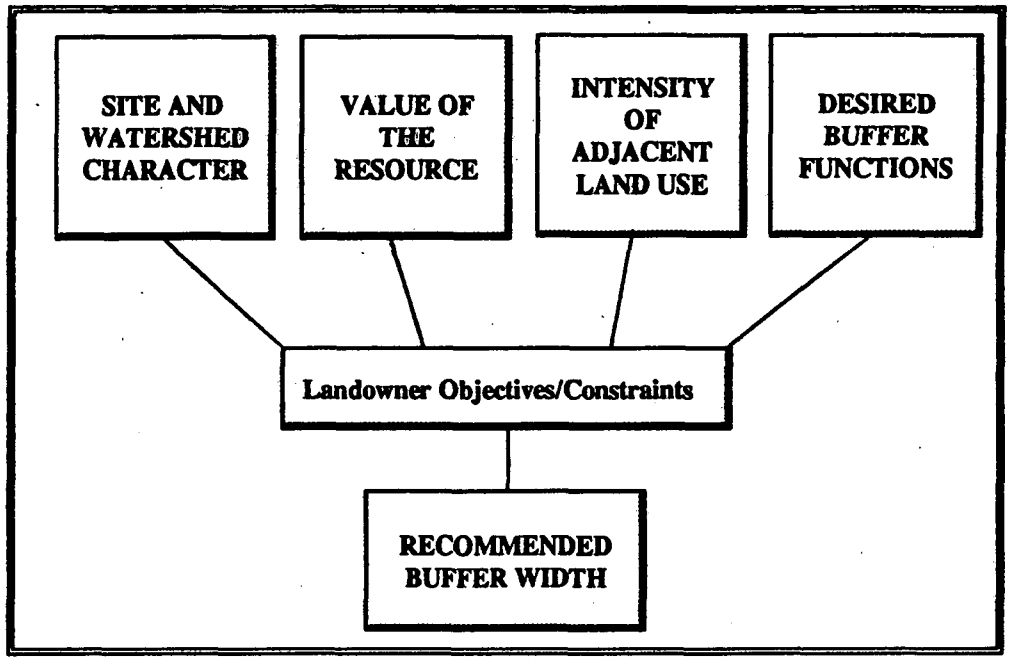


Figure 1: Schematic of Width Decision Criteria

Science-based Criteria

Decisions about buffer width can be made using professional judgement in choosing among the following criteria. Four criteria are discussed for which data may be available to support an informed decision. These criteria can form a "checklist" for buffer width determination.

1) Existing or Potential Resource Value

In general terms, smaller buffers are adequate when the stream, wetland, shorezone or lake is of relatively low functional value. Although the determination of "value" can involve subjective judgement, scientific information can be applied to assist in this assessment. For example, states routinely rate the value of fish habitat based on potential natural condition or the target species being managed. The Chesapeake Bay Program has identified priorities for stream blockage removal based on value to migratory fish (US EPA-CBP, 1995). Streams in watersheds providing municipal water supply or recreational use would likewise be considered of high functional value. Aquatic systems with a high disturbance regime or one that is dominated by non-native species may be considered of lower functional value. Conversely, degraded watershed, water quality, or habitat conditions may also be used as a criteria for increasing buffer width if desire for improvement of condition has been

specified. The designated uses of water or specific fish or wildlife species needs should be considered when buffers are established as a component of watershed restoration rather than protection strategies.

2) Watershed, Site, and Buffer Characteristics

Site Criteria affecting Buffer width
watershed condition
slope * stream order
soil depth and erodibility
hydrology * floodplains
wetlands * streambanks
* vegetation type
* stormwater system

Site characteristics are most important when evaluating performance in pollutant removal. This is because reliable generalizations about the role of riparian buffers as nutrient and sediment filters can be based on the condition of the soil in the buffer area (including plant, animal, and microbial communities present) and the route and rate of surface and groundwater movement through the buffer. However, these characteristics are complex, interrelated, and not always apparent to the field observer. For example, judgements about water quality performance of a buffer in the Coastal Plain may be made on observations of surface storm runoff, not recognizing that 50-80% of nitrogen loads are carried by subsurface water flow (Lowrance, et.al., 1995). Site factors are also discussed later in desired buffer functions, but some general comments can also be made.

Table 1: Site Factors that enhance or limit pollutant removal effectiveness of buffers (adapted from Schueler, 1995).

Factors that enhance effectiveness	Factors that reduce effectiveness
Slopes less than 5%	Slopes greater than 5%
Contributing Flow length < 150'	Overland flow paths over 300 feet
Seeps, high water table -subsurface flow	Flow path to deep or regional groundwater
Permeable, but not highly sandy soils	Compacted soils
Level spreaders or runoff dispersal	Concentrated storm flow
Organic matter, humus or mulch layer	Snowmelt, ice conditions, low organic soil
Entry runoff velocity less than 1.5 fps	Entry runoff velocity more than 5 fps
Routinely maintained	Sediment buildup at entrance
Deep rooted vegetation	Shallow root systems
Forest and dense grass cover (6"high)	Tall bunch grass, Sparse vegetative cover

Slope - slope has the greatest influence over sediment removal and is often a determinant in the rate and nature of water flow. In general terms, steep slopes increase runoff velocity and the volume of surface runoff. Buffers are often expanded to include steep slopes on small streams or buffer widths are increased on steeper slopes to provide a lower risk of impact from adjacent land use. For forestry practices in Maryland for example, a minimum 50' buffer width is modified for slope by adding 4 feet for each % of side slope.

Stream Order - to design an effective stream buffer system, it is important to understand spatial connections between the stream and its watershed. Stream order is a useful tool to classify elements of the stream network. Headwater streams, defined as first or second order, are generally short in length but comprise 75% or more of the total stream and river miles. In general terms, buffers have the greatest potential for control over water quality when adjacent to low-order streams. Lower order streams are small in size and have less contributing area per unit volume of water. Smaller buffers may be adequate to maintain the desired level of protection.

As stream order increases, the contributing area and volume of water available to the buffer zone may also increase, potentially diminishing the relative capability of the buffer to filter and remove pollutants as a % of total loading. This does not mean that the buffer's effectiveness in treating upslope pollutants may be compromised, only that the magnitude of control exerted over the water in the stream diminishes. An example of this type of relationship is portrayed in Figure 1. Likewise, as stream order increases so does stream size, thus decreasing the ability of streamside trees to provide control of water temperature. The importance of the buffer zone in flood mitigation, on the other hand, may increase with stream order, whereas, critical fish habitat may be maximized by streamside trees in low to mid-order streams.

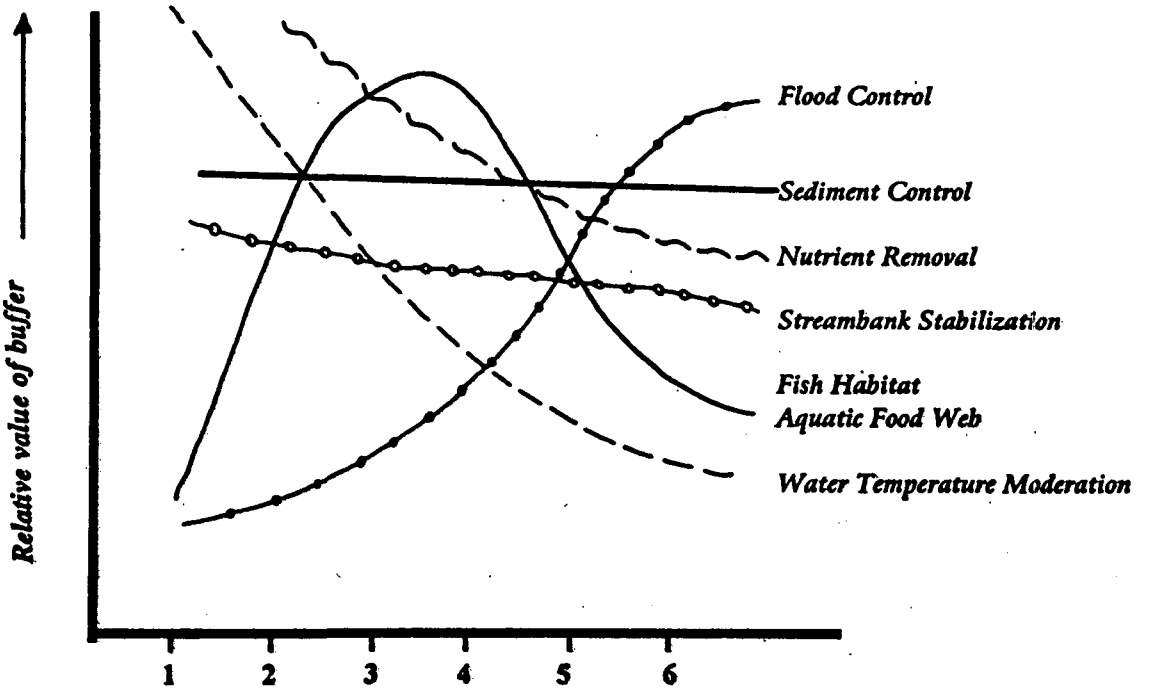


Figure 2. Effect of stream order on variations in buffer function.

Target Vegetation and Condition - In simple terms, adequate buffers may be smaller if they are designed properly and maintained in good condition. Most riparian buffers use adapted or enhanced natural vegetative systems. Therefore, buffers in better condition (e.g. dense native vegetation, undisturbed soils, healthy microbial community, etc.) are likely to provide a variety of functions more effectively. Common sense alone also tells us to look to the natural ecosystem for guidance in maintaining and restoring riparian functions. Although a number of vegetation types can be used to meet these specific buffer functions and provide multiple benefits, in the Chesapeake Bay region, as in much of the eastern United States, these benefits are amplified by or require a streamside zone that is forested. Forests provide the greatest range and number of potential environmental benefits, and therefore, should be promoted as the target vegetation whenever possible in a hierarchy of vegetation types. These benefits are summarized in Table 2.

Table 2. Benefits of Riparian Buffers that include woody vegetation.

Benefits of Riparian Buffers	
Benefit	***Greatly enhanced by or requiring Forest***
✦ Protection from Streambank Erosion	✔
✦ Increased removal of nitrogen	✔
✦ Removal of Phosphorus and sediment	✔
✦ Reduce downstream flooding	✔
✦ Provide thermal protection	✔
✦ Provide food and habitat for wildlife	✔
✦ Provide food and habitat for fish and amphibians	✔
✦ Foundation for present or future greenways	✔
✦ Increases urban/suburban property values	✔
✦ Provides corridor for conservation	
✦ Preserve "right-of-way" for lateral movement	
✦ Enhances potential for stream restoration	✔
✦ Reduces watershed imperviousness	✔
✦ Reduces small drainage complaints	
✦ Protects associated wetlands	✔

Incorporation of floodplains and wetlands - Buffer width is often expanded to incorporate sensitive landscape features such as floodplains and wetlands. Including the entire floodplain width is desirable but often difficult. Additional areas such as stormwater ponds and buffer infiltration areas will often be incorporated in buffer layout in urban areas.

Continuity - Achieving contiguous buffers on the landscape along a stream system may be given a higher priority than increased width in areas where aquatic and terrestrial habitat goals are important.

Soils - Along with hydrology, soil characteristics are important in determining potential for removal of nitrogen and pollutants carried by sediment such as phosphorus and some pesticides. Primary considerations are soil texture, depth to water table, and organic matter content of soils. Moderate to well-drained soils have the greatest ability to infiltrate large amounts of water that may enter the buffer as surface flow, thus promoting deposition of sediment and related pollutants. Conversely, moderate to fine-textured soils have superior potential to create conditions favorable for extensive denitrification.

Since denitrification is carried out by anaerobic microbes, soil conditions must be wet enough to allow oxygen depletion to occur. The large amount of decaying organic material on the ground and in upper soil layers in forested buffers helps to deplete oxygen supply and "fuel" the denitrification process. Although denitrification rates and duration vary depending on site conditions, even drier forest soils commonly have pockets which support these bacteria (Myrold and Tiedje, 1985). Under more poorly drained, higher organic matter soil, denitrification may proceed at relatively high rates in the top meter of soil. At better drained sites, denitrification depends on the cycling of plant biomass back to the surface in litter fall. Here denitrification will not be uniform but still active in surface soil (Ambus and Lowrance, 1991). A combination of soil properties which provide a gradation of coarse to finer grained materials closer to the water body seems ideal. Sites with a depth to water table of 3-15 feet meters will allow maximum root penetration by woody plants and sustain uptake of nutrients and chemicals in solution below the surface. The water table need only be present for a portion of the year.

Hydrologic Soil Groups are often used as criteria for determining buffer width and are commonly available in county soil survey reports. Buffers are established to include all soils in Hydrologic Group D and any Group C soils subject to frequent flooding. However, these guidelines are less reliable in dealing with intermittent streams in Hydrologic Groups A & B where other minimum criteria may be more applicable (Welsch, 1991).

3) Intensity of Adjacent Land Use

Generally, when the density, intensity, magnitude or potential impact of the activity increases, the width of the buffer necessary to contain the negative effects increases proportionally. The differences between developed or disturbed lands and the aquatic environment are significant; the more intensely developed or disturbed, the more significant. Likewise, the size or importance of the buffer increases as the potential yield of nutrients, chemicals, sediment and runoff from adjacent land use increases (Phillips, 1989). Table 3 illustrates how these loading can vary by land use. However, it is clearly recognized that a number of desired buffer functions, such as nutrient removal, are reduced in urban areas as impervious surface increases. Increased watershed runoff efficiency reduces base flow to the stream and limits the total volume of water passing through the buffer. Buffer widths prescribed in urbanized areas are often increased to account for the risk of future encroachments and to anticipate future changes in stream morphology due to increases in stormwater runoff (Heraty, 1993).

This stream "right-of-way" approach is useful in development site planning (Schueler, 1995). Maintaining larger wooded corridors along streams and rivers in urban planning help preserve open space and offset general forest loss in a watershed. It often most economical to consider this approach at the onset of land use change.

Table 4. Nutrient loading delivered to edge of stream as used in the Chesapeake Bay Watershed Model.

Land Use	Total N (lbs/acre/year)	Total P (lbs/acre/year)
Forest	3.56	0.07
Pasture	7.37	0.42
Urban	9.19	0.75
Cropland	14.89	1.38

Lowrance, et.al. (1986) described a relationship of buffer area to contributing area treated of 3:1 in agricultural areas with high nutrient loads. This ratio may be higher where potential impacts are less. Likewise, smaller buffers may be adequate where the magnitude of impact from land use is also low, e.g. parklands, haylands, or low-density development. Welsch (1991) prescribes a buffer strip width that is one third the distance from streambank to top of pollutant source area. The intent is to create a buffer between field and stream which occupies approximately 1/3 of the source area. This is reduced to 1/5 of the drainage area for lakes and ponds.

4) Desired Buffer Functions

One of the most important scientific criteria for determining buffer size requirements is to evaluate the specific functions that a buffer needs to provide under site-specific conditions (Castelle, et.al., 1992). A search of the literature clearly suggests that buffer sizes necessary for adequate performance of specific buffer functions vary widely. Accordingly some judgement and setting of priorities is nearly always necessary to attain a desired minimum buffer width for a desired set of functions. The following is an overview of some important buffer functions and discussion of their relationship to width. Scientific references for these discussions are extensive (NCASI, 1992; Shisler et.al., 1987; Lowrance, et.al., 1995; Wong and McCuen, 1982; Young, et.al., 1980; Lowrance, 1992; Lynch, et.al., 1985; Dillaha, et.al, 1989; Doyle, et.al, 1977, Dillaha, 1993).

Sustainability -Inevitably when discussing riparian buffer establishment, the concept of "anything is better than nothing" will be raised. This is probably an accurate assessment when it comes to maintaining the functions of stable streambanks and making some improvements in stream or shoreline habitat, however, it is important to recognize that for a riparian area to serve the water

quality functions of buffering impacts from adjacent land use, a "critical mass" or sustainable width is essential. Buffers of less than 50' have proven increasingly difficult to maintain as effective filters in the field except on small low order drainages..

Sustainability should be a key consideration of buffer layout and design, prior to making substantial investments or assumptions about expected buffer performance. Sustainability like other functions will be determined by site characteristics and adjacent land use. For example, very narrow buffer strips of 15-25' are generally inadequate for sediment or nutrient reductions except on small, low order streams (Dillaha, 1993). Narrow forest strips may provide shade and bank stability but may not sustain a forest ecosystem capable of accumulating organic matter and providing the water storage necessary for desired levels of nitrogen removal. These narrow strips are also far more susceptible to damage from floods.

Excess nitrogen removal - Determining the ability to provide nitrogen removal should consider; 1) the pathway by which nitrogen enters the buffer zone (e.g. surface runoff, deep or shallow groundwater, atmospheric deposition), and 2) the potential for transformation of nitrogen within the buffer strip due to site conditions. By filtering and absorbing runoff and reaching groundwater within the rooting zone, nutrients such as nitrogen (and dissolved phosphorus) are processed in plant uptake or transformed by denitrification. The denitrification process converts excess nitrogen

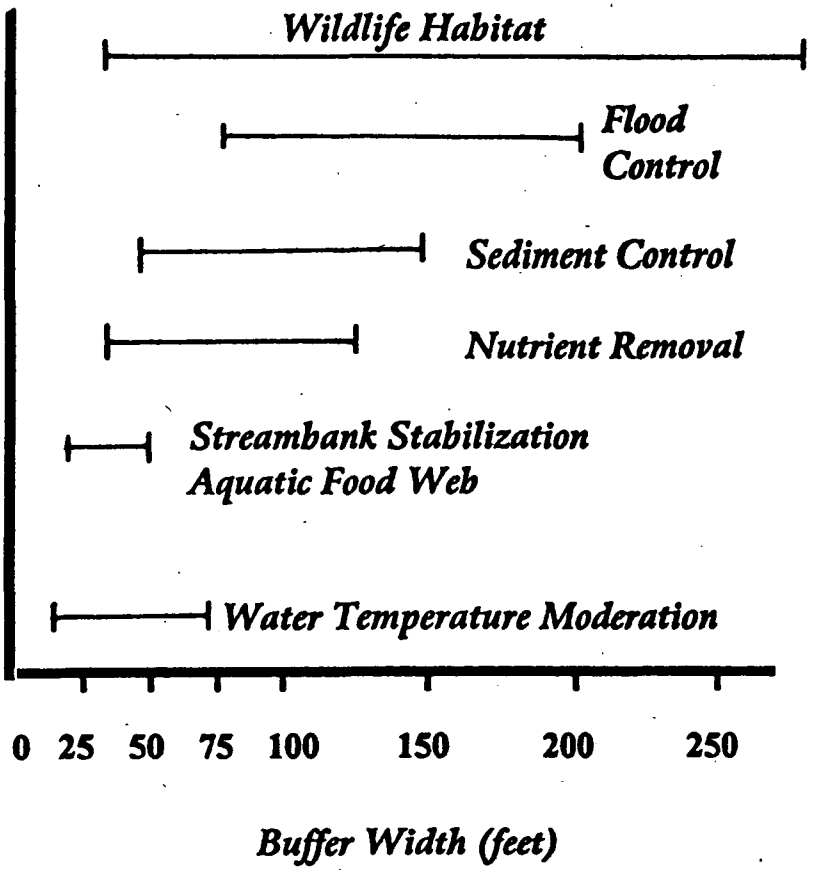


Figure 3. Range of minimum widths for meeting specific buffer objectives.

compounds into nitrogen gas which is released into the atmosphere. Microbes use organic compounds as food, degrading them into simpler compounds or synthesizing them into microbial biomass. Riparian forests in particular, support a variety of microbial degradation mechanisms, though the specific conditions that promote them are not yet well understood (Correll, 1996).

Although the focus of many studies is often placed on surface flow, it is important to recognize interactions with water traveling as shallow or deeper groundwater. Groundwater carrying nitrogen passes through or surfaces within the riparian zone where it can be acted upon by biological processes in the buffer strip. One should pay close attention to both localized and regional flow paths in determining this function. Lowrance, et. al. (1995) describe the variety of hydro-physiographic regions in the Chesapeake Bay watershed and how they affect nitrogen processing. Where conditions for water storage, vegetative uptake, and denitrification are ideal, widths as small as 35' may provide substantial removal of the nitrogen passing through the buffer.

Processes of denitrification occur under a wide range of conditions but will be most intense in the wetter streamside area, whereas, the uptake of nitrogen by vegetation will begin at the upslope edge of the vegetation. Woody plants enhance buffer functions through aggressive uptake of nitrogen in plant biomass, accumulation of organic matter, root-fungal interactions, and moisture retention (Fail, et.al., 1986). In this way, some reductions in overall buffer width may be possible when forests occupy a substantial portion of the buffer system. Efficiency will depend on residence time (affected by width) and nutrient load. In nearly all documented studies, most nitrogen removal occurred in the first 35-90' of forest. Nitrogen reductions of 25 to over 90% of total loadings have been shown in field studies (Lowrance, et.al., 1995).

Reduction of sediment and phosphorus - Vegetated buffers improve water quality by trapping sediment and debris, by stabilizing streambanks, and by promoting infiltration of runoff. Vegetation forms a physical barrier to movement and mechanically traps associated sediment. Roots maintain soil structure and prevent erosion of soil. Reducing flow rates and disrupting channelized flow by providing resistance is the role of vegetation, thus allowing more time for infiltration and settling of sediment. Because nearly 90% of phosphorus is carried to streams attached to soil particles or organic matter, reducing sediment transport helps to reduce phosphorus loads. The ability of vegetation to colonize sediment and rapidly use available phosphorus is a related function. Reductions in soil loss by 40-70% from lands using riparian buffers is typical.

Prevention of channelized flow is the primary concern for sediment removal and is significantly affected by slope. Most studies show buffer widths of 50-100 feet for adequate removal. While small buffers remove small amounts of sediments, the relationship between buffer width and sediment removal is not linear. Beyond efficiencies of 80% removal, disproportionately large buffer widths are required for incrementally greater sediment removal. Except under conditions of excessive channelized flow and steep slopes, buffer widths in excess of 150' did not show additional returns. Maintaining vegetation cover sufficient to reduce flow is key. Dillaha (1993) found that of the 35 or more grass filter strips he inspected after 3-5 years of use less than 10% continued to be effective due to channelized flow and sediment build-up at the field edge of the filter strip. The combination of grass filter strips with a forested buffer zone are especially efficient in performing this function.

Reduction of pesticides - Generally speaking, buffer strips of 45' or more have proven effective in reducing some pesticide contamination of streamflow. Factors which affect pesticide transport in buffer zones are similar to those affecting nutrients. Most pesticides in common use are adsorbed to soil particles or carried in runoff and subsurface flow. Organic pesticides are subject to microbial breakdown processes common in organically rich riparian forest environments. For example, buffers are an effective tool prescribed for protection of water supplies from atrazine.

Moderation of water temperature - Forested riparian buffers provide shade cover, thereby helping to lower water temperatures during summer and lessen temperature decreases in winter. Lack of shade has a direct effect on water quality and aquatic life. Elevated temperatures are a catalyst for water quality problems by accelerating or increasing the impacts of non-point source pollution by robbing oxygen from the system. Small streams flowing through exposed reaches, can increase as much as 1.5 degrees F for every 100' of exposure to summer sun. Maximum temperature fluctuations for daily peaks can be as much as 12-15 degrees higher and ambient temperatures of 6-8 degrees higher are not uncommon. The removal of streamside trees is one of the most significant causes of degradation for streams in the United States (Sweeney, 1992).

The ability of a buffer to provide shade is directly proportional to height of the vegetation and bankfull width of the stream. Even 15-25' buffers can provide adequate shade for small streams. 50-75' forest buffers are sufficient to ensure favorable conditions for trout and buffer widths along slopes can decrease with increasing tree height with no loss of shading. Aspect is also an important consideration. Grass filter strips along streams are generally unable to provide cover sufficient to moderate water temperature.

Preserving stream channel integrity and bank stability - Vegetation in the riparian area exerts a strong control over the condition and stability of the stream and its banks (Belt, 1992; Gregory, et.al., 1991; Lowrance, et.al, 1995; Karr and Schlosser, 1978; Sweeney, 1992; Sweeney, 1993). In the eastern United States, trees often defined the physical characteristics of stream channels. Trees anchor streambank soils through dense root mass and large roots provide physical resistance to flow energy. Woody debris, anchors channel substrate and determines bar formation, stores large amounts of stream bed sediment and gravel, helps control sinuosity and provides channel structure through pool/riffle or step formation. Until recently the value of this large woody debris was misunderstood and much was removed throughout the country. It is likely that the direct effect of buffer width on this function is limited. Only that vegetation within 25' of the stream channel will provide a powerful role in stabilization. However, increasing buffer width will continue to indirectly enhance stream stability by providing additional protection and stability during extreme flood events and as a physical barrier to human impact.

Moderation of storm flows and runoff - Stream corridors and natural forest vegetation helps to reduce the downstream effects of floods by dissipating stream energy, temporarily storing flood waters, and helping to remove sediment loads through incorporation in the floodplain. On a given site, a vegetated buffer zone that resists channelization is effective in decreasing the rate of flow, and in turn, increasing infiltration. Forests provide as much as 40 times the water storage of a cropped field and 15 times that of grass turf. These increases in storage are largely due to the forest's ability

to capture rainfall on the vast surface area of the leaves, stems and branches, the porosity and water holding capacity of organic material stored on the forest floor and in the soil, and the greater transpiration rates common to the associated community of vegetation. Forests are being evaluated more frequently for their role in reduction of water volume for stormwater management (Schueler, 1995; Herson-Jones, Heraty, and Jones, 1995).

Increasing width to incorporate the floodplain also increases the potential efficiency of water storage from upstream flow during storm events. Providing flood storage buffers where possible along smaller streams in a watershed may provide a valuable approach to downstream flood reduction (River Restoration Project, Ltd., 1996). However, once the entire floodplain is included within the buffer zone, the effect of buffer width on flood peak reductions is negligible.

Providing aquatic habitat and food - Leaf litter is the base food source in most stream ecosystems and streamside trees are critical in establishing this aquatic food web. Small fish, some amphibians, and most aquatic insects rely primarily on leaf detritus (dead leaf material) from trees as food. Studies have shown that when streamside trees are removed, many aquatic insects decline or even disappear, and with them, native fish, birds, and others species that may depend on them. Some insects are adapted to specific tree species and are unable reproduce or even survive when fed the leaves of grasses, non-native or exotic species (Sweeney, 1993).

Large woody debris also creates cover and habitat structure for fish and other aquatic species in streams and rivers as well as providing important functions in shallow water estuarine habitat. Here it may serve as a nursery area or refuge for fish, crabs and other organisms. This function is noteworthy in the Chesapeake Bay since the decline of submerged aquatic vegetation. Although the portion of the buffer nearest the waterbody exerts the greatest influence over this function, increasing buffer width provides support and sustainability. This is especially true when considering the need to provide long-term woody debris recruitment, diversity of vegetation for leaf detritus, and refuge for species during high water. The presence of trees is directly related to greater biodiversity in the stream ecosystem (Gregory et. al., 1991).

Provides terrestrial habitat corridors - The first question asked about providing habitat is, "habitat for what?". Riparian areas have the potential to provide rich habitats for a wide diversity of wildlife species. Species such as turtles, pheasant, turkey, wood ducks, great blue herons, woodpeckers, raptors, tree frogs, salamanders, songbirds, and many mammals require trees for breeding, nesting, feedings, and escape habitats. Even narrow forest strips will provide essential habitats for some of these species. However, the width and character of buffers will vary to meet the needs of particular species. A mixture of grasses and forbs, especially tall species, will provide suitable habitat for some game birds. In all cases, maintaining forests as a component of the buffer greatly enhances the diversity and abundance of birds and other wildlife (Pais, 1994).

Buffers also provide transition zones between upland and aquatic environments. Although buffers alone will not provide needed migratory songbird habitat, studies have shown that even narrow 100' corridors increased neotropical bird abundance when they connected small patches of remaining

forest. To provide corridors for movement of many larger mammals such as deer and bear, or to provide reliable breeding habitat for migratory songbirds, larger buffer widths (100-300') are needed.

Landowner-Based Criteria

Riparian buffers can also be designed to provide additional human benefits such as recreation, aesthetic enjoyment, as well as sites for hunting, fishing or observing nature. Buffers can provide the foundation for future greenways or be designed to provide recreational access. In addition, buffer width may be expanded to provide an economically-viable unit for future timber harvest or provide sufficient land base to sustain other secondary products derived from compatible activity within the buffer.

Landowner concerns most often serve to constrain the width of a buffer. These decisions may be due to economic considerations, livestock watering and pasture management, operation of adjacent farm fields, competing uses, or existing developments. As decisions are made, landowners should be aware of the potential changes in desired buffer functions that occur and the compromise of long-term values. This is especially important when buffers are being used within the context of overall nutrient management plans. In most cases, a buffer width can be determined which will meet landowner needs while also providing an adequate array of buffer functions.

APPLICATION

Given the practical need for simplicity, the operable question is how these multiple criteria can be incorporated in field applications. The problems related to using multiple criteria are not effectively addressed in the scientific literature. Most often, states or local agencies use an approach where multiple buffer criteria are simply stated as separate requirements and their interpretation is left to field staff. This approach has considerable merit, but results in inconsistency. There are several other methods with potential where multiple criteria are combined into a single requirement. One example is the cartographic modeling approach used in conjunction with a GIS (Dick, 1991). Here multiple criteria are expressed in spatial terms and mapping of buffer widths capable of meeting the criteria are displayed. For example, if temperature moderation is desired, a level of shading needed for the stream can be determined. Extension of this approach to multiple resource values and desired functions would be possible if additional criteria can be determined and expressed in spatial terms.

Another approach, maximum protection, evaluates each of several criteria and then adopts the greatest width so as to accommodate all desired functions. A variation on this approach commonly used is to utilize average widths in the same manner. A regional method might also be used to set a recommended buffer width. For example, buffer widths could be determined based on a set of criteria and desired function for selected stream reaches within a region. Then by evaluating the statistical probability of occurrence for various stream types within a watershed, a regional buffer width could be selected to meet the criterion a prescribed percent of the time (Belt, et. al, 1992). Approaches of this kind are also useful in prioritizing or targeting areas for protection or restoration.

The last and perhaps simplest approach may be to determine a minimum width that will meet a majority of the multiple desired functions with the target vegetation and provide a limited number of additional site criteria which will allow for modification and flexibility based on site conditions.

Fixed Minimum Vs. Variable Width Buffers

There are two principal ways by which most buffer widths are defined: the width may be set as a fixed distance usually measured from the stream bank on each side of the stream or the width may be variable depending on specific natural or man-made features adjacent to the waterway. Minimum width buffer strips are usually promoted primarily because of they are simple to implement and administer. Because minimum widths are most often arrived at by compromise or by considering an average of desired functions, it is likely that minimum width buffer strips may provide more than adequate protection in some areas, and inadequate protection in others. Where political compromise has resulted in very narrow buffer widths, people may be given a false perception that a stream is protected when serious risk may still exist. Fixed buffer widths in use across the country range from 25 to 300 feet or more (Herson-Jones, Heraty, and Jones, 1996).

Variable width approaches to buffers usually attempt to integrate buffer functions with site-specific conditions. In this way the width of the buffer depends not only on the minimum width needed for a specific function or set of functions, but also on the sensitivity and characteristics of the stream and watershed in which it is located. Adjacent slope, soil type, presence of wetlands and floodplains, mature forests or special habitats, scenic or cultural features, recreation use, and other local aspects of significance may be considered in determining buffer width. Buffer expansion and contraction as a characteristic of design width is promoted especially in urban settings (Schueler, 1995). A range of adequate widths may be provided (Coughlin, et.al, 1992). Although, variable width approaches are likely to be more science-based, they inevitably require extensive site investigation and evaluation, and ultimately more difficulty in monitoring and administration. Often a combination of these approaches is used. For example, a minimum width is determined and specific criteria for expansion and contraction are specified.

THE 3-ZONE FOREST BUFFER PLANNING MODEL

The concept of the Riparian Forest Buffer is to put the natural water quality functions of the riparian forest to work in pollution control. A 3-zone planning model has been proposed by the Forest Service (Welsch, 1991) and the Natural Resources Conservation Service (NRCS, 1996) as an excellent way to organize the planning and management of riparian forest buffers in both rural and urban settings. This three zone concept is a flexible approach that incorporates water quality, habitat functions as well as landowner objectives into determinations. Each zone has specific intended functions but all zones function together as an integrated system.

Zone 1 represents the inner core of the buffer, stretching upland from the edge of the stream. Its primary purpose is to stabilize the streambank, provide habitat for aquatic organisms, and help reduce flood impacts. Shade helps to moderate stream temperatures, leaves provide food to the aquatic system, roots and fallen logs create habitat. Zone 1 also aids in the filtering of surface runoff and

flood flows and in utilizing nutrients carried in groundwater that is discharged to the stream, as well as hyporheic flow (Hill, 1996). A minimum width of 15-35' is recommended for Zone 1.

Located immediately upslope from Zone 1, the primary function of Zone 2 is to remove, transform, or store excess nutrients, sediments, and other pollutants flowing over the surface or through the groundwater. Infiltration and sediment deposition are the primary mechanisms for treating surface flow. Zone 2 must be wide enough to trap and hold sediment coming from adjacent land uses while the ability to remove nutrients in groundwater will vary from landscape to landscape depending on whether the groundwater comes in contact with the root zone and if soil conditions promote denitrification as previously discussed. Another role of Zone 2 is to protect and sustain the viability of Zone 1. Widths of Zone 2 can vary from 25-200 feet..

Zone 3 is located on the outer edge of the buffer closest to the adjacent land use with potential to impact the stream. A grass filter strip or other runoff control measure is recommended (NRCS technical standard specifies Zone 3 under a separate filter strip practice). The primary function of Zone 3 is to slow runoff, filter sediments and its associated chemicals, and allow water to infiltrate into the ground. In urban areas, infiltration structures or stormwater control measures may also be common in Zone 3. A 20-30 foot grass filter strip is commonly used in Zone 3.

Figure 4. The 3-Zone Buffer Concept

CONCLUSION

The scientific literature would clearly support that there is no "ideal" buffer width for all applications in all areas. A number of criteria are appropriate for consideration in determining adequate buffer widths in an ecosystem context. Evaluating a combination of factors such as site and watershed characteristics, functional resource value, intensity of land use and desired buffer functions all provide considerations from a scientific viewpoint. Because most buffers are established on private lands or public lands managed for a variety of uses, landowner/manager and public constraints/objectives are also considered.

Many agencies rely predominantly on stream rating systems to establish minimum buffer sizes. Most minimum widths are determined by functional resource value alone or a specific intended use or group of uses rather than by site-specific factors. By looking at one function alone or one site criteria, application is simplified but most of the scientific information available may be ignored.

The most commonly prescribed minimum buffer widths for use in water quality and habitat maintenance are approximately 75-100'. The scientific literature appears to support that buffers of less than 35 feet can not sustain long-term protection of aquatic resources with an acceptable level of risk regardless of site. To provide an array of functions then, buffers should be a minimum of 35-100' in width under most circumstances. Buffer widths toward the lower end of the range appear to provide some physical and biological components of the stream ecosystem especially on small streams. While buffer widths at the upper end of the range are likely to provide protection of physical, chemical and biological characteristics of the aquatic resource.

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SECTION 4:
FINDINGS

RELATIONSHIP TO OTHER BAY PROGRAM GOALS

The 40% Nutrient Reduction Goal

Among the most serious problems facing the Chesapeake Bay and its tributaries is an excess of nutrients, nitrogen and phosphorous, caused by human activities In the land. To alleviate this problem the historic 1987 Chesapeake Bay Agreement set a goal to achieve "by the year 2000 at least a 40 percent reduction of nitrogen and phosphorous entering the mainstem of the Chesapeake Bay". This reduction in nutrients will result in a significant improvement in dissolved oxygen in the waters of the mainstem of the Bay. Improved oxygen levels will, in turn, significantly improve conditions for living resources such as crabs, oysters, striped bass and Bay grasses.

Directive 94-1 Riparian Forest Buffers clearly relates to achieving the goal of 40 percent reduction in nutrients. Riparian buffers are a valuable best management practice for maintaining and improving water quality. Riparian forests have been shown to be especially useful in removing nitrogen in surface and groundwater, and trapping phosphorous-laden sediment and other pollutants resulting from adjacent land uses, thereby protecting water quality. In fact studies have shown dramatic reductions of 30 -98 percent in nitrogen and phosphorous in surface and groundwater after passing through a riparian buffer.

The Joint Tributary Strategy Statement

In 1992, the EC committed their jurisdictions to a goal of developing tributary-specific nutrient reduction strategies. In these amendments, the EC also pledged that the Tributary Strategies would include a permanent cap on nutrient inputs. A "cap" implies that even in the face of increased population and development in the Chesapeake region, nutrients entering the Bay must remain at a level of 40 percent less than they were in 1985,. This goal implies that nutrient reduction techniques must be dynamic and long term. It also warrants incresed attention on approaches that restore or maintain watershed or ecosystem-scale functions, like those provided by riparian forest buffers.

Directive 94-1 Riparian Forest Buffers provides a means of achieving restoration goals in the tributaries. Directive 94-1 states that the tributary strategies to date have identified riparian forest buffers as an important best management practice in controlling nutrient loading to streams. Maintaining long-term caps on nutrients in the tributaries will require approaches that maintain ecosystem or watershed-scale functions like those provided by health riparian forests.

SAV Goals

Submerged aquatic vegetation (SAV) is an important indicator of Bay health. SAV beds provide shelter and nursery areas for many species of fish and wildlife and are important as a food source to many species of ducks, geese and swans. A clear and obvious link has been observed between water quality conditions and the survival and health of critically important SAV. Riparian forests and the values they provide are clearly beneficial to shallow water habitats and support SAV recovery. These relationships may be stronger when looked at in individual tributary rivers and embayments.

Directive 94-1: Riparian Forest Buffers states that riparian forests provide shade, organic matter and often control bank stability, which in turn provide a range of living resource habitat benefits, including the moderation of stream temperature, support of the food web, protection of fish habitat and sediment and erosion control. Riparian forests support SAV growth in many ways. Riparian forests are capable

of removing excess nutrients from the water, which otherwise encourages the growth of deleterious algae blooms.Woody debris enhances shallow water habitats. Riparian forests also stabilize streambanks and filter runoff thereby reducing sediment input into streams and the Bay..

Fish Passage Goals

In Directive 93-4, the EC recognized the importance of fish passages in restoring spawning habitat to migratory fish in the Bay watershed. To ensure the continued progress of the Fish Passage Goals Strategy, the EC agreed to seek the necessary funding and to commit resources to carry out the implementation of the policy. The EC committed to a ten year target for opening 1356.75 miles of fish spawning habitat in the major tributaries to the Bay and a five year goal to first open 582.05 miles.

Directive 94-1: Riparian Forest Buffers states that as the EC provides for migratory fish passage, it becomes even more important to ensure favorable water quality and habitat in those streams. Riparian buffers are instrumental in improving water quality and for providing tremendous diversity in habitat; but they also offer many benefits to migratory fish. Forested streams and rivers provide suitable spawning habitat for shad, herring, alewife, perch and striped bass. Cool stream temperatures maintained by riparian vegetation are essential to the health of aquatic species. Shading moderates water temperatures and protects against rapid fluctuations that can harm stream health and reduce fish spawning and survival. The decline of these species is partly due to destruction of habitat, which for some, like shad and herring, extends well into small streams.

Habitat Restoration Goals

The Executive Council is committed to restoring habitats in four areas: fresh water tributaries and streams for anadromous fish; shallow water for crabs and ducks; open water for fish and shellfish and lastly inlands and islands for waterfowl and birds. Riparian Forests are a key habitat of focus in the restoration of freshwater streams and rivers and shallow water habitats.

Directive 94-1 Riparian Forest Buffers recognizes that riparian forest buffers are capable of improving water quality and providing habitat. Riparian forest buffers remove sediment, pesticides, excess nutrients and other pollutants from surface and groundwater thereby improving the water quality. The leaf canopy of the riparian forest buffer provides shade which maintains cool water temperatures that are necessary for aquatic species and SAV. Leaves also provide food for small bottom dwelling creatures which are critical to the aquatic food chain. Woody debris serves as cover for fish while stabilizing stream bottom and increasing the diversity and amount of habitat for aquatic organisms.

The Toxics Reduction Strategy

The goal of the Toxics Reduction Strategy is a Chesapeake Bay free of toxics through reducing or eliminating the input of chemical contaminants from all controllable sources to levels that result in no toxic or bioaccumulative impact on the living resources that inhabit the Bay or on human health. Pesticide Management is a key component of the Toxics Reduction Strategy.

Directive 94-1 Riparian Forest Buffers identifies one of the key capabilities of riparian forest buffers is their ability to intercept surface runoff, subsurface flow and deeper ground water flows for the purpose of removing or buffering the effect of pesticides or other chemicals from upland land use.

CHESAPEAKE BAY RIPARIAN FOREST BUFFER INVENTORY

Final Report

31 December 1996

Rick L. Day
Paul L. Richards
Robert L. Brooks

Land Analysis Laboratory
Department of Agronomy
College of Agricultural Sciences
and
Penn State Cooperative Wetlands Center
School of Forest Resources
and
Environmental Resources Research Institute

The Pennsylvania State University
116 Agricultural Sciences and Industries Building
University Park, PA 16802
(814) 863-1615

Submitted To:

The Chesapeake Bay Program Office
Annapolis, MD

INTRODUCTION

The purpose of this project was to evaluate the extent of forest cover adjacent to streams and rivers throughout the Chesapeake Bay watershed using a geographic information system (GIS) approach. The intent was to use existing GIS datalayers that were readily available through federal or state agencies with understanding regarding limitations of data resolution and accuracy. The aim was to provide information useful primarily for broad-scale targeting and decision-making for policy while providing a watershed-scale assessment of riparian forest buffer status that could be refined in future efforts. The benefits of the completed project were to:

- Determine the extent and location of riparian forest at watershed, state and subwatershed scales.
- Provide a GIS land use layer that is compatible for state and Bay Program use.
- Produce information useful as a tool for resource managers for targeting forest buffer and habitat restoration projects.
- Provide a foundation of base information useful for future monitoring and more detailed surveys.

OBJECTIVES

In order to satisfy the above goals, the following specific objectives were formulated:

- Develop a GIS land use/land cover layer of riparian forests, using EMAP satellite-derived data, for the entire Bay watershed with separate files for each state and subwatershed within the Bay watershed.
- Use digital EMAP land use and stream network data to inventory riparian forest buffer conditions within 100 feet and 300 feet of each stream in the Bay watershed
- Prepare statistical summaries of land use and forest buffer conditions within subwatersheds, states and the entire Bay watershed.
- Conduct a verification of the inventory through air-photo analysis and field INVENTORY.

PROCEDURE

Database Development

The following GIS data for the entire Bay watershed (Figure 1) were obtained, and assembled into overlapping ARC/INFO GIS coverages:

Hydrology- A digital streams layer (Figure 2) for the entire Bay watershed that was compiled from data from various sources by USGS-Water Resources Division in LeMoyne, PA. It was provided by the Chesapeake Bay Program Office. Source data varied with each state. The New York portion was 1:100000 scale. Pennsylvania was 1:24000 scale and contains a higher density of streams that includes intermittent streams. Virginia, Maryland and West Virginia were 1:24000 scale but did not contain intermittent streams. There were no stream attributes except for length.

Watershed Boundaries - Databases consist of four layers consisting of 8-digit hydrologic units for the entire Bay watershed (Figure 3) (provided by the Chesapeake Bay Program Office), and 11-digit watershed boundaries for Virginia (Figure 4), Maryland (Figure 5), and Pennsylvania (Figure 6) (provided by the USDA Natural Resource Conservation Service).

Land User / Land Cover - EPA's Environmental Monitoring and Assessment (EMAP) level 2 land use data (Figure 7) were obtained from the Chesapeake Bay Program Office. The data are in raster format, with 25 meter cells derived from classified Thematic Mapper satellite data. The data were classified into the following land use categories:

- Low intensity developed
- High intensity developed
- Wooded
- Herbaceous vegetation
- Exposed soil
- Water
- No data

All data layers were georeferenced to UTM zone 18, datum NAD 1927.

Automated Buffer Inventory

In this study, an automated method was developed to conduct the inventory. Several logistical requirements affected the algorithm structure. The size of the input stream coverage (NBAYHYDRO) consisted of over 186,000 features occupying over 70

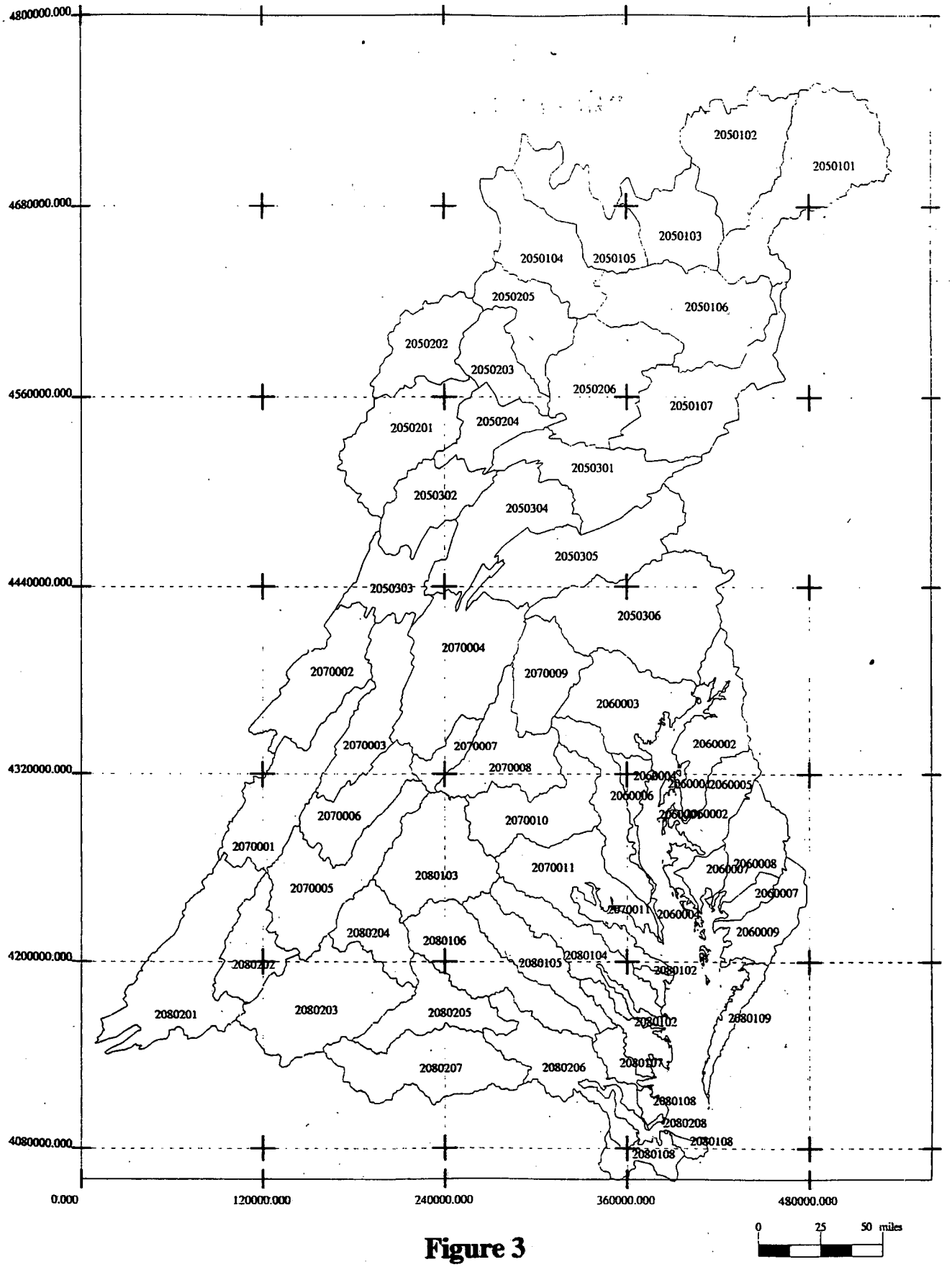

Figure 3

Index to 8 digit watersheds in the Chesapeake Bay
Projection UTM, Zone 18

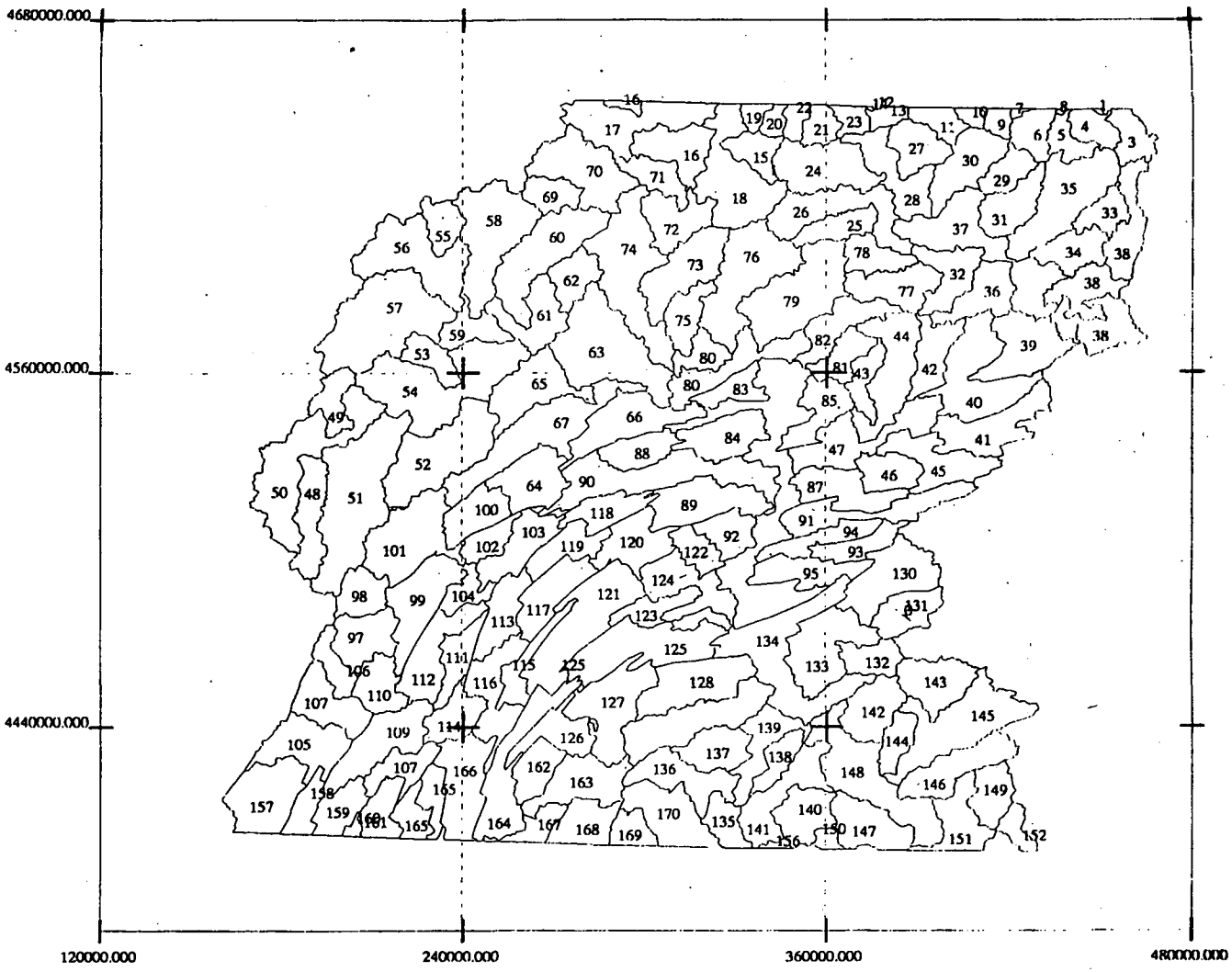

Figure 4

Index to 11 digit watersheds in the Chesapeake
Bay portion of Pennsylvania
Projection UTM, Zone 18

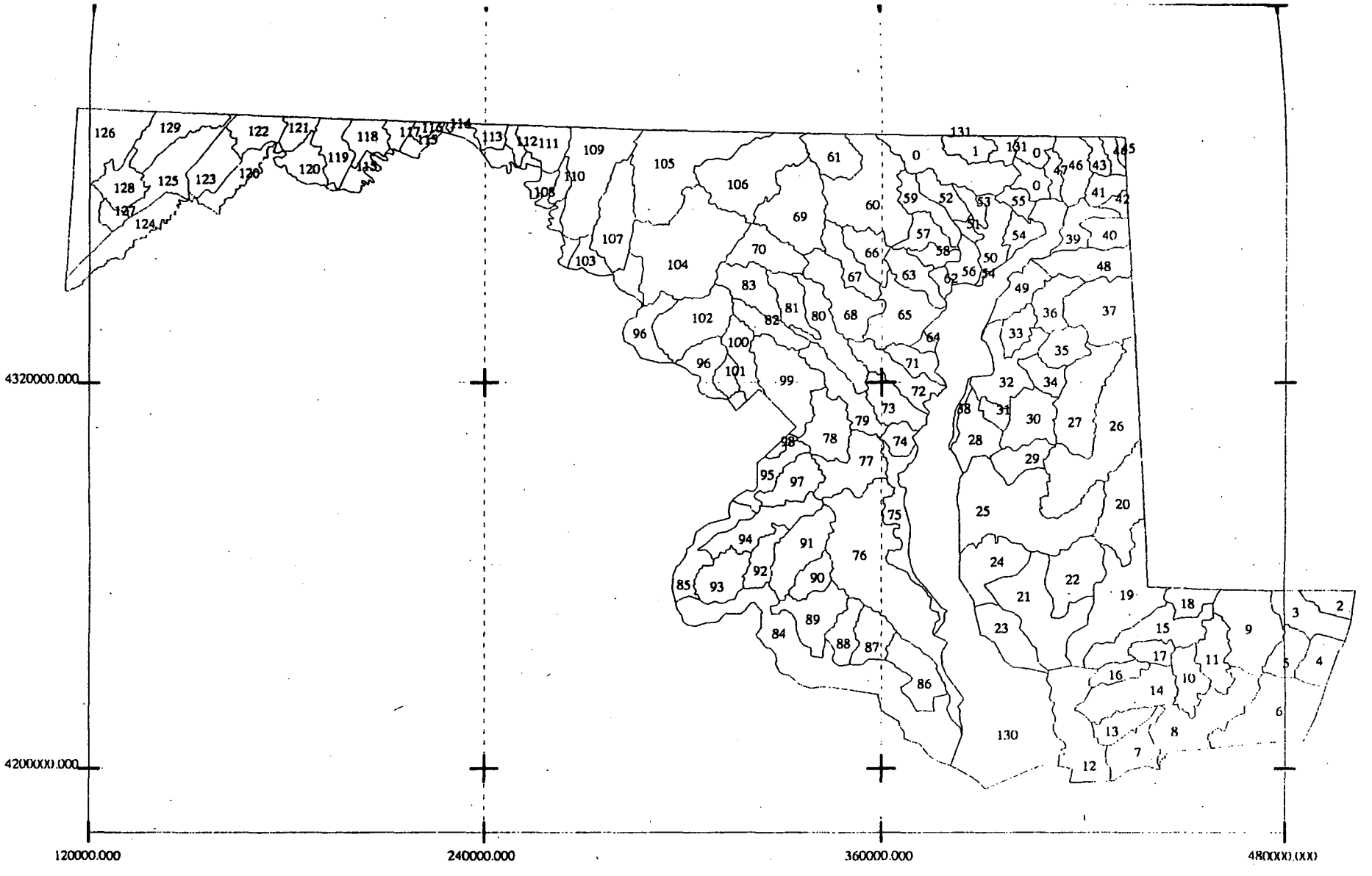

Figure 5

Index to 11 digit watersheds in the Chesapeake Bay portion of Maryland
Projection UTM, Zone 18

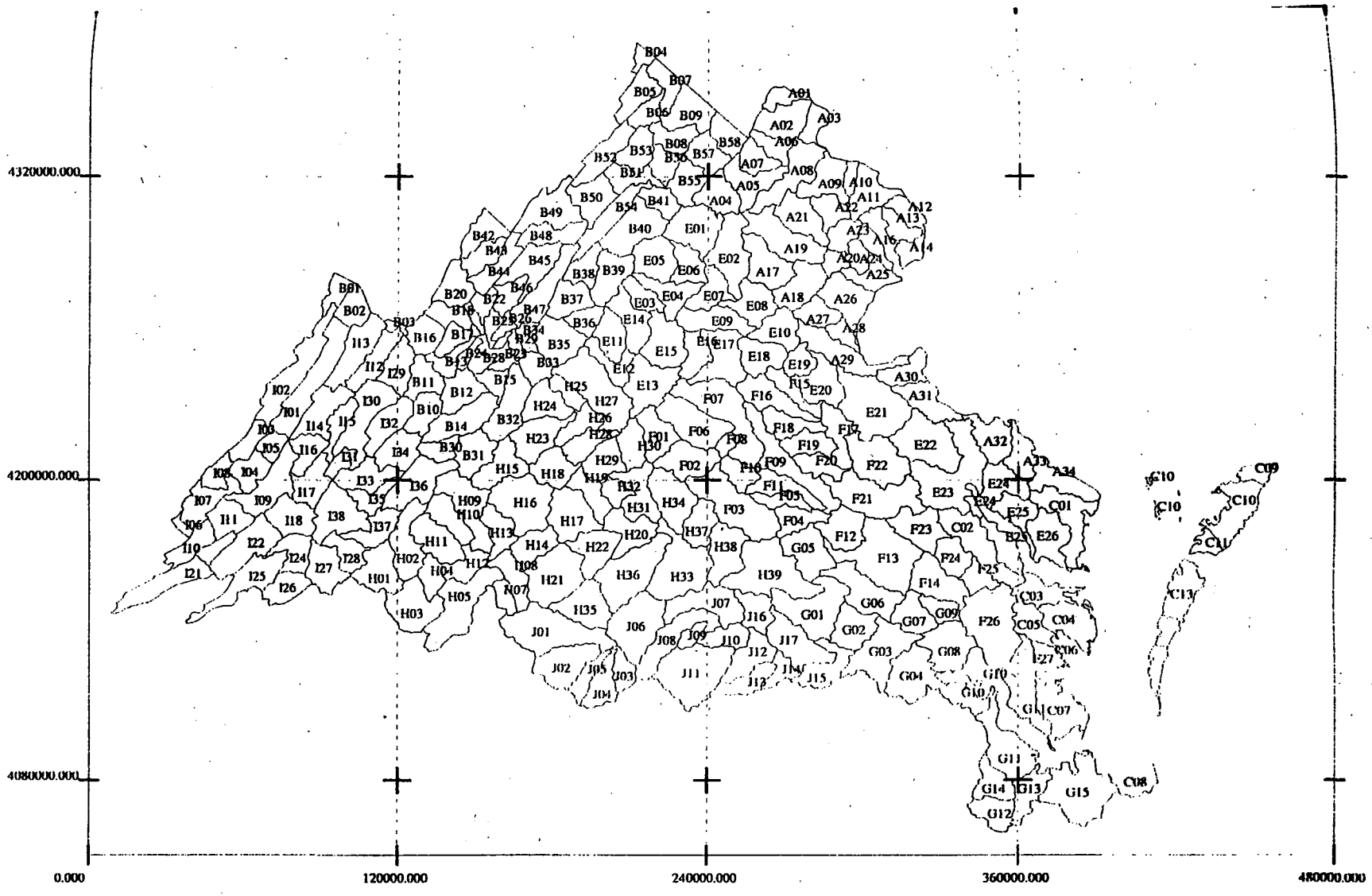

Figure 6

Index to 11 digit watersheds in the Chesapeake
Bay portion of Virginia
Projection UTM, Zone 18

megabytes of disk space. Because of its size, the streams coverage was divided into quadrangle sized tiles for processing (Figure 8a). Arcs in the input stream coverage were originally digitized at lengths much greater than the resolution (300 ft or less) required for this study, consequently, a new stream coverage composed of smaller stream segments, less than or equal to 300 ft. was created. Land use for each stream segment also had to be reported relative to each side of the arc (right or left).

Because of the long processing time, FORTRAN programs were written to perform tasks where Arc/Info AML macros were less efficient. As a result of these comparisons, FORTRAN programs were written, compiled and executed to carry out all of the tasks described above except for looking up the land use at locations along the orthogonal and generating and attributing the final streams coverage.

The automated algorithm worked as follows (Figure 8b-d). Each stream was divided into segments 300 feet or less. For each segment, an orthogonal axis, centered on the stream segment, was calculated based on the orientation of the stream segment. Each orthogonal axis extended on both sides of the stream segment for 300 feet and was traversed in 50 foot increments on both sides of the stream segment. At each 50 foot interval, the UTM x,y coordinate location is determined and the land use is obtained from the gridded EMAP land use datalayer. Orthogonal axes with forested land use continuous from the midpoint of the orthogonal are identified and statistics on land use are compiled on an orthogonal axis by orthogonal axis basis. To be considered buffered 300 ft on both sides, all contiguous locations along the orthogonal axis must be forested. This information is then used to create a new stream coverage (Figure 8e) consisting solely of 300 ft (or less) stream segments with the statistics of each orthogonal linked to it in its stream attribute table.

Once all of the quadrangles in the Chesapeake Bay were processed (1320 quadrangles total), the output stream coverages for each were appended together to form one large stream coverage. This coverage was clipped to component watersheds in order to obtain statistics on the total stream miles and relative percentages of various buffer conditions. Since the length of stream segments comprising the final stream coverage vary, yet each have one orthogonal segment with associated 13 land use observations, a length-weighted approach was used to adjust for stream segment length when calculating all statistics.

Data were summarized for one and both sides of the stream for :

- streams with 300 feet of forested buffer on both sides
- streams with 100 feet of forested buffer on both sides
- streams with 300 feet of forested buffer on one side only
- streams with 100 feet of forested buffer on one side only
- land use distribution within the entire 300 foot buffer
- land use distribution within the entire 100 foot buffer

In addition to land use statistics within each buffer, land use data was also summarized for each subwatershed. This was done to provide information that could be useful in evaluating potential pressures, associated with land use, that may be exerted on streams. Summary statistics were compiled for the entire Bay, each state and each watershed.

Validation and Accuracy Assessment

Validation and accuracy assessment was conducted through comparison of results from the automated inventory procedure with those determined through air-photo (Pennsylvania and Virginia) and digital orthophoto interpretation (Maryland). Approximately 103 quarter-quadrangle areas were randomly selected throughout the Bay watershed (Figure 9). For Pennsylvania and Virginia, NAPP 1:40000 scale black and white (1991-1993) air photos were obtained from the USGS EROS Date Center corresponding to each quarter-quadrangle (Table 1). Streams in the aerial photographs were examined for forested riparian buffer conditions using a magnifying stereoscope. Buffer widths were measured after determining the approximate scale of the aerial photograph through distance comparisons between known features on 1:24000 scale topographic maps and corresponding distances between the same features on the aerial photograph. Streams with less then 100', 100-300' and greater then 300' forested buffer were coded on quadrangle maps. The quadrangle map was then digitized, attributed and compared with the streams coverages created by the automated algorithm using EMAP data. In general, the minimum buffer segment marked on quad sheets was at least 100m in length with some minor exceptions.

In Maryland, Maryland DNR personnel conducted similar interpretations but used available digital orthophotos overlaid with digital streams data in their GIS. Data were sent to Penn State and statistical comparisons with the algorithm were completed.

Forested buffers were defined as areas with at least 30% canopy coverage, unless houses or lawns were obvious below the canopy. Minor roads or the occasional opening in the canopy (single house, minor clearing) were ignored. Major roads, highways, and railroads were considered to be breaks in the buffer width. In Pennsylvania and Virginia, photointerpreters cross-checked several segments of each other's work in the initial stages of the project to insure uniformity in the photo interpretation process.

After the photo-interpreted streams were digitized and attributed with buffer conditions, the total length of streams comprising a particular riparian buffer category was calculated in each quarter quadrangle for the aerial photography and the automated algorithm. To insure a fair comparison, care was taken to exclude all streams in the quality control coverages that did not have a counterpart in the streams analyzed by the automated algorithm. Differences in buffer conditions as determined from the two methods were determined for each of the quarter quadrangles and summarized statistically. Absolute and relative differences were calculated.

Table 1. Quadrangles evaluated for quality control and method applied.

Quad ID	Quadrangle Name	State	Method	Quad ID	Quadrangle Name	State	Method
177	EAST TROY	Pa.	1	671	ROMNEY	Md.	2
178	ULSTER	Pa.	1	727	SUDLERSVILLE	Md.	2
195	MARSHLANDS	Pa.	1	748	BELTSVILLE	Md.	2
197	ANTRUM	Pa.	1	755	CENTREVILLE	Md.	2
199	BLOSSBURG	Pa.	1	756	PRICE	Md.	2
205	WYALUSING	Pa.	1	850	BRANDYWINE	Md.	2
217	WHARTON	Pa.	1	969	NINEPIN	Md.	2
221	LEE FIRE TOWER	Pa.	1	998	PINEY POINT	Md.	2
228	SKUNK	Pa.	1	709	STEPHENSON	Va.	1
268	DENTS RUN	Pa.	1	775	MIDDLEBURG	Va.	1
271	KEATING	Pa.	1	808	THOROUGHFARE	Va.	1
273	RENOVA EAST	Pa.	1	837	LURAY	Va.	1
285	SWEET VALLEY	Pa.	1	841	EFERSONTON	Va.	1
289	AVOCA	Pa.	1	874	CASTLETON	Va.	1
296	DEVILS ELBOW	Pa.	1	903	HARRISONBURG	Va.	1
310	BENTON	Pa.	1	935	MONTEREY SE	Va.	1
311	STILLWATER	Pa.	1	942	MCGAHEYSVILLE	Va.	1
340	FREELAND	Pa.	1	946	MADISON MILLS	Va.	1
355	WOODWARD	Pa.	1	951	SALEM CHURCH	Va.	1
363	SHUMANS	Pa.	1	975	DEERFIELD	Va.	1
364	NUREMBURG	Pa.	1	988	BELMONT	Va.	1
374	ANDY RIDGE	Pa.	1	1010	WARM SPRINGS	Va.	1
375	PORT MATILDA	Pa.	1	1020	CHARLOTTESVILLE WEST	Va.	1
406	BEAVER SPRINGS	Pa.	1	1022	KESWICK	Va.	1
407	RICHFIELD	Pa.	1	1028	LADYSMITH	Va.	1
408	DALMATIA	Pa.	1	1092	LEXINGTON	Va.	1
410	KLINGERSTOWN	Pa.	1	1094	MONTBELLOW	Va.	1
424	BELLEVILLE	Pa.	1	1098	SCHUYLER	Va.	1
433	TOWER CITY	Pa.	1	1101	PALMYRA	Va.	1
438	CRESSON	Pa.	1	1111	AYLETT	Va.	1
451	HALIFAX	Pa.	1	1127	STROM	Va.	1
461	MARTINSBURG	Pa.	1	1133	EORKS OF BUFFALO	Va.	1
486	ORBISONIA	Pa.	1	1136	SHIPMAN	Va.	1
505	SCHELLSBURG	Pa.	1	1140	ARVONA	Va.	1
506	BEDFORD	Pa.	1	1151	KING AND QUEEN COURT HOUS	Va.	1
513	ROXBURY	Pa.	1	1155	IRVINGTON	Va.	1
526	NEW HOLLAND	Pa.	1	1169	BIG ISLAND	Va.	1
546	YORK	Pa.	1	1171	AMHERST	Va.	1
562	WILLIAMSON	Pa.	1	1182	MIDLOTHAN	Va.	1
564	WAYNESBORO	Pa.	1	1198	CRAIG SPRINGS	Va.	1
574	HOLTWOOD	Pa.	1	1214	HILLCREST	Va.	1
593	BLUE RIDGE SUMMIT	Md.	2	1215	CUMBERLAND	Va.	1
602	DELTA	Md.	2	1226	TOANO	Va.	1
608	BARTON	Md.	2	1229	WARE NECK	Va.	1
649	KEEDYSVILLE	Md.	2	1243	APPOMATTOX	Va.	1
671	ROMNEY	Md.	2	1257	CHARLES CITY	Va.	1
727	SUDLERSVILLE	Md.	2	1269	GREEN BAY	Va.	1
748	BELTSVILLE	Md.	2	1278	DISPUTANIA NORTH	Va.	1
755	CENTREVILLE	Md.	2				

Method 1 - Forest buffer evaluated using NAPP aerial photographs
Method 2 - Forest buffer evaluated using Maryland DNR digital orthophotos

A field inventory of riparian forest buffer conditions was conducted for limited sites to further validate the air photo and automated approach. Results of this analysis will be provided as an Addendum to this report.

RESULTS and DISCUSSION

Table 2. summarizes riparian forest buffer conditions for each state within the Bay watershed. Table 3 summarizes buffer conditions for the 54 8-digit hydrologic units within the Bay watershed. Table 4 summarizes land use distribution within the 100 and 300 foot buffers and entire watershed for each 8-digit hydrologic unit. Figures 10-13 illustrate relative forest buffer conditions for all 8-digit hydrologic units.

Tables 5 and 6 summarize riparian forest buffer and land use conditions for each 11-digit subwatershed in Maryland. Figures 14-17 illustrate relative forest buffer conditions for 11-digit subwatersheds in Maryland.

Tables 7 and 8 summarize riparian forest buffer and land use conditions for each 11-digit subwatershed in Pennsylvania. Figures 18-21 illustrate relative forest buffer conditions for 11-digit subwatersheds in Pennsylvania.

Tables 9 and 10 summarize riparian forest buffer and land use conditions for each 11-digit subwatershed in Virginia. Figures 22-25 illustrate relative forest buffer conditions for 11-digit subwatersheds in Virginia.

According to Table 1, approximately 52.8% of streams in the Bay watershed have at least 300 ft. of forest buffer on at least one side of the stream. Approximately 40 % of the streams in the watershed have forest buffers less than 100 ft. on both sides of the stream. Buffering conditions among the Bay states varies less than 10 % in all categories. Some of the variability among states may be due to variability in streams data that occur in the Bay streams coverage. The coverage is a combination of streams data from different sources and scales and may be impacting the results.

Highest percentages (60-75%) of adequately buffered streams were associated with watersheds in the unglaciated high plateau region (north central Pennsylvania). Heavily farmed watersheds of the coastal plain, as well as watersheds containing the metropolitan areas associated with Baltimore and Washington had lower percentages of buffered streams. Low percentages (0-15%) of poorly buffered streams were found in watersheds located on the eastern shore of the Chesapeake bay and Delmarva Penninsula. Watershed B27 (Pleasant Run) in Virginia had the honor of being the most inadequately buffered watershed in the Chesapeake Bay (no streams buffered 300' on any side).

Although a rigorous assessment was not conducted, casual comparison of the data and quality control quadrangles in the valley and ridge portion of the Bay watershed suggests some relationship between the degree of buffering and the scale and order of the stream.

Table 2. Riparian forest buffer statistics for each state in the Chesapeake Bay watershed.

State	Stream length		Both sides 300'		Both sides 100-300'		One side 300'+		One side 100-300'		Both sides < 100'	
	miles	%	miles	%	miles	%	miles	%	miles	%	miles	%
Delaware	1091	1.0	326	29.8	572	52.4	558	51.2	638	58.5	453	41.5
Maryland [1]	16756	14.9	4487	26.8	8032	47.9	7658	45.7	9050	54.0	7706	46.0
New York [2]	8015	7.1	2006	25.0	3744	46.7	3699	46.2	4353	54.3	3662	45.7
Pennsylvania	47585	42.2	17720	37.2	26938	56.6	26750	56.2	30450	64.0	17135	36.0
Virginia [3]	34381	30.5	11971	34.8	17857	51.9	18216	53.0	20065	58.4	14316	41.6
West Virginia	4956	4.4	1840	37.1	2582	52.1	2671	53.9	2913	58.8	2042	41.2
Chesapeake Bay Total	112784	100.0	38350	34.0	59726	53.0	59553	52.8	67470	59.8	45314	40.2

NOTES:
1. Does not include the District of Columbia
2. 1:100,000 scale streams only. Does not include intermittant streams.
3. Mixed 1:100,000 and 1:24000 scale streams. Not all areas include intermittant streams.

Table 3. Riparian forest buffer statistics for 8-digit hydrologic units in the Chesapeake Bay watershed.

Watershed	HUC code	Stream length		Both sides 300' +		Both sides 100' - 300'		One side 300' +		One side 100' - 300'		Both sides < 100'	
		miles	%	miles	%	miles	%	miles	%	miles	%	miles	%
UPPER SUSQUEHANNA	2050101	3399	2.96	801	23.6	1573	46.3	1554	45.7	1856	54.6	1544	45.4
CHENANGO	2050102	2226	1.94	662	29.7	1115	50.1	1102	49.5	1270	57.0	956	43.0
OWEGO-WAPPASENING	2050103	1786	1.56	426	23.9	782	43.8	773	43.3	907	50.8	879	49.2
TIOGA	2050104	1824	1.59	487	26.7	942	51.7	928	50.9	1105	60.6	718	39.4
CHEMUNG	2050105	1500	1.31	314	20.9	660	44.0	655	43.7	775	51.6	726	48.4
UPPER SUSQUEHANNA-TUNKHANNOCK	2050106	4498	3.92	1176	26.1	2243	49.9	2235	49.7	2625	58.4	1873	41.6
UPPER SUSQUEHANNA-LACKAWANNA	2050107	3478	3.03	1349	38.8	2136	61.4	2117	60.9	2393	68.8	1084	31.2
UPPER WEST BRANCH SUSQUEHANNA	2050201	3379	2.94	2068	61.2	2598	76.9	2737	81.0	2821	83.5	559	16.5
SINNEMAHONING	2050202	2183	1.90	1466	67.1	1707	78.2	1733	79.4	1806	82.7	377	17.3
MIDDLE WEST BRANCH SUSQUEHANNA	2050203	1428	1.24	995	69.7	1129	79.1	1151	80.6	1188	83.2	239	16.8
BALD EAGLE	2050204	1480	1.29	643	43.5	875	59.1	888	60.0	972	65.7	508	34.3
PINE	2050205	1893	1.65	1062	56.1	1324	70.0	1366	72.1	1436	75.9	457	24.1
LOWER WEST BRANCH SUSQUEHANNA	2050206	3994	3.48	1627	40.7	2346	58.7	2349	58.8	2608	65.3	1386	34.7
LOWER SUSQUEHANNA-PENNS	2050301	3459	3.01	746	21.6	1417	41.0	1357	39.2	1727	49.9	1731	50.1
UPPER JUNIATA	2050302	1942	1.69	849	43.7	1220	62.8	1229	63.3	1366	70.3	576	29.7
RAYSTOWN	2050303	2465	2.15	939	38.1	1383	56.1	1419	57.6	1576	64.0	888	36.0
LOWER JUNIATA	2050304	2962	2.58	1067	36.0	1617	54.6	1606	54.2	1843	62.2	1118	37.8
LOWER SUSQUEHANNA-SWATARA	2050305	3834	3.34	911	23.8	1735	45.3	1621	42.3	2063	53.8	1771	46.2
LOWER SUSQUEHANNA	2050306	5063	4.41	946	18.7	2119	41.8	1934	38.2	2517	49.7	2546	50.3
UPPER CHESAPEAKE BAY	2060001	263	0.23	2	0.8	9	3.5	9	3.3	13	4.9	250	95.1
CHESTER-SASSAFRAS	2060002	1981	1.73	347	17.5	845	42.7	749	37.8	972	49.1	1009	50.9
GUNPOWDER-PATAPSCO	2060003	2162	1.88	629	29.1	1185	54.8	1140	52.7	1340	62.0	822	38.0
SEVERN	2060004	702	0.61	197	28.1	312	44.5	308	43.8	342	48.8	359	51.2
CHOPTANK	2060005	1739	1.51	212	12.2	518	29.8	460	26.5	606	34.9	1132	65.1
PATUXENT	2060006	1770	1.54	678	38.3	1124	63.5	1079	60.9	1230	69.5	541	30.5
BLACKWATER-WICOMICO	2060007	1031	0.90	71	6.9	187	18.2	169	16.4	225	21.8	806	78.2
NANTICOKE	2060008	1451	1.26	349	24.1	658	45.3	637	43.9	739	50.9	712	49.1
POCOMOKE	2060009	1172	1.02	277	23.7	447	38.1	448	38.2	495	42.3	677	57.7
SOUTH BRANCH POTOMAC	2070001	2033	1.77	788	38.7	1003	49.3	1045	51.4	1112	54.7	922	45.3
NORTH BRANCH POTOMAC	2070002	2476	2.16	1080	43.6	1483	59.9	1530	61.8	1633	65.9	844	34.1
CACAPON-TOWN	2070003	1984	1.73	982	49.5	1353	68.2	1392	70.2	1491	75.1	493	24.9
CONOCOCHEAGUE-OPEQUON	2070004	4038	3.52	1238	30.7	2031	50.3	1971	48.8	2321	57.5	1717	42.5

Table 3. Riparian forest buffer statistics for 8-digit hydrologic units in the Chesapeake Bay watershed.

Watershed	HUC code	Stream length		Both sides 300'		Both sides 100'		One side 300'		One side 100'		Both sides < 100'	
		miles	%	miles	%	miles	%	miles	%	miles	%	miles	%
SOUTH FORK SHENANDOAH	2070005	1666	1.45	479	28.8	658	39.5	649	38.9	751	45.1	915	54.9
NORTH FORK SHENANDOAH	2070006	1135	0.99	381	33.5	516	45.5	520	45.9	573	50.5	562	49.5
SHENANDOAH	2070007	449	0.39	72	16.1	131	29.2	138	30.7	167	37.2	282	62.8
MIDDLE POTOMAC-CATOCTIN	2070008	1826	1.59	386	21.1	866	47.5	804	44.0	1023	56.0	803	44.0
MONOCACY	2070009	2225	1.94	437	19.6	963	43.3	852	38.3	1151	51.7	1074	48.3
MIDDLE POTOMAC-ANACOSTIA-OCCOQUAN	2070010	1690	1.47	415	24.6	825	48.8	783	46.3	954	56.5	736	43.5
LOWER POTOMAC	2070011	2731	2.38	1157	42.4	1618	59.3	1637	59.9	1751	64.1	980	35.9
GREAT WICOMICO-PIANKATANK	2080102	1066	0.93	408	38.2	543	50.9	563	52.8	590	55.3	477	44.7
RAPIDAN-UPPER RAPPAHANNOCK	2080103	1923	1.68	477	24.8	786	40.9	785	40.8	914	47.5	1009	52.5
LOWER RAPPAHANNOCK	2080104	2102	1.83	851	40.5	1211	57.6	1246	59.3	1339	63.7	763	36.3
MATTAPONI	2080105	1626	1.42	892	54.8	1200	73.8	1228	75.5	1288	79.2	338	20.8
PAMUNKEY	2080106	2473	2.15	1000	40.4	1443	58.3	1481	59.9	1591	64.3	882	35.7
YORK	2080107	616	0.54	147	23.9	243	39.5	267	43.2	290	47.1	326	52.9
LYNNHAVEN-POQUOSON	2080108	1482	1.29	88	5.9	206	13.9	209	14.1	271	18.3	1211	81.7
WESTERN LOWER DELMARVA	2080109	813	0.71	35	4.3	111	13.7	106	13.0	144	17.7	669	82.3
UPPER JAMES	2080201	3137	2.73	1540	49.1	1951	62.2	1998	63.7	2114	67.4	1023	32.6
MAURY	2080202	1051	0.92	403	38.3	576	54.8	584	55.5	639	60.8	412	39.2
MIDDLE JAMES-BUFFALO	2080203	3357	2.92	1403	41.8	2026	60.3	2092	62.3	2258	67.3	1099	32.7
RIVANNA	2080204	1000	0.87	272	27.2	463	46.3	477	47.6	543	54.3	457	45.7
MIDDLE JAMES-WILLIS	2080205	1525	1.33	536	35.1	857	56.2	883	57.9	978	64.1	547	35.9
LOWER JAMES	2080206	2819	2.46	795	28.2	1306	46.3	1339	47.5	1498	53.1	1321	46.9
APPOMATTOX	2080207	2505	2.18	1115	44.5	1654	66.1	1696	67.7	1820	72.7	685	27.3

Table 4. Land use data within 100 and 300 foot stream buffers and entire subwatersheds for 8-digit hydrologic units in the Chesapeake Bay watershed.

Watershed	HUC code	Land use statistics for the entire watershed							Land use statistics for the 300' Buffer							Land use statistics for the 100' Buffer						
		nodat	low	high	wood	herb	expo	water	nodat	low	high	wood	herb	expo	water	nodat	low	high	wood	herb	expo	water
UPPER SUSQUEHANNA	2050101	1.9	0.1	2.6	59.2	35.2	0.0	1.1	0.8	0.0	4.5	51.3	35.9	0.0	6.2	0.8	0.1	4.5	54.1	32.2	0.0	7.2
CHENANGO	2050102	3.3	0.1	2.0	59.9	33.8	0.0	0.8	2.6	0.0	3.4	53.9	34.8	0.0	5.1	2.6	0.1	3.2	56.6	31.5	0.0	5.9
OWEGO-WAPPASENING	2050103	1.6	0.4	4.7	52.9	39.6	0.1	0.7	1.5	0.0	6.6	47.4	39.4	0.1	4.8	1.5	0.2	6.8	50.2	36.1	0.0	5.2
TIOGA	2050104	0.5	0.0	3.4	66.5	29.0	0.0	0.5	0.3	0.0	7.6	57.5	30.1	0.0	4.0	0.3	0.0	7.5	60.4	26.2	0.1	5.1
CHEMUNG	2050105	3.3	0.3	4.7	53.2	37.7	0.0	0.8	2.0	0.0	7.1	48.3	36.1	0.0	6.2	2.0	0.3	6.6	51.0	32.9	0.0	7.1
UPPER SUSQUEHANNA-TUNKHANNOCK	2050106	0.0	0.0	1.6	58.8	38.1	0.0	1.5	0.0	0.0	3.0	54.7	33.8	0.0	7.4	0.0	0.0	3.0	57.7	29.7	0.1	8.5
UPPER SUSQUEHANNA-LACKAWANNA	2050107	1.8	1.9	5.8	61.9	25.9	1.4	1.3	1.3	0.2	5.9	64.0	18.5	0.3	5.2	1.3	1.5	5.7	67.7	15.4	1.8	4.8
UPPER WEST BRANCH SUSQUEHANNA	2050201	2.0	0.0	1.5	83.9	8.0	3.8	0.7	1.7	0.0	1.9	84.7	3.2	0.4	5.3	1.7	0.0	1.6	84.0	2.3	1.7	7.4
SINNEMAHONING	2050202	3.5	0.0	0.5	89.7	5.5	0.3	0.4	3.1	0.0	1.3	84.1	6.8	0.0	3.5	3.1	0.0	1.3	83.1	6.4	0.2	4.9
MIDDLE WEST BRANCH SUSQUEHANNA	2050203	0.1	0.0	0.7	90.6	7.1	0.5	1.0	0.1	0.0	1.5	84.0	7.1	0.0	5.7	0.1	0.0	1.4	83.5	6.6	0.1	6.8
BALD EAGLE	2050204	0.1	0.1	3.1	70.9	24.4	0.7	0.6	0.2	0.0	4.0	64.7	25.2	0.1	3.6	0.2	0.2	3.7	65.6	22.9	0.6	5.2
PINE	2050205	1.6	0.0	0.8	82.4	14.6	0.1	0.4	1.2	0.0	1.9	76.6	14.8	0.0	4.0	1.2	0.0	1.8	76.2	13.5	0.1	5.9
LOWER WEST BRANCH SUSQUEHANNA	2050206	0.0	0.1	2.3	65.9	30.7	0.1	1.0	0.0	0.0	3.3	63.1	26.9	0.0	5.3	0.0	0.0	3.4	65.0	23.6	0.1	6.5
LOWER SUSQUEHANNA-PENNS	2050301	0.8	0.1	1.8	53.8	40.2	1.4	1.9	0.5	0.0	2.1	46.2	38.5	0.2	10.0	0.5	0.1	1.9	49.2	34.0	1.3	11.6
UPPER JUNIATA	2050302	0.2	0.0	2.9	72.7	23.7	0.2	0.3	0.1	0.0	3.8	68.4	23.4	0.0	2.2	0.1	0.0	3.4	70.0	20.9	0.1	3.4
RAYSTOWN	2050303	1.8	0.0	0.9	68.1	27.3	0.1	1.8	0.8	0.0	1.4	62.6	29.6	0.1	4.7	0.8	0.0	1.3	63.7	27.0	0.1	6.3
LOWER JUNIATA	2050304	0.1	0.0	0.9	66.9	31.3	0.1	0.7	0.1	0.0	1.4	58.9	33.6	0.0	4.8	0.1	0.0	1.2	61.5	30.3	0.1	5.8
LOWER SUSQUEHANNA-SWATARA	2050305	0.4	0.9	6.9	46.6	43.4	0.3	1.4	0.1	0.1	6.7	48.7	35.6	0.1	6.5	0.1	0.6	6.3	52.7	30.5	0.4	8.1
LOWER SUSQUEHANNA	2050306	2.0	0.6	5.2	29.5	60.2	0.1	2.4	1.1	0.0	4.4	44.4	41.7	0.2	7.5	1.1	0.4	4.4	48.7	35.6	0.2	9.4
UPPER CHESAPEAKE BAY	2060001	0.0	0.1	6.4	11.3	60.1	0.4	21.6	0.0	0.0	3.7	5.4	48.2	0.3	42.3	0.0	0.2	3.4	5.0	45.0	0.4	46.1
CHESTER-SASSAFRAS	2060002	0.6	0.1	2.4	30.2	61.0	0.1	5.7	0.3	0.0	2.3	43.1	34.2	0.1	20.0	0.3	0.1	2.2	47.9	28.0	0.1	21.6
GUNPOWDER-PATAPSCO	2060003	0.0	5.6	16.4	38.3	35.4	0.4	3.9	0.0	0.1	11.0	55.2	21.8	0.4	8.7	0.0	2.6	10.4	59.2	18.1	0.3	9.3
SEVERN	2060004	0.0	2.2	18.2	48.4	19.9	0.2	11.1	0.0	0.1	12.9	47.7	10.7	0.3	26.4	0.0	2.0	11.8	48.7	9.4	0.2	27.8
CHOPTANK	2060005	0.3	0.2	1.5	28.3	61.5	0.1	8.2	0.2	0.0	0.7	28.4	49.1	0.2	21.0	0.2	0.5	0.6	31.1	45.0	0.2	22.4
PATUXENT	2060006	0.0	1.3	9.9	46.5	36.3	0.1	5.8	0.0	0.1	5.4	64.6	19.4	0.1	9.9	0.0	0.5	4.8	68.6	15.3	0.0	10.8
BLACKWATER-WICOMICO	2060007	-	-	-	-	-	-	-	0.0	0.0	1.6	19.9	62.2	0.0	15.8	0.0	0.6	1.4	20.5	60.4	0.0	17.1
NANTICOKE	2060008	0.4	0.2	1.5	38.4	57.6	0.0	1.9	0.9	0.0	0.9	47.1	45.6	0.0	5.4	0.9	0.2	0.7	50.4	42.0	0.0	5.9
POCOMOKE	2060009	3.4	0.0	0.8	48.0	44.1	0.0	3.6	2.1	0.0	0.6	41.2	40.6	0.2	15.4	2.1	0.0	0.5	42.3	39.3	0.3	15.6
SOUTH BRANCH POTOMAC	2070001	2.9	0.0	1.2	68.6	26.9	0.1	0.3	1.4	0.0	3.9	56.1	35.6	0.1	3.0	1.4	0.0	4.8	55.0	34.5	0.1	4.2
NORTH BRANCH POTOMAC	2070002	7.8	0.0	2.9	70.2	17.6	0.9	0.6	7.6	0.0	5.9	65.9	17.0	0.4	3.1	7.6	0.0	6.0	66.0	16.1	0.4	3.8
CACAPON-TOWN	2070003	0.0	0.0	0.8	79.9	18.8	0.0	0.5	0.0	0.0	1.5	74.6	20.0	0.0	3.9	0.0	0.0	1.5	75.1	17.9	0.0	5.5
CONOCOCHEAGUE-OPEQUON	2070004	0.1	0.3	4.2	47.8	47.0	0.1	0.6	0.1	0.0	3.1	53.9	39.5	0.1	3.3	0.1	0.1	2.9	56.8	36.2	0.1	3.8

nodata - EMAP data unavailable
low - low intensity developed
high - high intensity developed
wood - woody
herb - herbaceous vegetation
expo - exposed soil

Table 4. Land use data within 100 and 300 foot stream buffers and entire subwatersheds for 8-digit hydrologic units in the Chesapeake Bay watershed.

Watershed	HUC code	Land use statistics for the entire watershed							Land use statistics for the 300' Buffer							Land use statistics for the 100' Buffer						
		nodat	low	high	wood	herb	expo	water	nodat	low	high	wood	herb	expo	water	nodat	low	high	wood	herb	expo	water
SOUTH FORK SHENANDOAH	2070005	0.0	0.3	3.2	51.2	44.8	0.0	0.5	0.0	0.0	3.6	44.2	45.4	0.0	6.4	0.0	0.3	3.9	44.8	42.9	0.0	8.0
NORTH FORK SHENANDOAH	2070006	0.0	0.1	2.0	57.7	39.7	0.1	0.4	0.0	0.0	3.0	50.4	43.1	0.2	3.2	0.0	0.1	3.4	50.6	40.0	0.2	5.8
SHENANDOAH	2070007	0.2	0.1	1.8	39.4	57.0	0.2	1.4	0.2	0.0	1.5	37.8	47.1	0.1	13.1	0.2	0.1	1.3	37.6	46.2	0.1	14.5
MIDDLE POTOMAC-CATOCTIN	2070008	0.0	1.4	8.7	39.5	49.1	0.0	1.3	0.0	0.1	4.8	50.1	39.8	0.0	4.5	0.1	0.4	4.1	55.0	35.5	0.0	4.7
MONOCACY	2070009	0.0	0.2	4.6	36.7	57.8	0.2	0.4	0.0	0.0	3.8	45.5	47.7	0.2	2.7	0.0	0.1	3.6	50.4	41.8	0.2	4.0
MIDDLE POTOMAC-ANACOSTIA-OCCOQUAN	2070010	0.0	5.6	24.8	35.3	30.1	0.2	4.0	0.0	0.2	13.8	51.3	26.2	0.2	6.0	0.0	2.0	12.3	55.5	23.4	0.2	6.5
LOWER POTOMAC	2070011	0.0	0.3	3.9	58.0	27.6	0.1	10.2	0.0	0.0	2.3	61.9	16.7	0.2	18.7	0.0	0.3	2.0	63.0	14.1	0.3	20.3
GREAT WICOMICO-PIANKATANK	2080102	0.0	0.0	2.0	58.8	29.7	0.2	9.3	0.0	0.0	1.1	50.3	20.9	0.9	26.8	0.0	0.0	0.9	50.1	17.7	1.1	30.2
RAPIDAN-UPPER RAPPAHANNOCK	2080103	0.1	0.0	0.9	50.7	48.0	0.1	0.3	0.1	0.0	1.0	45.3	51.3	0.1	2.2	0.1	0.0	1.0	47.1	49.0	0.2	2.7
LOWER RAPPAHANNOCK	2080104	0.0	0.1	2.4	58.2	33.6	0.1	5.7	0.0	0.0	1.3	61.2	19.5	0.2	17.8	0.0	0.0	1.2	62.0	16.8	0.3	19.8
MATTAPONI	2080105	0.0	0.0	0.8	67.9	29.8	0.0	1.5	0.0	0.0	0.9	76.6	15.7	0.0	6.8	0.0	0.0	0.8	78.6	13.0	0.0	7.6
PAMUNKEY	2080106	0.1	0.0	1.3	59.8	35.4	0.1	3.2	0.1	0.0	0.9	63.7	22.6	0.3	12.4	0.1	0.0	0.8	64.2	19.9	0.5	14.5
YORK	2080107	0.0	0.4	8.2	45.6	26.2	0.1	19.5	0.0	0.0	4.0	47.3	25.3	0.0	23.2	0.0	0.1	3.3	46.8	23.8	0.0	25.9
LYNNHAVEN-POQUOSON	2080108	9.8	7.2	29.1	19.6	23.3	0.5	10.4	4.3	0.1	16.4	20.6	21.3	0.2	32.5	4.3	4.8	14.4	20.1	19.7	0.2	36.4
WESTERN LOWER DELMARVA	2080109	0.0	0.1	1.2	33.4	55.5	0.4	9.5	0.0	0.0	0.3	18.2	37.8	1.0	42.6	0.0	0.3	0.2	18.1	34.5	1.2	45.8
UPPER JAMES	2080201	5.4	0.1	1.3	76.1	16.6	0.1	0.5	3.5	0.0	2.8	67.1	23.2	0.1	3.2	3.6	0.1	2.7	67.3	22.0	0.1	4.2
MAURY	2080202	0.0	0.2	2.9	70.6	26.0	0.0	0.3	0.0	0.0	5.9	60.2	31.5	0.0	2.1	0.0	0.1	5.7	60.8	29.9	0.0	3.3
MIDDLE JAMES-BUFFALO	2080203	2.8	0.1	2.8	69.5	23.9	0.0	0.8	2.3	0.0	2.1	66.5	23.1	0.1	5.8	2.3	0.1	1.8	67.3	21.7	0.1	6.7
RIVANNA	2080204	0.0	0.3	3.0	61.5	34.6	0.0	0.7	0.0	0.0	2.6	54.8	37.1	0.0	5.4	0.0	0.0	2.3	54.7	36.2	0.1	6.7
MIDDLE JAMES-WILLIS	2080205	0.0	0.8	5.4	58.2	34.1	0.0	1.4	0.1	0.0	2.9	62.6	25.5	0.0	8.8	0.1	0.2	2.5	64.0	23.3	0.0	10.0
LOWER JAMES	2080206	3.6	1.6	12.5	49.0	26.5	0.2	6.5	2.0	0.0	5.6	53.4	17.2	0.2	21.1	2.0	0.6	4.8	53.8	14.6	0.2	24.0
APPOMATTOX	2080207	3.3	0.3	3.0	60.6	31.7	0.0	1.2	2.4	0.0	1.7	70.6	18.9	0.0	6.2	2.4	0.2	1.4	72.4	16.2	0.0	7.3

nodata - EMAP data unavailable
low - low intensity developed
high - high intensity developed
wood - woody
herb - herbaceous vegetation
expo - exposed soil

Table 5. Riparian forest buffer statistics for 11-digit hydrologic units in Maryland

ID	Watershed	Md-ID	Stream Length		Both sides 300'+		Both sides 100-300'		One side 300'+		One side 100-300'		Both sides < 100'	
			miles	%	miles	%	miles	%	miles	%	miles	%	miles	%
1	BROAD CREEK	2120205	62.0	0.33	19.3	26.3	37.8	54.4	36.7	50.7	43.1	59.7	18.8	40.3
7	POCOMOKE SOUND	2130201	150.8	0.80	9.8	31.5	30.2	66.4	29.1	63.9	37.7	75.1	113.0	24.9
8	LOWER POCOMOKE RIVER	2130202	201.8	1.07	69.3	42.5	126.2	61.0	127.9	62.5	138.8	65.2	63.1	34.8
9	UPPER POCOMOKE RIVER	2130203	125.8	0.67	56.7	31.2	72.8	61.0	72.8	59.3	75.5	69.6	50.3	30.4
10	DIVIDING CREEK	2130204	57.4	0.30	40.9	26.4	49.9	35.4	50.2	37.2	51.3	37.5	6.1	62.5
11	NASSAWANGO CREEK	2130205	60.2	0.32	34.9	6.5	44.4	20.0	44.3	19.3	46.2	25.0	14.0	75.0
12	TANGIER SOUND	2130206	215.1	1.14	0.5	34.4	2.8	62.5	2.6	63.4	4.2	68.8	210.9	31.2
13	BIG ANNEMESSEX RIVER	2130207	115.7	0.61	6.0	45.0	17.4	57.8	17.9	57.9	22.3	60.0	93.4	40.0
14	MANOKIN RIVER	2130208	204.4	1.08	23.9	71.2	50.0	86.9	48.4	87.4	59.1	89.4	145.3	10.6
15	LOWER WICOMICO RIVER	2130301	206.9	1.10	15.1	57.9	47.9	73.8	41.3	73.7	55.8	76.7	151.2	23.3
16	MONIE BAY	2130302	73.2	0.39	3.3	0.2	6.0	1.3	5.9	1.2	6.8	2.0	66.4	98.0
17	WICOMICO CREEK	2130303	44.4	0.24	6.1	5.2	14.3	15.0	12.6	15.5	16.7	19.2	27.7	80.8
18	WICOMICO RIVER HEAD	2130304	62.6	0.33	14.3	11.7	32.2	24.5	29.5	23.7	36.1	28.9	26.5	71.1
19	NANTICOKE RIVER	2130305	404.4	2.14	50.6	7.3	101.0	23.2	97.2	19.9	117.4	27.0	287.0	73.0
20	MARSHYHOPE CREEK	2130306	291.7	1.55	60.1	4.5	136.3	8.2	128.3	8.1	154.8	9.3	136.9	90.7
21	FISHING BAY	2130307	499.1	2.64	10.9	13.8	28.6	32.3	26.0	28.3	37.0	37.6	462.0	62.4
22	TRANSQUAKING RIVER	2130308	246.6	1.31	22.1	22.9	58.7	51.4	54.3	47.2	72.9	57.6	173.8	42.4
23	HONGA RIVER	2130401	212.2	1.12	6.1	12.5	8.8	25.0	9.7	24.0	11.3	29.0	200.9	71.0
24	LITTLE CHOPTANK	2130402	222.7	1.18	4.8	20.6	11.0	46.7	12.3	44.0	14.6	53.1	208.1	46.9
25	LOWER CHOPTANK	2130403	603.0	3.20	15.6	2.2	78.3	5.7	63.7	5.2	101.9	7.4	501.1	92.6
26	UPPER CHOPTANK	2130404	539.7	2.86	100.9	9.0	245.8	23.8	217.8	22.0	278.7	29.5	261.0	70.5
27	TUCKAHOE CREEK	2130405	352.1	1.87	51.3	2.9	124.6	4.2	105.5	4.6	147.5	5.3	204.6	94.7
28	EASTERN BAY	2130501	104.8	0.56	0.7	2.1	3.9	5.0	3.6	5.5	5.7	6.6	99.0	93.4
29	MILES RIVER	2130502	133.6	0.71	5.2	2.6	18.3	13.0	15.2	10.6	23.8	16.9	109.9	83.1
30	WYE RIVER	2130503	175.2	0.93	11.5	18.7	44.7	45.5	36.5	40.4	55.2	51.6	120.0	48.4
31	KENT NARROWS	2130504	49.9	0.26	0.1	14.6	2.0	35.4	1.9	30.0	3.2	41.9	46.7	58.1
32	LOWER CHESTER RIVER	2130505	201.0	1.06	9.4	0.7	33.7	3.7	29.7	3.4	41.1	5.5	159.8	94.5
33	LANGFORD CREEK	2130506	93.3	0.49	6.8	3.9	25.4	13.7	20.1	11.4	29.9	17.8	63.4	82.2
34	CORSICA RIVER	2130507	65.4	0.35	9.8	6.6	32.4	25.5	23.5	20.8	36.0	31.5	29.3	68.5
35	SOUTHEAST CREEK	2130508	99.8	0.53	14.1	0.3	50.7	3.9	40.2	3.8	58.0	6.4	41.7	93.6
36	MIDDLE CHESTER RIVER	2130509	88.6	0.47	7.9	4.7	31.5	16.8	25.6	14.8	36.1	20.5	52.4	79.5
37	UPPER CHESTER RIVER	2130510	219.9	1.17	42.2	7.3	108.8	27.2	94.3	21.6	124.2	32.1	95.6	67.9

Table 5. Riparian forest buffer statistics for 11-digit hydrologic units in Maryland

ID	Watershed	Md-ID	Stream Length		Both sides 300'+		Both sides 100-300'		One side 300'+		One side 100-300'		Both sides < 100'	
			miles	%	miles	%	miles	%	miles	%	miles	%	miles	%
38	KENT ISLAND BAY	2130511	34.1	0.18	0.5	15.1	2.6	49.5	1.8	36.0	3.2	55.1	31.0	44.9
39	LOWER ELK RIVER	2130601	95.5	0.51	24.6	14.1	41.2	50.8	41.2	40.3	46.4	58.2	49.1	41.8
40	BOHEMIA RIVER	2130602	76.4	0.41	11.8	8.9	35.3	35.6	33.2	29.0	42.6	40.8	33.8	59.2
41	UPPER ELK RIVER	2130603	81.7	0.43	33.2	19.2	48.5	49.5	50.4	42.9	52.8	56.5	28.9	43.5
42	BACK CREEK	2130604	29.4	0.16	5.4	1.5	12.7	7.5	11.9	5.4	14.5	9.2	15.0	90.8
43	LITTLE ELK CREEK	2130605	39.5	0.21	12.9	25.7	27.4	43.2	25.2	43.2	30.8	48.6	8.7	51.4
44	BIG ELK CREEK	2130606	26.2	0.14	13.4	15.5	21.2	46.2	20.9	43.4	22.9	55.7	3.3	44.3
45	CHRISTIANA RIVER	2130607	1.0	0.01	0.2	40.7	0.5	59.4	0.5	61.7	0.6	64.6	0.4	35.4
46	NORTHEAST RIVER	2130608	116.3	0.62	46.0	18.3	74.5	43.2	72.7	40.3	80.7	49.2	35.6	50.8
47	FURNACE BAY	2130609	41.8	0.22	11.9	32.5	24.3	69.2	22.3	63.7	27.8	78.0	13.9	22.0
48	SASSAFRAS RIVER	2130610	143.8	0.76	16.2	51.1	51.3	80.7	44.7	79.7	62.9	87.4	80.9	12.6
49	STILLPOND-FAIRLEE	2130611	110.6	0.59	11.1	20.7	39.1	53.8	34.6	53.4	46.2	59.5	64.4	40.5
50	BUSH RIVER	2130701	49.4	0.26	18.6	39.6	31.2	64.1	29.5	62.5	34.4	69.4	15.0	30.6
51	LOWER WINTERS RUN	2130702	21.9	0.12	6.3	28.4	13.3	58.1	12.8	53.4	15.4	66.7	6.5	33.3
52	ATKISSON RESERVOIR	2130703	56.4	0.30	19.7	11.3	38.3	35.7	36.9	31.1	42.9	43.7	13.5	56.3
53	BYNUM RUN	2130704	25.4	0.13	8.7	10.0	16.5	35.3	15.6	31.3	18.4	41.7	6.9	58.3
54	ABERDEEN PROVING GROUND	2130705	39.5	0.21	12.3	37.6	17.8	63.2	17.6	59.8	19.0	69.7	20.4	30.3
55	SWAN CREEK	2130706	36.1	0.19	13.4	28.7	25.3	60.9	24.1	58.4	27.5	70.2	8.6	29.8
56	GUNPOWDER RIVER	2130801	67.3	0.36	2.6	34.9	9.3	68.0	10.4	65.5	12.2	76.1	55.1	23.9
57	LOWER GUNPOWDER FALLS	2130802	49.1	0.26	15.9	34.2	26.3	65.1	26.2	61.4	29.8	72.7	19.3	27.3
58	BIRD RIVER	2130803	35.3	0.19	3.4	31.1	11.4	45.0	11.0	44.5	13.5	48.2	21.7	51.8
59	LITTLE GUNPOWDER FALLS	2130804	78.9	0.42	32.5	37.2	56.5	70.0	53.8	66.7	62.0	76.2	17.0	23.8
60	LOCH RAVEN RESERVOIR	2130805	426.4	2.26	174.4	3.9	288.4	13.8	278.5	15.5	318.1	18.1	108.2	81.9
61	PRETTYBOY RESERVOIR	2130806	136.4	0.72	36.0	32.5	74.3	53.5	75.0	53.4	86.3	60.7	50.1	39.3
62	MIDDLE RIVER BROWNS	2130807	35.2	0.19	0.2	9.8	1.6	32.4	2.0	31.1	2.4	38.4	32.8	61.6
63	BACK RIVER	2130901	89.2	0.47	3.2	41.2	14.1	71.6	11.7	68.2	18.8	78.5	70.4	21.5
64	BODKIN CREEK	2130902	25.9	0.14	1.6	40.9	5.1	67.7	5.3	65.3	5.9	74.6	20.0	25.4
65	BALTIMORE HARBOR	2130903	163.2	0.87	2.1	26.4	11.9	54.4	10.5	55.0	15.2	63.3	148.1	36.7
66	JONES FALLS	2130904	93.2	0.49	21.2	0.5	44.8	4.5	40.8	5.7	52.0	6.9	41.2	93.1
67	GWYNNS FALLS	2130905	109.0	0.58	18.0	3.6	44.0	15.8	40.3	13.1	54.0	21.1	55.0	78.9
68	PATAPSCO RIVER - L.N. BR.	2130906	220.7	1.17	76.1	6.2	126.7	19.5	125.0	20.5	142.1	22.8	78.6	77.2
69	LIBERTY RESERVOIR	2130907	350.3	1.86	110.9	1.3	222.7	7.3	215.3	6.4	250.1	9.3	100.2	90.7

Table 5. Riparian forest buffer statistics for 11-digit hydrologic units in Maryland

ID	Watershed	Md-ID	Stream Length		Both sides 300'+		Both sides 100-300'		One side 300'+		One side 100-300'		Both sides < 100'	
			miles	%	miles	%	miles	%	miles	%	miles	%	miles	%
70	PATAPSCO RIVER - S. BR.	2130908	203.6	1.08	55.5	22.7	120.1	48.1	113.8	43.8	138.3	55.8	65.2	44.2
71	MAGOTHY RIVER	2131001	85.7	0.45	5.3	16.5	18.2	40.4	16.7	37.0	21.8	49.5	63.9	50.5
72	SEVERN RIVER	2131002	173.5	0.92	32.2	34.5	62.7	57.4	60.3	56.7	71.2	64.4	102.3	35.6
73	SOUTH RIVER	2131003	131.5	0.70	43.5	31.7	61.8	63.6	60.3	61.5	65.0	71.4	66.5	28.6
74	WEST RIVER	2131004	80.7	0.43	13.7	27.3	27.4	59.0	26.2	55.9	31.1	68.0	49.6	32.0
75	WEST CHESAPEAKE BAY	2131005	220.5	1.17	86.5	6.1	118.1	21.3	120.7	19.5	127.8	25.4	92.8	74.6
76	PATUXENT RIVER - FERRY LDG. TO MOUT	2131101	763.3	4.04	285.9	18.6	430.0	36.1	425.8	34.7	461.0	41.1	302.3	58.9
77	PATUXENT RIVER - RT. 214 TO FERRY LD	2131102	234.6	1.24	78.9	33.1	152.6	47.0	145.1	45.8	170.1	49.4	64.5	50.6
78	WESTERN BRANCH	2131103	110.1	0.58	37.2	17.0	66.7	33.9	64.2	32.5	74.6	38.5	35.5	61.5
79	PATUXENT RIVER - UPPER	2131104	161.9	0.86	84.6	39.2	123.5	53.6	119.7	54.7	132.3	57.9	29.5	42.1
80	LITTLE PATUXENT RIVER	2131105	186.2	0.99	54.4	37.5	106.0	56.3	95.7	55.8	120.9	60.4	65.2	39.6
81	PATUXENT RIVER - MIDDLE	2131106	111.8	0.59	45.1	33.6	80.0	65.1	74.4	61.8	89.2	72.5	22.7	27.5
82	ROCKY GORGE DAM	2131107	121.6	0.64	51.7	33.8	85.3	60.6	85.0	58.3	93.1	67.7	28.5	32.3
83	BRIGHTON DAM	2131108	177.8	0.94	59.1	52.3	112.3	76.3	102.8	74.0	126.1	81.8	51.6	18.2
84	POTOMAC RIVER - L. TIDAL	2140101	256.3	1.36	39.6	29.2	64.6	57.0	64.9	51.4	75.1	65.0	181.2	35.0
85	POTOMAC RIVER	2140102	71.7	0.38	27.3	40.3	34.8	71.5	37.3	66.5	38.6	79.7	33.1	20.3
86	'ST. MARY"S RIVER'	2140103	174.4	0.92	67.7	42.6	94.7	70.1	95.0	69.9	100.7	76.6	73.7	23.4
87	BRETON BAY	2140104	80.5	0.43	33.0	33.3	46.5	63.2	46.4	57.8	49.4	70.9	31.2	29.1
88	ST. CLEMENT BAY	2140105	81.3	0.43	27.9	15.5	41.4	25.2	40.2	25.3	43.9	29.3	37.4	70.7
89	WICOMICO RIVER	2140106	187.9	1.00	64.8	38.1	98.5	48.6	96.3	52.0	105.5	53.8	82.4	46.2
90	GILBERT SWAMP	2140107	101.0	0.54	52.8	38.8	76.7	54.3	75.6	54.5	81.7	57.7	19.3	42.3
91	ZEKIAH SWAMP	2140108	241.8	1.28	154.4	41.0	202.3	57.7	198.7	57.7	210.8	61.3	31.0	38.7
92	PORT TOBACCO RIVER	2140109	89.8	0.48	40.7	34.3	58.8	50.9	58.7	49.5	63.2	54.0	26.7	46.0
93	NANJEMOY CREEK	2140110	138.4	0.73	73.6	34.5	91.0	52.4	92.5	51.3	95.8	56.1	42.6	43.9
94	MATTAWOMAN CREEK	2140111	158.6	0.84	82.7	52.3	114.0	76.0	115.5	74.8	122.8	80.9	35.7	19.1
95	POTOMAC RIVER - U. TIDAL	2140201	36.9	0.20	10.4	63.8	19.3	83.7	18.0	82.2	22.8	87.2	14.1	12.8
96	POTOMAC RIVER - MO CTY.	2140202	198.4	1.05	50.0	45.4	110.9	65.5	112.7	65.4	132.2	70.3	66.2	29.7
97	PISCATAWAY CREEK	2140203	70.1	0.37	29.7	53.2	53.0	65.8	49.9	66.9	57.6	69.2	12.5	30.8
98	OXEN CREEK DR.	2140204	9.8	0.05	0.9	52.2	4.1	71.9	3.2	72.9	4.7	77.5	5.1	22.5
99	ANACOSTIA RIVER	2140205	166.2	0.88	39.4	28.1	78.9	52.2	71.7	48.9	91.6	61.8	74.6	38.2
100	ROCK CREEK	2140206	52.5	0.28	18.3	25.2	37.0	55.9	32.4	56.8	40.2	66.6	12.3	33.4
101	CABIN JOHN CREEK	2140207	20.9	0.11	6.8	42.4	13.5	75.6	11.3	71.2	14.9	82.2	6.0	17.8

Table 5. Riparian forest buffer statistics for 11-digit hydrologic units in Maryland

ID	Watershed	Md-ID	Stream Length		Both sides 300'+		Both sides 100-300'		One side 300'+		One side 100-300'		Both sides < 100'	
			miles	%	miles	%	miles	%	miles	%	miles	%	miles	%
102	SENECA CREEK	2140208	195.7	1.04	60.1	9.3	124.7	41.5	112.4	32.6	139.6	47.8	56.1	52.2
103	POTOMAC RIVER	2140301	119.3	0.63	7.7	23.7	34.2	47.5	32.8	43.2	45.5	55.1	73.8	44.9
104	LOWER MONOCACY RIVER	2140302	743.0	3.94	151.5	34.8	327.2	70.4	301.3	61.7	389.0	76.5	354.0	23.5
105	UPPER MONOCACY RIVER	2140303	518.7	2.75	118.3	32.6	220.6	64.7	199.3	54.1	263.4	71.1	255.3	28.9
106	DOUBLE PIPE CREEK	2140304	410.2	2.17	47.2	30.7	152.9	63.7	124.2	57.5	190.1	71.3	220.0	28.7
107	CATOCTIN CREEK	2140305	209.5	1.11	35.0	6.5	81.1	28.7	71.9	27.5	98.0	38.2	111.4	61.8
108	POTOMAC RIVER	2140501	194.9	1.03	24.0	20.4	64.2	44.0	68.7	40.6	87.8	52.4	107.1	47.6
109	ANTIETAM CREEK	2140502	230.7	1.22	27.9	22.8	67.6	42.5	58.1	38.4	83.5	50.8	147.2	49.2
110	MARSH RUN	2140503	16.3	0.09	1.0	11.5	2.5	37.3	2.1	30.3	3.3	46.4	13.0	53.6
111	CONOCOCHEAQUE CREEK	2140504	89.4	0.47	2.2	16.7	11.6	38.7	10.4	34.3	16.3	46.8	73.1	53.2
112	LITTLE CONOCOCHEAQUE	2140505	20.4	0.11	4.8	12.3	9.1	33.0	8.6	35.2	10.9	45.1	9.5	54.9
113	LICKING CREEK	2140506	39.8	0.21	25.1	12.1	33.6	29.3	34.5	25.2	35.9	36.2	3.9	63.8
114	TONOLOWAY CREEK	2140507	3.8	0.02	0.8	5.9	2.7	15.3	2.8	12.8	3.2	20.2	0.6	79.8
115	POTOMAC RIVER - AL CTY.	2140508	123.9	0.66	38.3	2.4	61.4	13.0	71.8	11.6	79.6	18.2	44.3	81.8
116	LITTLE TONOLOWAY CREEK	2140509	23.5	0.12	11.5	23.6	18.7	44.6	19.0	42.3	20.4	53.6	3.1	46.4
117	SIDELING HILL CREEK	2140510	32.7	0.17	23.8	63.1	28.2	84.5	28.4	86.8	29.2	90.2	3.5	9.8
118	FIFTEEN MILE CREEK	2140511	81.4	0.43	66.0	20.5	73.0	70.4	74.2	73.3	75.5	83.2	5.8	16.8
119	TOWN CREEK	2140512	125.5	0.67	58.9	30.9	87.3	49.6	89.9	57.9	96.9	64.2	28.6	35.8
120	POTOMAC RIVER - L.N. BR.	2141001	340.6	1.81	129.8	48.8	187.4	79.8	193.2	81.0	212.3	87.0	128.4	13.0
121	EVITTS CREEK	2141002	73.6	0.39	22.7	72.9	36.2	86.3	38.4	87.0	42.1	89.2	31.5	10.8
122	WILLS CREEK	2141003	107.2	0.57	48.1	81.1	67.7	89.6	70.4	91.1	75.5	92.8	31.7	7.2
123	GEORGES CREEK	2141004	117.9	0.62	61.2	46.9	85.9	69.6	87.1	71.6	92.1	77.2	25.8	22.8
124	POTOMAC RIVER - U.N. BR.	2141005	219.4	1.16	88.5	38.1	126.9	55.0	135.2	56.7	141.7	62.3	77.6	37.7
125	SAVAGE RIVER	2141006	244.3	1.29	111.0	30.8	130.7	49.1	133.1	52.1	135.2	57.2	109.1	42.8
128	DEEP CREEK LAKE	5020203	8.7	0.05	1.1	44.9	2.4	63.1	2.5	65.7	2.6	70.4	6.1	29.6
130	MAIN BAY WATERSHED	2999	140.1	0.74	0.2	51.9	1.4	72.9	2.1	73.9	2.9	78.1	137.3	21.9
131	CONOWINGO DAM	2120204	34.8	0.18	14.8	40.4	21.3	57.8	21.8	61.6	22.7	64.6	12.1	35.4
132	L. SUSQUEHANNA RIVER	2120201	73.3	0.39	19.3	45.4	39.9	53.5	37.2	54.5	43.8	55.3	29.6	44.7
133	DEER CREEK	2120202	266.9	1.41	94.2	12.8	169.7	27.7	163.6	28.3	192.5	30.1	74.4	69.9
134	OCTORARO CREEK	2120203	66.2	0.35	20.8	0.1	44.0	1.0	42.3	1.5	49.7	2.0	16.5	98.0

Table 6. Land use data wihin 100 and 300 foot stream buffers and entire subwatersheds for 11-digit hydrologic units in Maryland.

ID	Watershed	Md-ID	Land use statistics for the entire watershed							Land use statistics for the 300' Buffer							Land use statistics for the 100' Buffer						
			nodat	low	high	wood	herb	exp	water	nodat	low	high	wood	herb	exp	water	nodat	low	high	wood	herb	exp	water
1	BROAD CREEK	2120205	0.0	0.0	1.0	46.1	52.9	0.0	0.0	0.0	0.0	1.1	63.2	32.5	0.0	3.3	0.0	0.0	1.1	68.0	26.6	4.3	26.6
7	POCOMOKE SOUND	2130201	0.0	0.0	0.3	33.2	41.2	0.0	25.3	0.0	0.0	0.0	26.1	55.8	0.0	18.2	0.0	0.0	0.0	25.8	55.1	19.1	55.1
8	LOWER POCOMOKE RIVER	2130202	0.8	0.1	1.6	55.7	41.8	0.0	0.0	1.1	0.0	0.5	64.0	24.1	0.0	10.4	1.1	0.0	0.4	68.0	20.6	9.9	20.6
9	UPPER POCOMOKE RIVER	2130203	12.9	0.0	0.5	42.0	44.6	0.0	0.0	12.8	0.0	0.2	58.5	28.5	0.0	0.0	12.8	0.0	0.2	59.9	27.1	0.0	27.1
10	DIVIDING CREEK	2130204	0.0	0.0	0.1	72.0	27.9	0.0	0.0	0.0	0.0	0.0	86.7	13.3	0.0	0.0	0.0	0.0	0.0	89.1	10.8	0.0	10.8
11	NASSAWANGO CREEK	2130205	0.0	0.0	0.0	62.6	37.2	0.0	0.1	0.0	0.0	0.1	73.8	25.9	0.0	0.1	0.0	0.0	0.1	76.0	23.8	0.0	23.8
12	TANGIER SOUND	2130206	0.0	0.0	0.8	2.6	13.1	0.2	83.3	0.0	0.0	1.5	2.6	45.7	1.5	48.7	0.0	0.0	1.5	2.1	45.5	49.5	45.5
13	BIG ANNEMESSEX RIVER	2130207	0.0	0.0	0.7	43.8	55.2	0.3	0.0	0.0	0.0	0.7	20.8	47.0	0.9	30.6	0.0	0.0	0.6	19.7	46.7	32.1	46.7
14	MANOKIN RIVER	2130208	0.0	0.0	1.2	43.1	55.6	0.1	0.0	0.0	0.0	0.6	28.0	47.9	0.5	23.1	0.0	0.0	0.5	28.9	46.1	24.1	46.1
15	LOWER WICOMICO RIVER	2130301	0.0	1.6	7.4	33.6	51.2	0.0	6.1	0.0	0.0	5.2	24.6	53.6	0.0	15.0	0.0	1.7	4.7	26.9	51.5	15.2	51.5
16	MONIE BAY	2130302	0.0	0.0	0.1	36.7	49.3	0.0	13.8	0.0	0.0	0.0	9.2	71.0	0.0	19.7	0.0	0.0	0.0	9.3	69.7	21.0	69.7
17	WICOMICO CREEK	2130303	0.0	0.2	0.6	45.6	51.4	0.0	2.1	0.0	0.2	0.8	33.4	44.5	0.0	20.3	0.0	1.3	0.8	36.9	38.5	22.6	38.5
18	WICOMICO RIVER HEAD	2130304	0.0	2.2	8.9	40.0	48.7	0.0	0.3	0.0	0.1	8.1	50.7	34.4	0.0	4.5	0.0	2.1	6.8	56.1	30.6	4.3	30.6
19	NANTICOKE RIVER	2130305	0.0	0.1	0.9	35.9	49.9	0.0	13.2	0.0	0.0	0.5	28.1	55.8	0.0	15.2	0.0	0.5	0.4	29.0	53.7	16.5	53.7
20	MARSHYHOPE CREEK	2130306	0.0	0.2	1.7	36.9	59.7	0.0	1.5	0.0	0.0	1.6	47.1	45.3	0.0	5.6	0.0	0.3	1.3	52.0	40.5	5.9	40.5
21	FISHING BAY	2130307	0.0	0.1	0.2	24.6	51.8	0.0	23.3	0.0	0.0	0.1	8.4	67.8	0.0	23.4	0.0	0.2	0.2	7.9	67.2	24.5	67.2
22	TRANSQUAKING RIVER	2130308	0.0	0.1	0.3	37.5	60.2	0.0	2.0	0.0	0.0	0.3	30.0	60.4	0.0	9.1	0.0	0.1	0.3	29.9	57.5	12.1	57.5
23	HONGA RIVER	2130401	0.0	1.0	0.3	25.9	72.2	0.6	0.0	0.0	0.0	0.2	7.0	50.8	1.0	40.0	0.0	1.0	0.3	5.7	50.6	41.5	50.6
24	LITTLE CHOPTANK	2130402	0.0	0.6	0.2	40.0	59.0	0.2	0.0	0.0	0.0	0.1	8.7	41.4	0.2	48.1	0.0	1.7	0.0	6.9	39.8	51.4	39.8
25	LOWER CHOPTANK	2130403	0.0	0.9	4.9	24.6	69.3	0.2	0.0	0.0	0.0	1.9	14.9	42.5	0.4	39.2	0.0	1.2	1.7	16.4	38.4	41.8	38.4
26	UPPER CHOPTANK	2130404	0.0	0.0	1.0	30.0	66.0	0.0	2.9	0.0	0.0	0.6	44.5	46.3	0.0	8.6	0.0	0.0	0.5	50.3	40.0	9.2	40.0
27	TUCKAHOE CREEK	2130405	0.0	0.0	0.4	25.9	72.7	0.0	1.0	0.0	0.0	0.2	35.8	58.9	0.0	5.1	0.0	0.0	0.2	40.5	53.5	5.8	53.5
28	EASTERN BAY	2130501	0.0	0.0	2.8	5.8	18.3	0.0	73.2	0.0	0.0	3.8	6.8	33.9	0.0	55.4	0.0	0.0	3.4	5.9	28.5	62.3	28.5
29	MILES RIVER	2130502	0.0	0.1	5.6	22.9	49.3	0.0	22.2	0.0	0.0	6.0	15.8	46.4	0.0	31.6	0.0	0.4	5.9	17.4	43.6	32.7	43.6
30	WYE RIVER	2130503	0.0	0.0	1.2	21.0	65.4	0.0	12.4	0.0	0.0	1.7	27.3	36.7	0.0	34.4	0.0	0.0	1.3	30.8	30.0	37.9	30.0
31	KENT NARROWS	2130504	0.0	0.0	6.1	15.7	33.6	0.0	44.6	0.0	0.0	5.6	6.3	35.4	0.0	52.6	0.0	0.0	4.9	6.3	29.7	59.1	29.7
32	LOWER CHESTER RIVER	2130505	0.0	0.0	1.9	16.4	36.6	0.0	45.2	0.0	0.0	2.2	18.9	36.3	0.0	42.6	0.0	0.0	2.0	20.3	32.1	45.6	32.1
33	LANGFORD CREEK	2130506	0.0	0.0	0.1	18.5	68.9	0.0	12.5	0.0	0.0	0.0	28.3	41.8	0.0	29.9	0.0	0.0	0.0	32.0	36.3	31.7	36.3
34	CORSICA RIVER	2130507	0.0	0.0	1.9	25.6	66.7	0.0	5.9	0.0	0.0	0.9	44.6	37.7	0.0	16.8	0.0	0.0	0.6	53.5	26.4	19.5	26.4
35	SOUTHEAST CREEK	2130508	0.0	0.0	0.4	26.9	70.5	0.0	2.2	0.0	0.0	0.3	46.6	43.6	0.0	9.4	0.0	0.0	0.4	55.9	33.1	10.6	33.1
36	MIDDLE CHESTER RIVER	2130509	0.0	0.0	3.3	12.1	84.5	0.0	0.0	0.0	0.0	2.7	36.0	39.3	0.0	21.9	0.0	0.0	2.3	40.6	31.5	25.7	31.5
37	UPPER CHESTER RIVER	2130510	0.0	0.0	0.6	29.5	68.3	0.0	1.6	0.0	0.0	0.6	47.7	43.7	0.0	8.0	0.0	0.0	0.6	54.8	36.1	8.5	36.1

nodata - EMAP data available
low - low intensity developed
high - high intensity developed
wood - wooded
herb - heraceous vegetation
expo - exposed soil

Table 6. Land use data wihin 100 and 300 foot stream buffers and entire subwatersheds for 11-digit hydrologic units in Maryland.

ID	Watershed	Md-ID	Land use statistics for the entire watershed							Land use statistics for the 300' Buffer							Land use statistics for the 100' Buffer						
			nodat	low	high	wood	herb	exp	water	nodat	low	high	wood	herb	exp	water	nodat	low	high	wood	herb	exp	water
38	KENT ISLAND BAY	2130511	0.0	0.0	24.4	19.9	35.3	0.4	20.2	0.0	0.0	21.2	10.0	22.8	0.7	45.3	0.0	0.0	20.7	9.8	20.7	47.7	20.7
39	LOWER ELK RIVER	2130601	0.0	0.0	1.7	51.8	46.4	0.0	0.0	0.0	0.0	1.2	49.7	14.7	0.0	34.4	0.0	0.1	1.0	49.4	11.2	38.2	11.2
40	BOHEMIA RIVER	2130602	0.0	0.0	1.1	21.9	65.7	0.0	11.2	0.0	0.0	0.6	50.8	19.8	0.0	28.7	0.0	0.2	0.5	54.5	13.7	31.1	13.7
41	UPPER ELK RIVER	2130603	0.0	1.0	9.5	60.3	29.2	0.1	0.0	0.0	0.0	5.6	64.0	15.2	0.0	15.1	0.0	0.2	5.3	64.4	13.9	16.3	13.9
42	BACK CREEK	2130604	0.0	0.1	3.1	37.0	58.9	0.9	0.0	0.0	0.0	4.6	46.2	18.4	0.0	30.6	0.0	0.4	4.2	48.8	11.5	35.2	11.5
43	LITTLE ELK CREEK	2130605	0.0	0.1	4.5	43.6	51.8	0.0	0.0	0.0	0.0	3.9	67.0	28.7	0.0	0.3	0.0	0.0	4.0	75.6	20.0	0.3	20.0
44	BIG ELK CREEK	2130606	2.2	0.4	7.3	56.2	34.0	0.0	0.0	0.0	0.0	7.6	80.8	11.5	0.0	0.0	0.0	0.1	7.5	85.6	6.8	0.0	6.8
45	CHRISTIANA RIVER	2130607	69.4	0.2	1.9	10.4	18.2	0.0	0.0	4.5	0.6	28.8	53.3	11.4	0.0	0.0	5.3	1.2	23.6	60.6	9.4	0.0	9.4
46	NORTHEAST RIVER	2130608	0.0	0.5	7.6	48.2	43.3	0.4	0.0	0.0	0.0	9.1	64.3	16.8	0.4	9.0	0.0	0.5	8.4	68.4	12.4	10.0	12.4
47	FURNACE BAY	2130609	0.0	0.1	2.8	45.8	50.0	1.4	0.0	0.0	0.0	1.8	57.3	27.7	2.3	10.9	0.0	0.0	1.8	64.1	20.5	11.5	20.5
48	SASSAFRAS RIVER	2130610	0.0	0.0	0.9	22.2	62.4	0.0	14.5	0.0	0.0	0.6	39.6	25.6	0.0	34.3	0.0	0.0	0.6	43.0	20.4	36.0	20.4
49	STILLPOND-FAIRLEE	2130611	0.0	0.0	1.4	27.6	60.8	0.0	10.2	0.0	0.0	1.6	38.5	24.6	0.0	35.4	0.0	0.0	1.5	41.3	20.7	36.6	20.7
50	BUSH RIVER	2130701	0.0	1.3	12.6	50.7	34.4	1.0	0.0	0.0	0.1	7.1	65.0	22.2	2.2	2.9	0.0	0.4	6.4	69.0	18.3	3.8	18.3
51	LOWER WINTERS RUN	2130702	0.0	3.7	28.1	41.2	24.4	2.6	0.0	0.0	0.2	19.5	63.6	14.3	0.1	1.2	0.0	1.0	19.2	69.3	9.8	0.7	9.8
52	ATKISSON RESERVOIR	2130703	0.0	1.5	10.4	39.1	49.0	0.0	0.0	0.0	0.1	4.1	68.5	26.9	0.0	0.0	0.0	0.6	3.2	74.4	21.8	0.0	21.8
53	BYNUM RUN	2130704	0.0	1.0	20.2	37.3	41.5	0.0	0.0	0.0	0.1	9.7	64.5	25.6	0.0	0.0	0.0	0.0	8.6	71.3	20.1	0.0	20.1
54	ABERDEEN PROVING GROUND	2130705	0.0	0.4	7.4	41.3	32.7	0.0	18.2	0.0	0.0	1.1	54.4	37.0	0.0	7.5	0.0	0.0	1.0	50.8	36.4	11.8	36.4
55	SWAN CREEK	2130706	0.0	0.7	12.6	41.0	41.1	0.0	4.6	0.0	0.0	6.1	68.9	16.2	0.0	8.4	0.0	0.5	5.0	75.5	9.4	9.5	9.4
56	GUNPOWDER RIVER	2130801	0.0	4.2	23.0	39.2	31.5	2.1	0.0	0.0	0.0	11.4	20.2	23.8	0.7	42.1	0.0	1.7	10.7	18.8	24.1	44.0	24.1
57	LOWER GUNPOWDER FALLS	2130802	0.0	1.5	14.2	41.9	41.9	0.6	0.0	0.0	0.0	8.0	59.8	27.9	0.1	4.0	0.0	0.2	7.3	61.6	25.3	5.7	25.3
58	BIRD RIVER	2130803	0.0	6.4	31.5	27.4	31.5	3.2	0.0	0.0	0.2	21.5	34.5	14.4	2.9	23.7	0.0	1.8	21.2	38.1	12.0	24.4	12.0
59	LITTLE GUNPOWDER FALLS	2130804	0.0	0.5	5.8	44.5	49.1	0.1	0.0	0.0	0.0	2.1	70.7	26.2	0.0	0.8	0.0	0.1	2.1	76.7	20.1	1.0	20.1
60	LOCH RAVEN RESERVOIR	2130805	0.0	0.8	5.0	54.0	39.8	0.4	0.0	0.0	0.1	3.3	68.7	22.8	0.5	4.2	0.0	0.4	3.1	73.4	18.1	4.5	18.1
61	PRETTYBOY RESERVOIR	2130806	0.0	0.0	0.6	44.0	51.9	0.0	3.6	0.0	0.0	0.2	59.2	27.7	0.0	12.8	0.0	0.1	0.2	62.5	23.8	13.4	23.8
62	MIDDLE RIVER BROWNS	2130807	0.0	13.7	39.4	33.1	13.9	0.1	0.0	0.0	0.0	30.8	7.4	4.2	0.0	51.3	0.0	6.4	30.1	6.6	3.8	52.9	3.8
63	BACK RIVER	2130901	0.0	15.7	49.5	9.4	13.8	0.0	11.6	0.0	0.3	38.9	18.8	14.9	0.0	19.4	0.0	6.2	38.3	21.1	14.0	20.4	14.0
64	BODKIN CREEK	2130902	0.0	1.3	24.3	48.7	9.2	0.0	16.6	0.0	0.0	20.7	24.0	5.0	0.0	47.9	0.0	1.4	17.2	23.5	4.1	53.8	4.1
65	BALTIMORE HARBOR	2130903	0.0	35.6	38.6	14.2	11.6	0.0	0.0	0.0	0.1	23.7	8.4	4.9	0.0	40.8	0.0	21.9	22.8	9.1	4.4	41.8	4.4
66	JONES FALLS	2130904	0.0	14.3	35.6	32.3	17.7	0.1	0.0	0.0	0.3	26.8	50.0	14.8	0.0	1.9	0.0	6.4	25.2	54.9	11.5	2.0	11.5
67	GWYNNS FALLS	2130905	0.0	16.0	41.2	23.6	18.8	0.3	0.0	0.0	0.3	32.9	43.3	15.6	0.7	0.5	0.0	5.5	31.4	48.1	13.5	0.8	13.5
68	PATAPSCO RIVER - L.N. BR.	2130906	0.0	5.3	27.5	45.1	21.4	0.7	0.0	0.0	0.3	19.4	61.3	12.2	1.0	3.3	0.0	2.3	18.4	64.0	9.9	4.6	9.9
69	LIBERTY RESERVOIR	2130907	0.0	0.6	3.8	41.2	54.2	0.2	0.0	0.0	0.1	1.6	65.1	26.3	0.2	6.6	0.0	0.2	1.3	70.3	21.5	6.5	21.5

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high - high intensity developed
wood - wooded
herb - heraceous vegetation
expo - exposed soil

Table 6. Land use data wihin 100 and 300 foot stream buffers and entire subwatersheds for 11-digit hydrologic units in Maryland.

ID	Watershed	Md-ID	Land use statistics for the entire watershed							Land use statistics for the 300' Buffer							Land use statistics for the 100' Buffer						
			nodat	low	high	wood	herb	exp	water	nodat	low	high	wood	herb	exp	water	nodat	low	high	wood	herb	exp	water
70	PATAPSCO RIVER - S. BR.	2130908	0.0	0.2	4.7	39.7	54.9	0.0	0.6	0.0	0.0	3.8	60.5	34.1	0.0	1.6	0.0	0.0	3.8	66.6	27.7	1.9	27.7
71	MAGOTHY RIVER	2131001	0.0	2.2	44.9	40.3	12.5	0.1	0.0	0.0	0.1	27.5	24.2	3.6	0.0	43.4	0.0	1.4	23.5	25.5	2.9	46.8	2.9
72	SEVERN RIVER	2131002	0.0	4.6	31.8	48.3	14.9	0.3	0.0	0.0	0.2	15.9	39.9	5.2	0.1	35.2	0.0	3.7	13.9	40.9	4.0	37.4	4.0
73	SOUTH RIVER	2131003	0.0	2.5	21.8	54.3	21.4	0.0	0.0	0.0	0.0	13.6	49.0	4.7	0.0	31.2	0.0	1.4	12.6	49.6	3.5	32.9	3.5
74	WEST RIVER	2131004	0.0	0.5	15.1	46.9	37.5	0.0	0.0	0.0	0.0	13.8	37.2	16.4	0.0	31.6	0.0	1.0	14.1	38.4	13.6	32.9	13.6
75	WEST CHESAPEAKE BAY	2131005	0.0	0.8	7.1	67.6	24.1	0.4	0.0	0.0	0.1	7.6	57.6	15.3	0.8	16.3	0.0	2.5	7.5	58.0	14.2	17.1	14.2
76	PATUXENT RIVER - FERRY LDG. TO MOUT	2131101	0.0	0.8	3.2	59.8	36.0	0.1	0.0	0.0	0.0	1.8	58.5	18.3	0.3	20.4	0.0	0.6	1.8	60.2	15.5	21.6	15.5
77	PATUXENT RIVER - RT. 214 TO FERRY LD	2131102	0.0	0.2	3.3	49.2	47.0	0.2	0.0	0.0	0.0	1.0	67.3	21.6	0.1	10.0	0.0	0.1	0.6	71.7	16.0	11.5	16.0
78	WESTERN BRANCH	2131103	0.0	3.0	19.7	38.2	39.0	0.1	0.0	0.0	0.2	14.8	62.1	19.1	0.3	2.3	0.0	1.1	14.1	66.8	15.6	2.2	15.6
79	PATUXENT RIVER - UPPER	2131104	-	-	-	-	-	-	-	0.0	0.1	9.2	76.8	11.0	0.4	0.8	0.0	1.5	8.3	81.1	7.3	1.5	7.3
80	LITTLE PATUXENT RIVER	2131105	0.0	4.8	32.4	37.8	25.0	0.0	0.0	0.0	0.3	22.6	57.6	15.9	0.0	2.3	0.0	0.9	19.5	63.4	13.5	2.7	13.5
81	PATUXENT RIVER - MIDDLE	2131106	0.0	0.3	7.6	42.5	49.5	0.0	0.1	0.0	0.0	4.1	70.2	25.3	0.0	0.5	0.0	0.0	3.4	77.6	18.5	0.5	18.5
82	ROCKY GORGE DAM	2131107	0.0	0.3	6.3	49.5	42.0	0.0	2.0	0.0	0.0	2.1	71.2	19.2	0.0	7.4	0.0	0.2	1.7	75.2	14.6	8.3	14.6
83	BRIGHTON DAM	2131108	0.0	0.1	1.2	41.9	55.2	0.0	1.7	0.0	0.0	0.7	63.3	31.5	0.0	4.6	0.0	0.0	0.5	69.5	24.9	5.0	24.9
84	POTOMAC RIVER - L. TIDAL	2140101	0.0	0.4	2.3	58.2	38.8	0.3	0.0	0.0	0.0	2.9	30.2	22.4	0.8	43.0	0.0	0.8	3.2	29.4	19.7	45.9	19.7
85	POTOMAC RIVER	2140102	0.0	0.3	8.6	76.6	14.3	0.2	0.0	0.0	0.0	3.1	58.6	6.4	0.0	31.9	0.0	0.0	2.8	55.2	5.5	36.5	5.5
86	'ST. MARY"S RIVER'	2140103	0.0	0.7	3.2	66.7	29.5	0.1	0.0	0.0	0.1	1.0	56.8	17.1	0.2	24.7	0.0	0.1	0.8	57.8	15.2	25.9	15.2
87	BRETON BAY	2140104	0.0	0.3	3.4	59.2	37.0	0.2	0.0	0.0	0.0	1.8	58.3	18.3	0.3	20.6	0.0	0.9	1.4	60.3	15.1	22.2	15.1
88	ST. CLEMENT BAY	2140105	0.0	0.1	1.9	50.2	47.7	0.2	0.0	0.0	0.0	0.9	50.7	23.4	0.0	24.8	0.0	0.1	0.6	53.3	20.4	25.5	20.4
89	WICOMICO RIVER	2140106	0.0	0.1	3.2	51.4	45.2	0.1	0.0	0.0	0.0	1.7	52.6	25.4	0.0	20.3	0.0	0.0	1.6	55.4	20.3	22.7	20.3
90	GILBERT SWAMP	2140107	0.0	0.0	1.9	56.0	41.9	0.1	0.0	0.0	0.0	0.5	77.5	19.0	0.0	3.0	0.0	0.0	0.5	80.3	15.7	3.5	15.7
91	ZEKIAH SWAMP	2140108	0.0	0.4	7.2	60.4	31.9	0.1	0.0	0.0	0.0	3.0	82.5	13.4	0.0	0.7	0.0	0.3	2.5	86.4	9.9	0.9	9.9
92	PORT TOBACCO RIVER	2140109	0.0	0.5	7.9	64.4	27.2	0.0	0.0	0.0	0.0	2.6	68.3	18.3	0.0	10.7	0.0	0.1	2.3	70.1	15.5	12.0	15.5
93	NANJEMOY CREEK	2140110	0.0	0.0	0.6	72.0	21.0	0.0	6.3	0.0	0.0	0.1	70.0	12.3	0.0	17.7	0.0	0.0	0.1	69.6	9.5	20.9	9.5
94	MATTAWOMAN CREEK	2140111	0.0	0.9	11.2	67.5	20.3	0.1	0.0	0.0	0.0	5.2	75.1	11.2	0.1	7.6	0.0	0.8	4.7	76.9	9.2	8.3	9.2
95	POTOMAC RIVER - U. TIDAL	2140201	0.0	4.0	23.5	32.3	21.8	0.0	18.5	0.0	0.4	16.4	57.3	18.9	0.0	5.2	0.0	1.8	13.5	61.3	17.0	6.4	17.0
96	POTOMAC RIVER - MO CTY.	2140202	0.0	2.4	14.9	41.3	41.5	0.0	0.0	0.0	0.0	4.7	59.9	23.4	0.0	11.1	0.0	0.8	3.8	65.4	19.5	10.6	19.5
97	PISCATAWAY CREEK	2140203	0.0	3.2	17.1	44.2	33.5	0.0	2.0	0.0	0.2	9.1	73.9	16.5	0.0	0.1	0.0	0.2	6.9	80.7	12.1	0.1	12.1
98	OXEN CREEK DR.	2140204	0.0	9.2	48.6	17.8	24.2	0.0	0.2	0.0	1.2	35.5	37.9	21.6	0.0	0.0	0.0	3.2	32.3	46.8	17.6	0.0	17.6
99	ANACOSTIA RIVER	2140205	0.0	9.0	46.1	26.3	17.5	1.2	0.0	0.0	0.3	31.9	48.1	12.8	0.9	0.0	0.0	4.8	30.9	53.5	10.1	0.0	10.1
100	ROCK CREEK	2140206	0.0	7.5	42.8	27.4	22.0	0.0	0.4	0.0	0.5	18.3	66.5	11.9	0.0	0.1	0.0	2.3	14.2	75.0	8.4	0.0	8.4
101	CABIN JOHN CREEK	2140207	0.0	6.3	48.6	31.9	13.3	0.0	0.0	0.0	0.6	28.9	62.3	6.4	0.0	0.0	0.0	2.0	22.4	69.9	5.6	0.0	5.6

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high - high intensity developed
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herb - heraceous vegetation
expo - exposed soil

Table 6. Land use data wihin 100 and 300 foot stream buffers and entire subwatersheds for 11-digit hydrologic units in Maryland.

ID	Watershed	Md-ID	Land use statistics for the entire watershed							Land use statistics for the 300' Buffer							Land use statistics for the 100' Buffer						
			nodat	low	high	wood	herb	exp	water	nodat	low	high	wood	herb	exp	water	nodat	low	high	wood	herb	exp	water
102	SENECA CREEK	2140208	0.0	2.1	10.8	36.0	51.1	0.0	0.0	0.0	0.1	6.3	61.7	28.1	0.0	3.3	0.0	0.3	5.4	69.3	21.1	3.8	21.1
103	POTOMAC RIVER	2140301	0.0	0.7	4.8	37.6	56.8	0.1	0.0	0.0	0.0	3.5	34.5	40.7	0.1	20.9	0.0	0.1	3.6	37.1	37.9	21.2	37.9
104	LOWER MONOCACY RIVER	2140302	0.0	0.3	7.3	34.4	57.6	0.4	0.0	0.0	0.0	5.4	46.9	45.4	0.1	2.0	0.0	0.1	5.0	51.3	40.6	3.0	40.6
105	UPPER MONOCACY RIVER	2140303	-	-	-	-	-	-	-	0.0	0.0	2.4	46.7	44.8	0.1	6.0	0.0	0.0	2.2	50.1	38.4	9.3	38.4
106	DOUBLE PIPE CREEK	2140304	0.0	0.1	1.5	24.2	73.9	0.4	0.0	0.0	0.0	1.4	37.7	60.3	0.4	0.2	0.0	0.0	1.4	44.5	53.6	0.2	53.6
107	CATOCTIN CREEK	2140305	0.0	0.0	2.4	38.8	58.7	0.0	0.0	0.0	0.0	2.0	42.3	55.5	0.0	0.2	0.0	0.0	1.9	46.4	51.5	0.2	51.5
108	POTOMAC RIVER	2140501	0.2	0.1	3.4	51.9	44.4	0.0	0.0	0.2	0.0	2.1	45.4	18.4	0.3	33.6	0.3	0.0	1.8	46.1	15.9	35.7	15.9
109	ANTIETAM CREEK	2140502	-	-	-	-	-	-	-	0.0	0.0	8.0	32.5	58.2	0.2	1.0	0.0	0.1	7.6	35.8	55.3	1.1	55.3
110	MARSH RUN	2140503	0.0	0.8	13.4	17.7	68.1	0.0	0.1	0.0	0.0	4.1	20.5	73.2	0.0	1.6	0.0	0.6	4.0	20.7	72.8	1.9	72.8
111	CONOCOCHEAQUE CREEK	2140504	0.3	1.0	12.8	18.6	67.3	0.0	0.0	0.2	0.0	7.8	21.5	62.0	0.0	8.1	0.2	0.3	7.4	19.1	57.9	15.1	57.9
112	LITTLE CONOCOCHEAQUE	2140505	0.0	0.0	2.8	47.5	49.6	0.0	0.1	0.0	0.0	2.8	46.7	50.2	0.0	0.4	0.0	0.0	2.2	51.9	45.3	0.6	45.3
113	LICKING CREEK	2140506	0.0	0.0	0.3	85.5	14.2	0.0	0.0	0.0	0.0	0.1	85.2	14.6	0.0	0.0	0.0	0.0	0.2	88.8	11.0	0.0	11.0
114	TONOLOWAY CREEK	2140507	0.0	0.0	2.7	74.7	21.6	0.0	1.0	0.0	0.0	4.1	67.5	18.8	0.0	9.6	0.0	0.0	4.6	78.9	7.6	9.0	7.6
115	POTOMAC RIVER - AL CTY.	2140508	0.0	0.0	0.3	86.4	8.7	0.0	4.6	0.0	0.0	2.0	63.5	7.8	0.0	26.7	0.0	0.0	1.6	63.0	6.4	29.0	6.4
116	LITTLE TONOLOWAY CREEK	2140509	0.0	0.0	3.3	79.2	17.4	0.0	0.1	0.0	0.0	5.8	80.0	13.3	0.0	0.9	0.0	0.0	3.7	84.9	9.9	1.5	9.9
117	SIDELING HILL CREEK	2140510	0.0	0.0	2.7	83.4	13.9	0.0	0.0	0.0	0.0	5.4	86.9	7.4	0.0	0.3	0.0	0.0	5.7	89.0	5.0	0.4	5.0
118	FIFTEEN MILE CREEK	2140511	0.0	0.0	1.1	91.5	7.4	0.1	0.0	0.0	0.0	1.8	91.2	6.9	0.0	0.0	0.0	0.0	1.6	91.9	6.4	0.0	6.4
119	TOWN CREEK	2140512	0.0	0.0	0.6	79.3	20.1	0.0	0.0	0.0	0.0	1.1	73.7	25.2	0.0	0.0	0.0	0.0	1.1	76.3	22.6	0.0	22.6
120	POTOMAC RIVER - L.N. BR.	2141001	0.0	0.2	8.0	75.2	16.5	0.1	0.0	0.0	0.0	12.5	64.1	16.5	0.1	6.6	0.0	0.1	12.9	62.7	14.8	9.4	14.8
121	EVITTS CREEK	2141002	0.0	0.1	9.0	68.7	22.1	0.1	0.0	0.0	0.0	10.8	59.1	27.0	0.1	2.9	0.0	0.1	11.7	57.8	27.3	3.0	27.3
122	WILLS CREEK	2141003	1.1	0.0	9.8	76.9	11.7	0.5	0.0	0.0	0.0	19.7	69.7	10.5	0.0	0.1	0.0	0.0	20.3	70.2	9.4	0.1	9.4
123	GEORGES CREEK	2141004	0.2	0.0	5.7	75.3	14.2	4.6	0.0	0.0	0.0	16.7	75.9	5.9	1.4	0.1	0.0	0.0	16.7	77.6	4.6	0.0	4.6
124	POTOMAC RIVER - U.N. BR.	2141005	21.6	0.0	1.3	63.1	13.1	1.0	0.0	11.3	0.0	3.7	67.7	6.3	0.2	10.7	11.3	0.0	3.7	65.6	4.8	14.5	4.8
125	SAVAGE RIVER	2141006	39.8	0.0	0.6	53.8	5.5	0.3	0.0	41.0	0.0	1.2	54.2	2.4	0.0	1.3	41.0	0.0	1.0	55.0	2.0	0.9	2.0
128	DEEP CREEK LAKE	5020203	-	-	-	-	-	-	-	54.8	0.0	2.8	32.4	10.0	0.0	0.0	55.7	0.0	2.2	31.5	10.5	0.0	10.5
130	MAIN BAY WATERSHED	2999	-	-	-	-	-	-	-	0.0	0.0	2.2	2.8	47.3	1.9	45.6	0.0	0.2	2.0	2.1	44.9	48.1	44.9
131	CONOWINGO DAM	2120204	0.0	0.0	0.9	49.9	28.2	0.1	21.0	0.0	0.0	0.8	64.5	7.0	0.0	27.7	0.0	0.0	1.0	64.9	4.7	29.5	4.7
132	L. SUSQUEHANNA RIVER	2120201	-	-	-	-	-	-	-	0.0	0.1	8.4	52.9	11.2	0.1	26.1	0.0	1.3	7.4	58.3	7.2	25.7	7.2
133	DEER CREEK	2120202	-	-	-	-	-	-	-	0.0	0.0	0.1	65.2	32.8	0.0	1.8	0.0	0.0	0.1	70.5	26.1	3.3	26.1
134	OCTORARO CREEK	2120203	-	-	-	-	-	-	-	0.0	0.0	2.7	69.0	24.2	0.0	4.1	0.0	0.0	2.2	74.1	16.8	6.8	16.8

nodata - EMAP data available
low - low intensity developed
high - high intensity developed
wood - wooded
herb - heraceous vegetation
expo - exposed soil

Table 7. Riparian forest buffer statistics for 11-digit hydrologic units in Pennsylvania.

ID	11 digit HUC code	Stream length		Both sides 300'+		Both sides 100-300'		One side 300'+		One side 100-300'		Both sides <100'	
		miles	%	miles	%	miles	%	miles	%	miles	%	miles	%
1	2050101220	5.6	0.01	0.5	8.3	1.7	30.8	2.2	40.4	2.4	43.1	3.2	56.9
2	2050101230	4.2	0.01	1.3	31.4	2.6	60.9	2.5	58.8	2.9	69.4	1.3	30.6
3	2050101250	198.3	0.42	63.9	32.2	107.6	54.2	111.2	56.1	123.4	62.2	74.9	37.8
4	2050101280	159.2	0.34	46.4	29.1	80.4	50.5	80.5	50.6	91.7	57.6	67.5	42.4
5	2050101290	140.4	0.30	34.4	24.5	62.8	44.7	64.2	45.7	72.6	51.7	67.7	48.3
6	2050101320	180.6	0.38	42.4	23.5	89.3	49.4	89.7	49.6	106.2	58.8	74.4	41.2
7	2050101340	13.2	0.03	2.3	17.4	5.3	40.1	4.9	37.4	6.1	46.1	7.1	53.9
8	2050101370	6.3	0.01	1.5	23.3	2.3	37.3	2.4	38.2	2.6	41.3	3.7	58.7
9	2050103050	68.5	0.14	18.8	27.4	35.9	52.4	35.8	52.3	40.9	59.7	27.6	40.3
10	2050103090	42.3	0.09	12.4	29.3	22.1	52.1	21.1	49.9	24.7	58.3	17.7	41.7
11	2050103190	146.8	0.31	32.1	21.9	64.7	44.0	64.4	43.9	75.6	51.5	71.2	48.5
12	2050103200	2.2	0.00	0.1	3.1	0.4	19.5	0.4	16.1	0.5	23.8	1.7	76.2
13	2050103210	67.4	0.14	15.0	22.3	31.8	47.2	31.1	46.1	38.0	56.3	29.4	43.7
14	2050103220	3.6	0.01	0.1	4.0	1.5	41.0	1.2	32.7	1.7	47.9	1.9	52.1
15	2050104010	117.6	0.25	29.4	25.0	61.6	52.4	57.5	48.9	73.2	62.2	44.4	37.8
16	2050104020	233.1	0.49	74.8	32.1	132.2	56.7	129.7	55.6	154.4	66.2	78.8	33.8
16	2050104110	28.2	0.06	8.3	29.6	16.7	59.4	16.2	57.7	19.5	69.2	8.7	30.8
17	2050104130	380.3	0.80	88.9	23.4	201.6	53.0	194.3	51.1	238.7	62.8	141.6	37.2
18	2050104170	518.6	1.09	148.1	28.6	247.1	47.7	250.9	48.4	292.5	56.4	226.1	43.6
19	2050105190	46.1	0.10	2.2	4.8	10.4	22.7	10.6	23.1	14.2	30.8	31.9	69.2
20	2050105200	40.4	0.09	2.0	5.0	11.7	29.1	9.4	23.2	15.7	38.9	24.7	61.1
21	2050105230	93.3	0.20	20.6	22.1	45.0	48.3	45.8	49.1	53.1	56.9	40.2	43.1
22	2050105240	52.3	0.11	6.4	12.3	20.3	38.8	20.5	39.2	25.2	48.2	27.1	51.8
23	2050105270	73.3	0.15	13.4	18.2	33.1	45.1	32.4	44.2	39.4	53.8	33.9	46.2
24	2050106010	322.9	0.68	78.2	24.2	170.0	52.7	160.0	49.5	201.3	62.4	121.5	37.6
25	2050106020	181.5	0.38	104.0	57.3	131.9	72.7	137.5	75.7	142.9	78.7	38.6	21.3
26	2050106030	450.9	0.95	117.3	26.0	231.7	51.4	224.8	49.9	274.0	60.8	176.9	39.2
27	2050106040	238.5	0.50	41.6	17.4	101.9	42.7	101.0	42.4	121.9	51.1	116.6	48.9
28	2050106050	371.4	0.78	61.9	16.7	144.1	38.8	140.8	37.9	176.8	47.6	194.7	52.4
29	2050106060	156.5	0.33	23.4	14.9	61.7	39.4	60.2	38.5	76.9	49.2	79.6	50.8
30	2050106070	348.6	0.73	71.9	20.6	152.7	43.8	154.8	44.4	182.2	52.3	166.4	47.7
31	2050106080	252.3	0.53	49.7	19.7	117.8	46.7	113.6	45.0	136.6	54.2	115.6	45.8
32	2050106090	245.1	0.52	138.6	56.5	175.3	71.5	180.8	73.8	190.1	77.5	55.1	22.5

Table 7. Riparian forest buffer statistics for 11-digit hydrologic units in Pennsylvania.

ID	11 digit HUC code	Stream length		Both sides 300'+		Both sides 100-300'		One side 300'+		One side 100-300'		Both sides <100'	
		miles	%	miles	%	miles	%	miles	%	miles	%	miles	%
33	2050106100	167.0	0.35	46.2	27.7	93.6	56.0	94.2	56.4	108.0	64.7	59.0	35.3
34	2050106110	235.8	0.50	66.3	28.1	129.4	54.9	129.8	55.1	150.8	64.0	84.9	36.0
35	2050106120	611.4	1.29	128.0	20.9	281.6	46.1	284.8	46.6	339.4	55.5	272.0	44.5
36	2050106130	193.2	0.41	105.4	54.6	142.2	73.6	144.0	74.6	153.5	79.5	39.7	20.5
37	2050106140	566.0	1.19	111.0	19.6	246.9	43.6	244.8	43.2	298.2	52.7	267.9	47.3
38	2050107010	755.2	1.59	289.5	38.3	439.2	58.1	446.4	59.1	494.2	65.4	261.0	34.6
39	2050107020	282.0	0.59	79.0	28.0	139.1	49.3	141.3	50.1	165.5	58.7	116.5	41.3
40	2050107030	467.0	0.98	213.3	45.7	319.6	68.4	324.1	69.4	355.9	76.2	111.1	23.8
41	2050107040	302.7	0.64	147.3	48.7	205.7	67.9	206.5	68.2	220.4	72.8	82.3	27.2
42	2050107050	220.9	0.46	111.6	50.5	163.9	74.2	164.9	74.6	179.3	81.2	41.5	18.8
43	2050107060	137.6	0.29	48.1	34.9	85.8	62.4	82.1	59.6	95.3	69.3	42.3	30.7
44	2050107070	414.3	0.87	170.3	41.1	268.9	64.9	265.0	64.0	296.7	71.6	117.6	28.4
45	2050107080	271.9	0.57	146.2	53.8	203.4	74.8	201.1	73.9	216.2	79.5	55.7	20.5
46	2050107090	155.4	0.33	49.1	31.6	89.9	57.8	86.2	55.5	102.4	65.9	53.0	34.1
47	2050107100	418.2	0.88	68.2	16.3	185.8	44.4	164.6	39.4	232.8	55.7	185.4	44.3
48	2050201010	293.6	0.62	165.1	56.2	227.6	77.5	237.7	81.0	249.0	84.8	44.6	15.2
49	2050201020	144.6	0.30	109.1	75.4	126.5	87.4	127.6	88.2	131.1	90.6	13.6	9.4
50	2050201030	612.2	1.29	331.0	54.1	428.1	69.9	447.7	73.1	469.2	76.6	142.9	23.4
51	2050201040	790.4	1.66	495.6	62.7	623.6	78.9	657.0	83.1	677.1	85.7	113.3	14.3
52	2050201050	613.5	1.29	350.5	57.1	468.5	76.4	510.6	83.2	525.8	85.7	87.7	14.3
53	2050201060	154.7	0.33	127.0	82.1	139.5	90.1	141.4	91.4	142.7	92.2	12.1	7.8
54	2050201070	711.6	1.50	452.9	63.6	537.1	75.5	573.7	80.6	582.2	81.8	129.4	18.2
55	2050202010	176.3	0.37	115.4	65.5	131.8	74.8	134.2	76.1	138.1	78.3	38.2	21.7
56	2050202020	543.6	1.14	357.1	65.7	425.7	78.3	435.8	80.2	457.4	84.1	86.2	15.9
57	2050202030	719.3	1.51	514.7	71.6	597.2	83.0	601.3	83.6	623.6	86.7	95.7	13.3
58	2050202040	596.8	1.26	377.1	63.2	443.6	74.3	452.0	75.7	472.4	79.2	124.4	20.8
59	2050202050	136.3	0.29	89.4	65.6	97.1	71.3	98.1	72.0	104.5	76.7	31.8	23.3
60	2050203010	518.5	1.09	388.0	74.8	433.1	83.5	444.6	85.8	452.7	87.3	65.7	12.7
61	2050203020	203.0	0.43	129.4	63.7	148.8	73.3	152.5	75.1	159.2	78.4	43.8	21.6
62	2050203030	132.3	0.28	114.5	86.5	121.5	91.8	122.7	92.7	123.4	93.3	8.9	6.7
63	2050203040	577.8	1.22	362.3	62.7	425.7	73.7	432.0	74.8	454.2	78.6	123.6	21.4
64	2050204010	215.7	0.45	38.2	17.7	71.7	33.2	67.2	31.1	86.4	40.0	129.3	60.0

Table 7. Riparian forest buffer statistics for 11-digit hydrologic units in Pennsylvania.

ID	11 digit HUC code	Stream length		Both sides 300'+		Both sides 100-300'		One side 300'+		One side 100-300'		Both sides <100'	
		miles	%	miles	%	miles	%	miles	%	miles	%	miles	%
65	2050204020	370.3	0.78	233.8	63.1	283.9	76.7	303.5	82.0	310.8	83.9	59.5	16.1
66	2050204030	269.7	0.57	109.8	40.7	148.3	55.0	143.3	53.1	164.5	61.0	105.2	39.0
67	2050204040	616.8	1.30	255.8	41.5	364.3	59.1	369.2	59.9	405.4	65.7	211.4	34.3
68	2050204050	0.8	0.00	0.8	100.0	0.8	100.0	0.8	100.0	0.8	100.0	0.0	0.0
69	2050205010	154.0	0.32	118.3	76.8	133.7	86.8	136.5	88.7	138.1	89.7	15.9	10.3
70	2050205020	421.6	0.89	250.9	59.5	321.1	76.2	324.2	76.9	339.6	80.5	82.0	19.5
71	2050205030	146.3	0.31	59.2	40.5	86.8	59.3	86.0	58.8	96.0	65.6	50.3	34.4
72	2050205040	225.2	0.47	101.7	45.1	134.6	59.7	142.5	63.3	153.1	68.0	72.1	32.0
73	2050205050	346.9	0.73	180.0	51.9	238.4	68.7	247.1	71.2	262.3	75.6	84.6	24.4
74	2050205060	582.7	1.23	342.1	58.7	398.5	68.4	417.3	71.6	433.8	74.4	148.9	25.6
75	2050206010	167.4	0.35	97.8	58.4	128.3	76.7	128.4	76.7	135.7	81.1	31.7	18.9
76	2050206020	620.9	1.31	334.2	53.8	436.7	70.3	442.2	71.2	470.9	75.8	150.0	24.2
77	2050206030	300.0	0.63	189.2	63.1	232.7	77.6	243.3	81.1	248.3	82.8	51.7	17.2
78	2050206040	186.4	0.39	65.7	35.3	111.0	59.6	112.0	60.1	126.5	67.9	59.9	32.1
79	2050206050	594.6	1.25	328.1	55.2	417.4	70.2	426.1	71.7	447.4	75.2	147.2	24.8
80	2050206060	408.1	0.86	116.6	28.6	187.2	45.9	189.6	46.5	219.1	53.7	189.0	46.3
81	2050206070	196.1	0.41	50.5	25.7	107.7	54.9	105.4	53.8	126.7	64.6	69.4	35.4
82	2050206080	282.8	0.60	124.9	44.2	179.0	63.3	185.9	65.7	198.4	70.2	84.4	29.8
83	2050206090	125.1	0.26	61.3	49.0	89.3	71.4	85.8	68.6	96.4	77.1	28.7	22.9
84	2050206100	262.6	0.55	97.5	37.1	151.8	57.8	146.4	55.7	168.0	64.0	94.6	36.0
85	2050206110	273.0	0.57	40.4	14.8	83.4	30.6	74.7	27.4	102.5	37.5	170.5	62.5
86	2050206120	533.8	1.12	105.8	19.8	197.2	37.0	184.9	34.6	237.2	44.4	296.6	55.6
87	2050301010	257.4	0.54	62.7	24.4	113.2	44.0	108.6	42.2	134.2	52.1	123.2	47.9
88	2050301020	137.4	0.29	56.7	41.3	74.0	53.8	73.5	53.5	80.2	58.4	57.2	41.6
89	2050301030	418.1	0.88	118.9	28.4	200.7	48.0	193.5	46.3	232.4	55.6	185.7	44.4
90	2050301040	626.1	1.32	194.6	31.1	281.9	45.0	281.0	44.9	327.2	52.3	298.9	47.7
91	2050301050	284.0	0.60	56.7	20.0	104.3	36.7	108.7	38.3	129.1	45.5	154.9	54.5
92	2050301060	224.1	0.47	39.6	17.7	91.7	40.9	92.1	41.1	111.2	49.6	112.9	50.4
93	2050301070	112.4	0.24	22.7	20.2	58.8	52.4	52.4	46.6	70.5	62.7	41.9	37.3
94	2050301080	232.4	0.49	10.9	4.7	54.2	23.3	41.2	17.7	77.1	33.2	155.2	66.8
95	2050301090	241.1	0.51	64.4	26.7	119.3	49.5	110.3	45.7	137.1	56.9	104.0	43.1
96	2050301100	873.4	1.84	106.9	12.2	299.8	34.3	276.3	31.6	407.2	46.6	466.2	53.4

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ID	11 digit HUC code	Stream length		Both sides 300'+		Both sides 100-300'		One side 300'+		One side 100-300'		Both sides <100'	
		miles	%	miles	%	miles	%	miles	%	miles	%	miles	%
97	2050302010	305.4	0.64	103.0	33.7	153.6	50.3	155.2	50.8	177.3	58.1	128.1	41.9
98	2050302020	164.3	0.35	71.5	43.5	106.0	64.6	105.5	64.2	118.0	71.9	46.2	28.1
99	2050302030	367.6	0.77	101.8	27.7	178.3	48.5	186.1	50.6	219.5	59.7	148.2	40.3
100	2050302040	131.7	0.28	42.0	31.9	66.0	50.1	63.9	48.5	74.6	56.6	57.1	43.4
101	2050302050	461.6	0.97	252.2	54.6	344.1	74.6	348.3	75.5	376.6	81.6	84.9	18.4
102	2050302060	126.0	0.27	62.1	49.3	87.1	69.1	86.6	68.7	97.0	76.9	29.1	23.1
103	2050302070	233.3	0.49	140.7	60.3	178.7	76.6	178.3	76.4	188.7	80.9	44.6	19.1
104	2050302080	135.3	0.28	55.3	40.9	83.1	61.4	86.1	63.7	93.9	69.4	41.4	30.6
105	2050303010	404.0	0.85	171.8	42.5	255.0	63.1	254.2	62.9	282.6	69.9	121.4	30.1
106	2050303020	159.8	0.34	59.7	37.4	82.4	51.5	80.5	50.3	90.7	56.7	69.1	43.3
107	2050303030	343.6	0.72	96.7	28.2	161.0	46.9	157.5	45.8	186.3	54.2	157.3	45.8
107	2050303040	209.8	0.44	81.7	38.9	138.2	65.9	138.0	65.8	157.5	75.1	52.2	24.9
109	2050303050	481.1	1.01	187.1	38.9	273.1	56.8	283.0	58.8	314.1	65.3	167.0	34.7
110	2050303060	236.9	0.50	68.3	28.8	99.2	41.9	99.1	41.8	111.1	46.9	125.7	53.1
111	2050303070	214.4	0.45	110.3	51.4	148.5	69.3	149.4	69.7	161.4	75.3	53.0	24.7
112	2050303080	407.5	0.86	167.8	41.2	229.2	56.2	259.0	63.6	273.9	67.2	133.6	32.8
113	2050304010	204.7	0.43	89.1	43.5	117.1	57.2	121.0	59.1	134.2	65.5	70.5	34.5
114	2050304020	242.0	0.51	135.9	56.2	188.6	77.9	189.8	78.4	202.4	83.6	39.6	16.4
115	2050304030	106.0	0.22	38.0	35.9	61.5	58.1	60.6	57.2	70.5	66.5	35.5	33.5
116	2050304040	341.8	0.72	146.4	42.8	215.5	63.1	220.4	64.5	244.7	71.6	97.1	28.4
117	2050304050	249.2	0.52	71.0	28.5	97.8	39.2	98.4	39.5	118.8	47.7	130.4	52.3
118	2050304060	138.6	0.29	74.0	53.4	92.0	66.3	91.2	65.8	98.5	71.0	40.2	29.0
119	2050304070	171.9	0.36	42.2	24.5	66.7	38.8	65.3	38.0	74.2	43.2	97.7	56.8
120	2050304080	254.9	0.54	62.4	24.5	112.9	44.3	104.1	40.8	136.5	53.5	118.4	46.5
121	2050304090	599.9	1.26	227.8	38.0	354.7	59.1	349.0	58.2	398.9	66.5	201.1	33.5
122	2050304100	130.1	0.27	28.7	22.1	55.0	42.3	56.2	43.2	65.1	50.1	65.0	49.9
123	2050304110	162.3	0.34	70.4	43.4	109.7	67.6	105.4	64.9	121.1	74.7	41.1	25.3
124	2050304120	311.8	0.66	69.5	22.3	126.0	40.4	121.7	39.1	153.6	49.3	158.1	50.7
125	2050305010	511.7	1.08	186.8	36.5	277.2	54.2	273.1	53.4	317.5	62.1	194.1	37.9
126	2050305020	261.2	0.55	100.1	38.3	163.5	62.6	153.5	58.7	183.7	70.3	77.5	29.7
127	2050305030	447.7	0.94	106.6	23.8	213.9	47.8	192.2	42.9	256.6	57.3	191.1	42.7
128	2050305040	259.5	0.55	16.4	6.3	70.7	27.2	61.1	23.5	98.4	37.9	161.1	62.1

Table 7. Riparian forest buffer statistics for 11-digit hydrologic units in Pennsylvania.

ID	11 digit HUC code	Stream length		Both sides 300'+		Both sides 100-300'		One side 300'+		One side 100-300'		Both sides <100'	
		miles	%	miles	%	miles	%	miles	%	miles	%	miles	%
129	2050305050	386.5	0.81	128.8	33.3	213.0	55.1	209.9	54.3	246.5	63.8	140.0	36.2
130	2050305060	314.4	0.66	107.9	34.3	176.2	56.0	173.2	55.1	200.4	63.7	114.0	36.3
131	2050305070	169.5	0.36	8.0	4.7	34.0	20.1	29.5	17.4	45.9	27.1	123.6	72.9
132	2050305080	97.1	0.20	7.9	8.1	17.6	18.1	15.8	16.3	21.7	22.4	75.4	77.6
133	2050305090	508.2	1.07	48.7	9.6	157.7	31.0	127.4	25.1	202.1	39.8	306.1	60.2
134	2050305100	802.7	1.69	185.0	23.0	387.4	48.3	360.9	45.0	459.5	57.2	343.2	42.8
135	2050306010	165.7	0.35	13.6	8.2	52.1	31.5	43.1	26.0	65.8	39.7	99.9	60.3
136	2050306020	406.3	0.86	69.7	17.2	172.5	42.5	146.8	36.1	209.0	51.4	197.4	48.6
137	2050306030	238.9	0.50	29.8	12.5	107.4	45.0	83.7	35.0	130.6	54.7	108.3	45.3
138	2050306040	152.4	0.32	15.2	10.0	61.6	40.4	45.6	29.9	74.8	49.1	77.6	50.9
139	2050306050	304.5	0.64	82.7	27.2	146.3	48.0	138.1	45.3	175.6	57.7	128.9	42.3
140	2050306060	204.3	0.43	37.7	18.4	97.4	47.7	88.7	43.4	116.1	56.9	88.1	43.1
141	2050306070	327.3	0.69	43.2	13.2	121.6	37.2	107.5	32.8	146.6	44.8	180.8	55.2
142	2050306080	229.5	0.48	15.9	6.9	67.1	29.3	49.2	21.4	85.6	37.3	143.8	62.7
143	2050306090	233.1	0.49	35.2	15.1	77.1	33.1	69.1	29.6	93.4	40.1	139.7	59.9
144	2050306100	83.5	0.18	11.3	13.5	26.2	31.3	23.6	28.3	30.8	36.8	52.8	63.2
145	2050306110	438.2	0.92	31.9	7.3	92.9	21.2	81.9	18.7	114.6	26.1	323.6	73.9
146	2050306120	285.4	0.60	44.6	15.6	93.9	32.9	85.3	29.9	109.5	38.4	175.9	61.6
147	2050306150	248.8	0.52	92.6	37.2	169.4	68.1	161.4	64.9	188.4	75.7	60.4	24.3
148	2050306160	691.9	1.46	143.1	20.7	287.3	41.5	287.5	41.6	346.2	50.0	345.6	50.0
149	2050306180	194.9	0.41	38.1	19.5	81.8	42.0	75.8	38.9	97.5	50.0	97.4	50.0
150	2050306200	43.1	0.09	9.3	21.7	20.5	47.6	18.4	42.6	24.1	56.0	18.9	44.0
151	2050306220	246.0	0.52	53.7	21.8	109.7	44.6	104.4	42.5	129.5	52.7	116.5	47.3
152	2060002020	82.3	0.17	23.2	28.2	50.9	61.9	45.7	55.6	57.1	69.4	25.2	30.6
153	2060002040	21.0	0.04	2.9	13.6	10.8	51.7	9.4	44.7	12.7	60.6	8.3	39.4
155	2060002080	13.2	0.03	2.1	16.2	5.7	43.2	4.7	35.4	6.6	49.5	6.7	50.5
156	2060003120	18.2	0.04	1.3	7.4	4.5	24.7	3.5	19.2	5.6	30.9	12.6	69.1
157	2070002070	408.9	0.86	213.0	52.1	274.9	67.2	281.6	68.9	295.8	72.3	113.1	27.7
158	2070002130	155.5	0.33	80.0	51.4	103.2	66.4	106.8	68.7	113.1	72.7	42.4	27.3
159	2070003060	213.9	0.45	131.9	61.7	169.3	79.2	171.3	80.1	179.2	83.8	34.7	16.2
160	2070003100	31.2	0.07	22.5	72.2	26.9	86.1	27.0	86.5	28.2	90.2	3.1	9.8

Table 7. Riparian forest buffer statistics for 11-digit hydrologic units in Pennsylvania.

ID	11 digit HUC code	Stream length		Both sides 300'+		Both sides 100-300'		One side 300'+		One side 100-300'		Both sides <100'	
		miles	%	miles	%	miles	%	miles	%	miles	%	miles	%
161	2070003130	229.2	0.48	129.9	56.7	178.5	77.9	178.1	77.7	190.5	83.1	38.7	16.9
162	2070004010	234.4	0.49	47.4	20.2	101.8	43.4	88.1	37.6	121.2	51.7	113.2	48.3
163	2070004020	345.2	0.73	92.7	26.8	151.9	44.0	138.9	40.2	175.6	50.9	169.6	49.1
164	2070004030	475.6	1.00	172.2	36.2	268.6	56.5	254.1	53.4	303.8	63.9	171.7	36.1
165	2070004120	363.2	0.76	192.2	52.9	282.5	77.8	279.2	76.9	303.8	83.7	59.4	16.3
166	2070004220	530.9	1.12	274.9	51.8	402.2	75.8	400.2	75.4	431.7	81.3	99.2	18.7
167	2070004310	106.5	0.22	9.1	8.5	29.4	27.6	25.0	23.5	38.6	36.3	67.8	63.7
168	2070004400	162.8	0.34	49.3	30.3	64.0	39.3	61.7	37.9	70.8	43.5	92.0	56.5
169	2070009030	114.9	0.24	53.7	46.8	77.1	67.1	74.7	65.1	85.0	74.0	29.9	26.0
170	2070009040	436.7	0.92	69.3	15.9	187.6	43.0	155.8	35.7	225.8	51.7	210.9	48.3

Table 8. Land use data within 100 and 300 foot stream buffers and entire subwatersheds for 11-digit hydrologic units in Pennsylvania.

ID	11 digit HUC code	Land use statistics for the entire watershed							Land use statistics for the 300' buffer							Land use statistics for the 100' buffer						
		nodata	low	high	wood	herb	expo	water	nodata	low	high	wood	herb	expo	water	nodata	low	high	wood	herb	expo	water
1	2050101220	0.0	0.0	4.1	71.2	19.6	0.0	5.2	0.0	0.0	3.1	39.3	28.7	0.0	28.9	0.0	0.0	1.8	41.0	24.8	0.0	32.4
2	2050101230	0.0	0.0	4.1	81.9	14.0	0.0	0.0	0.0	0.0	4.0	67.6	28.3	0.0	0.0	0.0	0.0	3.4	66.5	30.1	0.0	0.0
3	2050101250	5.7	0.0	0.9	69.5	22.5	0.0	1.5	5.9	0.0	3.0	60.4	24.4	0.0	6.3	5.9	0.0	3.8	61.9	21.3	0.0	7.1
4	2050101280	0.0	0.0	3.4	74.6	21.9	0.0	0.0	0.0	0.0	5.5	55.2	24.7	0.0	14.6	0.0	0.0	5.0	57.1	21.4	0.1	16.4
5	2050101290	0.0	0.1	5.9	67.1	25.3	0.0	1.6	0.0	0.0	12.9	50.3	28.2	0.0	8.2	0.0	0.3	13.9	51.4	25.2	0.0	9.1
6	2050101320	0.0	0.0	1.6	61.9	35.2	0.1	1.2	0.0	0.0	3.2	53.6	37.0	0.0	6.2	0.0	0.0	3.4	57.6	32.0	0.0	6.9
7	2050101340	0.0	0.0	2.5	53.4	39.9	0.0	4.2	0.0	0.0	6.5	44.1	37.5	0.0	11.9	0.0	0.0	8.3	46.4	31.5	0.0	13.8
8	2050101370	0.0	0.0	13.1	60.5	21.2	0.0	5.3	0.0	0.0	20.9	40.3	18.3	0.0	20.5	0.0	0.0	19.6	41.5	15.9	0.0	23.0
9	2050103050	0.0	0.0	1.7	61.6	35.8	0.0	1.0	0.0	0.0	3.6	54.7	36.7	0.0	5.0	0.0	0.0	4.2	58.5	32.4	0.0	5.0
10	2050103090	0.0	0.0	1.7	63.7	34.1	0.0	0.6	0.0	0.0	4.2	55.4	37.2	0.0	3.3	0.0	0.0	5.3	58.0	32.9	0.0	3.8
11	2050103190	0.0	0.0	1.1	51.9	46.5	0.0	0.5	0.0	0.0	3.8	48.6	45.1	0.0	2.6	0.0	0.0	5.1	51.3	40.8	0.0	2.8
12	2050103200	0.0	0.0	8.7	17.0	73.9	0.0	0.4	0.0	0.0	4.6	32.2	57.6	0.0	5.6	0.0	0.0	6.7	31.8	56.7	0.0	4.8
13	2050103210	0.0	0.4	7.2	47.1	42.9	0.0	2.3	0.0	0.0	7.5	49.8	30.7	0.0	11.7	0.0	0.3	8.1	54.4	25.6	0.0	11.5
14	2050103220	0.0	8.1	57.0	12.2	22.8	0.0	0.0	0.0	0.0	53.4	39.5	5.9	0.0	0.0	0.0	0.4	53.9	44.8	0.8	0.0	0.0
15	2050104010	0.0	0.0	2.2	58.5	39.1	0.0	0.2	0.0	0.0	5.6	55.8	36.9	0.0	1.8	0.0	0.0	5.2	60.3	32.4	0.0	2.1
16	2050104020	0.0	0.0	1.8	69.1	27.9	0.0	1.1	0.0	0.0	5.5	61.2	29.3	0.0	4.0	0.0	0.0	5.9	64.8	25.1	0.0	4.1
16	2050104110	0.0	0.0	1.2	75.2	23.6	0.0	0.0	0.0	0.0	1.4	64.9	33.8	0.0	0.0	0.0	0.0	1.1	68.0	30.9	0.0	0.0
17	2050104130	0.1	0.0	1.7	67.5	30.8	0.0	0.0	0.0	0.0	4.5	56.8	36.5	0.0	2.2	0.0	0.0	4.0	61.4	32.0	0.0	2.5
18	2050104170	0.0	0.0	3.4	64.8	31.6	0.2	0.0	0.0	0.0	7.5	54.6	29.6	0.0	6.6	0.0	0.0	7.5	55.9	25.8	0.3	9.2
19	2050105190	0.0	0.0	1.3	32.9	65.7	0.0	0.1	0.0	0.0	5.4	27.1	66.3	0.0	1.1	0.0	0.0	6.5	29.6	62.7	0.0	1.3
20	2050105200	0.0	0.0	1.4	37.8	60.7	0.0	0.1	0.0	0.0	5.1	30.6	64.2	0.0	0.2	0.0	0.0	5.4	37.2	57.2	0.0	0.2
21	2050105230	0.0	0.0	1.0	49.4	48.6	0.0	1.1	0.0	0.0	3.1	52.2	37.1	0.0	7.6	0.0	0.0	3.8	55.6	31.7	0.0	8.8
22	2050105240	0.0	0.0	0.7	48.0	50.9	0.0	0.4	0.0	0.0	0.9	42.9	53.4	0.0	2.8	0.0	0.0	0.7	46.5	49.4	0.0	3.4
23	2050105270	0.0	0.4	5.3	50.3	43.7	0.4	0.0	0.0	0.0	5.1	48.6	33.8	0.2	12.2	0.0	0.1	5.1	52.9	28.5	0.1	13.3
24	2050106010	0.0	0.1	2.6	57.3	39.6	0.0	0.4	0.0	0.0	5.5	56.2	34.3	0.0	2.5	0.0	0.1	5.8	61.2	28.3	0.0	3.2
25	2050106020	0.0	0.0	0.3	87.0	12.0	0.1	0.7	0.0	0.0	0.9	80.4	12.1	0.1	4.0	0.0	0.0	1.2	79.6	11.2	0.3	5.4
26	2050106030	0.0	0.0	2.2	59.8	38.0	0.0	0.0	0.0	0.0	4.7	55.9	36.2	0.0	2.9	0.0	0.0	4.9	59.7	31.0	0.0	4.2
27	2050106040	0.0	0.0	0.1	43.4	55.5	0.0	0.9	0.0	0.0	0.1	45.3	49.8	0.0	4.7	0.0	0.0	0.1	49.7	44.8	0.0	5.4
28	2050106050	0.0	0.1	2.8	47.6	49.4	0.2	0.0	0.0	0.0	4.1	44.4	34.9	0.0	15.4	0.0	0.0	4.2	47.2	30.2	0.3	17.2
29	2050106060	0.0	0.0	1.5	44.0	53.7	0.0	0.8	0.0	0.0	2.0	42.5	50.7	0.0	4.4	0.0	0.0	1.9	47.6	45.2	0.0	4.9
30	2050106070	0.0	0.0	0.5	54.8	43.8	0.0	0.9	0.0	0.0	1.2	48.4	44.8	0.0	5.0	0.0	0.0	1.2	51.4	39.9	0.0	6.9
31	2050106080	0.0	0.0	0.4	45.4	53.2	0.0	1.1	0.0	0.0	0.8	49.2	42.3	0.0	6.3	0.0	0.0	0.7	53.5	37.1	0.0	7.3
32	2050106090	0.0	0.0	0.2	81.4	17.8	0.0	0.6	0.0	0.0	0.8	76.9	16.9	0.0	3.5	0.0	0.0	0.9	77.5	15.2	0.0	4.5

nodata - EMAP data unavailable
low - low intensity developed
high - high intensity developed
wood - wooded
herb - **herbaceous vegetation**
expo - **exposed soil**

Table 8. Land use data within 100 and 300 foot stream buffers and entire subwatersheds for 11-digit hydrologic units in Pennsylvania.

ID	11 digit HUC code	Land use statistics for the entire watershed							Land use statistics for the 300' buffer							Land use statistics for the 100' buffer						
		nodata	low	high	wood	herb	expo	water	nodata	low	high	wood	herb	expo	water	nodata	low	high	wood	herb	expo	water
33	2050106100	0.0	0.0	1.8	59.8	36.6	0.2	1.6	0.0	0.0	3.7	59.4	28.9	0.0	7.1	0.0	0.0	3.4	63.4	24.3	0.5	7.9
34	2050106110	0.0	0.2	5.0	57.1	37.8	0.0	0.0	0.0	0.0	5.9	59.8	23.9	0.0	9.8	0.0	0.1	5.5	63.0	19.5	0.0	11.5
35	2050106120	0.0	0.0	1.5	58.4	38.3	0.0	1.8	0.0	0.0	3.2	52.7	34.4	0.0	9.2	0.0	0.0	3.1	55.1	30.0	0.0	11.2
36	2050106130	0.0	0.0	1.0	83.2	15.4	0.0	0.4	0.0	0.0	3.8	76.4	16.2	0.0	1.8	0.0	0.0	4.2	78.6	13.4	0.0	1.9
37	2050106140	0.0	0.0	1.8	56.7	41.4	0.1	0.0	0.0	0.0	3.1	49.2	30.5	0.0	15.0	0.0	0.0	3.0	52.2	27.2	0.3	15.4
38	2050107010	4.0	4.0	10.7	67.3	13.9	0.0	0.0	2.7	0.5	11.3	62.5	9.9	0.3	5.7	2.7	3.8	10.6	64.8	8.1	1.9	6.1
39	2050107020	2.3	9.7	17.3	56.1	14.6	0.0	0.0	0.7	0.8	14.3	54.3	11.9	0.4	8.9	0.7	6.8	13.8	57.2	10.8	1.8	8.0
40	2050107030	0.0	0.4	2.7	76.4	20.0	0.4	0.0	0.0	0.1	3.6	71.9	13.0	0.3	8.6	0.0	0.3	3.7	75.1	11.1	1.6	7.2
41	2050107040	8.0	0.7	5.7	65.9	19.7	0.0	0.0	7.4	0.1	3.1	69.5	9.3	0.7	2.1	7.4	0.2	2.7	71.9	6.9	5.8	2.1
42	2050107050	0.0	0.0	0.4	71.0	28.5	0.0	0.0	0.0	0.0	0.8	75.6	19.4	0.0	2.6	0.0	0.0	0.8	79.6	15.4	0.0	2.6
43	2050107060	0.0	0.1	1.1	54.4	44.4	0.0	0.0	0.0	0.0	2.9	63.3	32.9	0.0	0.0	0.0	0.1	3.2	67.9	28.0	0.0	0.0
44	2050107070	0.0	0.1	1.8	59.6	38.4	0.0	0.0	0.0	0.0	3.5	67.0	26.4	0.0	1.7	0.0	0.2	3.7	70.8	21.7	0.1	2.4
45	2050107080	4.1	0.0	1.0	74.1	20.7	0.0	0.0	1.4	0.0	1.2	75.0	14.5	0.5	1.9	1.4	0.0	1.3	78.5	10.4	4.6	1.9
46	2050107090	0.0	0.0	0.7	53.4	45.8	0.0	0.0	0.0	0.0	1.5	58.5	33.3	0.0	2.7	0.0	0.0	1.6	64.2	27.7	0.0	2.6
47	2050107100	0.0	0.7	6.4	40.0	52.8	0.1	0.0	0.0	0.0	6.6	45.4	35.3	0.0	9.7	0.0	0.5	6.1	52.9	30.8	0.0	7.2
48	2050201010	0.8	0.0	1.3	76.2	18.4	3.2	0.0	1.0	0.0	1.5	84.9	7.5	0.4	2.6	1.0	0.0	1.3	85.6	5.3	1.7	4.6
49	2050201020	3.2	0.0	1.6	85.4	8.4	1.4	0.0	2.5	0.0	2.9	88.9	2.7	0.1	1.8	2.5	0.0	2.3	90.3	1.7	0.9	1.8
50	2050201030	9.8	0.2	2.4	77.5	10.2	0.0	0.0	7.0	0.0	3.8	77.1	4.6	0.3	4.5	7.0	0.2	3.2	76.9	3.3	0.9	6.9
51	2050201040	0.0	0.0	1.6	88.3	10.1	0.0	0.0	0.0	0.0	1.3	87.5	3.3	0.4	4.3	0.0	0.0	1.0	86.7	2.4	1.5	6.7
52	2050201050	0.0	0.0	2.2	88.2	4.4	5.3	0.0	0.0	0.0	2.8	87.4	1.3	0.7	4.3	0.0	0.0	2.1	86.0	0.9	2.7	7.2
53	2050201060	0.0	0.0	0.5	94.7	2.4	2.3	0.2	0.0	0.0	0.9	92.6	1.9	0.4	1.0	0.0	0.0	0.7	92.6	1.9	1.7	1.1
54	2050201070	0.0	0.0	0.6	94.2	5.2	0.0	0.0	0.0	0.0	0.5	84.1	1.7	0.4	11.0	0.0	0.1	0.5	82.3	1.4	1.4	13.1
55	2050202010	13.5	0.0	0.7	82.7	3.1	0.0	0.0	10.0	0.0	2.2	79.2	5.8	0.0	1.6	10.0	0.0	2.5	78.6	5.5	0.0	2.1
56	2050202020	0.5	0.0	0.6	92.3	6.5	0.0	0.0	0.2	0.0	2.1	85.8	7.6	0.0	3.5	0.2	0.1	2.0	84.7	7.1	0.0	5.1
57	2050202030	1.5	0.0	0.5	90.7	6.6	0.7	0.0	1.1	0.0	1.1	87.6	5.7	0.1	3.1	1.1	0.0	0.9	87.0	5.1	0.6	4.4
58	2050202040	8.2	0.0	0.1	87.7	4.0	0.0	0.0	6.9	0.0	0.4	80.5	8.2	0.0	3.2	6.9	0.0	0.5	79.5	7.9	0.0	4.3
59	2050202050	0.0	0.0	0.6	94.3	3.9	0.0	1.2	0.0	0.0	2.9	79.7	3.3	0.0	11.8	0.0	0.0	2.6	77.0	2.7	0.0	15.4
60	2050203010	0.2	0.0	0.0	94.4	5.1	0.3	0.0	0.2	0.0	0.5	89.2	5.5	0.0	3.1	0.3	0.0	0.6	87.8	5.2	0.0	4.7
61	2050203020	0.1	0.1	0.7	92.0	7.1	0.0	0.0	0.1	0.0	1.8	79.8	6.9	0.1	9.1	0.1	0.0	2.0	78.7	6.8	0.3	10.3
62	2050203030	0.0	0.0	0.1	95.7	4.2	0.0	0.0	0.0	0.0	0.5	94.0	3.6	0.0	0.0	0.0	0.0	0.3	93.9	3.9	0.1	0.0
63	2050203040	0.0	0.0	1.4	87.8	10.2	0.5	0.0	0.0	0.0	2.7	78.2	9.3	0.1	8.3	0.0	0.0	2.5	78.6	8.2	0.2	9.2
64	2050204010	0.2	0.1	9.1	38.2	52.4	0.0	0.0	0.1	0.0	11.0	37.2	48.6	0.0	0.9	0.1	0.1	9.9	39.5	47.0	0.2	1.3

nodata - EMAP data unavailable
low - low intensity developed
high - high intensity developed
wood - wooded
herb - herbaceous vegetation
expo - exposed soil

Table 8. Land use data within 100 and 300 foot stream buffers and entire subwatersheds for 11-digit hydrologic units in Pennsylvania.

ID	11 digit HUC code	Land use statistics for the entire watershed							Land use statistics for the 300' buffer							Land use statistics for the 100' buffer						
		nodata	low	high	wood	herb	expo	water	nodata	low	high	wood	herb	expo	water	nodata	low	high	wood	herb	expo	water
65	2050204020	0.2	0.0	0.7	93.3	5.7	0.0	0.0	0.4	0.0	0.8	86.6	5.5	0.4	3.6	0.5	0.0	0.8	84.7	4.2	1.9	6.7
66	2050204030	0.0	0.0	2.1	67.6	30.1	0.1	0.1	0.0	0.0	3.9	57.8	34.2	0.0	1.7	0.0	0.0	3.7	60.4	30.6	0.3	2.9
67	2050204040	0.1	0.1	2.3	78.3	19.2	0.0	0.0	0.1	0.0	3.5	64.0	25.1	0.0	5.6	0.1	0.4	3.3	65.4	22.4	0.0	7.1
68	2050204050	0.0	0.0	0.5	96.0	3.5	0.0	0.0	0.0	0.0	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0	0.0	0.0	0.0
69	2050205010	3.8	0.0	0.2	91.8	4.1	0.0	0.1	2.6	0.0	0.8	89.6	5.5	0.0	0.6	2.6	0.0	0.7	89.8	5.3	0.0	0.7
70	2050205020	5.2	0.0	0.8	81.6	12.4	0.0	0.0	4.1	0.0	2.1	79.1	13.8	0.0	0.3	4.1	0.0	1.7	80.5	12.7	0.0	0.4
71	2050205030	0.0	0.1	2.7	77.0	20.2	0.0	0.0	0.0	0.0	4.8	62.8	26.0	0.0	3.4	0.0	0.2	4.2	65.1	24.1	0.2	3.7
72	2050205040	0.0	0.0	0.7	71.5	26.8	0.6	0.3	0.0	0.0	1.8	69.4	24.3	0.0	2.2	0.0	0.0	2.0	68.4	23.7	0.3	3.6
73	2050205050	0.0	0.0	0.8	80.1	18.6	0.2	0.4	0.0	0.0	1.9	76.6	17.9	0.0	3.2	0.0	0.0	2.0	76.3	15.8	0.0	5.4
74	2050205060	0.0	0.0	0.6	89.8	9.6	0.1	0.0	0.0	0.0	1.2	77.9	9.0	0.0	9.5	0.0	0.0	1.1	75.5	7.3	0.0	13.8
75	2050206010	0.0	0.0	0.5	80.2	19.3	0.0	0.0	0.0	0.0	2.4	78.5	18.2	0.0	0.0	0.0	0.0	2.7	80.5	15.9	0.0	0.0
76	2050206020	0.0	0.0	1.7	80.2	18.0	0.0	0.0	0.0	0.0	3.4	75.5	16.6	0.0	3.1	0.0	0.0	3.3	76.1	14.1	0.3	5.0
77	2050206030	0.0	0.0	0.9	87.0	11.6	0.4	0.0	0.0	0.0	2.5	84.1	9.6	0.0	2.7	0.0	0.0	3.5	83.2	9.2	0.2	3.0
78	2050206040	0.0	0.0	0.8	58.7	40.1	0.0	0.4	0.0	0.0	2.2	62.4	30.4	0.0	2.1	0.0	0.0	2.1	66.2	26.3	0.0	2.4
79	2050206050	0.0	0.0	0.7	81.9	16.5	0.0	1.0	0.0	0.0	1.5	76.4	14.4	0.0	6.6	0.0	0.0	1.7	75.8	12.1	0.0	9.2
80	2050206060	0.0	0.4	6.1	60.7	32.8	0.0	0.0	0.0	0.0	5.3	52.6	27.3	0.0	12.9	0.0	0.1	5.1	54.3	23.9	0.0	14.7
81	2050206070	0.0	0.1	1.0	52.1	46.8	0.0	0.0	0.0	0.0	2.6	57.8	37.9	0.0	0.2	0.0	0.2	3.4	63.0	31.9	0.0	0.2
82	2050206080	0.0	0.0	1.9	72.0	26.0	0.0	0.0	0.0	0.0	4.7	68.9	23.4	0.0	1.5	0.0	0.0	6.1	70.1	20.6	0.1	1.7
83	2050206090	0.0	0.0	0.2	73.9	25.7	0.0	0.1	0.0	0.0	0.3	72.2	26.3	0.0	0.6	0.0	0.0	0.3	76.6	21.7	0.0	0.9
84	2050206100	0.0	0.0	1.5	59.7	38.7	0.0	0.1	0.0	0.0	2.1	59.5	35.7	0.0	1.0	0.0	0.0	2.1	63.4	31.5	0.0	1.2
85	2050206110	0.0	0.2	1.5	25.7	72.4	0.3	0.0	0.0	0.0	2.0	31.6	64.5	0.1	1.0	0.0	0.1	1.9	36.2	60.0	0.5	0.9
86	2050206120	0.0	0.3	6.1	43.9	49.7	0.0	0.0	0.0	0.0	6.2	40.4	37.3	0.0	14.4	0.0	0.1	5.7	43.9	32.8	0.0	15.9
87	2050301010	0.0	0.7	6.1	53.5	33.8	5.9	0.0	0.0	0.0	7.6	48.3	34.6	0.9	1.6	0.0	0.7	7.6	51.3	30.5	6.4	2.4
88	2050301020	0.0	0.0	0.5	62.3	37.2	0.0	0.0	0.0	0.0	1.0	54.8	43.0	0.0	0.0	0.0	0.0	1.1	57.1	40.6	0.0	0.0
89	2050301030	0.0	0.0	0.7	56.0	42.7	0.0	0.6	0.0	0.0	0.9	51.4	44.5	0.0	2.4	0.0	0.0	0.8	54.6	41.1	0.0	2.7
90	2050301040	0.0	0.0	0.8	58.9	39.6	0.0	0.8	0.0	0.0	0.8	51.5	39.0	0.0	7.1	0.0	0.0	0.7	52.2	34.4	0.0	11.1
91	2050301050	8.7	0.3	3.2	62.1	25.7	0.0	0.0	6.5	0.1	3.5	47.0	25.4	1.0	6.5	6.5	0.4	3.2	46.2	22.1	7.6	10.8
92	2050301060	0.0	0.0	0.1	49.8	50.0	0.0	0.0	0.0	0.0	0.1	45.6	53.1	0.0	0.0	0.0	0.0	0.1	48.9	49.9	0.0	0.0
93	2050301070	0.0	0.0	1.4	62.5	34.3	1.8	0.0	0.0	0.0	0.9	50.8	41.8	0.2	0.4	0.0	0.0	1.0	59.6	33.0	1.7	0.4
94	2050301080	0.0	0.0	0.2	34.5	64.8	0.0	0.5	0.0	0.0	0.4	30.2	62.4	0.0	5.8	0.0	0.0	0.4	33.4	53.3	0.0	11.6
95	2050301090	0.0	0.0	3.0	58.0	38.6	0.5	0.0	0.0	0.0	3.7	50.0	44.8	0.1	0.7	0.0	0.0	3.0	55.6	39.2	0.9	1.4
96	2050301100	0.0	0.1	1.7	48.2	50.0	0.0	0.0	0.0	0.0	2.3	41.1	27.4	0.0	28.5	0.0	0.1	2.0	45.5	22.9	0.0	28.9

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Table 8. Land use data within 100 and 300 foot stream buffers and entire subwatersheds for 11-digit hydrologic units in Pennsylvania.

ID	11 digit HUC code	Land use statistics for the entire watershed							Land use statistics for the 300' buffer							Land use statistics for the 100' buffer						
		nodata	low	high	wood	herb	expo	water	nodata	low	high	wood	herb	expo	water	nodata	low	high	wood	herb	expo	water
97	2050302010	0.3	0.1	3.0	64.7	32.0	0.0	0.0	0.0	0.0	4.7	56.6	35.1	0.1	0.6	0.0	0.0	5.0	57.7	33.3	0.4	1.2
98	2050302020	0.9	0.1	13.7	72.1	13.1	0.0	0.0	0.4	0.0	13.6	67.9	12.9	0.0	2.7	0.4	0.4	12.4	70.9	10.9	0.2	2.9
99	2050302030	0.0	0.0	0.9	66.0	32.6	0.0	0.6	0.0	0.0	1.7	59.4	31.8	0.0	4.2	0.0	0.0	1.3	60.0	28.3	0.0	7.6
100	2050302040	0.0	0.0	0.1	61.5	38.3	0.0	0.0	0.0	0.0	0.3	53.1	42.5	0.0	0.1	0.0	0.0	0.4	55.7	39.8	0.0	0.1
101	2050302050	0.0	0.0	4.2	78.6	17.1	0.2	0.0	0.0	0.0	5.6	79.9	11.6	0.0	2.1	0.0	0.0	4.7	81.5	9.4	0.1	3.7
102	2050302060	0.1	0.0	0.0	77.6	22.2	0.0	0.2	0.0	0.0	0.0	73.2	23.9	0.0	1.1	0.0	0.0	0.0	75.8	21.0	0.1	1.3
103	2050302070	0.3	0.0	0.1	83.0	16.6	0.0	0.0	0.4	0.0	0.1	78.2	19.5	0.0	0.3	0.5	0.0	0.0	80.5	17.0	0.0	0.4
104	2050302080	0.0	0.0	3.2	78.0	17.7	0.0	1.1	0.0	0.0	3.8	68.7	18.1	0.0	7.0	0.0	0.0	3.4	69.5	15.7	0.0	9.0
105	2050303010	1.0	0.0	1.9	74.0	23.0	0.0	0.0	0.4	0.0	2.8	66.3	27.5	0.0	1.9	0.4	0.0	2.3	69.2	24.4	0.0	2.7
106	2050303020	13.1	0.0	0.9	58.1	27.8	0.0	0.0	10.0	0.0	1.4	54.6	33.9	0.0	0.0	10.1	0.0	1.5	56.1	32.1	0.1	0.0
107	2050303030	3.6	0.0	0.4	56.4	39.6	0.0	0.0	0.8	0.0	0.5	53.0	43.6	0.0	1.4	0.8	0.0	0.4	54.1	41.4	0.0	2.5
107	2050303040	0.0	0.0	0.7	67.5	31.5	0.1	0.2	0.0	0.0	0.8	70.8	27.2	0.0	1.2	0.0	0.0	0.6	74.1	22.6	0.0	2.7
109	2050303050	0.0	0.0	1.4	73.4	24.7	0.4	0.0	0.0	0.0	1.7	65.7	25.7	0.3	6.0	0.0	0.0	1.4	65.3	22.2	0.4	10.2
110	2050303060	0.0	0.0	0.6	53.4	46.0	0.0	0.1	0.0	0.0	1.9	45.9	49.6	0.0	0.3	0.0	0.0	2.3	46.8	48.2	0.0	0.4
111	2050303070	0.0	0.0	0.1	77.3	21.3	0.8	0.4	0.0	0.0	0.4	72.0	26.1	0.0	0.8	0.0	0.0	0.4	74.3	23.7	0.1	1.0
112	2050303080	0.0	0.0	0.6	86.2	13.1	0.1	0.0	0.0	0.0	1.0	69.0	12.3	0.0	17.0	0.0	0.0	0.9	67.7	10.5	0.0	20.1
113	2050304010	0.4	0.0	1.4	79.9	18.4	0.0	0.0	0.5	0.0	2.5	65.2	18.6	0.0	11.3	0.4	0.0	1.6	65.2	17.0	0.0	13.9
114	2050304020	0.0	0.0	0.6	77.6	21.7	0.0	0.1	0.0	0.0	0.3	79.1	19.8	0.0	0.4	0.0	0.0	0.2	82.6	16.4	0.0	0.4
115	2050304030	0.4	0.0	0.8	80.0	18.8	0.0	0.0	0.3	0.0	3.3	64.4	29.7	0.1	0.0	0.3	0.0	3.8	66.3	27.3	0.8	0.0
116	2050304040	0.2	0.0	0.6	77.1	22.0	0.1	0.0	0.3	0.0	1.0	69.9	26.0	0.0	2.6	0.3	0.0	0.8	71.3	22.7	0.1	4.8
117	2050304050	0.0	0.1	0.9	63.3	35.5	0.2	0.0	0.0	0.0	0.8	46.3	36.2	0.0	15.7	0.0	0.0	0.5	47.6	32.5	0.0	18.5
118	2050304060	0.0	0.1	0.3	76.9	22.6	0.0	0.2	0.0	0.0	0.6	67.7	28.1	0.0	1.2	0.0	0.2	0.8	70.1	25.4	0.0	1.4
119	2050304070	0.0	0.2	3.0	45.3	51.5	0.0	0.0	0.0	0.1	5.7	39.5	52.8	0.0	0.6	0.0	0.3	5.2	42.3	50.2	0.0	1.1
120	2050304080	0.0	0.0	1.3	60.9	37.7	0.1	0.0	0.0	0.0	2.1	47.9	40.1	0.0	7.6	0.0	0.0	1.5	52.0	35.7	0.1	8.6
121	2050304090	5.9	0.0	0.1	65.9	28.0	0.1	0.0	0.0	0.0	0.3	61.8	36.0	0.0	0.4	0.0	0.0	0.3	65.5	32.2	0.1	0.6
122	2050304100	0.0	0.0	0.1	54.8	45.1	0.0	0.1	0.0	0.0	0.2	48.3	50.6	0.0	0.3	0.0	0.0	0.3	49.7	49.1	0.0	0.3
123	2050304110	0.0	0.0	0.1	64.3	35.6	0.0	0.0	0.0	0.0	0.1	68.5	31.3	0.0	0.1	0.0	0.0	0.0	73.4	26.4	0.0	0.2
124	2050304120	0.0	0.0	1.5	56.7	41.7	0.1	0.0	0.0	0.0	2.4	46.7	36.7	0.0	13.2	0.0	0.0	2.0	48.7	33.5	0.1	14.9
125	2050305010	0.0	0.0	0.6	66.6	32.5	0.0	0.4	0.0	0.0	1.2	60.2	34.2	0.0	3.1	0.0	0.0	1.2	61.8	30.1	0.0	5.6
126	2050305020	0.1	0.4	2.6	56.1	40.8	0.0	0.0	0.1	0.0	1.8	63.4	33.6	0.0	1.0	0.1	0.0	1.5	68.6	28.8	0.0	1.1
127	2050305030	0.0	0.2	2.7	40.6	56.5	0.1	0.0	0.0	0.0	3.0	50.4	43.2	0.0	1.7	0.0	0.1	2.8	55.6	36.9	0.0	3.1
128	2050305040	0.0	1.4	11.7	24.4	62.4	0.1	0.0	0.0	0.0	9.8	35.9	38.4	0.0	14.6	0.0	0.2	8.2	37.7	31.0	0.0	21.9

nodata - EMAP data unavailable
low - low intensity developed
high - high intensity developed
wood - wooded
herb - herbaceous vegetation
expo - exposed soil

Table 8. Land use data within 100 and 300 foot stream buffers and entire subwatersheds for 11-digit hydrologic units in Pennsylvania.

ID	11 digit HUC code	Land use statistics for the entire watershed							Land use statistics for the 300' buffer							Land use statistics for the 100' buffer						
		nodata	low	high	wood	herb	expo	water	nodata	low	high	wood	herb	expo	water	nodata	low	high	wood	herb	expo	water
129	2050305050	0.0	1.0	7.6	55.0	36.2	0.2	0.0	0.0	0.1	8.5	61.0	24.6	0.0	4.3	0.0	0.6	8.0	63.8	19.2	0.0	7.6
130	2050305060	0.0	0.0	2.9	66.8	28.8	1.6	0.0	0.0	0.0	6.1	60.1	24.6	0.4	3.2	0.0	0.0	5.7	63.0	20.4	3.2	4.8
131	2050305070	2.9	0.1	2.9	22.9	71.1	0.0	0.0	0.9	0.0	4.3	21.4	67.1	0.0	0.1	0.9	0.0	5.2	25.8	61.9	0.0	0.1
132	2050305080	2.4	2.3	15.1	12.8	67.3	0.0	0.0	0.0	0.0	12.5	19.2	62.5	0.2	1.9	0.0	2.4	12.4	21.7	60.4	1.1	1.9
133	2050305090	0.0	0.8	10.5	28.1	60.5	0.1	0.0	0.0	0.0	7.7	32.9	49.8	0.0	7.5	0.0	0.3	6.7	38.0	42.3	0.0	11.0
134	2050305100	0.0	2.5	12.3	60.1	25.0	0.1	0.0	0.0	0.3	10.7	49.6	21.9	0.1	14.8	0.0	1.7	10.5	55.4	17.8	0.2	13.7
135	2050306010	0.0	0.5	5.7	16.2	77.4	0.2	0.0	0.0	0.0	2.1	31.4	62.8	0.3	3.3	0.0	0.1	2.4	37.8	55.4	0.3	4.0
136	2050306020	0.0	0.1	1.8	38.6	59.6	0.0	0.0	0.0	0.0	1.6	44.5	49.7	0.0	4.1	0.0	0.0	1.5	50.3	40.9	0.0	7.3
137	2050306030	0.0	0.0	0.9	30.0	68.7	0.4	0.0	0.0	0.0	1.3	43.2	51.9	0.4	3.1	0.0	0.1	1.2	52.2	41.5	0.3	4.7
138	2050306040	0.0	0.1	6.2	19.9	73.6	0.1	0.0	0.0	0.0	4.1	37.9	57.8	0.0	0.1	0.0	0.1	4.2	47.0	48.6	0.0	0.0
139	2050306050	0.0	0.0	2.4	47.8	48.0	0.0	1.8	0.0	0.0	3.6	55.9	29.9	0.0	10.4	0.0	0.1	3.3	57.4	21.8	0.0	17.1
140	2050306060	0.0	0.0	3.1	30.4	66.4	0.0	0.0	0.0	0.0	2.3	50.2	42.9	0.0	3.7	0.0	0.1	2.4	55.4	37.2	0.0	4.1
141	2050306070	0.0	1.8	14.1	25.3	58.8	0.1	0.0	0.0	0.1	9.1	40.1	42.8	0.0	6.3	0.0	1.6	8.9	44.2	37.2	0.1	8.0
142	2050306080	0.0	0.5	5.0	16.9	77.6	0.0	0.0	0.0	0.0	5.6	27.8	65.0	0.0	0.3	0.0	0.3	6.8	35.2	56.6	0.0	0.3
143	2050306090	2.9	0.7	7.0	32.9	56.6	0.0	0.0	1.1	0.0	9.4	34.6	50.2	0.0	3.4	1.1	0.6	9.8	38.7	44.8	0.3	4.2
144	2050306100	0.0	3.9	25.7	13.3	56.8	0.4	0.0	0.0	0.1	18.8	32.0	46.0	1.0	0.3	0.0	1.3	17.1	35.7	44.3	1.2	0.3
145	2050306110	7.5	1.9	10.3	17.5	62.7	0.0	0.0	4.7	0.0	9.4	25.3	50.9	0.1	7.5	4.7	0.4	8.6	26.3	45.3	0.2	13.0
146	2050306120	5.6	0.3	4.4	25.5	64.2	0.0	0.0	4.0	0.0	5.2	34.3	55.8	0.0	0.2	4.0	0.3	6.4	37.7	51.3	0.0	0.3
147	2050306150	0.0	0.0	0.5	36.6	62.9	0.0	0.0	0.0	0.0	0.1	68.6	30.1	0.0	1.3	0.0	0.0	0.1	74.5	23.4	0.0	2.1
148	2050306160	0.0	0.7	5.1	37.4	56.6	0.2	0.0	0.0	0.1	5.6	47.5	18.7	0.7	26.4	0.0	0.9	5.3	49.5	15.5	0.7	28.0
149	2050306180	13.4	0.1	1.8	21.5	63.3	0.0	0.0	8.5	0.0	2.0	44.1	41.2	0.0	4.2	8.5	0.0	2.4	48.7	35.8	0.0	4.6
150	2050306200	0.0	0.0	4.0	24.8	71.2	0.1	0.0	0.0	0.0	2.7	48.8	47.3	0.0	1.1	0.0	0.0	2.2	53.9	42.6	0.0	1.3
151	2050306220	0.0	0.1	0.9	26.7	72.4	0.0	0.0	0.0	0.0	0.7	49.7	43.8	0.0	5.4	0.0	0.0	0.7	52.4	38.3	0.0	8.2
152	2060002020	11.9	0.1	1.8	27.9	58.4	0.0	0.0	5.5	0.0	1.1	59.2	34.2	0.0	0.0	5.5	0.0	1.0	67.4	26.1	0.0	0.0
153	2060002040	0.0	0.3	2.5	26.2	70.9	0.0	0.0	0.0	0.0	0.1	49.8	50.1	0.0	0.0	0.0	0.0	0.0	58.8	41.2	0.0	0.0
154	2060002060	0.0	0.0	0.0	22.5	77.5	0.0	0.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-
155	2060002080	0.0	0.0	2.5	24.1	73.2	0.0	0.2	0.0	0.0	0.9	39.1	57.7	0.0	2.4	0.0	0.0	1.0	47.4	48.8	0.0	2.8
156	2060003120	0.0	0.0	1.1	21.1	77.9	0.0	0.0	0.0	0.0	1.3	27.7	71.0	0.0	0.0	0.0	0.0	1.1	31.1	67.8	0.0	0.0
157	2070002070	12.8	0.0	0.7	70.6	16.0	0.0	0.0	12.6	0.0	2.8	70.8	13.7	0.0	0.1	12.6	0.0	3.3	71.7	12.2	0.0	0.1
158	2070002130	0.0	0.0	0.5	79.5	19.0	0.0	1.0	0.0	0.0	0.8	71.6	23.4	0.0	4.2	0.0	0.0	0.8	72.8	21.5	0.0	4.9
159	2070003060	0.0	0.0	0.0	82.1	17.9	0.0	0.0	0.0	0.0	0.0	81.3	18.7	0.0	0.0	0.0	0.0	0.0	83.3	16.7	0.0	0.0
160	2070003100	0.0	0.0	0.0	88.0	12.0	0.0	0.0	0.0	0.0	0.0	88.1	11.9	0.0	0.0	0.0	0.0	0.0	89.7	10.3	0.0	0.0

nodata - EMAP data unavailable
low - low intensity developed
high - high intensity developed
wood - wooded
herb - herbaceous vegetation
expo - exposed soil

Table 8. Land use data within 100 and 300 foot stream buffers and entire subwatersheds for 11-digit hydrologic units in Pennsylvania.

ID	11 digit HUC code	Land use statistics for the entire watershed							Land use statistics for the 300' buffer							Land use statistics for the 100' buffer						
		nodata	low	high	wood	herb	expo	water	nodata	low	high	wood	herb	expo	water	nodata	low	high	wood	herb	expo	water
161	2070003130	0.0	0.0	0.0	79.4	20.6	0.0	0.0	0.0	0.0	0.0	80.1	19.9	0.0	0.0	0.0	0.0	0.0	82.6	17.4	0.0	0.0
162	2070004010	0.0	0.1	2.0	37.5	60.4	0.0	0.0	0.0	0.0	2.0	44.2	53.3	0.0	0.4	0.0	0.1	1.9	50.1	47.5	0.0	0.5
163	2070004020	0.0	0.9	8.0	41.3	49.6	0.2	0.0	0.0	0.0	7.3	46.6	42.5	0.1	2.8	0.0	0.6	7.4	50.2	37.9	0.0	3.8
164	2070004030	0.3	0.0	1.0	52.5	46.2	0.0	0.0	0.3	0.0	0.8	57.8	40.1	0.1	0.6	0.3	0.0	0.7	62.4	35.6	0.1	0.5
165	2070004120	0.0	0.0	0.7	74.5	24.8	0.0	0.0	0.0	0.0	1.3	77.8	20.9	0.0	0.0	0.0	0.0	1.3	82.2	16.5	0.0	0.0
166	2070004220	0.0	0.0	0.5	76.5	22.8	0.0	0.2	0.0	0.0	0.5	76.6	22.6	0.0	0.4	0.0	0.0	0.5	80.3	18.7	0.0	0.4
167	2070004310	0.1	0.7	5.6	20.2	73.4	0.0	0.0	0.0	0.0	2.4	34.5	57.3	0.0	5.6	0.0	0.1	2.4	36.2	51.3	0.0	9.9
168	2070004400	0.0	0.5	7.2	37.4	54.9	0.0	0.0	0.0	0.0	9.0	42.0	48.4	0.0	0.6	0.0	0.0	9.3	43.2	46.9	0.0	0.7
169	2070009030	0.0	0.1	4.4	68.3	26.9	0.4	0.0	0.0	0.0	4.8	69.0	23.7	0.5	1.9	0.0	0.1	4.4	72.7	20.2	0.5	2.1
170	2070009040	0.0	0.2	5.1	35.1	59.5	0.1	0.0	0.0	0.0	4.8	43.5	49.2	0.1	2.3	0.0	0.1	4.5	49.7	42.0	0.1	3.6

nodata - EMAP data unavailable
low - low intensity developed
high - high intensity developed
wood - wooded
herb - herbaceous vegetation
expo - exposed soil

Table 9. Riparian forest buffer statistics for 11-digit hydrologic units in Virginia.

ID	Watershed	HUC code	Stream Length		Both 300'+		Both 100'-300'		One side 300'+		One side 100'-300'		Both sides < 100'	
			miles	%	miles	%	miles	%	miles	%	miles	%	miles	%
A01	POTOMAC RIVER/PINEY RUN/DUTCHMAN CREEK	2070008	51	0.15	12.4	24.4	26.0	51.1	26.6	52.2	32.3	63.5	18.6	36.5
A02	CATOCTIN CREEK	2070008	136	0.39	18.6	13.7	52.2	38.5	45.4	33.4	64.2	47.3	71.4	52.7
A03	POTOMAC RIVER/LIMESTONE BRANCH	2070008	75	0.22	10.8	14.3	27.0	35.8	25.4	33.6	34.4	45.6	41.0	54.4
A04	UPPER GOOSE CREEK/GAP RUN	2070008	113	0.32	21.2	18.8	45.9	40.8	41.6	36.9	55.2	49.0	57.5	51.0
A05	MIDDLE GOOSE CREEK/PANTHER SKIN CREEK	2070008	126	0.36	27.0	21.4	63.3	50.1	59.9	47.4	73.9	58.5	52.4	41.5
A06	NORTH FORK GOOSE CREEK	2070008	66	0.19	9.3	14.2	25.1	38.4	21.9	33.4	30.3	46.2	35.3	53.8
A07	BEAVERDAM CREEK	2070008	75	0.21	14.6	19.6	35.4	47.4	32.2	43.1	42.3	56.6	32.4	43.4
A08	LOWER GOOSE CREEK/LITTLE RIVER	2070008	165	0.47	32.5	19.7	69.6	42.2	64.7	39.2	83.2	50.4	81.9	49.6
A09	POTOMAC RIVER/BROAD RUN	2070008	132	0.38	26.7	20.2	58.6	44.3	55.1	41.7	69.0	52.2	63.3	47.8
A10	SUGARLAND RUN	2070008	36	0.10	6.2	17.3	16.6	46.3	14.7	40.9	19.9	55.4	16.0	44.6
A11	POTOMAC RIVER/DIFFICULT RUN	2070008	144	0.41	47.8	33.2	91.3	63.4	91.0	63.2	104.3	72.5	39.6	27.5
A12	POTOMAC RIVER/FOURMILE RUN/PIMMIT RUN	2070010	47	0.14	3.9	8.1	14.5	30.5	10.8	22.8	18.4	38.8	29.1	61.2
A13	CAMERON RUN	2070010	48	0.14	3.6	7.5	15.0	31.4	11.1	23.2	17.6	37.0	30.1	63.0
A14	POTOMAC RIVER/DOGUE CREEK/LITTLE HUNTING CREEK	2070010	54	0.16	6.6	12.1	16.6	30.5	15.2	27.9	20.6	37.8	33.8	62.2
A15	ACCOTINK CREEK	2070010	82	0.23	19.3	23.7	39.8	48.8	35.2	43.2	46.1	56.6	35.4	43.4
A16	POHICK CREEK	2070010	58	0.16	14.5	25.2	31.2	54.1	29.2	50.6	36.9	63.9	20.9	36.1
A17	UPPER CEDAR RUN/LICKING RUN	2070010	160	0.46	26.1	16.3	62.6	39.0	61.1	38.1	74.2	46.3	86.1	53.7
A18	LOWER CEDAR RUN/TOWN RUN	2070010	151	0.43	50.3	33.2	80.5	53.2	79.2	52.4	90.6	59.9	60.6	40.1
A19	BROAD RUN/KETTLE RUN	2070010	208	0.59	43.6	21.0	89.0	42.8	85.2	41.0	104.7	50.4	103.0	49.6
A20	UPPER OCCOQUAN RIVER/LAKE JACKSON	2070010	50	0.14	21.9	43.7	33.6	67.2	34.7	69.3	38.0	75.9	12.1	24.1
A21	UPPER BULL RUN/LITTLE BULL RUN	2070010	141	0.40	40.0	28.3	82.2	58.2	76.9	54.5	91.8	65.0	49.4	35.0
A22	CUB RUN	2070010	74	0.21	15.9	21.6	33.7	45.8	30.4	41.3	38.5	52.3	35.1	47.7
A23	LOWER BULL RUN/POPES HEAD CREEK	2070010	76	0.22	27.8	36.4	47.8	62.6	48.6	63.7	53.6	70.2	22.7	29.8
A24	OCCOQUAN RIVER - RESERVOIR	2070010	70	0.20	14.8	21.0	33.8	48.1	35.7	50.8	43.1	61.4	27.1	38.6
A25	POTOMAC RIVER/LOWER OCCOQUAN RIVER/NEABSCO CREEK	2070010	102	0.29	21.8	21.3	43.0	42.0	43.7	42.7	51.4	50.2	51.0	49.8
A26	POTOMAC RIVER/QUANTICO CREEK/CHOPAWAMSIC CREEK	2070011	167	0.48	89.9	53.7	113.4	67.8	115.5	69.0	121.5	72.6	45.8	27.4
A27	UPPER AQUIA CREEK/BEAVERDAM RUN	2070011	93	0.27	53.7	57.7	70.6	75.8	73.5	79.0	76.0	81.6	17.1	18.4
A28	LOWER AQUIA CREEK	2070011	53	0.15	11.5	21.7	21.2	40.2	22.3	42.4	24.8	47.0	28.0	53.0
A29	POTOMAC RIVER/POTOMAC CREEK	2070011	203	0.58	104.0	51.2	135.1	66.5	140.2	69.0	145.7	71.7	57.6	28.3
A30	POTOMAC RIVER/UPPER MACHODOC CREEK	2070011	110	0.31	52.7	48.0	65.5	59.7	69.1	63.0	71.4	65.1	38.3	34.9
A31	POTOMAC RIVER/MATTOX CREEK/POPES CREEK/ROSIER CREEK	2070011	166	0.47	59.0	35.5	83.4	50.2	85.6	51.6	91.8	55.3	74.2	44.7
A32	POTOMAC RIVER/NOMINI CREEK/LOWER MACHODOC CREEK	2070011	185	0.53	47.6	25.7	74.0	40.0	75.3	40.7	84.0	45.4	101.0	54.6

Table 9. Riparian forest buffer statistics for 11-digit hydrologic units in Virginia.

ID	Watershed	HUC code	Stream Length		Both 300'+		Both 100'-300'		One side 300'+		One side 100'-300'		Both sides < 100'	
			miles	%	miles	%	miles	%	miles	%	miles	%	miles	%
A33	POTOMAC RIVER/YEOCOMICO RIVER	2070011	147	0.42	42.3	27.8	73.6	48.4	72.7	47.8	82.1	54.0	65.3	46.0
A34	POTOMAC RIVER/COAN RIVER/LITTLE WICOMICO RIVER	2070011	210	0.60	33.9	14.1	69.6	29.0	76.8	32.0	87.2	36.3	123.1	63.7
B01	UPPER NORTH FORK SOUTH BRANCH POTOMAC RIVER/LAUREL FORK	2070001	39	0.11	25.7	65.2	27.7	70.4	28.6	72.5	28.6	72.7	10.8	27.3
B02	UPPER SOUTH BRANCH POTOMAC RIVER	2070001	49	0.14	5.2	10.8	9.5	19.5	10.6	21.8	11.5	23.6	37.1	76.4
B03	UPPER SOUTH FORK SOUTH BRANCH POTOMAC RIVER	2070001	8	0.02	1.1	13.9	2.8	33.8	3.3	39.9	3.3	40.3	4.9	59.7
B04	SLEEPY CREEK	2070004	29	0.08	12.0	41.2	16.7	57.1	16.8	57.6	18.5	63.4	10.7	36.6
B05	UPPER BACK CREEK/ISAACS CREEK	2070004	115	0.33	36.6	31.9	60.4	52.7	62.1	54.1	69.5	60.6	45.2	39.4
B06	HOGUE CREEK	2070004	61	0.17	19.9	32.7	29.6	48.8	29.8	49.1	33.2	54.7	27.5	45.3
B07	LOWER BACK CREEK/BRUSH CREEK/BABBS RUN	2070004	68	0.19	17.8	26.1	32.6	47.7	34.2	50.1	38.1	55.8	30.2	44.2
B08	UPPER OPEQUON CREEK	2070004	72	0.21	5.1	7.1	20.7	28.7	17.1	23.7	26.5	36.8	45.6	63.2
B09	LOWER OPEQUON CREEK	2070004	99	0.28	2.8	2.8	18.4	18.6	15.7	15.9	25.0	25.3	73.6	74.7
B10	UPPER MIDDLE RIVER	2070005	36	0.10	0.2	0.4	1.6	4.5	1.2	3.4	3.6	9.9	32.2	90.1
B11	MIDDLE RIVER/JENNINGS BRANCH	2070005	54	0.15	20.0	37.1	27.3	50.6	27.9	51.7	30.4	56.3	23.6	43.7
B12	MIDDLE RIVER/LEWIS CREEK	2070005	59	0.17	0.7	1.2	9.9	16.9	8.3	14.2	14.4	24.5	44.3	75.5
B13	MOFFETT CREEK	2070005	17	0.05	2.2	12.9	2.9	16.9	3.1	18.0	3.5	20.1	13.7	79.9
B14	CHRISTIANS CREEK	2070005	73	0.21	2.7	3.7	11.5	15.8	10.4	14.2	17.2	23.6	55.7	76.4
B15	LOWER MIDDLE RIVER	2070005	37	0.11	0.3	0.9	3.9	10.5	2.7	7.1	7.2	19.3	30.2	80.7
B16	UPPER NORTH RIVER	2070005	69	0.20	58.0	84.2	62.5	90.8	64.0	93.0	64.5	93.7	4.4	6.3
B17	MIDDLE NORTH RIVER	2070005	35	0.10	3.7	10.8	8.2	23.9	7.5	21.8	10.6	30.7	23.9	69.3
B18	BRIERY BRANCH	2070005	38	0.11	19.6	52.1	22.8	60.7	23.4	62.3	24.5	65.1	13.1	34.9
B19	MOSSY CREEK	2070005	14	0.04	0.0	0.0	0.1	0.8	0.2	1.5	0.2	1.5	13.4	98.5
B20	UPPER DRY RIVER	2070005	95	0.27	86.0	91.0	88.7	93.8	90.1	95.3	90.3	95.4	4.3	4.6
B21	LOWER DRY RIVER	2070005	15	0.04	1.5	9.9	3.3	21.3	3.3	21.0	3.9	25.0	11.6	75.0
B22	MUDDY CREEK	2070005	28	0.08	3.0	10.8	4.1	14.5	4.1	14.7	4.6	16.2	23.5	83.8
B23	LOWER NORTH RIVER	2070005	69	0.20	0.1	0.1	1.7	2.5	1.7	2.4	4.6	6.6	64.5	93.4
B24	LONG GLADE CREEK	2070005	17	0.05	0.0	0.0	0.2	1.3	0.3	1.6	0.3	1.9	16.4	98.1
B25	COOKS CREEK	2070005	14	0.04	0.0	0.0	0.1	0.6	0.0	0.2	0.2	1.5	13.7	98.5
B26	BLACKS RUN	2070005	11	0.03	0.0	0.0	0.1	0.5	0.0	0.4	0.2	1.5	11.1	98.5
B27	PLEASANT RUN	2070005	6	0.02	0.0	0.0	0.0	0.4	0.0	0.0	0.0	0.7	6.3	99.3
B28	NAKED CREEK	2070005	19	0.06	0.4	1.9	0.9	4.8	1.3	6.5	1.5	7.6	18.0	92.4
B29	MILL CREEK	2070005	16	0.05	0.1	0.5	0.7	4.4	0.6	3.6	1.0	6.4	14.8	93.6
B30	UPPER SOUTH RIVER	2070005	62	0.18	18.8	30.5	26.1	42.4	25.5	41.5	29.0	47.1	32.6	52.9

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			miles	%	miles	%	miles	%	miles	%	miles	%	miles	%
B31	MIDDLE SOUTH RIVER/BACK CREEK	2070005	108	0.31	52.6	48.8	67.6	62.7	68.9	64.0	73.6	68.2	34.2	31.8
B32	LOWER SOUTH RIVER	2070005	105	0.30	31.6	30.0	52.7	50.1	47.1	44.7	60.6	57.6	44.6	42.4
B33	UPPER SOUTH FORK SHENANDOAH RIVER	2070005	49	0.14	24.7	50.8	27.6	56.8	27.3	56.2	28.5	58.7	20.1	41.3
B34	CUB RUN	2070005	17	0.05	2.9	16.8	5.0	28.8	4.2	24.3	6.0	34.3	11.4	65.7
B35	SOUTH FORK SHENANDOAH RIVER/ELK RUN/BOONE RUN	2070005	134	0.38	39.2	29.3	49.7	37.1	50.2	37.5	55.2	41.2	78.7	58.8
B36	NAKED CREEK	2070005	42	0.12	23.1	55.1	27.9	66.5	28.0	66.7	29.2	69.5	12.8	30.5
B37	SOUTH FORK SHENANDOAH RIVER/CUB RUN	2070005	94	0.27	22.6	24.0	34.2	36.3	34.4	36.5	41.1	43.7	53.1	56.3
B38	SOUTH FORK SHENANDOAH RIVER/MILL CREEK	2070005	57	0.16	7.0	12.2	14.2	24.9	13.9	24.3	19.4	34.0	37.7	66.0
B39	HAWKSBILL CREEK	2070005	74	0.21	14.8	19.9	23.9	32.2	22.9	30.9	26.8	36.1	47.4	63.9
B40	SOUTH FORK SHENANDOAH RIVER/GOONEY RUN	2070005	149	0.43	36.8	24.6	64.6	43.3	63.3	42.4	80.5	53.9	68.8	46.1
B41	LOWER SOUTH FORK SHENANDOAH RIVER	2070005	53	0.15	6.6	12.3	13.8	25.9	12.9	24.2	18.4	34.4	35.0	65.6
B42	UPPER NORTH FORK SHENANDOAH RIVER/GERMAN RIVER	2070006	73	0.21	41.5	56.8	52.5	71.7	53.3	73.0	56.2	76.8	16.9	23.2
B43	NORTH FORK SHENANDOAH RIVER/LITTLE DRY RIVER	2070006	71	0.20	49.9	70.0	54.9	77.0	55.8	78.3	56.7	79.6	14.5	20.4
B44	NORTH FORK SHENANDOAH RIVER/SHOEMAKER RIVER	2070006	74	0.21	36.0	48.5	45.8	61.6	47.2	63.5	50.0	67.2	24.4	32.8
B45	NORTH FORK SHENANDOAH RIVER/HOLMANS CREEK	2070006	86	0.25	0.3	0.3	3.4	4.0	3.1	3.6	6.1	7.1	80.2	92.9
B46	LINVILLE CREEK	2070006	42	0.12	0.3	0.8	1.2	2.8	1.3	3.1	2.2	5.2	39.8	94.8
B47	SMITH CREEK	2070006	88	0.25	15.2	17.2	23.3	26.4	22.5	25.4	28.1	31.8	60.2	68.2
B48	NORTH FORK SHENANDOAH RIVER/MILL CREEK	2070006	87	0.25	23.3	26.9	31.4	36.3	31.9	36.9	34.9	40.3	51.7	59.7
B49	STONY CREEK	2070006	127	0.36	41.9	32.9	62.6	49.1	63.9	50.1	71.4	56.0	56.1	44.0
B50	NORTH FORK SHENANDOAH RIVER/NARROW PASSAGE CREEK	2070006	90	0.26	10.3	11.4	19.3	21.4	19.1	21.2	24.1	26.8	65.9	73.2
B51	LOWER NORTH FORK SHENANDOAH RIVER/TUMBLING RUN	2070006	69	0.20	8.9	12.8	16.3	23.4	16.4	23.6	20.1	28.9	49.4	71.1
B52	UPPER CEDAR CREEK	2070006	119	0.34	73.9	62.0	98.9	83.1	99.2	83.3	105.3	88.4	13.8	11.6
B53	LOWER CEDAR CREEK	2070006	102	0.29	24.0	23.5	39.3	38.5	38.2	37.4	45.6	44.6	56.6	55.4
B54	PASSAGE CREEK	2070006	98	0.28	53.6	54.4	64.8	65.9	65.8	66.9	69.2	70.3	29.2	29.7
B55	UPPER SHENANDOAH RIVER	2070007	92	0.26	16.3	17.8	29.0	31.6	30.5	33.2	37.0	40.3	54.7	59.7
B56	CROOKED RUN	2070007	67	0.19	7.5	11.2	16.8	25.1	18.7	27.9	21.6	32.3	45.3	67.7
B57	SHENANDOAH RIVER/SPOUT RUN	2070007	104	0.30	22.6	21.8	39.1	37.7	38.5	37.1	47.1	45.4	56.7	54.6
B58	LOWER SHENANDOAH RIVER	2070007	69	0.20	15.0	21.6	22.7	32.7	23.5	33.9	27.7	39.9	41.7	60.1
C01	CHESAPEAKE BAY/GREAT WICOMICO RIVER	2080102	190	0.54	75.8	20.7	119.1	32.4	128.1	34.9	142.6	38.8	47.1	61.2
C02	DRAGON SWAMP	2080102	303	0.86	221.6	73.2	275.8	91.1	277.6	91.7	285.5	94.3	17.2	5.7
C03	PIANKATANK RIVER	2080102	63	0.18	49.0	31.5	69.1	44.4	76.5	49.1	81.1	52.1	-17.8	47.9

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			miles	%	miles	%	miles	%	miles	%	miles	%	miles	%
C04	CHESAPEAKE BAY/EAST RIVER/NORTH RIVER	2080102	291	0.83	30.7	8.9	49.0	14.2	56.7	16.4	62.4	18.0	228.5	82.0
C05	WARE RIVER	2080102	152	0.43	56.3	37.2	83.2	54.9	85.8	56.6	91.1	60.1	60.4	39.9
C06	CHESAPEAKE BAY/SEVERN RIVER	2080102	131	0.37	9.2	7.0	12.6	9.6	13.2	10.1	14.4	10.9	116.9	89.1
C07	CHESAPEAKE BAY/BACK RIVER/POQUOSON RIVER	2080108	366	1.04	9.8	2.5	30.5	7.7	32.1	8.1	43.1	10.8	322.7	89.2
C08	LYNNHAVEN RIVER/LITTLE CREEK	2080108	334	0.95	37.4	10.5	70.0	19.6	70.9	19.9	89.9	25.3	244.4	74.7
C09	POCOMOKE RIVER/PITTS CREEK	2060009	45	0.13	9.9	22.0	19.9	44.5	19.7	43.9	23.1	51.5	21.8	48.5
C10	CHESAPEAKE BAY/HOLDENS CREEK	2080109	418	1.19	17.0	4.1	48.7	11.7	44.4	10.6	57.9	13.8	360.2	86.2
C11	CHESAPEAKE BAY/ONANCOCK CREEK	2080109	135	0.39	0.9	0.7	6.3	4.7	5.3	3.9	8.4	6.2	126.9	93.8
C12	PUNGOTEAGUE CREEK	2080109	39	0.11	4.4	11.1	8.1	20.6	8.4	21.5	9.3	23.8	29.9	76.2
C13	NANDUA CREEK/OCCOHANNOCK CREEK/NASSAWADOX CREEK	2080109	253	0.72	8.7	3.4	26.4	10.4	26.8	10.6	35.6	14.1	217.4	85.9
C14	CHESAPEAKE BAY/HUNGARS CREEK	2080109	94	0.27	1.9	2.0	10.6	11.4	10.1	10.8	16.3	17.4	77.3	82.6
C15	CHERRYSTONE INLET/KINGS CREEK	2080109	51	0.14	1.0	2.1	6.1	12.1	6.2	12.2	9.1	18.0	41.6	82.0
C16	CHESAPEAKE BAY/OLD PLANTATION CREEK	2080109	45	0.13	0.8	1.7	5.5	12.3	5.2	11.6	8.3	18.7	36.2	81.3
D06	MAGOTHY BAY/MOCKHORN BAY	2080109	3	0.01	0.0	0.5	0.2	8.0	0.3	11.9	0.4	14.1	2.3	85.9
E01	UPPER RAPPAHANNOCK RIVER/THUMB RUN/JORDAN RIVER	2080103	150	0.43	39.8	26.5	68.4	45.5	68.8	45.8	80.5	53.5	69.9	46.5
E02	RAPPAHANNOCK RIVER/CARTER RUN/GREAT RUN	2080103	207	0.59	56.6	27.3	96.2	46.5	94.4	45.6	112.2	54.2	94.7	45.8
E03	HUGHES RIVER	2080103	55	0.16	18.8	34.2	23.1	42.1	23.1	42.0	25.4	46.3	29.5	53.7
E04	UPPER HAZEL RIVER	2080103	94	0.27	23.4	25.0	37.4	39.9	38.1	40.6	43.6	46.5	50.1	53.5
E05	UPPER THORNTON RIVER	2080103	84	0.24	26.4	31.4	39.4	47.0	40.2	47.9	43.9	52.3	40.0	47.7
E06	LOWER THORNTON RIVER	2080103	68	0.19	7.6	11.3	19.5	28.9	20.3	30.0	26.5	39.2	41.1	60.8
E07	LOWER HAZEL RIVER/MUDDY RUN/INDIAN RUN	2080103	88	0.25	18.9	21.4	35.2	39.9	33.7	38.3	41.9	47.6	46.1	52.4
E08	RAPPAHANNOCK RIVER/MARSH RUN	2080103	116	0.33	16.4	14.2	40.6	35.1	38.4	33.2	49.6	42.9	66.1	57.1
E09	MOUNTAIN RUN	2080103	131	0.37	10.4	7.9	28.6	21.8	29.3	22.3	37.6	28.7	93.6	71.3
E10	RAPPAHANNOCK RIVER/DEEP RUN/ROCK RUN	2080103	120	0.34	54.2	45.3	77.3	64.7	80.8	67.6	85.6	71.6	33.9	28.4
E11	UPPER RAPIDAN RIVER/CONWAY RIVER	2080103	71	0.20	36.0	50.6	40.5	56.9	41.5	58.3	43.6	61.2	27.6	38.8
E12	RAPIDAN RIVER/SOUTH RIVER	2080103	63	0.18	12.6	19.9	19.7	31.2	19.7	31.2	22.5	35.5	40.7	64.5
E13	RAPIDAN RIVER/BLUE RUN/BEAUTIFUL RUN	2080103	123	0.35	11.9	9.6	32.7	26.5	30.8	25.0	41.5	33.7	81.8	66.3
E14	UPPER ROBINSON RIVER/WHITE OAK RUN	2080103	90	0.26	26.2	29.1	32.2	35.7	33.6	37.2	35.6	39.5	54.7	60.5
E15	LOWER ROBINSON RIVER/CROOKED RUN/DEEP RUN	2080103	121	0.35	16.5	13.6	31.2	25.8	31.9	26.3	38.8	32.0	82.3	68.0
E16	RAPIDAN RIVER/CEDAR RUN	2080103	70	0.20	12.0	17.2	25.5	36.4	20.2	28.8	30.1	42.9	40.0	57.1
E17	RAPIDAN RIVER/MINE RUN/MOUNTAIN RUN	2080103	157	0.45	41.4	26.4	73.5	47.0	71.4	45.6	82.9	52.9	73.7	47.1
E18	LOWER RAPIDAN RIVER	2080103	116	0.33	47.6	41.2	65.1	56.3	68.3	59.0	72.5	62.6	43.2	37.4

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			miles	%	miles	%	miles	%	miles	%	miles	%	miles	%
E19	RAPPAHANNOCK RIVER/MOTTS RUN	2080104	78	0.22	33.9	43.4	51.9	66.5	58.0	74.3	60.6	77.6	17.5	22.4
E20	RAPPAHANNOCK RIVER/MASSAPONAX CREEK	2080104	152	0.43	53.2	35.0	88.7	58.4	87.0	57.3	99.4	65.4	52.5	34.6
E21	RAPPAHANNOCK RIVER/MILL CREEK/GOLDENVALE CREEK	2080104	372	1.06	163.7	44.0	238.5	64.1	246.2	66.2	264.3	71.0	107.8	29.0
E22	RAPPAHANNOCK RIVER/OCCUPACIA CREEK/PEEDEE CREEK	2080104	330	0.94	113.4	34.3	167.0	50.5	165.0	49.9	184.3	55.8	146.2	44.2
E23	RAPPAHANNOCK RIVER/CATPOINT CREEK/PISCATAWAY CREEK	2080104	484	1.38	235.6	48.7	309.1	63.9	313.0	64.7	328.9	68.0	154.8	32.0
E24	RAPPAHANNOCK RIVER/TOTUSKEY CREEK	2080104	174	0.50	85.1	49.0	112.2	64.6	115.2	66.3	120.6	69.5	53.0	30.5
E25	RAPPAHANNOCK RIVER/LAGRANGE CREEK/LANCASTER CREEK	2080104	298	0.85	98.9	33.2	143.2	48.0	148.8	49.9	158.4	53.2	139.6	46.8
E26	LOWER RAPPAHANNOCK RIVER/CORROTOMAN RIVER	2080104	260	0.74	81.0	25.1	123.0	38.2	139.0	43.1	152.0	47.1	107.6	52.9
F01	UPPER SOUTH ANNA RIVER	2080106	93	0.27	22.2	23.8	38.1	40.8	37.7	40.4	45.9	49.2	47.3	50.8
F02	SOUTH ANNA RIVER/ROUNDABOUT CREEK	2080106	149	0.42	62.7	42.1	89.4	60.1	93.0	62.5	98.6	66.3	50.2	33.7
F03	SOUTH ANNA RIVER/TAYLORS CREEK	2080106	280	0.80	142.1	50.7	199.3	71.2	201.0	71.8	214.7	76.7	65.3	23.3
F04	LOWER SOUTH ANNA RIVER	2080106	97	0.28	42.1	43.3	68.1	70.1	70.2	72.3	75.0	77.2	22.2	22.8
F05	NEWFOUND RIVER	2080106	61	0.17	32.9	54.0	47.9	78.6	48.4	79.4	51.6	84.7	9.3	15.3
F06	UPPER NORTH ANNA RIVER	2080106	168	0.48	52.4	31.2	75.7	45.0	79.5	47.3	85.6	51.0	82.4	49.0
F07	LAKE ANNA/PAMUNKEY CREEK	2080106	304	0.87	58.3	17.6	104.4	31.5	117.1	35.3	130.6	39.4	172.9	60.6
F08	CONTRARY CREEK	2080106	30	0.09	10.8	35.8	14.6	48.4	16.2	53.5	17.2	56.9	13.0	43.1
F09	LOWER NORTH ANNA RIVER/NORTHEAST CREEK	2080106	204	0.58	132.7	60.1	175.9	79.7	178.1	80.7	186.0	84.3	18.4	15.7
F10	UPPER LITTLE RIVER	2080106	83	0.24	36.6	43.9	55.0	66.0	56.3	67.5	59.7	71.6	23.6	28.4
F11	LOWER LITTLE RIVER	2080106	122	0.35	74.5	61.3	99.1	81.5	100.7	82.8	104.5	86.0	17.1	14.0
F12	UPPER PAMUNKEY RIVER/MECHUMPS CREEK	2080106	163	0.47	71.4	43.7	103.7	63.5	105.5	64.6	115.4	70.7	47.8	29.3
F13	MIDDLE PAMUNKEY RIVER/BLACK CREEK/TOTOPOTOMOY CREEK	2080106	411	1.17	203.0	49.3	287.2	69.8	288.5	70.1	311.1	75.6	100.3	24.4
F14	LOWER PAMUNKEY RIVER	2080106	307	0.88	68.0	22.1	101.8	33.2	108.0	35.2	117.5	38.2	189.7	61.8
F15	NI RIVER	2080105	83	0.24	45.7	55.4	61.5	74.5	63.0	76.4	66.4	80.5	16.1	19.5
F16	PO RIVER	2080105	133	0.38	81.4	61.3	102.4	77.1	105.6	79.5	108.6	81.8	24.2	18.2
F17	UPPER MATTAPONI RIVER/PONI RIVER	2080105	137	0.39	75.4	55.1	102.6	75.0	106.1	77.6	111.2	81.3	25.6	18.7
F18	MATTA RIVER	2080105	90	0.26	56.5	62.9	72.3	80.4	73.5	81.8	77.0	85.7	12.9	14.3
F19	SOUTH RIVER	2080105	93	0.26	55.0	59.3	71.6	77.3	72.1	77.8	75.5	81.5	17.2	18.5
F20	POLECAT CREEK	2080105	89	0.25	48.9	54.8	64.6	72.4	66.0	74.0	68.7	77.0	20.5	23.0
F21	MATTAPONI RIVER/HERRING CREEK/CHAPEL CREEK	2080105	305	0.87	188.8	61.8	252.7	82.8	256.6	84.1	268.1	87.8	37.2	12.2
F22	MARACOSSIC CREEK/BEVERLY RUN	2080105	248	0.71	152.3	61.5	199.4	80.5	205.1	82.8	212.8	85.9	35.0	14.1
F23	MATTAPONI RIVER/GARNETTS CREEK	2080105	204	0.58	91.8	45.0	140.0	68.6	142.0	69.5	154.0	75.4	50.1	24.6

Table 9. Riparian forest buffer statistics for 11-digit hydrologic units in Virginia.

ID	Watershed	HUC code	Stream Length		Both 300'+		Both 100'-300'		One side 300'+		One side 100'-300'		Both sides < 100'	
			miles	%	miles	%	miles	%	miles	%	miles	%	miles	%
F24	MATTAPONI RIVER/COURTHOUSE CREEK	2080105	142	0.40	54.2	38.3	78.3	55.2	81.7	57.6	86.9	61.3	54.9	38.7
F25	LOWER MATTAPONI RIVER	2080105	103	0.29	41.9	40.5	54.5	52.7	55.6	53.8	58.4	56.5	45.0	43.5
F26	UPPER YORK RIVER/POROPOTANK RIVER/QUEEN CREEK/WARE CREEK	2080107	442	1.26	125.0	28.1	198.9	44.7	217.5	48.9	233.6	52.5	208.2	47.5
F27	LOWER YORK RIVER/CARTER CREEK/KING CREEK	2080107	182	0.52	22.6	12.4	44.4	24.5	48.8	26.9	56.5	31.1	125.1	68.9
G01	JAMES RIVER/FALLING CREEK/PROCTORS CREEK	2080206	229	0.65	43.0	18.8	102.0	44.5	96.7	42.2	119.3	52.1	109.7	47.9
G02	JAMES RIVER/TURKEY ISLAND CREEK/FOURMILE CREEK	2080206	228	0.65	55.5	24.4	89.4	39.3	93.2	41.0	103.9	45.7	123.7	54.3
G03	JAMES RIVER/POWELL CREEK/WEST RUN/BAILEY CREEK	2080206	244	0.70	80.5	33.0	118.5	48.5	124.1	50.8	132.4	54.2	111.8	45.8
G04	JAMES RIVER/WARDS CREEK/UPPER CHIPPOKES CREEK	2080206	257	0.73	77.0	30.0	113.4	44.2	120.0	46.7	128.2	49.9	128.7	50.1
G05	UPPER CHICKAHOMINY RIVER/UPHAM BROOK/STONY RUN	2080206	154	0.44	43.4	28.3	84.2	54.8	80.7	52.5	96.8	63.1	56.7	36.9
G06	CHICKAHOMINY RIVER/WHITE OAK SWAMP/BEAVERDAM CREEK	2080206	293	0.83	154.8	52.9	216.4	74.0	218.3	74.6	233.3	79.7	59.2	20.3
G07	CHICKAHOMINY RIVER/RUMLEY MARSH	2080206	175	0.50	90.4	51.6	120.1	68.6	123.7	70.7	129.4	73.9	45.7	26.1
G08	LOWER CHICKAHOMINY RIVER/MORRIS CREEK/LOWER DIASCUND CREEK	2080206	278	0.79	120.2	22.0	221.6	40.5	233.9	42.7	274.6	50.2	3.1	49.8
G09	UPPER DIASCUND CREEK/DIASCUND CREEK RESERVOIR	2080206	91	0.26	37.9	41.6	52.3	57.5	55.4	60.9	59.1	64.9	31.9	35.1
G10	JAMES RIVER/POWHATAN CREEK/GRAYS CREEK	2080206	286	0.82	102.2	28.3	168.8	46.8	174.4	48.3	193.6	53.6	92.4	46.4
G11	JAMES RIVER/PAGEN RIVER/WARWICK RIVER/CHUCKATUCK CREEK	2080206	650	1.85	76.5	11.8	181.8	28.0	188.7	29.0	230.4	35.5	419.5	64.5
G12	SPEIGHTS RUN/LAKE COHOON/LAKE MEADE/LAKE KILBY	2080208	82	0.23	11.5	9.5	28.6	23.6	30.1	24.9	36.0	29.7	46.0	70.3
G13	NANSEMOND RIVER/BENNETT CREEK	2080208	254	0.72	25.1	9.9	50.6	19.9	48.6	19.1	62.6	24.6	191.5	75.4
G14	WESTERN BRANCH RESERVOIR	2080208	90	0.26	16.6	10.3	42.6	26.6	45.0	28.1	55.6	34.7	34.4	65.3
G15	HAMPTON ROADS/ELIZABETH RIVER	2080208	489	1.39	11.5	2.4	33.0	6.7	34.2	7.0	45.7	9.4	443.2	90.6
H01	JAMES RIVER/REED CREEK	2080203	189	0.54	92.0	48.8	109.4	58.0	112.8	59.8	116.5	61.8	72.1	38.2
H02	PEDLAR RIVER	2080203	177	0.51	111.0	62.6	132.7	74.8	136.4	76.9	140.5	79.2	37.0	20.8
H03	JAMES RIVER/BLACKWATER CREEK/IVY CREEK	2080203	220	0.63	59.4	27.0	102.7	46.7	104.4	47.5	116.9	53.2	103.0	46.8
H04	HARRIS CREEK	2080203	87	0.25	34.4	39.3	52.9	60.6	55.2	63.2	60.5	69.2	26.9	30.8
H05	JAMES RIVER/BEAVER CREEK/BECK CREEK	2080203	303	0.86	114.8	38.0	180.9	59.8	188.5	62.3	201.4	66.6	101.1	33.4
H06	WRECK ISLAND CREEK	2080203	90	0.26	32.0	35.5	55.1	61.2	54.3	60.2	62.2	69.0	27.9	31.0
H07	BENT CREEK	2080203	43	0.12	20.9	48.5	29.0	67.5	30.5	71.0	33.1	76.9	9.9	23.1
H08	JAMES RIVER/DAVID CREEK	2080203	123	0.35	58.8	47.7	83.4	67.7	86.4	70.1	91.7	74.4	31.6	25.6
H09	UPPER TYE RIVER	2080203	210	0.60	90.9	43.2	127.6	60.7	132.6	63.1	142.4	67.7	67.8	32.3
H10	PINEY RIVER	2080203	115	0.33	54.1	47.0	72.4	62.9	72.8	63.3	79.0	68.6	36.1	31.4
H11	UPPER BUFFALO RIVER	2080203	155	0.44	50.0	32.3	79.7	51.5	84.7	54.7	92.9	60.0	62.0	40.0
H12	LOWER BUFFALO RIVER	2080203	95	0.27	41.5	43.8	66.3	69.9	68.0	71.7	73.2	77.2	21.6	22.8
H13	LOWER TYE RIVER/RUCKER RUN	2080203	97	0.28	35.4	36.6	52.6	54.3	54.9	56.7	60.5	62.5	36.3	37.5

Table 9. Riparian forest buffer statistics for 11-digit hydrologic units in Virginia.

ID	Watershed	HUC code	Stream Length		Both 300'+		Both 100'-300'		One side 300'+		One side 100'-300'		Both sides < 100'	
			miles	%	miles	%	miles	%	miles	%	miles	%	miles	%
H14	JAMES RIVER/SYCAMORE CREEK	2080203	136	0.39	62.1	45.5	85.1	62.4	88.7	65.1	96.2	70.6	40.2	29.4
H15	NORTH FORK ROCKFISH RIVER/SOUTH FORK ROCKFISH RIVER	2080203	152	0.43	64.8	42.6	90.6	59.6	91.6	60.2	100.2	65.8	52.0	34.2
H16	LOWER ROCKFISH RIVER	2080203	253	0.72	120.7	47.8	159.6	63.2	168.5	66.7	177.3	70.1	75.4	29.9
H17	JAMES RIVER/TOTIER CREEK/ROCK ISLAND CREEK	2080203	188	0.53	65.6	35.0	102.4	54.6	106.0	56.5	117.4	62.6	70.2	37.4
H18	NORTH FORK HARDWARE RIVER/SOUTH FORK HARDWARE RIVER	2080203	107	0.31	33.9	31.5	52.5	48.9	55.4	51.6	61.4	57.1	46.1	42.9
H19	HARDWARE RIVER	2080203	91	0.26	25.7	28.3	47.8	52.7	50.1	55.3	55.7	61.4	35.0	38.6
H20	JAMES RIVER/BEAR GARDEN CREEK/SOUTH CREEK	2080203	159	0.45	52.0	32.7	80.9	50.8	83.4	52.4	94.0	59.0	65.2	41.0
H21	UPPER SLATE RIVER	2080203	241	0.69	137.6	57.0	189.5	78.5	192.8	79.9	203.6	84.3	37.8	15.7
H22	LOWER SLATE RIVER	2080203	126	0.36	45.8	36.4	72.9	57.8	73.7	58.5	81.6	64.8	44.3	35.2
H23	MECHUMS RIVER	2080204	136	0.39	35.7	26.3	67.4	49.8	68.2	50.3	80.0	59.0	55.5	41.0
H24	MOORMANS RIVER	2080204	76	0.22	37.5	49.1	51.6	67.6	51.1	66.9	56.3	73.7	20.1	26.3
H25	BUCK MOUNTAIN CREEK	2080204	38	0.11	10.0	26.5	15.5	41.2	16.0	42.6	18.1	48.1	19.5	51.9
H26	SOUTH FORK RIVANNA RIVER/IVY CREEK	2080204	71	0.20	14.5	20.3	30.9	43.3	33.4	46.7	38.5	53.9	32.9	46.1
H27	NORTH FORK RIVANNA RIVER/SWIFT RUN/PREDDY CREEK	2080204	198	0.56	40.6	20.6	70.9	35.8	76.3	38.6	85.7	43.3	112.1	56.7
H28	UPPER RIVANNA RIVER/MOORES CREEK	2080204	70	0.20	16.3	23.2	28.4	40.3	27.7	39.2	33.0	46.9	37.4	53.1
H29	MIDDLE RIVANNA RIVER/BUCK ISLAND CREEK	2080204	115	0.33	31.4	27.2	51.0	44.3	53.0	46.0	60.9	52.8	54.3	47.2
H30	MECHUNK CREEK	2080204	87	0.25	19.2	22.0	37.5	43.0	37.6	43.2	44.8	51.5	42.3	48.5
H31	LOWER RIVANNA RIVER/BALLINGER CREEK	2080204	153	0.44	46.2	30.2	76.9	50.3	79.6	52.0	89.3	58.4	63.7	41.6
H32	CUNNINGHAM CREEK	2080204	56	0.16	21.0	37.5	32.6	58.4	33.7	60.3	36.5	65.4	19.3	34.6
H33	JAMES RIVER/DEEP CREEK/MUDDY CREEK	2080205	286	0.82	89.0	31.1	145.3	50.8	155.1	54.2	170.4	59.5	116.0	40.5
H34	BYRD CREEK	2080205	165	0.47	60.6	36.6	98.0	59.2	101.2	61.2	110.1	66.5	55.4	33.5
H35	UPPER WILLIS RIVER	2080205	178	0.51	78.7	44.2	116.3	65.4	118.9	66.8	129.5	72.8	48.5	27.2
H36	LOWER WILLIS RIVER	2080205	269	0.77	118.2	44.0	179.8	66.9	183.5	68.3	198.3	73.8	70.3	26.2
H37	BIG LICKINGHOLE CREEK	2080205	110	0.31	37.9	34.4	63.0	57.2	64.3	58.4	72.4	65.8	37.6	34.2
H38	JAMES RIVER/BEAVERDAM CREEK/FINE CREEK	2080205	166	0.47	49.1	29.5	83.2	50.0	87.8	52.8	98.1	59.0	68.2	41.0
H39	JAMES RIVER/TUCKAHOE CREEK/NORWOOD CREEK	2080205	350	1.00	102.3	29.2	171.8	49.0	172.4	49.2	199.4	56.9	151.0	43.1
I01	UPPER JACKSON RIVER	2080201	110	0.31	27.5	25.0	45.5	41.3	46.7	42.4	52.5	47.7	57.5	52.3
I02	BACK CREEK	2080201	116	0.33	39.0	33.7	51.9	44.9	54.4	47.1	57.3	49.6	58.2	50.4
I03	LAKE MOOMAW/HUGHES DRAFT	2080201	72	0.20	26.2	36.5	34.3	47.9	36.6	51.1	38.4	53.6	33.3	46.4
I04	JACKSON RIVER/FALLING SPRING CREEK	2080201	111	0.32	55.1	49.7	66.1	59.6	68.4	61.7	72.9	65.8	37.9	34.2
I05	CEDAR CREEK	2080201	44	0.13	24.1	54.8	29.9	68.0	31.4	71.3	32.2	73.3	11.8	26.7
I06	COVE CREEK/SWEET SPRINGS CREEK	2080201	16	0.05	5.5	34.2	7.0	43.6	6.9	43.0	7.7	47.6	8.4	52.4

Table 9. Riparian forest buffer statistics for 11-digit hydrologic units in Virginia.

ID	Watershed	HUC code	Stream Length		Both 300'+		Both 100'-300'		One side 300'+		One side 100'-300'		Both sides < 10	
			miles	%	miles	%	miles	%	miles	%	miles	%	miles	%
I07	DUNLAP CREEK	2080201	144	0.41	85.6	59.3	102.6	71.1	105.1	72.9	109.8	76.1	34.5	23.9
I08	OGLE CREEK	2080201	70	0.20	31.2	44.5	38.5	54.8	40.6	58.0	42.2	60.2	27.9	39.8
I09	LOWER JACKSON RIVER/WILSON CREEK/KARNES CREEK	2080201	166	0.47	102.7	61.8	120.6	72.6	122.3	73.6	127.2	76.6	38.9	23.4
I10	UPPER POTTS CREEK	2080201	115	0.33	77.3	67.1	89.8	78.0	91.4	79.4	95.3	82.7	19.9	17.3
I11	LOWER POTTS CREEK	2080201	124	0.35	74.3	60.0	92.0	74.4	93.1	75.2	99.6	80.4	24.2	19.6
I12	UPPER COWPASTURE RIVER	2080201	67	0.19	29.3	43.7	39.5	59.0	41.6	62.1	44.5	66.5	22.4	33.5
I13	BULLPASTURE RIVER	2080201	82	0.23	17.9	21.9	27.8	34.1	28.6	35.0	32.3	39.5	49.4	60.5
I14	COWPASTURE RIVER/THOMPSON CREEK/DRY RUN	2080201	77	0.22	32.4	42.1	50.8	66.0	51.4	66.8	55.9	72.5	21.1	27.5
I15	STUART RUN	2080201	52	0.15	21.1	41.0	33.1	64.3	35.1	68.1	37.7	73.1	13.9	26.9
I16	COWPASTURE RIVER/MILL CREEK	2080201	83	0.24	48.7	58.7	60.8	73.3	62.7	75.6	65.1	78.6	17.8	21.4
I17	LOWER COWPASTURE RIVER/SIMPSON CREEK/PADS CREEK	2080201	121	0.34	81.5	67.6	96.7	80.2	98.3	81.5	100.5	83.3	20.1	16.7
I18	UPPER JAMES RIVER/SINKING CREEK/MILL CREEK	2080201	156	0.44	76.1	48.9	99.9	64.1	102.4	65.7	107.9	69.2	47.9	30.8
I19	UPPER CRAIG CREEK	2080201	180	0.51	124.0	69.0	141.1	78.5	142.9	79.5	147.5	82.1	32.2	17.9
I20	MEADOW CREEK	2080201	12	0.04	1.9	15.0	3.3	26.6	3.6	28.9	3.9	31.3	8.5	68.7
I21	JOHNS CREEK	2080201	193	0.55	121.9	63.0	146.4	75.7	149.2	77.2	155.5	80.4	37.9	19.6
I22	LOWER CRAIG CREEK/PATTERSON CREEK/LOWER BARBOURS CREEK	2080201	207	0.59	119.2	57.5	158.2	76.3	159.8	77.1	171.2	82.6	36.1	17.4
I23	UPPER BARBOURS CREEK	2080201	50	0.14	42.2	83.7	45.5	90.4	46.0	91.4	46.5	92.3	3.9	7.7
I24	JAMES RIVER/LAPSLEY RUN	2080201	118	0.34	27.3	23.1	48.4	41.0	51.5	43.6	58.6	49.6	59.4	50.4
I25	CATAWBA CREEK	2080201	192	0.55	61.7	32.2	87.4	45.6	90.8	47.4	98.7	51.5	92.9	48.5
I26	LOONEY CREEK/MILL CREEK	2080201	116	0.33	20.4	17.5	33.4	28.7	34.7	29.8	39.8	34.2	76.6	65.8
I27	JAMES RIVER/JENNINGS CREEK	2080201	130	0.37	60.3	46.3	73.3	56.3	73.5	56.4	77.5	59.5	52.8	40.5
I28	JAMES RIVER/ELK CREEK/CEDAR CREEK	2080201	106	0.30	51.7	48.8	67.9	64.1	69.4	65.6	73.7	69.6	32.2	30.4
I29	UPPER CALFPASTURE RIVER	2080202	83	0.24	52.9	64.0	64.1	77.5	65.7	79.4	67.7	81.9	15.0	18.1
I30	LOWER CALFPASTURE RIVER/MILL CREEK	2080202	129	0.37	57.0	44.3	82.8	64.4	83.8	65.2	92.1	71.7	36.4	28.3
I31	BRATTONS RUN	2080202	43	0.12	31.4	72.3	37.6	86.5	37.8	87.1	38.7	89.0	4.8	11.0
I32	LITTLE CALFPASTURE RIVER	2080202	80	0.23	27.6	34.3	44.7	55.6	44.0	54.7	49.9	62.1	30.5	37.9
I33	UPPER MAURY RIVER/KERRS CREEK	2080202	133	0.38	37.8	28.4	58.6	43.9	59.9	44.9	67.2	50.4	66.3	49.6
I34	HAYS CREEK	2080202	91	0.26	17.5	19.3	31.1	34.3	31.4	34.5	36.7	40.4	54.1	59.6
I35	MIDDLE MAURY RIVER/MILL CREEK	2080202	66	0.19	9.4	14.2	20.5	30.9	19.6	29.5	25.6	38.6	40.7	61.4
I36	SOUTH RIVER	2080202	153	0.44	77.6	50.7	94.7	61.8	96.9	63.3	101.9	66.5	51.2	33.5
I37	LOWER MAURY RIVER/POAGUE RUN	2080202	98	0.28	40.2	41.0	48.9	49.8	48.8	49.7	53.0	54.0	45.2	46.0
I38	BUFFALO CREEK	2080202	174	0.50	51.4	29.5	93.2	53.5	95.7	54.9	105.9	60.8	68.2	39.2

Table 9. Riparian forest buffer statistics for 11-digit hydrologic units in Virginia.

ID	Watershed	HUC code	Stream Length		Both 300'+		Both 100'-300'		One side 300'+		One side 100'-300'		Both sides < 100'	
			miles	%	miles	%	miles	%	miles	%	miles	%	miles	%
J01	UPPER APPOMATTOX RIVER	2080207	314	0.90	144.4	46.0	222.2	70.7	225.9	71.9	244.6	77.8	69.6	22.2
J02	BUFFALO CREEK/SPRING CREEK	2080207	184	0.52	81.5	44.3	118.2	64.3	123.4	67.1	130.8	71.1	53.2	28.9
J03	SANDY RIVER	2080207	65	0.19	29.2	44.9	43.9	67.5	44.4	68.2	47.8	73.5	17.2	26.5
J04	BUSH RIVER	2080207	98	0.28	47.4	48.4	68.6	70.0	70.1	71.5	73.7	75.3	24.2	24.7
J05	BRIERY CREEK	2080207	67	0.19	18.8	28.2	31.4	47.1	32.4	48.5	35.6	53.3	31.2	46.7
J06	APPOMATTOX RIVER/BIG GUINEA CREEK/SAYLERS CREEK	2080207	249	0.71	101.6	40.8	165.5	66.4	168.7	67.7	183.5	73.7	65.6	26.3
J07	APPOMATTOX RIVER/SKINQUARTER CREEK/ROCKY FORD CREEK	2080207	174	0.50	81.7	46.8	122.5	70.2	124.7	71.5	134.1	76.9	40.4	23.1
J08	FLAT CREEK	2080207	178	0.51	79.3	44.7	122.0	68.7	123.2	69.4	134.3	75.6	43.3	24.4
J09	NIBBS CREEK	2080207	35	0.10	10.8	30.4	21.4	60.4	21.6	61.1	25.4	72.0	9.9	28.0
J10	APPOMATTOX RIVER/SMACKS CREEK/SAPPONY CREEK	2080207	85	0.24	46.8	54.9	61.3	71.9	63.8	74.8	66.7	78.2	18.6	21.8
J11	DEEP CREEK	2080207	316	0.90	147.2	46.6	214.2	67.8	219.2	69.4	233.5	73.9	82.4	26.1
J12	LAKE CHESDIN/WINTERPOCK CREEK/WINTICOMACK CREEK	2080207	129	0.37	73.4	57.1	95.3	74.1	98.6	76.7	102.8	79.9	25.8	20.1
J13	NAMOZINE CREEK	2080207	92	0.26	57.2	61.8	71.4	77.3	72.6	78.5	75.2	81.4	17.2	18.6
J14	LAKE CHESDIN/WHIPPONOCK CREEK	2080207	75	0.21	16.9	22.7	33.3	44.7	38.2	51.3	42.4	56.9	32.1	43.1
J15	LOWER APPOMATTOX RIVER/ASHTON CREEK	2080207	160	0.46	31.0	19.4	64.2	40.1	64.0	40.0	74.9	46.8	85.3	53.2
J16	UPPER SWIFT CREEK/SWIFT CREEK RESERVOIR	2080207	102	0.29	55.0	54.0	70.7	69.5	72.9	71.7	75.8	74.5	25.9	25.5
J17	LOWER SWIFT CREEK	2080207	183	0.52	93.2	50.9	129.0	70.5	133.2	72.8	139.1	76.0	43.8	24.0
K15	LITTLE NOTTOWAY RIVER	3010201	1	0.00	0.0	3.2	0.2	25.4	0.3	30.8	0.3	36.1	0.6	63.9

Table 10. Land use data within 100 and 300 foot stream buffers and entire subwatersheds for 11-digit hydrologic units in Virginia.

ID	Watershed	Land use statistics for the entire watershed							Land use statistics for the 300' buffer							Land use statistics for the 100' buffer						
		nodat	low	high	wood	herb	exp	water	nodat	low	high	wood	herb	exp	water	nodat	low	high	wood	herb	exp	water
A01	POTOMAC RIVER/PINEY RUN/DUTCHMAN CREEK	0.0	0.0	0.2	52.7	46.8	0.0	0.4	0.0	0.0	0.3	56.7	32.3	0.0	10.7	0.0	0.0	0.3	61.6	27.5	0.0	10.6
A02	CATOCTIN CREEK	0.0	0.0	0.6	34.7	64.6	0.0	0.1	0.0	0.0	0.4	41.6	57.1	0.0	0.9	0.0	0.0	0.4	46.5	52.1	0.0	1.0
A03	POTOMAC RIVER/LIMESTONE BRANCH	0.0	0.0	1.7	39.1	58.8	0.0	0.4	0.0	0.0	1.4	40.3	49.0	0.0	9.3	0.0	0.0	1.3	44.6	44.7	0.0	9.4
A04	UPPER GOOSE CREEK/GAP RUN	0.2	0.0	1.2	51.2	47.3	0.0	0.0	0.2	0.0	1.2	43.9	53.6	0.0	1.1	0.3	0.0	0.9	47.8	50.0	0.0	1.0
A05	MIDDLE GOOSE CREEK/PANTHER SKIN CREEK	0.3	0.0	0.6	37.0	61.9	0.0	0.1	0.5	0.0	0.4	52.3	45.7	0.0	1.2	0.6	0.0	0.3	57.7	40.1	0.0	1.3
A06	NORTH FORK GOOSE CREEK	0.0	0.0	1.2	35.0	63.1	0.0	0.7	0.0	0.0	0.6	42.4	51.8	0.0	5.3	0.0	0.0	0.4	45.6	48.7	0.0	5.3
A07	BEAVERDAM CREEK	0.0	0.0	0.2	35.8	63.9	0.0	0.2	0.0	0.0	0.1	50.0	48.6	0.0	1.3	0.0	0.0	0.2	55.4	43.1	0.0	1.3
A08	LOWER GOOSE CREEK/LITTLE RIVER	0.0	0.2	4.1	42.2	53.2	0.3	0.0	0.0	0.0	3.0	47.5	45.4	0.1	4.0	0.0	0.0	2.5	50.2	42.0	0.1	5.2
A09	POTOMAC RIVER/BROAD RUN	0.0	3.4	16.0	37.4	43.2	0.0	0.0	0.0	0.0	12.6	47.7	35.6	0.0	2.9	0.0	1.0	12.7	51.8	31.3	0.0	3.2
A10	SUGARLAND RUN	0.0	9.5	41.8	31.3	17.3	0.0	0.1	0.0	0.3	29.1	45.9	17.6	0.0	2.2	0.0	3.6	25.2	53.3	15.7	0.0	2.2
A11	POTOMAC RIVER/DIFFICULT RUN	0.0	4.8	25.6	51.2	18.4	0.0	0.0	0.0	0.4	11.4	65.7	9.6	0.1	9.4	0.0	1.5	8.0	71.2	7.7	0.1	9.6
A12	POTOMAC RIVER/FOURMILE RUN/PIMMIT RUN	0.0	18.0	58.5	12.6	10.4	0.0	0.4	0.0	0.1	34.9	29.9	11.8	0.1	11.5	0.0	12.2	29.1	36.5	12.6	0.0	9.6
A13	CAMERON RUN	0.0	13.3	57.9	14.6	13.4	0.0	0.8	0.0	0.7	38.3	30.0	12.1	0.0	8.2	0.0	8.9	34.5	35.7	11.4	0.0	9.6
A14	POTOMAC RIVER/DOGUE CREEK/LITTLE HUNTING CREEK	0.0	4.8	40.4	26.6	21.6	0.0	6.7	0.0	0.3	21.3	36.7	19.3	0.0	19.3	0.0	3.2	17.4	38.2	19.7	0.0	21.5
A15	ACCOTINK CREEK	0.0	8.8	45.5	27.8	17.9	0.1	0.0	0.0	0.5	24.0	50.1	12.4	0.1	5.7	0.0	2.7	19.8	55.4	11.2	0.0	6.6
A16	POHICK CREEK	0.0	1.9	40.8	35.9	21.4	0.0	0.0	0.0	0.2	17.4	57.1	16.4	0.1	7.5	0.0	1.5	13.2	62.6	14.6	0.2	7.9
A17	UPPER CEDAR RUN/LICKING RUN	0.0	0.3	6.6	37.2	55.9	0.1	0.0	0.0	0.0	5.1	41.1	50.9	0.1	2.6	0.0	0.2	4.8	45.1	47.1	0.0	2.8
A18	LOWER CEDAR RUN/TOWN RUN	0.0	0.1	1.6	50.0	48.2	0.1	0.0	0.0	0.0	0.9	55.5	42.0	0.0	1.5	0.0	0.1	0.8	59.0	38.6	0.0	1.5
A19	BROAD RUN/KETTLE RUN	0.0	0.7	8.9	42.1	48.2	0.1	0.0	0.0	0.0	7.1	45.8	40.4	0.5	5.7	0.0	0.6	7.1	49.6	36.2	0.7	5.8
A20	UPPER OCCOQUAN RIVER/LAKE JACKSON	0.0	0.2	8.7	67.3	22.1	0.0	1.7	0.0	0.0	1.9	76.1	9.8	0.0	12.2	0.0	0.0	1.4	76.3	8.8	0.0	13.5
A21	UPPER BULL RUN/LITTLE BULL RUN	0.0	1.5	14.5	40.9	43.1	0.1	0.0	0.0	0.1	10.0	56.4	32.3	0.0	0.5	0.0	0.7	9.0	63.1	26.7	0.0	0.5
A22	CUB RUN	0.0	5.4	26.1	33.3	35.0	0.3	0.0	0.0	0.0	20.2	47.0	28.7	0.2	0.8	0.0	2.1	19.4	51.4	25.6	0.2	0.9
A23	LOWER BULL RUN/POPES HEAD CREEK	0.0	2.1	12.4	55.3	29.5	0.0	0.7	0.0	0.2	8.5	65.6	20.8	0.0	4.6	0.0	0.1	7.5	69.1	18.4	0.0	4.9
A24	OCCOQUAN RIVER - RESERVOIR	0.0	0.4	11.9	62.9	24.7	0.1	0.0	0.0	0.0	3.4	57.7	19.1	0.0	19.6	0.0	0.3	2.2	60.1	17.6	0.0	19.8
A25	POTOMAC RIVER/LOWER OCCOQUAN RIVER/NEABSCO CREEK	0.0	3.6	19.9	45.3	30.6	0.6	0.0	0.0	0.3	10.8	50.7	19.4	0.2	15.9	0.0	2.9	9.0	51.0	18.2	0.2	18.7
A26	POTOMAC RIVER/QUANTICO CREEK/CHOPAWAMSIC CREEK	0.0	0.7	8.8	81.0	9.4	0.2	0.0	0.0	0.0	7.4	72.2	7.0	0.0	12.2	0.0	1.1	6.4	72.6	7.1	0.0	12.7
A27	UPPER AQUIA CREEK/BEAVERDAM RUN	0.0	0.1	7.2	76.5	16.2	0.1	0.0	0.0	0.0	3.6	79.8	7.8	0.0	8.8	0.0	0.0	2.8	80.9	7.2	0.0	9.1
A28	LOWER AQUIA CREEK	0.0	0.6	16.9	65.8	16.8	0.1	0.0	0.0	0.1	7.3	48.6	15.8	0.0	28.0	0.0	0.3	5.8	48.1	12.9	0.0	33.0
A29	POTOMAC RIVER/POTOMAC CREEK	0.0	0.0	2.1	73.9	23.9	0.1	0.0	0.0	0.0	1.2	71.9	14.2	0.0	12.7	0.0	0.0	1.0	72.1	12.2	0.0	14.8
A30	POTOMAC RIVER/UPPER MACHODOC CREEK	0.0	0.3	3.2	70.3	26.2	0.0	0.0	0.0	0.0	2.6	67.0	9.6	0.0	20.7	0.0	0.0	2.3	66.0	7.7	0.0	23.9
A31	POTOMAC RIVER/MATTOX CREEK/POPES CREEK/ROSIER CREEK	0.0	0.2	3.0	66.4	30.4	0.0	0.0	0.0	0.0	3.8	53.5	21.2	0.0	20.7	0.0	0.9	4.1	54.8	18.1	0.0	22.1
A32	POTOMAC RIVER/NOMINI CREEK/LOWER MACHODOC CREEK	0.0	0.1	1.2	55.1	43.5	0.1	0.0	0.0	0.0	2.3	45.7	16.7	0.4	34.6	0.0	0.4	2.1	45.9	13.7	0.4	37.6

nodata - EMAP data unavailable
low - low intensity developed
high - h[redacted]nsity developed
wood - wooded
herb - herbaceous vegetation
exp - exposed soil

Table 10. Land use data within 100 and 300 foot stream buffers and entire subwatersheds for 11-digit hydrologic units in Virginia.

ID	Watershed	Land use statistics for the entire watershed							Land use statistics for the 300' buffer							Land use statistics for the 100' buffer						
		nodat	low	high	wood	herb	exp	water	nodat	low	high	wood	herb	exp	water	nodat	low	high	wood	herb	exp	water
A33	POTOMAC RIVER/YEOCOMICO RIVER	0.0	0.0	0.3	53.0	46.6	0.1	0.0	0.0	0.0	0.3	52.0	18.9	0.1	28.5	0.0	0.2	0.4	53.8	16.6	0.2	28.8
A34	POTOMAC RIVER/COAN RIVER/LITTLE WICOMICO RIVER	0.0	0.0	0.2	46.6	39.2	0.4	13.6	0.0	0.0	0.0	38.1	20.9	1.6	39.4	0.0	0.0	0.0	36.7	18.7	2.3	42.1
B01	UPPER NORTH FORK SOUTH BRANCH POTOMAC RIVER/LAUREL FORK	0.0	0.0	0.1	92.4	7.5	0.0	0.0	20.3	0.0	0.0	73.3	6.5	0.0	0.0	20.2	0.0	0.0	72.6	7.3	0.0	0.0
B02	UPPER SOUTH BRANCH POTOMAC RIVER	0.0	0.0	0.9	37.6	61.5	0.0	0.0	0.0	0.0	5.0	24.8	70.1	0.0	0.0	0.0	0.0	6.9	23.5	69.5	0.0	0.0
B03	UPPER SOUTH FORK SOUTH BRANCH POTOMAC RIVER	0.0	0.0	0.1	75.5	24.3	0.0	0.0	0.0	0.0	0.2	43.1	56.7	0.0	0.0	0.0	0.0	0.2	41.2	58.6	0.0	0.0
B04	SLEEPY CREEK	0.0	0.0	0.7	73.2	26.1	0.0	0.0	0.0	0.0	1.1	62.4	36.3	0.0	0.2	0.0	0.0	0.6	63.7	35.4	0.0	0.3
B05	UPPER BACK CREEK/ISAACS CREEK	0.0	0.0	2.5	62.5	34.0	0.3	0.7	0.0	0.0	4.0	59.1	32.1	0.6	4.2	0.0	0.0	3.5	60.7	30.3	0.7	4.8
B06	HOGUE CREEK	0.0	0.0	2.9	63.0	34.1	0.0	0.0	0.0	0.0	3.8	55.0	39.6	0.0	1.6	0.0	0.0	3.1	55.8	39.3	0.0	1.8
B07	LOWER BACK CREEK/BRUSH CREEK/BABBS RUN	0.0	0.0	0.9	54.0	45.0	0.0	0.2	0.0	0.0	0.9	54.9	42.3	0.0	1.9	0.0	0.0	0.9	55.4	41.4	0.0	2.2
B08	UPPER OPEQUON CREEK	0.0	0.3	7.3	22.7	69.7	0.0	0.1	0.0	0.0	4.3	32.3	62.1	0.0	1.3	0.0	0.0	4.1	35.9	58.4	0.0	1.6
B09	LOWER OPEQUON CREEK	0.0	0.4	8.6	19.1	71.7	0.2	0.0	0.0	0.0	4.8	22.2	72.3	0.2	0.5	0.0	0.0	4.2	25.0	69.9	0.2	0.6
B10	UPPER MIDDLE RIVER	0.0	0.0	0.4	31.5	68.1	0.0	0.1	0.0	0.0	1.1	9.0	89.1	0.0	0.7	0.0	0.0	1.4	9.4	88.5	0.0	0.7
B11	MIDDLE RIVER/JENNINGS BRANCH	0.0	0.0	1.0	68.4	30.6	0.0	0.0	0.0	0.0	3.6	56.0	40.4	0.0	0.0	0.0	0.0	4.2	56.7	39.0	0.0	0.0
B12	MIDDLE RIVER/LEWIS CREEK	0.0	1.0	10.1	22.2	66.7	0.0	0.1	0.0	0.0	7.8	22.3	67.8	0.0	1.0	0.0	1.4	8.1	24.5	64.3	0.0	1.8
B13	MOFFETT CREEK	0.0	0.0	0.8	35.4	63.8	0.0	0.0	0.0	0.0	3.5	23.9	72.6	0.0	0.0	0.0	0.0	5.4	21.3	73.3	0.0	0.0
B14	CHRISTIANS CREEK	0.0	0.2	4.4	25.7	69.7	0.0	0.0	0.0	0.0	2.8	22.3	74.3	0.1	0.5	0.0	0.0	2.7	23.5	73.1	0.1	0.6
B15	LOWER MIDDLE RIVER	0.0	0.3	2.4	14.3	82.9	0.0	0.1	0.0	0.0	0.7	15.7	83.0	0.0	0.6	0.0	0.0	0.7	18.2	80.2	0.0	0.9
B16	UPPER NORTH RIVER	0.0	0.0	0.3	98.6	0.9	0.0	0.2	0.0	0.0	1.9	94.3	2.4	0.0	1.4	0.0	0.0	3.3	93.8	2.0	0.0	0.9
B17	MIDDLE NORTH RIVER	0.0	0.0	1.8	37.0	61.1	0.0	0.1	0.0	0.0	6.3	28.8	63.5	0.0	1.5	0.0	0.0	8.5	31.1	58.2	0.0	2.3
B18	BRIERY BRANCH	0.0	0.0	1.3	79.0	19.7	0.0	0.0	0.0	0.0	8.1	66.8	24.2	0.0	0.8	0.0	0.2	11.7	65.7	21.6	0.0	0.8
B19	MOSSY CREEK	0.0	0.0	1.7	12.3	86.0	0.0	0.0	0.0	0.0	3.5	2.4	94.1	0.0	0.0	0.0	0.0	4.1	1.7	94.2	0.0	0.0
B20	UPPER DRY RIVER	0.0	0.0	0.4	98.7	0.6	0.0	0.2	0.0	0.0	1.2	96.2	1.2	0.0	1.4	0.0	0.0	1.7	95.7	1.2	0.0	1.4
B21	LOWER DRY RIVER	0.0	0.0	4.3	25.2	70.4	0.0	0.1	0.0	0.0	14.3	26.8	57.7	0.0	1.2	0.0	0.0	21.6	25.8	50.6	0.0	1.9
B22	MUDDY CREEK	0.0	0.1	1.6	32.0	66.3	0.0	0.0	0.0	0.0	4.7	17.6	77.5	0.0	0.0	0.0	0.1	3.9	16.4	79.5	0.0	0.0
B23	LOWER NORTH RIVER	0.0	0.6	6.0	10.2	80.6	0.0	2.7	0.0	0.0	4.9	9.9	61.4	0.0	23.7	0.0	0.0	3.5	7.2	51.7	0.0	37.7
B24	LONG GLADE CREEK	0.0	0.0	1.6	9.4	89.0	0.0	0.0	0.0	0.0	4.5	3.0	92.4	0.0	0.1	0.0	0.0	5.6	2.4	91.9	0.0	0.1
B25	COOKS CREEK	0.0	1.0	7.3	5.8	85.9	0.0	0.1	0.0	0.0	6.4	1.3	89.1	0.0	1.3	0.0	2.1	7.9	1.2	87.0	0.0	1.8
B26	BLACKS RUN	0.0	12.7	28.0	6.9	52.4	0.0	0.0	0.0	0.0	21.7	1.0	56.3	0.0	1.0	0.0	17.2	21.7	1.3	59.0	0.0	0.8
B27	PLEASANT RUN	0.0	0.1	4.1	9.7	86.1	0.0	0.0	0.0	0.0	4.4	0.5	94.7	0.0	0.3	0.0	0.0	4.0	0.5	95.1	0.0	0.3
B28	NAKED CREEK	0.0	0.1	2.5	15.3	82.1	0.0	0.0	0.0	0.0	3.3	10.5	86.1	0.0	0.1	0.0	0.0	3.3	8.1	88.6	0.0	0.1
B29	MILL CREEK	0.0	0.1	5.5	10.1	84.0	0.0	0.5	0.0	0.0	4.8	7.5	83.7	0.0	4.0	0.0	0.0	4.7	6.9	83.6	0.0	4.7
B30	UPPER SOUTH RIVER	0.0	0.0	3.0	48.9	47.9	0.0	0.3	0.0	0.0	3.8	47.0	46.6	0.0	2.7	0.0	0.0	3.6	47.6	45.7	0.0	3.0

nodata - EMAP data unavailable
low - low intensity developed
high - high intensity developed
wood - wooded
herb - herbaceous vegetation
exp - exposed soil

Table 10. Land use data within 100 and 300 foot stream buffers and entire subwatersheds for 11-digit hydrologic units in Virginia.

ID	Watershed	Land use statistics for the entire watershed							Land use statistics for the 300' buffer							Land use statistics for the 100' buffer						
		nodat	low	high	wood	herb	exp	water	nodat	low	high	wood	herb	exp	water	nodat	low	high	wood	herb	exp	water
B31	MIDDLE SOUTH RIVER/BACK CREEK	0.0	0.1	2.3	67.9	29.4	0.0	0.3	0.0	0.0	0.9	66.2	30.1	0.0	2.9	0.0	0.0	0.9	67.7	28.2	0.0	3.2
B32	LOWER SOUTH RIVER	0.0	0.8	7.9	52.6	38.7	0.0	0.0	0.0	0.1	7.9	50.9	39.5	0.0	0.9	0.0	0.4	7.8	55.7	35.0	0.0	1.1
B33	UPPER SOUTH FORK SHENANDOAH RIVER	0.0	0.0	1.6	73.1	24.1	0.0	1.2	0.0	0.0	4.0	58.3	21.6	0.0	16.1	0.0	0.0	4.3	58.8	15.5	0.0	21.4
B34	CUB RUN	0.0	0.1	3.5	39.8	56.7	0.0	0.0	0.0	0.1	4.2	30.0	65.6	0.0	0.0	0.0	0.0	4.4	33.5	62.2	0.0	0.0
B35	SOUTH FORK SHENANDOAH RIVER/ELK RUN/BOONE RUN	0.0	0.2	3.6	58.3	37.7	0.2	0.0	0.0	0.0	4.5	41.2	44.1	0.3	9.8	0.0	0.0	4.3	41.2	41.3	0.3	12.8
B36	NAKED CREEK	0.0	0.0	0.4	80.5	19.0	0.0	0.1	0.0	0.0	1.7	68.5	28.9	0.0	0.8	0.0	0.0	2.2	69.6	27.2	0.0	1.0
B37	SOUTH FORK SHENANDOAH RIVER/CUB RUN	0.0	0.1	2.2	61.0	36.5	0.2	0.0	0.0	0.0	2.2	45.2	34.5	0.1	17.9	0.0	0.1	1.9	43.5	32.3	0.0	22.2
B38	SOUTH FORK SHENANDOAH RIVER/MILL CREEK	0.0	0.0	0.7	44.9	54.4	0.1	0.0	0.0	0.0	1.9	31.4	48.2	0.0	18.6	0.0	0.0	1.8	32.7	43.4	0.0	22.1
B39	HAWKSBILL CREEK	0.0	0.0	1.1	53.2	45.7	0.0	0.0	0.0	0.0	2.1	34.4	62.7	0.0	0.7	0.0	0.0	2.5	36.0	60.7	0.0	0.8
B40	SOUTH FORK SHENANDOAH RIVER/GOONEY RUN	0.0	0.0	0.4	72.3	27.3	0.0	0.0	0.0	0.0	0.6	51.0	34.9	0.0	13.4	0.0	0.0	0.6	52.4	32.6	0.0	14.3
B41	LOWER SOUTH FORK SHENANDOAH RIVER	0.0	0.7	6.4	57.0	35.9	0.0	0.0	0.0	0.0	5.3	34.3	38.9	0.0	17.7	0.0	3.4	4.2	34.2	37.4	0.0	20.8
B42	UPPER NORTH FORK SHENANDOAH RIVER/GERMAN RIVER	0.0	0.0	0.9	87.1	12.0	0.0	0.0	0.0	0.0	5.1	76.3	18.6	0.0	0.0	0.0	0.0	7.6	76.7	15.7	0.0	0.0
B43	NORTH FORK SHENANDOAH RIVER/LITTLE DRY RIVER	0.0	0.0	1.0	91.4	7.6	0.0	0.0	0.0	0.0	5.3	80.5	14.2	0.0	0.0	0.0	0.0	7.8	80.0	12.2	0.0	0.0
B44	NORTH FORK SHENANDOAH RIVER/SHOEMAKER RIVER	0.0	0.0	0.8	83.1	16.1	0.0	0.0	0.0	0.0	3.9	65.9	30.0	0.0	0.2	0.0	0.0	5.3	66.6	27.9	0.0	0.2
B45	NORTH FORK SHENANDOAH RIVER/HOLMANS CREEK	0.0	0.2	3.1	18.9	77.2	0.0	0.7	0.0	0.0	4.4	9.2	79.5	0.0	6.5	0.0	0.4	4.5	8.0	75.8	0.0	11.4
B46	LINVILLE CREEK	0.0	0.2	4.4	14.4	80.9	0.2	0.0	0.0	0.0	7.2	6.6	84.9	0.8	0.0	0.0	0.2	7.6	5.4	86.1	0.8	0.0
B47	SMITH CREEK	0.0	0.1	3.7	42.1	54.0	0.0	0.0	0.0	0.0	3.5	30.0	66.6	0.0	0.0	0.0	0.0	3.9	31.3	64.8	0.0	0.0
B48	NORTH FORK SHENANDOAH RIVER/MILL CREEK	0.0	0.1	2.7	47.0	49.6	0.0	0.7	0.0	0.0	3.6	40.3	51.2	0.0	4.9	0.0	0.0	3.4	40.3	47.0	0.0	9.3
B49	STONY CREEK	0.0	0.1	1.8	64.4	33.7	0.0	0.0	0.0	0.0	3.3	53.5	42.2	0.0	0.7	0.0	0.3	3.4	55.3	40.4	0.0	0.6
B50	NORTH FORK SHENANDOAH RIVER/NARROW PASSAGE CREEK	0.0	0.0	2.3	42.8	54.8	0.0	0.0	0.0	0.0	2.1	32.6	50.6	0.0	14.8	0.0	0.0	1.7	28.8	41.5	0.0	27.9
B51	LOWER NORTH FORK SHENANDOAH RIVER/TUMBLING RUN	0.0	0.1	4.8	48.1	44.9	0.0	2.1	0.0	0.0	4.0	38.3	42.7	0.0	14.8	0.0	0.2	3.6	32.4	35.7	0.0	28.0
B52	UPPER CEDAR CREEK	0.0	0.0	0.2	87.9	11.9	0.0	0.0	0.0	0.0	0.6	83.3	15.9	0.0	0.2	0.0	0.0	0.6	87.0	12.2	0.0	0.2
B53	LOWER CEDAR CREEK	0.0	0.0	1.0	38.5	59.5	0.9	0.1	0.0	0.0	0.8	42.6	54.7	1.5	0.4	0.0	0.0	0.7	44.6	52.7	1.5	0.5
B54	PASSAGE CREEK	0.0	0.0	0.1	82.9	17.0	0.0	0.1	0.0	0.0	0.2	69.3	29.1	0.0	1.5	0.0	0.0	0.1	70.0	28.4	0.0	1.5
B55	UPPER SHENANDOAH RIVER	0.0	0.0	0.9	51.5	46.0	0.0	1.6	0.0	0.0	1.9	40.9	39.1	0.0	18.1	0.0	0.0	1.7	40.3	36.9	0.0	21.1
B56	CROOKED RUN	0.0	0.3	3.2	27.3	68.8	0.0	0.5	0.0	0.1	1.7	35.7	58.2	0.0	4.2	0.0	0.2	1.5	33.7	59.1	0.0	5.4
B57	SHENANDOAH RIVER/SPOUT RUN	0.0	0.0	0.7	45.0	53.3	0.0	1.0	0.0	0.0	1.1	44.2	45.1	0.0	9.6	0.0	0.0	0.8	45.5	43.5	0.0	10.3
B58	LOWER SHENANDOAH RIVER	0.3	0.0	2.1	38.4	59.1	0.0	0.0	0.7	0.0	1.0	39.9	46.6	0.0	11.9	0.7	0.0	0.8	39.5	45.6	0.0	13.5
C01	CHESAPEAKE BAY/GREAT WICOMICO RIVER	0.0	0.0	0.5	54.0	29.2	0.2	16.2	0.0	0.0	0.2	40.8	20.5	1.1	37.5	0.0	0.0	0.2	39.4	17.7	1.4	41.3
C02	DRAGON SWAMP	0.0	0.0	0.4	71.1	28.4	0.0	0.1	0.0	0.0	0.1	90.5	8.6	0.0	0.9	0.0	0.0	0.1	93.4	5.4	0.0	1.1
C03	PIANKATANK RIVER	0.0	0.0	0.5	55.5	23.9	0.2	20.1	0.0	0.0	0.6	55.8	11.5	0.9	31.2	0.0	0.0	0.4	53.3	9.6	1.4	35.3
C04	CHESAPEAKE BAY/EAST RIVER/NORTH RIVER	0.0	0.1	3.2	57.0	38.8	1.0	0.0	0.0	0.0	1.6	20.7	30.9	3.5	43.2	0.0	0.0	1.2	18.6	26.6	3.9	49.6

nodata - EMAP data unavailable
low - low intensity developed
high - high intensity developed
wood - wooded
herb - herbaceous vegetation
exp - exposed soil

Table 10. Land use data within 100 and 300 foot stream buffers and entire subwatersheds for 11-digit hydrologic units in Virginia.

ID	Watershed	Land use statistics for the entire watershed							Land use statistics for the 300' buffer							Land use statistics for the 100' buffer						
		nodat	low	high	wood	herb	exp	water	nodat	low	high	wood	herb	exp	water	nodat	low	high	wood	herb	exp	water
C05	WARE RIVER	0.0	0.1	4.5	64.0	31.3	0.1	0.0	0.0	0.0	1.6	57.7	20.9	0.0	19.8	0.0	0.0	1.2	59.5	17.2	0.0	22.1
C06	CHESAPEAKE BAY/SEVERN RIVER	0.0	0.1	12.3	43.9	43.7	0.0	0.0	0.0	0.0	4.0	12.1	40.4	0.1	43.4	0.0	0.0	3.2	11.3	36.9	0.0	48.5
C07	CHESAPEAKE BAY/BACK RIVER/POQUOSON RIVER	0.0	7.4	42.8	25.5	24.4	0.0	0.0	0.0	0.1	20.7	11.6	30.4	0.0	33.9	0.0	3.6	19.0	11.1	29.6	0.0	36.7
C08	LYNNHAVEN RIVER/LITTLE CREEK	9.1	11.5	50.5	18.6	10.2	0.0	0.0	2.4	0.1	20.8	27.2	6.9	1.5	35.7	2.4	5.6	17.6	26.2	7.0	2.2	39.0
C09	POCOMOKE RIVER/PITTS CREEK	1.1	0.0	0.3	50.3	44.2	0.0	4.1	0.0	0.0	0.0	53.3	35.5	0.0	11.2	0.0	0.0	0.0	52.6	33.6	0.0	13.8
C10	CHESAPEAKE BAY/HOLDENS CREEK	0.0	0.0	0.2	15.8	23.8	0.1	60.1	0.0	0.0	0.0	13.2	43.1	1.0	42.7	0.0	0.0	0.0	13.8	41.2	1.0	44.0
C11	CHESAPEAKE BAY/ONANCOCK CREEK	0.0	0.0	2.2	30.1	39.2	0.2	28.2	0.0	0.0	0.9	6.9	33.3	1.0	57.9	0.0	0.0	0.8	6.4	30.6	1.2	61.0
C12	PUNGOTEAGUE CREEK	0.0	0.0	0.3	42.3	46.8	0.0	10.6	0.0	0.0	0.0	25.0	30.6	0.1	44.3	0.0	0.0	0.0	24.5	25.8	0.1	49.7
C13	NANDUA CREEK/OCCOHANNOCK CREEK/NASSAWADOX CREEK	0.2	0.1	1.0	35.7	63.0	0.0	0.0	0.0	0.0	0.1	16.0	28.6	1.7	53.6	0.0	0.1	0.0	14.8	24.9	2.4	57.7
C14	CHESAPEAKE BAY/HUNGARS CREEK	0.0	0.0	0.7	25.8	72.2	1.3	0.0	0.0	0.0	0.0	18.8	21.8	1.4	58.0	0.0	0.0	0.0	18.1	17.1	1.7	63.0
C15	CHERRYSTONE INLET/KINGS CREEK	0.0	0.3	6.0	20.6	71.9	1.2	0.0	0.0	0.0	1.1	18.5	32.0	1.2	46.8	0.0	0.7	0.7	18.1	28.9	1.6	50.0
C16	CHESAPEAKE BAY/OLD PLANTATION CREEK	0.0	1.9	2.9	20.9	73.0	1.3	0.0	0.0	0.0	1.2	18.3	23.8	3.6	51.2	0.0	2.4	1.0	18.8	20.5	4.1	53.2
D06	MAGOTHY BAY/MOCKHORN BAY	79.6	0.1	0.2	4.0	16.1	0.0	0.0	0.0	0.0	5.8	16.3	68.7	5.2	3.7	0.0	0.0	6.4	13.7	73.1	4.3	2.4
E01	UPPER RAPPAHANNOCK RIVER/THUMB RUN/JORDAN RIVER	0.0	0.0	0.2	54.8	44.9	0.0	0.1	0.0	0.0	0.2	49.7	48.9	0.0	1.2	0.0	0.0	0.3	52.6	45.7	0.0	1.4
E02	RAPPAHANNOCK RIVER/CARTER RUN/GREAT RUN	0.5	0.0	1.2	46.0	52.3	0.0	0.0	0.5	0.0	0.4	50.0	47.6	0.1	1.4	0.5	0.0	0.4	53.1	44.4	0.1	1.5
E03	HUGHES RIVER	0.0	0.0	0.0	67.8	32.1	0.1	0.0	0.0	0.0	0.0	46.6	53.4	0.0	0.0	0.0	0.0	0.0	46.6	53.4	0.0	0.0
E04	UPPER HAZEL RIVER	0.0	0.0	0.2	57.2	42.6	0.0	0.0	0.0	0.0	0.4	45.0	54.4	0.0	0.2	0.0	0.0	0.4	46.1	53.5	0.0	0.1
E05	UPPER THORNTON RIVER	0.0	0.0	0.4	68.5	31.0	0.0	0.1	0.0	0.0	1.4	50.4	47.6	0.0	0.6	0.0	0.0	1.5	52.0	45.9	0.0	0.6
E06	LOWER THORNTON RIVER	0.0	0.0	0.4	43.8	55.7	0.0	0.1	0.0	0.0	0.2	36.5	62.0	0.0	1.3	0.0	0.0	0.2	38.4	59.8	0.0	1.5
E07	LOWER HAZEL RIVER/MUDDY RUN/INDIAN RUN	0.0	0.0	0.1	41.7	58.1	0.1	0.0	0.0	0.0	0.0	43.8	55.6	0.0	0.5	0.0	0.0	0.0	46.8	52.6	0.0	0.6
E08	RAPPAHANNOCK RIVER/MARSH RUN	0.1	0.1	2.3	32.2	65.4	0.0	0.0	0.1	0.0	1.7	38.8	55.8	0.4	3.1	0.1	0.0	1.5	42.3	50.9	0.4	4.8
E09	MOUNTAIN RUN	0.2	0.1	4.2	25.0	70.6	0.0	0.0	0.2	0.0	3.6	24.8	65.0	1.0	5.5	0.2	0.0	3.7	27.3	62.0	1.2	5.5
E10	RAPPAHANNOCK RIVER/DEEP RUN/ROCK RUN	0.0	0.0	0.5	71.1	27.7	0.0	0.6	0.0	0.0	0.4	73.0	21.2	0.0	5.4	0.0	0.0	0.3	72.0	19.3	0.0	8.3
E11	UPPER RAPIDAN RIVER/CONWAY RIVER	0.0	0.0	0.0	78.6	21.4	0.0	0.0	0.0	0.0	0.0	61.4	38.1	0.0	0.5	0.0	0.0	0.0	61.1	38.3	0.0	0.6
E12	RAPIDAN RIVER/SOUTH RIVER	0.0	0.0	0.6	47.7	51.5	0.1	0.1	0.0	0.0	0.8	34.6	63.4	0.4	0.9	0.0	0.0	0.6	35.0	63.1	0.4	0.9
E13	RAPIDAN RIVER/BLUE RUN/BEAUTIFUL RUN	0.0	0.1	0.6	37.5	61.7	0.1	0.0	0.0	0.0	0.2	29.9	68.3	0.2	1.5	0.0	0.0	0.2	32.8	65.3	0.2	1.6
E14	UPPER ROBINSON RIVER/WHITE OAK RUN	0.0	0.0	0.1	66.7	33.1	0.0	0.1	0.0	0.0	0.5	42.4	55.8	0.1	1.2	0.0	0.0	0.9	40.2	57.6	0.1	1.2
E15	LOWER ROBINSON RIVER/CROOKED RUN/DEEP RUN	0.0	0.0	0.5	39.1	60.4	0.0	0.1	0.0	0.0	0.2	30.9	67.7	0.0	1.1	0.0	0.0	0.2	31.8	66.8	0.0	1.1
E16	RAPIDAN RIVER/CEDAR RUN	0.0	0.0	0.7	37.8	61.5	0.0	0.0	0.0	0.0	1.0	35.5	62.4	0.0	1.0	0.0	0.0	0.7	41.5	57.0	0.0	0.9
E17	RAPIDAN RIVER/MINE RUN/MOUNTAIN RUN	0.4	0.0	0.6	47.0	52.0	0.0	0.0	0.3	0.0	0.3	48.6	50.0	0.0	0.8	0.4	0.0	0.3	52.1	46.3	0.1	0.8
E18	LOWER RAPIDAN RIVER	0.0	0.0	2.1	70.9	27.0	0.1	0.0	0.0	0.0	5.1	66.4	19.1	0.1	9.2	0.0	0.0	5.7	64.5	17.4	0.2	12.2

nodata - EMAP data unavailable
low - low intensity developed
high - high intensity developed
wood - wooded
herb - herbaceous vegetation
exp - exposed soil

Table 10. Land use data within 100 and 300 foot stream buffers and entire subwatersheds for 11-digit hydrologic units in Virginia.

ID	Watershed	Land use statistics for the entire watershed							Land use statistics for the 300' buffer							Land use statistics for the 100' buffer						
		nodat	low	high	wood	herb	exp	water	nodat	low	high	wood	herb	exp	water	nodat	low	high	wood	herb	exp	water
E19	RAPPAHANNOCK RIVER/MOTTS RUN	0.0	0.4	3.5	71.2	24.9	0.0	0.0	0.0	0.0	0.9	73.9	8.1	0.0	17.1	0.0	0.0	0.6	75.7	7.0	0.0	16.7
E20	RAPPAHANNOCK RIVER/MASSAPONAX CREEK	0.0	1.3	17.5	48.6	32.5	0.2	0.0	0.0	0.1	10.1	60.9	18.8	0.1	9.5	0.0	0.4	8.5	64.6	15.6	0.1	10.8
E21	RAPPAHANNOCK RIVER/MILL CREEK/GOLDENVALE CREEK	0.0	0.1	1.5	66.6	31.8	0.1	0.0	0.0	0.0	0.4	68.7	17.5	0.1	13.3	0.0	0.0	0.4	70.7	14.0	0.1	14.8
E22	RAPPAHANNOCK RIVER/OCCUPACIA CREEK/PEEDEE CREEK	0.0	0.0	0.4	49.7	38.5	0.0	11.4	0.0	0.0	0.4	54.1	27.9	0.0	17.6	0.0	0.0	0.5	55.7	24.0	0.0	19.8
E23	RAPPAHANNOCK RIVER/CATPOINT CREEK/PISCATAWAY CREEK	0.0	0.0	0.9	56.7	35.5	0.0	7.0	0.0	0.0	1.2	67.2	20.3	0.0	11.3	0.0	0.0	1.3	68.1	17.7	0.0	12.8
E24	RAPPAHANNOCK RIVER/TOTUSKEY CREEK	0.0	0.0	0.6	55.6	33.7	0.0	10.1	0.0	0.0	1.3	68.6	19.5	0.0	10.6	0.0	0.0	1.5	69.2	17.8	0.0	11.5
E25	RAPPAHANNOCK RIVER/LAGRANGE CREEK/LANCASTER CREEK	0.0	0.0	0.3	46.5	24.2	0.1	29.0	0.0	0.0	0.2	54.3	18.6	0.2	26.7	0.0	0.0	0.2	53.9	16.7	0.3	28.9
E26	LOWER RAPPAHANNOCK RIVER/CORROTOMAN RIVER	0.0	0.0	0.4	42.3	22.3	0.2	34.8	0.0	0.0	0.1	50.1	13.6	1.1	35.0	0.0	0.0	0.1	48.1	11.6	1.5	38.8
F01	UPPER SOUTH ANNA RIVER	0.0	0.0	1.3	48.8	49.0	0.0	0.9	0.0	0.0	0.6	47.6	43.2	0.0	8.6	0.0	0.0	0.6	48.6	41.3	0.0	9.5
F02	SOUTH ANNA RIVER/ROUNDABOUT CREEK	0.0	0.0	1.8	64.4	33.3	0.0	0.5	0.0	0.0	0.9	66.9	29.7	0.0	2.4	0.0	0.0	0.8	67.1	29.4	0.0	2.7
F03	SOUTH ANNA RIVER/TAYLORS CREEK	0.2	0.0	0.9	63.1	35.6	0.3	0.0	0.2	0.0	0.4	74.3	23.2	0.1	1.8	0.2	0.0	0.4	76.3	21.0	0.1	2.0
F04	LOWER SOUTH ANNA RIVER	0.0	0.0	1.1	56.8	41.8	0.0	0.4	0.0	0.0	0.7	71.7	24.6	0.0	3.0	0.0	0.0	0.7	76.0	19.8	0.0	3.4
F05	NEWFOUND RIVER	0.0	0.0	0.2	60.7	39.1	0.0	0.1	0.0	0.0	0.1	78.7	20.4	0.0	0.8	0.0	0.0	0.1	83.3	15.7	0.0	0.9
F06	UPPER NORTH ANNA RIVER	0.1	0.0	0.7	61.2	37.8	0.2	0.0	0.1	0.0	0.6	52.7	33.4	1.2	12.0	0.1	0.0	0.7	51.6	32.9	1.8	12.9
F07	LAKE ANNA/PAMUNKEY CREEK	0.2	0.0	1.1	53.2	45.5	0.0	0.0	0.1	0.0	0.9	41.1	28.1	1.8	28.0	0.1	0.0	0.7	39.9	26.6	2.9	29.7
F08	CONTRARY CREEK	0.6	0.0	2.2	73.6	23.6	0.0	0.0	0.5	0.0	2.2	61.7	18.6	0.0	16.9	0.9	0.0	3.0	57.6	20.7	0.0	17.8
F09	LOWER NORTH ANNA RIVER/NORTHEAST CREEK	0.0	0.0	1.7	70.0	28.2	0.0	0.1	0.0	0.0	1.8	80.7	16.6	0.0	0.9	0.0	0.0	1.8	83.4	13.9	0.0	1.0
F10	UPPER LITTLE RIVER	0.4	0.0	0.6	64.2	34.6	0.0	0.3	0.5	0.0	0.3	71.4	25.2	0.0	2.6	0.5	0.0	0.3	72.0	24.2	0.0	3.1
F11	LOWER LITTLE RIVER	0.0	0.0	0.7	67.5	31.8	0.0	0.1	0.0	0.0	0.7	82.2	16.7	0.0	0.4	0.0	0.0	0.7	85.2	13.6	0.0	0.5
F12	UPPER PAMUNKEY RIVER/MECHUMPS CREEK	0.0	0.0	3.0	60.4	35.0	0.0	1.6	0.0	0.0	1.8	71.7	18.0	0.0	8.5	0.0	0.0	1.2	71.5	13.7	0.0	13.6
F13	MIDDLE PAMUNKEY RIVER/BLACK CREEK/TOTOPOTOMOY CREEK	0.0	0.0	2.1	62.1	34.1	0.0	1.8	0.0	0.0	1.0	75.1	13.5	0.0	10.5	0.0	0.0	0.8	75.9	9.1	0.0	14.2
F14	LOWER PAMUNKEY RIVER	0.0	0.0	1.3	64.1	34.5	0.0	0.0	0.0	0.0	0.5	40.9	21.7	0.1	36.9	0.0	0.0	0.4	39.0	18.0	0.1	42.5
F15	NI RIVER	0.0	0.0	1.7	71.3	26.7	0.2	0.0	0.0	0.0	0.7	78.0	13.5	0.1	7.5	0.0	0.0	0.7	80.1	11.4	0.1	7.7
F16	PO RIVER	0.0	0.0	0.6	72.7	26.0	0.1	0.6	0.0	0.0	0.4	79.7	15.4	0.2	4.3	0.0	0.0	0.4	81.4	13.2	0.3	4.8
F17	UPPER MATTAPONI RIVER/PONI RIVER	0.0	0.0	1.4	69.0	29.2	0.0	0.3	0.0	0.0	1.8	78.3	17.7	0.0	2.2	0.0	0.0	1.7	80.3	15.4	0.0	2.6
F18	MATTA RIVER	0.0	0.0	0.3	73.0	26.6	0.0	0.1	0.0	0.0	0.2	82.9	16.0	0.0	0.9	0.0	0.0	0.1	84.9	14.0	0.0	1.0
F19	SOUTH RIVER	0.0	0.0	1.8	68.0	29.9	0.0	0.3	0.0	0.0	1.2	79.5	16.7	0.0	2.6	0.0	0.0	1.2	81.3	14.5	0.0	3.0
F20	POLECAT CREEK	0.0	0.0	3.5	70.1	25.3	0.0	1.2	0.0	0.0	6.1	75.4	11.8	0.0	6.7	0.0	0.0	5.5	76.7	10.3	0.0	7.5
F21	MATTAPONI RIVER/HERRING CREEK/CHAPEL CREEK	0.0	0.0	0.3	68.6	30.9	0.0	0.2	0.0	0.0	0.4	83.6	14.7	0.0	1.3	0.0	0.0	0.5	86.9	11.2	0.0	1.5
F22	MARACOSSIC CREEK/BEVERLY RUN	0.0	0.0	0.6	65.1	33.9	0.0	0.4	0.0	0.0	0.3	82.8	13.5	0.0	3.4	0.0	0.0	0.3	84.9	10.9	0.0	3.8
F23	MATTAPONI RIVER/GARNETTS CREEK	0.0	0.0	0.6	63.0	33.5	0.0	2.9	0.0	0.0	0.2	72.6	13.7	0.0	13.4	0.0	0.0	0.2	74.8	9.8	0.0	15.2

nodata - EMAP data unavailable
low - low intensity developed
high - high intensity developed
wood - wooded
herb - herbaceous vegetation
exp - exposed soil

Table 10. Land use data within 100 and 300 foot stream buffers and entire subwatersheds for 11-digit hydrologic units in Virginia.

ID	Watershed	Land use statistics for the entire watershed							Land use statistics for the 300' buffer							Land use statistics for the 100' buffer						
		nodat	low	high	wood	herb	exp	water	nodat	low	high	wood	herb	exp	water	nodat	low	high	wood	herb	exp	water
F24	MATTAPONI RIVER/COURTHOUSE CREEK	0.0	0.0	0.3	65.6	28.4	0.0	5.6	0.0	0.0	0.2	60.8	19.1	0.0	19.8	0.0	0.0	0.3	61.1	16.0	0.0	22.6
F25	LOWER MATTAPONI RIVER	0.0	0.0	0.7	62.6	29.1	0.0	7.7	0.0	0.0	0.8	56.4	25.5	0.0	17.4	0.0	0.0	0.7	56.6	23.9	0.0	18.8
F26	UPPER YORK RIVER/POROPOTANK RIVER/QUEEN CREEK/WARE CREEK	0.0	0.3	5.0	60.1	34.6	0.1	0.0	0.0	0.0	1.3	52.5	27.3	0.0	18.9	0.0	0.0	1.2	52.1	25.7	0.0	21.0
F27	LOWER YORK RIVER/CARTER CREEK/KING CREEK	0.0	1.4	25.1	46.4	27.0	0.1	0.0	0.0	0.0	11.2	32.1	19.3	0.0	36.9	0.0	0.6	9.1	31.3	17.8	0.0	41.1
G01	JAMES RIVER/FALLING CREEK/PROCTORS CREEK	0.0	6.3	37.9	32.1	23.6	0.2	0.0	0.0	0.2	21.0	47.2	14.2	0.4	14.5	0.0	2.5	18.0	51.4	11.5	0.4	16.3
G02	JAMES RIVER/TURKEY ISLAND CREEK/FOURMILE CREEK	0.0	0.7	4.5	57.1	37.4	0.3	0.0	0.0	0.0	2.0	46.9	19.8	0.4	30.3	0.0	0.7	1.8	46.7	16.9	0.4	33.5
G03	JAMES RIVER/POWELL CREEK/WEST RUN/BAILEY CREEK	15.8	1.0	4.7	51.6	27.0	0.0	0.0	9.6	0.0	2.2	55.6	13.0	0.0	19.2	9.7	0.3	1.7	55.1	10.4	0.0	22.8
G04	JAMES RIVER/WARDS CREEK/UPPER CHIPPOKES CREEK	17.9	0.0	0.6	58.8	22.7	0.0	0.0	12.1	0.0	0.2	52.6	10.3	0.0	24.9	12.1	0.0	0.1	51.2	7.7	0.1	28.9
G05	UPPER CHICKAHOMINY RIVER/UPHAM BROOK/STONY RUN	0.0	4.0	30.7	40.1	24.8	0.0	0.4	0.0	0.1	21.2	57.0	17.7	0.0	3.0	0.0	0.9	18.6	61.9	14.5	0.0	4.0
G06	CHICKAHOMINY RIVER/WHITE OAK SWAMP/BEAVERDAM CREEK	0.0	0.8	13.0	56.2	30.1	0.0	0.0	0.0	0.0	5.4	77.3	12.1	0.0	5.0	0.0	0.2	4.8	79.4	9.4	0.0	6.1
G07	CHICKAHOMINY RIVER/RUMLEY MARSH	0.0	0.1	2.3	74.5	19.5	0.0	3.7	0.0	0.0	1.3	73.2	6.9	0.0	18.7	0.0	0.0	1.1	74.1	4.9	0.0	19.9
G08	LOWER CHICKAHOMINY RIVER/MORRIS CREEK/LOWER DIASCUND CREE	0.0	0.0	2.5	71.7	25.7	0.1	0.0	0.0	0.0	0.9	52.7	16.4	0.1	29.9	0.0	0.0	0.6	51.1	13.6	0.0	34.6
G09	UPPER DIASCUND CREEK/DIASCUND CREEK RESERVOIR	0.0	0.0	3.1	79.0	13.2	0.0	4.7	0.0	0.0	2.1	67.6	7.3	0.0	23.0	0.0	0.0	2.1	66.1	5.5	0.0	26.3
G10	JAMES RIVER/POWHATAN CREEK/GRAYS CREEK	5.8	0.5	13.4	48.0	32.3	0.0	0.0	2.1	0.0	6.1	53.5	20.1	0.1	17.9	2.1	0.2	5.1	53.9	18.4	0.1	20.3
G11	JAMES RIVER/PAGEN RIVER/WARWICK RIVER/CHUCKATUCK CREEK	0.0	3.4	18.0	40.9	36.7	1.0	0.0	0.0	0.0	7.4	35.2	26.5	0.7	28.6	0.0	1.5	6.2	35.4	23.8	0.9	32.2
G12	SPEIGHTS RUN/LAKE COHOON/LAKE MEADE/LAKE KILBY	36.9	0.7	5.4	22.8	34.2	0.0	0.0	22.0	0.1	2.5	30.0	17.6	0.0	27.7	22.1	0.2	2.0	30.4	14.3	0.0	31.1
G13	NANSEMOND RIVER/BENNETT CREEK	15.4	2.4	12.0	28.7	41.6	0.0	0.0	8.7	0.0	5.4	23.7	39.8	0.0	21.8	8.6	0.5	4.5	24.5	35.9	0.0	25.9
G14	WESTERN BRANCH RESERVOIR	0.0	0.4	2.0	39.1	58.2	0.3	0.0	0.0	0.0	0.6	35.9	23.9	0.1	39.5	0.0	0.0	0.6	35.7	19.3	0.1	44.3
G15	HAMPTON ROADS/ELIZABETH RIVER	10.2	14.4	47.9	13.0	14.5	0.0	0.0	8.1	0.0	23.0	10.5	10.9	0.2	35.7	8.1	11.8	20.2	9.8	10.0	0.2	39.9
H01	JAMES RIVER/REED CREEK	20.3	0.1	1.8	71.1	6.7	0.0	0.0	13.4	0.0	3.1	63.3	7.9	0.1	12.0	13.4	0.2	2.5	62.1	7.5	0.1	14.2
H02	PEDLAR RIVER	0.0	0.0	0.7	84.7	14.3	0.0	0.2	0.0	0.0	0.3	80.8	17.5	0.0	1.4	0.0	0.0	0.3	79.8	18.4	0.0	1.5
H03	JAMES RIVER/BLACKWATER CREEK/IVY CREEK	22.2	1.4	23.5	45.4	7.4	0.0	0.0	17.4	0.1	12.6	52.2	5.6	0.0	11.0	17.4	0.8	10.5	53.3	4.8	0.0	13.1
H04	HARRIS CREEK	0.0	0.1	6.9	67.0	25.7	0.0	0.3	0.0	0.0	5.2	67.6	25.3	0.0	1.9	0.0	0.1	4.6	69.3	24.0	0.0	2.1
H05	JAMES RIVER/BEAVER CREEK/BECK CREEK	6.5	0.3	6.7	68.0	18.5	0.0	0.0	4.9	0.1	4.3	64.1	15.4	0.2	10.7	4.9	0.3	3.8	66.0	13.1	0.2	11.6
H06	WRECK ISLAND CREEK	0.0	0.1	2.8	57.5	39.6	0.0	0.0	0.0	0.0	2.3	64.2	33.0	0.0	0.5	0.0	0.0	2.3	68.5	28.6	0.0	0.7
H07	BENT CREEK	0.0	0.0	0.3	68.1	31.5	0.0	0.1	0.0	0.0	0.1	73.7	26.0	0.0	0.3	0.0	0.0	0.0	75.4	24.2	0.0	0.5
H08	JAMES RIVER/DAVID CREEK	0.0	0.0	0.2	74.6	23.9	0.0	1.3	0.0	0.0	0.2	72.4	19.1	0.0	8.3	0.0	0.0	0.2	74.2	16.8	0.0	8.8
H09	UPPER TYE RIVER	0.0	0.0	0.4	73.3	26.2	0.0	0.1	0.0	0.0	0.5	67.7	30.9	0.0	0.9	0.0	0.0	0.5	67.8	30.2	0.0	1.5
H10	PINEY RIVER	0.0	0.0	0.2	75.1	24.5	0.1	0.1	0.0	0.0	0.6	67.3	31.4	0.3	0.5	0.0	0.0	0.7	68.1	30.3	0.3	0.6
H11	UPPER BUFFALO RIVER	0.0	0.0	0.7	70.3	28.5	0.0	0.5	0.0	0.0	0.3	61.8	35.3	0.0	2.6	0.0	0.0	0.3	60.7	36.0	0.0	3.0
H12	LOWER BUFFALO RIVER	0.0	0.1	2.3	68.4	29.0	0.0	0.2	0.0	0.0	2.1	73.2	22.9	0.0	1.8	0.0	0.0	1.8	76.2	19.9	0.0	2.1
H13	LOWER TYE RIVER/RUCKER RUN	0.0	0.0	0.9	69.7	28.9	0.0	0.5	0.0	0.0	1.1	63.9	31.5	0.0	3.5	0.0	0.0	0.7	63.6	29.6	0.0	6.1

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low - low intensity developed
high - high intensity developed
wood - wooded
herb - herbaceous vegetation
exp - exposed soil

Table 10. Land use data within 100 and 300 foot stream buffers and entire subwatersheds for 11-digit hydrologic units in Virginia.

ID	Watershed	Land use statistics for the entire watershed							Land use statistics for the 300' buffer							Land use statistics for the 100' buffer						
		nodat	low	high	wood	herb	exp	water	nodat	low	high	wood	herb	exp	water	nodat	low	high	wood	herb	exp	water
H14	JAMES RIVER/SYCAMORE CREEK	0.0	0.0	0.3	79.8	17.4	0.1	2.4	0.0	0.0	0.3	69.2	12.9	0.7	16.9	0.0	0.0	0.2	70.2	10.0	0.8	18.8
H15	NORTH FORK ROCKFISH RIVER/SOUTH FORK ROCKFISH RIVER	0.0	0.0	0.4	76.6	22.8	0.0	0.1	0.0	0.0	0.6	65.0	33.6	0.0	0.9	0.0	0.0	0.8	65.7	32.4	0.0	1.1
H16	LOWER ROCKFISH RIVER	0.0	0.0	0.7	81.7	17.4	0.0	0.2	0.0	0.0	1.4	73.1	24.3	0.0	1.2	0.0	0.0	1.2	71.5	25.3	0.0	2.0
H17	JAMES RIVER/TOTIER CREEK/ROCK ISLAND CREEK	0.0	0.0	0.5	64.5	32.8	0.0	2.2	0.0	0.0	0.6	60.7	23.4	0.0	15.3	0.0	0.1	0.4	62.5	20.3	0.0	16.7
H18	NORTH FORK HARDWARE RIVER/SOUTH FORK HARDWARE RIVER	0.0	0.0	1.1	69.2	29.5	0.1	0.2	0.0	0.0	1.8	56.4	40.2	0.0	1.7	0.0	0.0	1.6	56.9	39.4	0.0	2.1
H19	HARDWARE RIVER	0.0	0.0	0.4	56.7	42.5	0.0	0.4	0.0	0.0	0.4	60.3	36.7	0.0	2.7	0.0	0.0	0.4	61.6	35.0	0.0	3.0
H20	JAMES RIVER/BEAR GARDEN CREEK/SOUTH CREEK	0.0	0.0	1.4	64.5	34.0	0.0	0.0	0.0	0.0	1.7	58.5	24.4	0.0	15.4	0.0	0.0	1.9	59.3	21.6	0.0	17.1
H21	UPPER SLATE RIVER	0.0	0.0	0.7	74.7	24.4	0.0	0.2	0.0	0.0	0.1	80.4	18.3	0.0	1.3	0.0	0.0	0.1	83.6	14.8	0.0	1.6
H22	LOWER SLATE RIVER	0.0	0.0	1.2	61.5	36.5	0.5	0.4	0.0	0.0	0.3	64.7	33.6	0.5	0.8	0.0	0.0	0.2	65.4	33.1	0.4	0.8
H23	MECHUMS RIVER	0.0	0.0	2.2	62.6	34.8	0.0	0.5	0.0	0.0	2.5	57.5	36.0	0.0	4.1	0.0	0.0	2.3	58.9	34.3	0.0	4.6
H24	MOORMANS RIVER	0.0	0.0	0.0	82.2	17.6	0.0	0.2	0.0	0.0	0.0	70.5	27.3	0.0	2.2	0.0	0.0	0.0	72.9	24.8	0.0	2.3
H25	BUCK MOUNTAIN CREEK	0.0	0.0	0.1	62.5	37.4	0.0	0.1	0.0	0.0	0.3	47.9	50.7	0.3	0.8	0.0	0.0	0.2	48.4	50.2	0.4	0.9
H26	SOUTH FORK RIVANNA RIVER/IVY CREEK	0.0	0.4	6.2	50.6	41.1	0.0	1.7	0.0	0.0	2.9	52.0	30.3	0.0	14.8	0.0	0.0	2.2	53.0	27.6	0.0	17.2
H27	NORTH FORK RIVANNA RIVER/SWIFT RUN/PREDDY CREEK	0.0	0.0	0.6	58.0	41.4	0.0	0.0	0.0	0.0	0.5	44.9	50.8	0.2	3.7	0.0	0.0	0.2	43.6	51.9	0.2	4.0
H28	UPPER RIVANNA RIVER/MOORES CREEK	0.0	3.1	17.5	56.0	22.8	0.0	0.7	0.0	0.0	12.8	48.9	31.3	0.0	6.5	0.0	0.3	12.0	48.2	30.6	0.0	8.9
H29	MIDDLE RIVANNA RIVER/BUCK ISLAND CREEK	0.0	0.0	2.2	60.3	36.6	0.0	0.9	0.0	0.0	1.5	55.2	37.3	0.0	5.9	0.0	0.0	1.3	54.1	36.0	0.0	8.6
H30	MECHUNK CREEK	0.0	0.0	1.3	58.0	40.4	0.0	0.4	0.0	0.0	2.0	52.1	42.6	0.0	3.3	0.0	0.0	1.9	52.4	41.9	0.0	3.8
H31	LOWER RIVANNA RIVER/BALLINGER CREEK	0.0	0.0	3.6	60.5	34.4	0.0	1.5	0.0	0.0	4.7	59.5	27.7	0.0	8.1	0.0	0.0	4.3	58.7	25.8	0.0	11.3
H32	CUNNINGHAM CREEK	0.0	0.0	0.2	67.2	32.2	0.0	0.4	0.0	0.0	0.1	67.7	29.0	0.0	3.1	0.0	0.0	0.0	67.0	29.3	0.0	3.6
H33	JAMES RIVER/DEEP CREEK/MUDDY CREEK	0.0	0.0	1.2	60.7	36.1	0.0	2.1	0.0	0.0	1.4	59.1	26.3	0.0	13.1	0.0	0.0	1.4	59.6	23.9	0.0	15.1
H34	BYRD CREEK	0.0	0.0	0.4	60.2	39.3	0.0	0.2	0.0	0.0	0.2	65.9	32.8	0.0	1.0	0.0	0.0	0.3	66.9	31.7	0.0	1.1
H35	UPPER WILLIS RIVER	0.0	0.0	1.1	64.6	33.6	0.0	0.7	0.0	0.0	0.6	71.4	24.4	0.0	3.6	0.0	0.0	0.5	72.8	22.5	0.0	4.3
H36	LOWER WILLIS RIVER	0.0	0.0	0.8	63.1	35.8	0.0	0.3	0.0	0.0	0.2	72.6	24.7	0.0	2.5	0.0	0.0	0.2	74.1	22.9	0.0	2.8
H37	BIG LICKINGHOLE CREEK	0.0	0.0	1.3	60.4	38.0	0.0	0.3	0.0	0.0	0.7	64.5	31.8	0.0	3.0	0.0	0.0	0.6	65.4	30.5	0.0	3.4
H38	JAMES RIVER/BEAVERDAM CREEK/FINE CREEK	0.4	0.1	1.7	57.7	40.1	0.0	0.0	0.5	0.0	1.2	57.1	26.6	0.0	14.6	0.4	0.1	1.0	58.6	23.4	0.0	16.5
H39	JAMES RIVER/TUCKAHOE CREEK/NORWOOD CREEK	0.0	1.8	18.2	53.1	26.8	0.0	0.0	0.1	0.1	9.9	53.7	20.0	0.0	15.4	0.0	0.8	8.6	56.1	17.3	0.0	17.1
I01	UPPER JACKSON RIVER	0.0	0.0	0.6	69.8	29.6	0.0	0.0	0.0	0.0	2.7	47.0	50.2	0.0	0.2	0.0	0.0	3.9	47.6	48.3	0.0	0.2
I02	BACK CREEK	25.7	0.0	0.4	61.2	11.9	0.9	0.0	12.5	0.0	2.5	51.4	28.2	2.6	2.8	12.5	0.0	3.4	50.3	28.1	2.6	3.1
I03	LAKE MOOMAW/HUGHES DRAFT	26.7	0.0	0.1	71.5	1.7	0.0	0.0	13.3	0.0	0.4	56.4	5.1	0.0	24.7	13.3	0.1	0.6	53.7	6.0	0.0	26.3
I04	JACKSON RIVER/FALLING SPRING CREEK	0.0	0.4	1.3	78.9	18.6	0.0	0.8	0.0	0.0	1.6	68.5	25.2	0.0	3.8	0.0	0.8	1.2	66.3	25.7	0.0	5.9
I05	CEDAR CREEK	0.0	0.0	1.0	86.7	12.2	0.0	0.0	0.0	0.0	2.6	73.3	24.1	0.0	0.0	0.0	0.0	2.9	73.2	24.0	0.0	0.0
I06	COVE CREEK/SWEET SPRINGS CREEK	0.0	0.0	0.1	78.6	21.3	0.0	0.0	5.4	0.0	0.1	49.2	45.3	0.0	0.0	5.4	0.0	0.0	48.4	46.2	0.0	0.0

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high - high intensity developed
wood - wooded
herb - herbaceous vegetation
exp - exposed soil

Table 10. Land use data within 100 and 300 foot stream buffers and entire subwatersheds for 11-digit hydrologic units in Virginia.

ID	Watershed	Land use statistics for the entire watershed							Land use statistics for the 300' buffer							Land use statistics for the 100' buffer						
		nodat	low	high	wood	herb	exp	water	nodat	low	high	wood	herb	exp	water	nodat	low	high	wood	herb	exp	water
I07	DUNLAP CREEK	9.6	0.1	1.0	81.7	7.6	0.0	0.0	8.0	0.0	1.9	75.8	14.1	0.0	0.1	8.0	0.2	1.6	76.2	14.0	0.0	0.1
I08	OGLE CREEK	0.0	0.0	1.8	92.0	6.2	0.0	0.0	23.9	0.0	3.0	60.1	12.9	0.0	0.0	23.9	0.0	3.0	60.0	13.2	0.0	0.0
I09	LOWER JACKSON RIVER/WILSON CREEK/KARNES CREEK	0.0	0.8	4.8	86.7	6.9	0.0	0.9	0.0	0.1	7.9	77.0	8.0	0.0	6.1	0.0	0.7	6.6	76.6	7.3	0.0	8.9
I10	UPPER POTTS CREEK	0.0	0.0	0.1	89.7	10.2	0.0	0.0	0.0	0.0	0.3	81.2	18.6	0.0	0.0	0.0	0.0	0.3	82.3	17.4	0.0	0.0
I11	LOWER POTTS CREEK	0.0	0.0	0.3	87.4	12.4	0.0	0.0	0.0	0.0	0.6	78.5	20.9	0.0	0.0	0.0	0.0	0.5	80.0	19.5	0.0	0.0
I12	UPPER COWPASTURE RIVER	0.0	0.0	0.3	86.6	13.1	0.0	0.0	0.0	0.0	1.9	66.5	31.6	0.0	0.0	0.0	0.0	3.0	66.3	30.7	0.0	0.0
I13	BULLPASTURE RIVER	0.0	0.0	0.3	68.2	31.5	0.0	0.0	0.0	0.0	1.9	42.8	55.3	0.0	0.0	0.0	0.0	2.7	40.4	56.9	0.0	0.0
I14	COWPASTURE RIVER/THOMPSON CREEK/DRY RUN	0.0	0.0	0.6	80.7	18.4	0.0	0.3	0.0	0.0	2.2	68.9	25.8	0.0	3.1	0.0	0.0	2.1	71.7	21.6	0.0	4.5
I15	STUART RUN	0.0	0.0	0.6	87.7	11.6	0.0	0.1	0.0	0.0	2.3	70.5	26.0	0.0	1.3	0.0	0.0	2.5	72.2	23.8	0.0	1.5
I16	COWPASTURE RIVER/MILL CREEK	0.0	0.0	0.4	86.2	12.7	0.0	0.7	0.0	0.0	0.7	80.4	14.4	0.0	4.5	0.0	0.0	0.4	80.0	10.7	0.0	8.9
I17	LOWER COWPASTURE RIVER/SIMPSON CREEK/PADS CREEK	0.0	0.0	2.8	90.2	6.6	0.0	0.4	0.0	0.0	5.9	83.7	8.3	0.0	2.2	0.0	0.0	5.3	83.8	6.7	0.0	4.2
I18	UPPER JAMES RIVER/SINKING CREEK/MILL CREEK	0.0	0.0	1.4	81.8	15.8	0.0	0.9	0.0	0.0	3.1	68.9	20.0	0.0	8.0	0.0	0.0	2.8	69.1	17.2	0.0	11.0
I19	UPPER CRAIG CREEK	0.0	0.0	0.3	91.6	8.1	0.0	0.0	1.1	0.0	0.5	81.9	16.6	0.0	0.0	1.2	0.0	0.4	82.1	16.4	0.0	0.0
I20	MEADOW CREEK	0.0	0.0	0.3	50.4	49.2	0.0	0.0	0.0	0.0	0.5	36.3	63.1	0.0	0.0	0.0	0.0	0.2	33.3	66.5	0.0	0.0
I21	JOHNS CREEK	4.3	0.0	0.2	85.5	10.0	0.0	0.0	2.3	0.0	0.4	78.5	18.8	0.0	0.0	2.3	0.0	0.4	80.0	17.3	0.0	0.0
I22	LOWER CRAIG CREEK/PATTERSON CREEK/LOWER BARBOURS CREEK	0.0	0.0	0.5	84.9	14.4	0.1	0.1	0.0	0.0	0.7	78.8	20.0	0.0	0.5	0.0	0.0	0.6	81.5	17.1	0.0	0.7
I23	UPPER BARBOURS CREEK	0.0	0.0	0.0	96.1	3.9	0.0	0.0	0.0	0.0	0.2	91.8	8.0	0.0	0.0	0.0	0.0	0.2	92.3	7.5	0.0	0.0
I24	JAMES RIVER/LAPSLEY RUN	0.0	0.0	2.6	65.6	30.1	0.0	1.7	0.0	0.0	6.2	48.6	30.7	0.0	14.5	0.0	0.0	5.2	48.3	27.7	0.0	18.7
I25	CATAWBA CREEK	5.5	0.0	2.7	59.7	32.2	0.0	0.0	4.1	0.0	4.2	51.4	40.3	0.0	0.0	4.1	0.0	4.5	51.6	39.8	0.0	0.0
I26	LOONEY CREEK/MILL CREEK	16.1	0.0	4.3	39.5	40.1	0.0	0.0	14.0	0.0	8.0	34.5	43.5	0.0	0.0	14.0	0.0	8.9	34.4	42.7	0.0	0.0
I27	JAMES RIVER/JENNINGS CREEK	5.5	0.0	3.4	76.7	14.4	0.0	0.0	5.9	0.0	6.5	61.1	15.0	0.1	11.5	5.9	0.0	5.8	60.1	13.0	0.1	15.1
I28	JAMES RIVER/ELK CREEK/CEDAR CREEK	0.5	0.2	3.5	75.4	20.4	0.0	0.0	0.1	0.0	5.3	68.2	17.5	0.0	8.9	0.0	0.1	4.2	69.2	15.4	0.0	11.1
I29	UPPER CALFPASTURE RIVER	0.0	0.0	0.5	91.5	8.1	0.0	0.0	0.0	0.0	2.3	80.6	16.9	0.0	0.2	0.0	0.0	3.0	81.3	15.5	0.0	0.3
I30	LOWER CALFPASTURE RIVER/MILL CREEK	0.0	0.0	1.3	83.0	15.6	0.0	0.2	0.0	0.0	5.2	68.7	24.6	0.0	1.5	0.0	0.0	5.4	70.9	21.2	0.0	2.5
I31	BRATTONS RUN	0.0	0.1	1.0	90.0	8.5	0.4	0.0	0.0	0.2	0.6	87.8	10.8	0.6	0.0	0.0	0.1	0.3	89.0	10.1	0.5	0.0
I32	LITTLE CALFPASTURE RIVER	0.0	0.1	2.4	78.8	17.9	0.0	0.9	0.0	0.1	8.4	59.4	27.2	0.0	4.7	0.0	0.2	8.5	61.8	24.4	0.0	5.0
I33	UPPER MAURY RIVER/KERRS CREEK	0.0	0.0	3.2	62.0	34.1	0.0	0.7	0.0	0.0	5.8	53.8	36.4	0.0	4.0	0.0	0.0	5.7	51.7	35.3	0.0	7.3
I34	HAYS CREEK	0.0	0.0	1.4	48.7	49.8	0.0	0.0	0.0	0.0	5.3	39.8	54.9	0.0	0.0	0.0	0.0	6.1	40.7	53.3	0.0	0.0
I35	MIDDLE MAURY RIVER/MILL CREEK	0.0	1.1	13.8	41.8	42.7	0.0	0.6	0.0	0.0	15.3	38.6	42.2	0.0	3.6	0.0	0.4	12.4	39.1	42.5	0.0	5.6
I36	SOUTH RIVER	0.0	0.0	2.8	69.4	27.8	0.0	0.1	0.0	0.0	5.2	66.3	28.1	0.0	0.4	0.0	0.0	5.7	66.5	27.4	0.0	0.4
I37	LOWER MAURY RIVER/POAGUE RUN	0.0	1.0	6.4	64.6	26.9	0.0	1.1	0.0	0.1	8.3	55.2	28.3	0.0	7.1	0.0	0.9	6.8	54.3	26.1	0.0	12.0
I38	BUFFALO CREEK	0.0	0.0	2.1	69.6	28.2	0.0	0.1	0.0	0.0	4.6	59.1	35.5	0.0	0.8	0.0	0.0	4.1	60.6	34.2	0.0	1.1

nodata - EMAP data unavailable
low - low intensity developed
high - high intensity developed
wood - wooded
herb - herbaceous vegetation
exp - exposed soil

Table 10. Land use data within 100 and 300 foot stream buffers and entire subwatersheds for 11-digit hydrologic units in Virginia.

ID	Watershed	Land use statistics for the entire watershed							Land use statistics for the 300' buffer							Land use statistics for the 100' buffer						
		nodat	low	high	wood	herb	exp	water	nodat	low	high	wood	herb	exp	water	nodat	low	high	wood	herb	exp	water
J01	UPPER APPOMATTOX RIVER	0.3	0.1	2.1	65.4	32.1	0.0	0.0	0.2	0.0	0.9	73.4	23.8	0.0	1.5	0.2	0.1	0.8	77.0	20.1	0.0	1.9
J02	BUFFALO CREEK/SPRING CREEK	8.9	0.0	1.4	60.0	29.7	0.0	0.0	5.9	0.0	0.9	69.8	19.1	0.0	4.4	5.9	0.0	0.9	70.9	17.5	0.0	4.7
J03	SANDY RIVER	0.6	0.0	1.9	58.5	38.4	0.0	0.7	0.0	0.0	1.1	70.2	23.6	0.0	5.1	0.0	0.0	0.9	72.6	21.1	0.0	5.4
J04	BUSH RIVER	10.1	0.0	1.3	62.5	26.0	0.0	0.2	6.8	0.0	0.4	73.7	18.4	0.0	0.7	6.8	0.0	0.4	75.2	16.5	0.0	1.1
J05	BRIERY CREEK	14.1	0.1	1.9	52.6	31.4	0.0	0.0	14.2	0.0	0.7	51.4	21.1	0.0	12.7	14.1	0.0	0.4	52.7	18.9	0.0	13.8
J06	APPOMATTOX RIVER/BIG GUINEA CREEK/SAYLERS CREEK	0.0	0.0	0.8	56.4	42.4	0.0	0.5	0.0	0.0	0.2	70.5	26.3	0.0	3.1	0.0	0.0	0.2	73.1	23.3	0.0	3.5
J07	APPOMATTOX RIVER/SKINQUARTER CREEK/ROCKY FORD CREEK	0.3	0.0	0.5	60.4	38.8	0.0	0.0	0.2	0.0	0.4	75.0	20.7	0.0	3.7	0.2	0.0	0.4	77.2	17.4	0.0	4.8
J08	FLAT CREEK	0.0	0.0	1.3	56.7	42.0	0.1	0.0	0.0	0.0	0.4	72.7	25.3	0.0	1.6	0.0	0.0	0.3	75.2	22.7	0.0	1.8
J09	NIBBS CREEK	0.0	0.2	2.3	45.3	51.9	0.0	0.3	0.0	0.0	1.2	63.5	34.2	0.0	1.2	0.0	0.0	1.1	68.5	29.0	0.0	1.4
J10	APPOMATTOX RIVER/SMACKS CREEK/SAPPONY CREEK	0.2	0.0	1.8	69.8	28.1	0.0	0.0	0.2	0.0	1.1	79.1	15.7	0.0	3.9	0.2	0.0	0.9	79.3	13.7	0.0	6.0
J11	DEEP CREEK	6.5	0.1	1.0	56.9	35.5	0.0	0.0	5.7	0.0	0.3	71.0	20.7	0.0	2.3	5.7	0.0	0.3	73.3	18.1	0.0	2.6
J12	LAKE CHESDIN/WINTERPOCK CREEK/WINTICOMACK CREEK	0.1	0.0	0.9	76.3	20.2	0.0	2.5	0.1	0.0	0.1	81.3	10.0	0.0	8.5	0.1	0.0	0.1	81.0	7.8	0.0	11.0
J13	NAMOZINE CREEK	7.9	0.0	0.5	68.2	22.7	0.0	0.8	5.7	0.0	0.3	78.6	11.9	0.0	3.6	5.7	0.0	0.3	80.6	10.2	0.0	3.2
J14	LAKE CHESDIN/WHIPPONOCK CREEK	1.1	0.0	0.8	65.8	32.2	0.0	0.0	0.0	0.0	0.5	56.7	14.5	0.0	28.3	0.0	0.0	0.3	57.2	11.1	0.0	31.3
J15	LOWER APPOMATTOX RIVER/ASHTON CREEK	11.6	3.6	20.2	38.6	26.0	0.0	0.0	5.2	0.1	9.7	48.3	10.5	0.0	23.7	5.2	2.3	8.0	47.5	7.9	0.0	29.1
J16	UPPER SWIFT CREEK/SWIFT CREEK RESERVOIR	0.0	0.1	6.5	71.0	18.4	0.0	4.0	0.0	0.0	6.8	72.1	9.7	0.0	11.4	0.0	0.0	6.2	73.8	7.5	0.0	12.5
J17	LOWER SWIFT CREEK	0.0	0.6	9.2	69.0	19.9	0.0	1.3	0.0	0.1	4.9	75.4	9.3	0.0	9.8	0.0	0.5	4.0	76.3	7.2	0.0	11.9
K15	LITTLE NOTTOWAY RIVER	76.6	0.2	1.5	10.4	11.3	0.0	0.0	0.0	0.0	10.8	33.2	31.4	0.0	24.6	0.0	0.0	13.7	31.5	26.7	0.0	28.1

nodata - EMAP data unavailable
low - low intensity developed
high - high intensity developed
wood - wooded
herb - herbaceous vegetation
exp - exposed soil

Head water streams (1-2 order) located on ridge tops were buffered 300' or more on both sides a larger percent of the time contrasted with higher ordered streams located in the valleys which were not buffered as well. Larger (> 5th order) and trunk streams were generally showed relatively low buffering. Further fragmentation and correlation analysis is necessary to support and quantify these observations.

The percentage of land use was generally comparable between the 100 and 300' buffer zones. However two minor differences were noted between the land use statistics in the buffers and the overall watershed. A higher percentage of water and lower percentage of urbanization was observed in the 100' and 300' riparian corridor. The former makes sense given that the riparian corridor contains fewer total pixels, allowing the water pixels caused by streams to be more influential in the statistics. Casual observation of the raw pixels in one 300' corridor in one quadrangle revealed that water pixels were not always observed in the riparian corridor. Furthermore, when water pixels were observed, they were not always located in the center. Several possible interpretations can explain this including, (1) streams are sometimes obscured by surrounding land use (canopy, for example) or local conditions at the time the imagery was collected so as to not be classified as water, (2) thematic mapper imagery and classification procedures were not sensitive enough to pick up water bodies below the 30m pixel size, or (3) streams coverages may not always accurate represent the location of stream margins, causing the location of the riparian corridor to be offset of its true position. This third interpretation is definitely true in some areas, where the stream meander can be directly observed at the edge of the data.

Evaluation of the approximately 100 quality control quadrangles suggest that the algorithm performs pretty well for predicting streams with 300' or greater buffering on one or both sides but is more inaccurate at predicting streams with 100-300' of buffering (Table 11). The median absolute error between the miles of streams predicted by the automated algorithm to be buffered both 300' or more on both sides for a quarter quadrangle and the quality control results using aerial photography or digital orthophotos is 7.3% for the Bay and varies from 5-7% among the states. Algorithm accuracy was generally less for the 100 foot buffer compared to the 300 foot buffer. This was expected due limitations caused by the scale and quality of the input datalayers as discussed above. The variability in error among the states was generally very consistent suggesting that the algorithm worked equally well throughout the Bay watershed.

The inconsistencies in stream density throughout the Chesapeake Bay streams datalayer may be reflected in the data. For example, Pennsylvania exhibits a relatively low percentage of streams that have a buffer less than 100 feet. This may be due to the fact that the streams data for Pennsylvania was digitized at a larger scale than other parts of the Bay streams layer and exhibits a visibly higher density of streams. It may be that small intermittent streams have been digitized in Pennsylvania and not throughout other parts of the Bay and that these small streams may be more likely to be on steeper terrain that is less likely to be disturbed and has a higher chance of being forested. We will look at these types of data artifacts in the future.

Table 11. Quality control summary statistics Maryland, Pennsylvania, Virginia, and the Chesapeake Bay.

Region	Statistic	Relative Error[1]				Absolute Error[2]			
		Both sides 300' + %	Both sides 100-300 %	One side 300' + %	One side 100-300' %	Both sides 300' + %	Both sides 100-300 %	One side 300' + %	One side 100-300' %
MD	n	12	12	12	12	12	12	12	.12
	mean	-6.57	-3.61	-16.74	-4.87	11.00	13.16	23.43	11.76
	median	-1.44	1.42	-8.29	-1.16	5.02	8.80	13.71	7.28
	minimum	-43.87	-40.99	-78.22	-34.19	0.67	0.06	0.72	0.49
	maximum	9.11	18.29	15.85	19.45	43.87	40.99	78.22	34.19
	5% rank	-40.67	-36.43	-71.34	-34.05	1.15	1.55	3.31	0.70
	95%rank	8.50	17.48	13.50	16.71	40.67	36.43	71.34	34.05
PA	n	44	44	44	44	44	44	44	44
	mean	2.01	15.64	2.94	0.29	9.80	17.42	9.39	9.56
	median	1.24	15.97	4.73	-0.93	7.65	15.97	7.29	6.51
	minimum	-21.49	-13.24	-23.34	-31.50	0.24	0.09	0.18	0.70
	maximum	38.28	48.09	33.80	44.40	38.28	48.09	33.80	44.40
	5% rank	-18.49	-6.32	-17.14	-17.79	0.62	1.07	0.79	1.21
	95%rank	21.64	43.09	18.78	20.28	21.90	43.09	22.72	22.87
VA	n	41	41	41	41	41	41	41	41
	mean	1.14	18.26	-2.24	-4.30	8.75	19.09	9.26	10.77
	median	0.68	17.91	-0.96	-4.63	7.42	17.91	6.53	10.35
	minimum	-26.52	-13.63	-29.30	-38.60	0.04	0.07	0.03	0.20
	maximum	25.66	51.26	33.26	38.99	26.52	51.26	33.26	38.99
	5% rank	-15.94	-0.07	-22.76	-19.05	0.34	1.89	0.37	1.06
	95%rank	17.09	42.85	21.09	15.69	21.00	42.85	23.43	24.66
C. BAY	n	103	103	103	103	103	103	103	103
	mean	0.58	14.37	-1.69	-2.29	9.50	17.60	11.07	10.34
	median	0.67	14.88	0.37	-2.80	7.31	15.48	7.94	7.91
	minimum	-43.87	-40.99	-78.22	-38.60	0.04	0.06	0.03	0.20
	maximum	38.28	51.26	33.80	44.40	43.87	51.26	78.22	44.40
	5% rank	-21.44	-13.47	-28.71	-30.71	0.62	0.28	0.68	0.72
	95%rank	19.71	42.72	19.01	19.45	26.16	42.72	32.95	33.70

Notes: 1 - Automated method results minus quality control results
2 - Absolute value of relative errors

The automated algorithm took only 20 days on a SUN Ultra Sparc workstation to process the entire Bay watershed. This is much less than any manual inventory method and will produce better, more consistent results. This provides a good tool to reevaluate buffer conditions in the future as better data layers become available and will allow us to inexpensively keep up with rapidly changing land use conditions.

CONCLUSIONS

Riparian stream conditions throughout the Bay watershed estimated using the automated approach show lower percentages of streams with 300 foot forest buffers compared to 100 foot buffers. Results for the Bay were approximately 34% for 300 ft. buffers on both sides, 53% for 100-300 ft. buffers on both sides, 53% for 300 ft. buffers on one side and 60% for 100-300 ft. buffers on one side. Approximately 40% of the streams in the Bay watershed have less than 100 ft. of forest buffer. Variability among the states less than 10% in all buffer categories.

Significant variability was found in buffer conditions among 8 and 11-digit subwatersheds within the Bay. Some correlation between stream buffering conditions and stream order, topography and landscape position were noted.

The automated algorithm was able to predict stream buffer conditions within 8% for 300 ft. buffers and 7-15% for 100 ft. buffers. Algorithm error levels were relatively consistent among states indicating equal reliability throughout the Bay watershed.

The automated algorithm is a significantly better method to inventory riparian forest buffer conditions compared to other manual methods. The method is fast and provides repeatable and consistent results. It provides a powerful tool that will reduce future assessment costs as improved stream and land cover datasets become available.

RECOMMENDATIONS

The algorithm could be rerun on improved streams, land cover, and watershed boundary datasets. The streams coverage for the Bay watershed used in this project had obvious inconsistencies in scale, density and accuracy that may have impacted the results. Improved streams coverages should be produced and used in future analyses. Stream attributes characterizing the stream type, size etc. should be added to the coverage. Land use data is available for the Bay as part of the MRLC program and should be evaluated as an improved land use coverage. Watershed boundaries (11-digit), which currently do not edge-match correctly at state boundaries should be improved.

Additional analyses can be done to better evaluate riparian forest buffer conditions. Fragmentation analyses can be used to quantify the spatial distribution of forest buffer conditions along streams to enhance the current knowledge of percent buffer. Separations could be made in watersheds that may have equal percentages of streams buffered but with differing distributions. The fragmentation analysis could be combined with a better assessment of potential contaminant loadings (nutrient and sediment) for each subwatershed to separate basins that may have similar buffer conditions but different contaminant pressures being exerted upon the buffer. In other words, the analysis would help identify and prioritize those subwatershed that have low buffering coupled with high contaminant pressures. Simple non-point source modeling could be done for each subwatershed using largely available GIS data.

Additional analyses can be done to quantify the relationships between riparian forest buffer conditions and other stream conditions. This might include, but not be limited to, stream order, landscape position, topography, geology, and stream gradient. For example, it might be interesting to see including or not including intermittent streams would affect the results.

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SECTION 5:
STANDARDS, SPECIFICATIONS, AND GUIDELINES

USDA
NATURAL RESOURCES
CONSERVATION SERVICE
MARYLAND
CONSERVATION PRACTICE
STANDARD
RIPARIAN FOREST BUFFER

CODE 391
(Reported in Acres)

DEFINITION

An area of trees and/or shrubs located adjacent to and up-gradient from water bodies.

PURPOSES

1) Reduce excess amounts of sediment, organic material, nutrients, pesticides and other pollutants in surface runoff and reduce excess nutrients and other chemicals in shallow ground water flow.

2) Create shade to moderate water temperatures to improve habitat for fish and other aquatic organisms.

3) Provide a source of detritus and large woody debris for fish and other aquatic organisms.

4) To provide riparian habitat and corridors for wildlife.

CONDITIONS WHERE PRACTICE APPLIES

On stable areas adjacent to permanent or intermittent streams, lakes, ponds, wetlands and areas with ground water recharge. (For areas with unstable banks refer to Streambank Stabilization, practice 580.)

CRITERIA

Criteria Applicable To All Purposes

The location, layout, width, length and woody plant density of the riparian forest buffer will be selected to accomplish the intended purpose and function. The buffer will consist of a zone (identified as zone 1) that begins top of bank, and extends a minimum distance of 15 feet, measured horizontally on a line perpendicular to the water course or water body.

NOTE: The ability to sustain a healthy forest condition, and reduction of sediment, organic material, nutrients and pesticide will be limited if only Zone 1 is established. A minimum buffer width of 35 feet is required in the Chesapeake Bay drainage area.

Dominant vegetation will consist of existing or planted trees and shrubs suited to the site and the intended purpose. Selection of locally native species will be a priority when feasible. Plantings will consist of two or more species in an attempt to achieve greater diversity. Individual plants selected will be suited to the seasonal variation of soil moisture status of individual planting sites. Plant types and species shall be selected based on their compatibility in growth rates and shade tolerance. Select species from the Plant Lists located in Specifications.

Occasional removal of some tree and shrub products such as high value trees is permitted provided the intended purpose is not compromised by the loss of vegetation or harvesting disturbance. *(An approved sediment and erosion control plan is required when harvesting disturbs over 5000 sq. ft., and in the Chesapeake Bay Critical Area a Timber Harvest Plan is required.)*

An adequate upstream or adjacent seed source must be present when using natural regeneration to establish a buffer. Planting is preferred over natural regeneration due to control of plant species present and reduced time for woody plants to reach maturity.

Conservation practice standards are reviewed periodically, and updated if needed. To obtain the current version of this standard, contact the Natural Resources Conservation Service.

Necessary site preparation and planting for establishing new buffers shall be done at a time and manner to insure survival and growth of selected species. Refer to Specifications for care, handling, and planting requirements for woody planting stock.

Only viable, high quality, and adapted planting stock will be used. The method of planting for new buffers shall include hand or machine planting techniques, suited to achieving proper depths and placement for intended purpose and function of the buffer.

Site preparation shall be sufficient for establishment and growth of selected species and be done in a manner that does not compromise the intended purpose. Refer to Specifications for woody planting stock quality requirements and detailed site preparation procedures. Supplemental moisture will be applied if and when necessary to assure early survival and establishment of selected species.

Livestock shall be controlled or excluded as necessary to achieve and maintain the intended purpose. Water course crossings and livestock watering shall be located and sized to minimize impact to buffer vegetation and function. (See Fencing, 382 and Stream Crossing, 232 Standards.)

Harmful pests present on the site will be controlled or eliminated as necessary to achieve and maintain the intended purpose.

Additional Criteria Purpose 1

To reduce excess amounts of sediment, organic material, nutrients, pesticides and other pollutants in surface runoff and reduce excess nutrients and other chemicals in shallow ground water flow.

An additional strip or area of land, (Zone 2), will begin at the edge and up-gradient of zone 1 and extend a minimum distance of 20 feet, measured horizontally on a line perpendicular to the water course or water body. The minimum combined width of zones 1 and 2 will be 100 feet OR 30 percent of the geomorphic flood plain whichever is less, but not less than 35 feet. A Geomorphic floodplain is defined as the area adjacent to a river or stream that is built of alluvial sediments that are associated with the present depositional activity. *(Note: The geomorphic floodplain does not include older land forms, such as terraces, that were formed by similar process but under different hydrologic conditions. These upland terrace positions no longer flood and subsequently do not receive additional alluvial sediments.)* Figure 1 illustrates examples of zone 1 and 2 widths for water courses and water bodies.

Zone 2 may need to be adjusted to include important resource features such as wetlands, steep slopes, or critical habitats.

In this zone the removal of tree and shrub products such as timber, nuts and fruit is permitted on regular basis provided the intended purpose is not compromised by loss of vegetation or harvesting disturbance.

Additional Criteria Purpose 2

To create shade to moderate water temperatures to improve habitat for fish and other aquatic organisms.

A buffer for controlling warm-season water temperatures shall consist of at least zone 1 for water course reaches or water bodies less than or equal to 30 feet in width or water bodies greater than 30 feet wide but less than 1 acre. (NOTE: Buffers for wider water courses or larger water bodies may be valuable but will have only site-specific effects.)

Buffers shall be established or maintained on south and west sides of water courses and bodies insofar as practical. The buffer canopy shall be established to achieve at least 50 percent crown cover with average canopy heights equal to or greater than the width of the water course or 30 feet for water bodies. (See figure 2.)

Buffer species shall include those species listed in the Plant List, Table 1, Specifications, with sufficient height potential. Place drooping or wide-crowned trees and shrubs nearest the water course or body. Shoreline or channel relief (e.g., deeply incised channels) and topographic shading will be taken into account in selecting species.

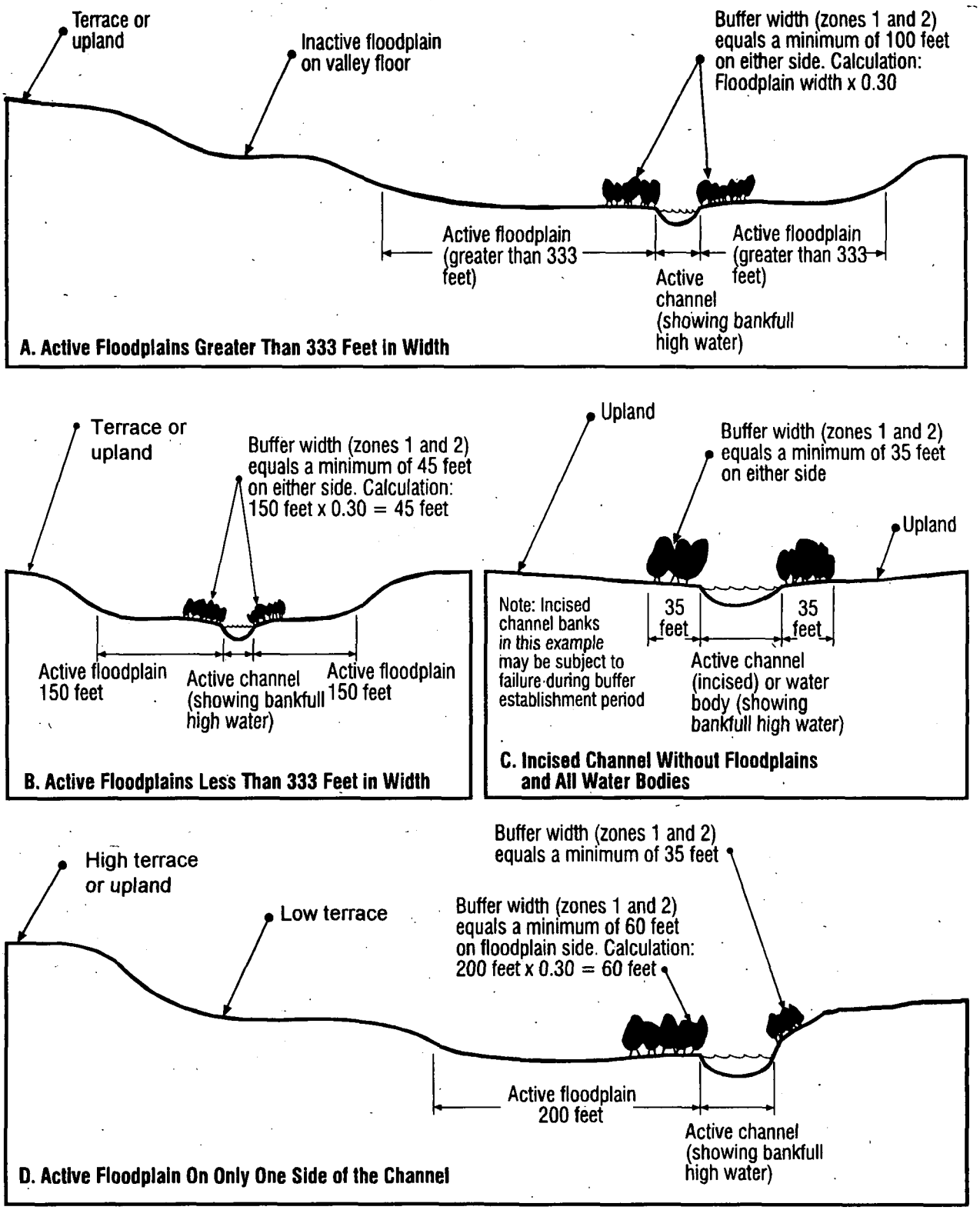

Figure 1. Examples of riparian forest buffer widths for water courses and water bodies.

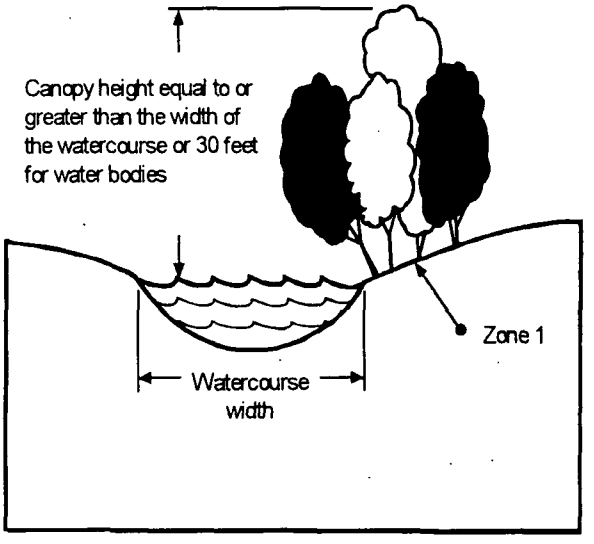

Figure 2. Canopy height for water temperature control.

Additional Criteria Purpose 3

To provide a source of detritus and large woody debris for fish and other aquatic organisms.

Within zone 1 as a minimum, establish, favor or manage species capable of producing stems and limbs of sufficient size to provide an eventual source of large woody debris for in-stream habitat for fish and other aquatic organisms.

Additional Criteria Purpose 4

To provide wildlife habitat.

Select trees and shrubs that provide food cover and shelter for the targeted wildlife species. See Plant list in the Specifications section and refer to Wildlife/Wetland Habitat Management Standards 644, 645 for more information.

Buffer Width Guide for Selected Wildlife Species.

Widths below include the sum of buffer widths on one or both sides of water courses or water bodies and may extend beyond riparian boundaries (in such cases refer to Tree/Shrub Establishment, 612 for design of upland forests).

Species:	Desired Width in Feet
Bald eagle nesting, cavity nesting ducks, heron rookery	600
Neotropical migrants	300
Beaver, dabbling ducks, mink, salmonids	300
Deer	200
Frog, salamander	100

CONSIDERATIONS

The severity of bank erosion and its influence on existing or potential riparian trees and shrubs should be assessed. Watershed-level treatment or bank stability activities may be needed before establishing a riparian forest buffer. (Refer to Streambank Protection Standard, 580 and to Chapter 18 of the Engineering Field Handbook.)

Complex ownership patterns of riparian areas may require group planning for proper buffer design, function and management.

Where ephemeral, concentrated flow or sheet and rill erosion and sedimentation is a concern in the area up-gradient of zone 2, consider the application of a vegetated strip consisting of grasses and forbs, (Zone 3). Grasses and forbs from plant list #2 established at the up-gradient edge of zone 2 will accelerate deposition of sediment. (See figure 3.) When concentrated flow or excessive sheet and rill erosion and sedimentation cannot be controlled vegetatively, consider structural or mechanical treatments.

Joining existing and new buffers increases the continuity of cover and will further moderate water temperatures, improve habitat and enhance water quality functions. A mix of species with growth forms that are tall and wide-crowned or drooping will increase moderation effects. For water courses, buffers established on both sides will enhance multiple values.

Favor tree and shrub species that are native and have multiple values such as those suited for timber, biomass, nuts, fruit, browse, nesting, aesthetics and tolerance to locally used herbicides. Consider species that resprout when establishing new rows nearest to water courses or bodies. For detritus and large woody debris, use species that will meet the specific requirements of fish and other aquatic organisms for food, habitat, migration and spawning.

Use recommendations from regional or other large-scale evaluations and plans when designing, locating and connecting buffers for indicator and/or target species of wildlife, fish and other aquatic organisms.

Avoid tree and shrub species which may be alternate hosts to undesirable pests or that may be considered noxious or undesirable. Species diversity should be considered to avoid loss of function due to species-specific pests.

The location, layout and density of the buffer should complement natural features. Avoid layouts and locations that would concentrate flood flows or return flows. Low, flexible-stemmed shrubs will minimize obstruction of local flood flows.

Consider the positive and negative impacts beaver, muskrat, deer, rabbits and other local species may have on the successful management of the riparian and stream system. Temporary and local population control methods of these kinds of local species should be used cautiously and within state and local regulations.

Consider the type of human use (rural, suburban, urban) and the aesthetic, social and safety aspects of the area to determine the vegetation selection, arrangement and management. For example, avoiding tall shrubs that block views and pruning low tree branches near recreation trails allows for ease of patrolling.

Species selection criteria to improve aesthetics include seasonal foliage color, showy flowers and fruit, foliage texture, form and branching habit. The layout and design should be appropriate for the setting as determined by adjacent land uses.

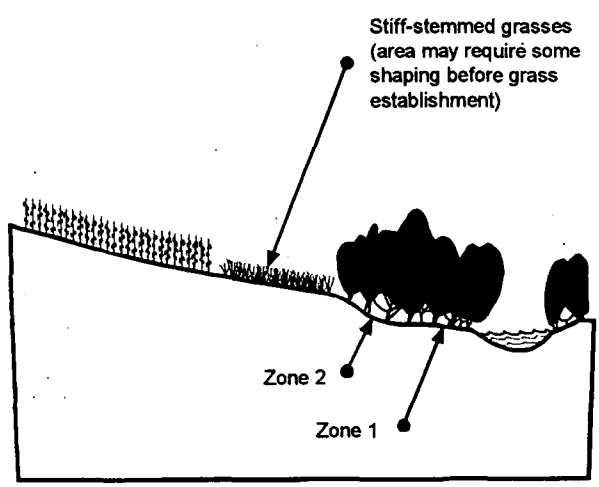

Figure 3. Sediment-trapping above zone 2.

SPECIFICATIONS

Specifications for this practice shall be prepared for each site. Requirements for operation and maintenance of the practice shall be incorporated into site specifications.

Procedures, technical details and other information listed below provide additional guidance for carrying out selected components of the named practice. This material is referenced from the conservation practice standard for the named practice and supplements the requirements and considerations listed therein.

Planting Densities

Initial plant-to-plant densities for trees and shrubs will depend on their potential height at 20 years of age. Be sure to consider management when planting. If mowing will be method of weed control, row widths must be wide enough to allow access. Heights may be estimated based on: 1) performance of the individual species (or comparable species) in nearby areas on similar sites, or 2) predetermined and documented heights using Conservation Tree/Shrub Suitability Groups, Section II of the Field Office Technical Guide.

Planting density specifications are:

Plant Types/Heights:	Plant-to-Plant Spacing in feet:
• Shrubs less than 10 feet in height	6
• Shrubs and trees from 10 to 25 feet in height (includes columnar trees)	6 to 8
• Trees greater than 25 feet in height	8 to 12

Plant List

Table 1 lists woody plant species (trees and shrubs) commonly associated with and suited to riparian areas. Key attributes are listed for each plant to assist with the design process for establishing new buffers.

Care, Handling, Size And Planting Requirements For Woody Planting Stock

During all stages of handling and storage, keep stock tops dry and free of mold and roots moist and cool. Destroy stock that has been allowed to dry, to heat up in storage (e.g., within a bale, delivery carton or container), or that has developed mold or other pests.

Seedlings shall no be less than 1/4" in caliper at 1" above the root collar. Rooted planting stock must not exceed a 2:1 shoot-to-root ratio. (See figure 4.) Container stock shall normally not exceed a 1-gallon size.

Roots of bareroot stock shall be kept moist during planting operations by placing in a water-soil (mud) slurry, peat moss, superabsorbent (e.g., polyacrylamide) slurry or other equivalent material. Rooting medium of container or potted stock shall be kept moist at all times by periodic watering. Stock shall not be planted when the soil frozen or dry. Rooted stock will be planted in a vertical position with the root collars approximately 1/2-inch below the soil surface. Insert cuttings to the depth

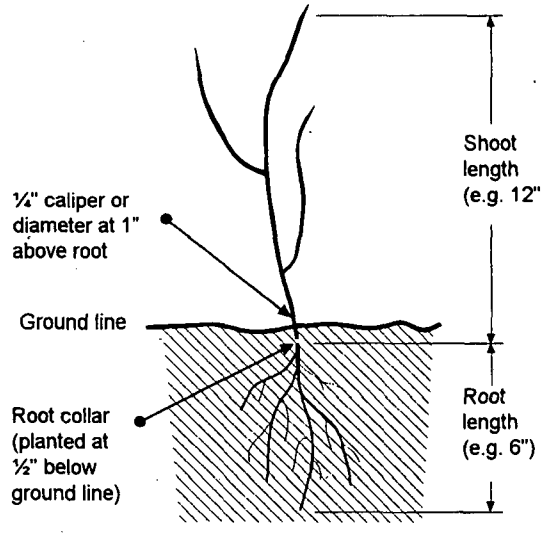

Figure 5. Plant or stock size requirements.

required to reach adequate soil moisture with at least 2-3 buds above ground. The planting trench or hole must be deep and wide enough to permit roots to spread out and down without J-rooting or L-rooting. After planting of rooted stock, pack soil around each plant firmly to eliminate air pockets. (See figure 5.)

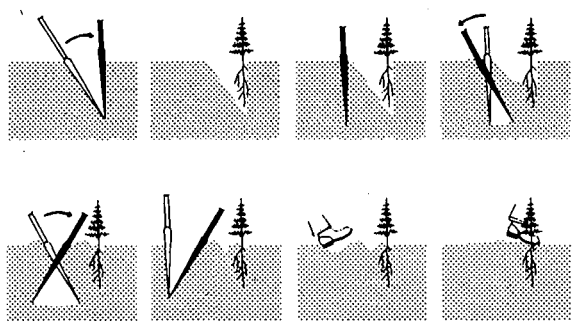

Figure 5. Proper plant and root placement of rooted stock using a planting bar.

Recommended Planting Dates

MLRA 149A, 153C and 153D - March 1 to May 11; planting may be done on sandy soils, when soil is not frozen, during the fall and winter months. (After November 1)

MLRA 148 - March 1 to May 1

MLRA 147 and 130 - March 15 to May 1

MLRA 127 - April 1 to May 15

Containerized stock can be planted at any time the ground is not frozen provided a water source is available.

Preparation Of Planting Sites

Planting sites shall be properly prepared based on the soil type and vegetative conditions listed below. For sites to be tilled, leave a 3-foot undisturbed strip at the edge of the bank or shoreline. Competitive weeds, particularly Canada Thistle and Multiflora Rose should be controlled prior to planting. Avoid sites that have had recent application of pesticides harmful to woody species to be planted. If pesticides are used, apply only when needed and handle and dispose of properly and within federal, state and local regulations. Follow label directions and heed all precautions listed on the container.

Fabric mulch may be used for weed control and moisture conservation for new plantings, particularly those with pronounced growing season moisture deficits or invasive, weedy species. Refer to Mulching, 484, for installation procedures.

Based on site conditions and predominant soil texture of the fine earth fraction, procedures include:

Tillable sites with loamy/clayey soils:

- Sod and alfalfa sites

  Summer fallow 1 year to kill the sod or alfalfa. Till (moldboard plow, disk plow, rototiller or similar equipment) in the spring before planting the stock. A fall-sown crop of oats may be used where needed to control erosion.

  Sod may be killed by non-selective herbicides the year previous to planting stock. Plant stock in the residue. On heavy soils, tillage is usually necessary to achieve a satisfactory planting when a tree planting machine is used.

- Small grain or row crop sites

  If the site is in row crop, till (moldboard plow, disk plow, rototiller or similar equipment) in the fall or in the spring prior to planting the trees or shrubs. If the site has a plow or hard pan in subsoil, perform a deep disking or ripping operation in the fall. A fall-sown crop of oats may be used where needed to control erosion.

  If the site is in small grain stubble, the stock may be planted in the spring without further preparation. If fabric mulch is to be installed, till in the spring before planting.

  Tillage on steep slopes must be on the contour or cross-slope. A cover crop between the rows may be necessary to

control erosion and sediment deposition on planted stock.

Tillable sites with sandy soils:

- Sod and alfalfa sites

Till (moldboard plow, disk plow, rototiller or similar equipment) and plant to a spring cover crop (corn, grain, sorghum, etc.) the year prior to planting. Leave a stubble cover in which to plant. A light disking may be needed before planting if fabric mulch is used.

Sod may be killed by nonselective herbicides the year prior to planting. Plant trees or shrubs in the residue.

When hand planting, scalp or strip an area at least 3 feet in diameter and two-to-four inches deep. (place plants in the center of the scalped area.)

Rototill a 3-foot wide strip. (Place plants in the center of the tilled area.) Where a drip watering system will not be used, rototill the strip the year prior to planting.

- Small grain or row crop sites

If the site is in small grain, corn, or similar clean tilled crop, and it is reasonably free of weeds, plant stock in the stubble without prior preparation. It may be necessary to till a narrow strip with a disk or other implement to kill weeds or volunteer grain, or to prevent stalks and other residue from clogging the tree planter. If fabric mulch is used, disking may also be needed. A cover crop or stubble may be needed between the rows to protect the planting from water or wind erosion.

Non-tillable sites and/or erosive sites (including sites with undesirable brushy or herbaceous species):

On sites where it is not practical or possible to operate equipment (steepness, rockiness, etc.), where tillage of the site will cause excessive erosion, or where tillage of the site is impractical, the methods listed below may be used. Sites with undesirable brush will need initial treatments that physically removes and kills the brush species to facilitate planting of desired stock and prevent re-encroachment of the brush. Suitable methods include hand-cutting and removal, brush hogging, brush-blading, or other equivalent procedure with repeated treatment or use of herbicides to control re-sprouting.

Machine or hand scalp an area at least 36 inches in diameter with subsequent plant placement in the center of the scalped area.

Rototill a strip at least 36 inches wide the year prior to tree planting with subsequent plant placement in the center of the tilled strip.

Kill the vegetation in a 36-inch diameter or larger area or in a 36-inch or wider strip with a non-selective herbicide the year prior to planting and plant in the center or along the center-line of the treated area.

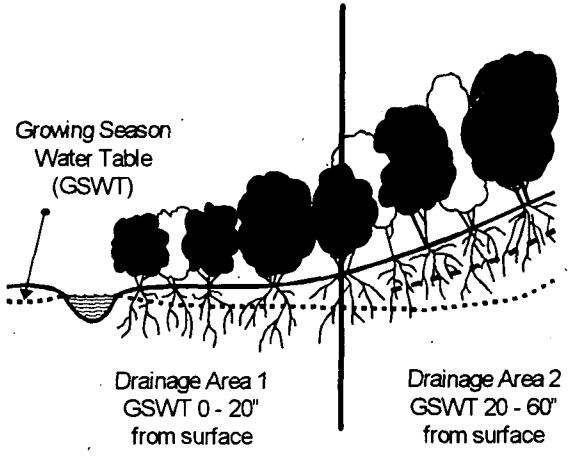

Figure 6. Drainage Class Suitability

This is a simplified drawing depicting the major drainage areas found in a riparian area and is intended to facilitate the plant selection process. Area 1 is made up of poorly drained to somewhat poorly drained soils with the growing season water table (GSWT) fluctuating from 0 to 20" from the soil surface in most years. This area has the greatest potential for inundation.

Area 2 is made up of moderately well to well-drained soils with the GSWT fluctuating from 20" to 60" from the soil surface in most years. This area is prone to moisture stress during the summer months.

The plants in the following tables have been separated according to their suitability for the conditions in Area 1 or 2. Plants with both areas listed are tolerated of a wide range of conditions.

TABLE 1 - TREES

Plant Names	Drainage Area Suitability	Tolerance to Flooding	Shade Value	Height 20 Years	Native Species	Wildlife Value	Notes
ATLANTIC WHITE CEDAR Chamaecyparis thyoides	1	M	M	30'	Y	Low: seed and browsing	cannot compete with hardwoods, best planted in stands
BALD CYPRESS Taxodium distichum	1	H	M	40'	Y	Low: seeds, food for ducks and marsh birds	recommended for lower Eastern Shore only
BLACK ALDER Alnus glutinosa	1	H	M	40'	N	Medium: food for beaver and ruffed goose	seeds freely along banks, nitrogen fixing
BLACK WALNUT Juglans nigra	1	M	H	60'	Y	Medium: twigs and nuts, food for some wildlife	very important lumber tree
BLACK WILLOW Salix nigra	1	H	H	75'	Y	Medium: nesting, food for grouse, beaver, and deer	important for stream stabilization, fast growth rate

TABLE 1 - TREES

Plant Names	Drainage Area Suitability	Tolerance to Flooding	Shade Value	Height 20 Years	Native Species	Wildlife Value	Notes
BOX ELDER Acer negundo	1	H	M	30'	Y	Low: seeds, food for some wildlife	fast growth rate
RIVER BIRCH Betula nigra	1	H	M	40'	Y	Medium: food for ducks, songbirds, rabbits, and fox	unique peeling reddish bark
SANDBAR WILLOW Salix exigua	1	H	M	25'	Y	Low: nesting	forms thickets by suckering
SILVER MAPLE Acer saccharinum	1	M	H	50'	Y	Low: nesting	good source of woody debris
SWAMP WHITE OAK Quercus bicolor	1	H	M	30'	Y	High: acorns, food for quail, turkey, grouse, woodpeckers, raccoons, opossum and deer	good choice for wet sites, important lumber tree
CHINQUAPIN Quercus muehlenbergii	1 & 2	M	M	40'	Y	High: acorns, food for quail, turkey, grouse, and deer	under used, native tree
GREEN ASH Fraxinus pennsylvanica	1 & 2	M	H	50'	Y	Medium: seeds and foliage, food for wood ducks, grosbeaks, squirrels, and deer	important lumber tree
HACKBERRY Celtis occidentalis	1 & 2	M	M	40'	Y	High: fruits and twigs, food for mourning doves, quail, squirrels, and deer	adaptable to a wide range of conditions
OVERCUP OAK Quercus lyrata	1 & 2	M	M	30'	Y	High: same as Swamp White Oak	important lumber tree
PIN OAK Quercus palustris	1 & 2	M	M	40'	Y	High: same as Swamp White Oak	bronze or red fall foliage
RED MAPLE Acer rubrum	1 & 2	H	M	40'	Y	High: seeds and sap, food for songbirds, chipmunks, and deer	red fall color and bloom
SWEET GUM Liquidambar styraciflua	1 & 2	M	H	60'	Y	Low: seeds for mourning doves, beaver, squirrels, and chipmunks	yellow-red fall color

TABLE 1 - TREES

Plant Names	Drainage Area Suitability	Tolerance to Flooding	Shade Value	Height 20 Years	Native Species	Wildlife Value	Notes
SYCAMORE Platanus occidentalis	1 & 2	M	H	60'	Y	Low: nesting cavities, seeds, food for finches, and squirrels	unique peeling bark, fast growth rate
BLACK LOCUST Robinia pseudoacacia	2	L	M	40'	Y	Low: seeds, food for some wildlife	nitrogen fixing, seeds freely and suckers
LOBLOLLY PINE Pinus taeda	2	L	M	60'	Y	Medium: seeds and sap, food for doves, woodpeckers, nut-hatches, and squirrels	recommended for coastal plain area, fast growth rate
RED OAK Quercus rubra	2	L	M	40'	Y	High: same as Swamp White Oak	excellent red fall color
WHITE OAK Quercus alba	2	L	M	30'	Y	High: same as Swamp White Oak	variable fall color, stately tree

TABLE 1 - SHRUBS

Plant Names	Drainage Area Suitability	Tolerance to Flooding	Shade Tolerance	Shade Value	Height 20 years	Native Species	Wildlife Value	Notes
BUTTONBUSH Cephalanthus occidentalis	1	H	full sun to partial shade	L	8'	Y	Medium: seeds and nectar, food for hummingbirds, ducks, beavers, and rails	unusual, round white flowers
SILKY DOGWOOD Cornus amomum	1	M	full sun to partial shade	L	10'	Y	High: berries and twigs, food for woodpeckers, pine warblers, finches, cardinals, and deer	produces fruit at 3-5 years of age
SMOOTH ALDER Alnus serrulata	1	H	partial shade	L	10'	Y	Medium: seeds, food for ducks, quail, doves and deer	nitrogen fixing
WINTERBERRY Ilex verticillata	1	M	full sun to partial shade	L	10'	Y	High: berries, food for woodpeckers, waxwings, cardinals, chickadees and deer	need male and female plants for fruit production
ARROWWOOD VIBURNUM Viburnum dentatum	1 & 2	M	full sun to partial shade	L	10'	Y	Medium: berries and foliage, food for grouse, squirrels, and deer	suckers freely, wood used to make arrows
CRANBERRY BUSH Viburnum trilobum	1 & 2	M	full sun to partial shade	L	12'	Y	Medium: same as Arrowwood Viburnum	yellow to red fall color, white flower clusters
ELDERBERRY Sambucus canadensis	1 & 2	H	full sun to partial shade	L	12'	Y	High: berries and nectar, food for woodpeckers, blue jays, grosbeaks, rabbits, and squirrels	large clusters of white flowers followed by purple berries, fast growth rate
GRAY DOGWOOD Cornus racemosa	1 & 2	L	full sun to shade	L	10'	Y	High: same as Silky Dogwood	White flowers, white berries

TABLE 1 - SHRUBS

Plant Names	Drainage Area Suitability	Tolerance to Flooding	Shade Tolerance	Shade Value	Height 20 years	Native Species	Wildlife Value	Notes
NANNYBERRY Viburnum lentago	1 & 2	L	full sun to shade	M	20'	Y	Medium: same as Arrowwood Viburnum	often suckers
PAWPAW Asimina triloba	1 & 2	M	full sun to partial shade	M	20'	Y	High: important food source for fox and opossum	suckers and forms colonies
REDOSIER DOGWOOD Cornus sericea	1 & 2	L	full sun to shade	L	8'	Y	High: same as Silky Dogwood	good for streambank stabilization
BRISTLY LOCUST Robinia hipsida	2	L	full sun to partial shade	L	8'	N	Low	nitrogen fixing, good for steep sandy slopes
NINEBARK Physocarpus opulifolius	2	M	full sun to partial shade	L	9'	Y	Low	peeling bark, hidden by dense foliage
SPICEBUSH Lindera benzoin	2	M	full sun to partial shade	L	12'	Y	Medium: berries, food for thrushes, catbirds, and kingbirds	fragrant leaves and twigs, yellow fall color

NOTE: Native refers to species that occur naturally in the state of Maryland.

TABLE 2: Zone 3 Planting

1. Native, warm-season grass mix for somewhat poorly to well drained sites

Name	Planting Rate - Pure Live Seed			
	lbs/ac	Drilled		Broadcast seeds per sq. foot
		Seeds per linear ft.	Row spacing	
SWITCHGRASS Panicum virgatum 'shelter'	8	30	36"	40
EASTERN GAMAGRASS Tripsacum dactyloides 'Pete'	10	4	36"	
OATS	20			

For added wildlife and aesthetic value add ¼ lb/ac to ½ lb/ac of a mix of 2 or more of the following:

GREAT ASTER	Aster grandiflorus	(height 2-5')
SMOOTH ASTER	Aster laevis	(height 2-5')
FALL PHLOX	Phlox paniculata	(height 2-5')
SNEEZEWEED	Helenium flexuosum	(height 2-5')
WILD BERGAMONT	Monarda fistulosa	(height 2-4')
PURPLE CONEFLOWER	Echinacea purpurea	(height 3')
MONKEY FLOWER	Mimulus alatus & M. Ringens	(height 1')
BLAZING STAR	Liatris spicata	(height 2-5')
BEE BALM	Monarda didyma	(height 2-4')
GREEN CONEFLOWER	Rudbeckia lanciniata	(height 2-8')

2. Native, warm-season grass for mix moderately well to well drained sites

Name	Planting Rate - Pure Live Seed			
	lbs/ac	Drilled		Broadcast seeds per sq. foot
		Seeds per linear ft.	Row spacing	
BIG BLUESTEM Andropogon gerardii 'niagara'	10	30	30"	40
SWITCHGRASS Panicum virgatum 'shelter'	8	30	36"	40
INDIANGRASS Sorghastrum nutans	5	30	30"	30
OATS	20			

For added wildlife and aesthetic value add ¼ lb/ac to ½ lb/ac of a mix of two or more of the following:

MARYLAND GOLDENASTER	Chrysopsis mariana	(height 1-2')
TICKSEED	Coreopsis tinctoria	(height 2-3')
WILD BLUE INDIGO	Baptisia australis	(height 3-5')
SHOWY ASTER	Aster spectabilis	(height 2-5')
BUTTERFLYWEED	Asclepias tuberosa	(height 1-2')
COMMON MILKWEED	Asclepias syriaca	(height 2-5')
WILD COLUMBINE	Aquilegia canadensis	(height 1-2')
BLACK-EYED SUSAN	Rudbeckia hirta 'golden jubilee'	(height 2-3')

NOTE: On slopes greater than 6% plant a cover crop in the fall, cut in the spring and no-till warm season grass seed into the stubble.

TABLE 2: Zone 3 Planting

For each of the following mixes, add one of these crops:

Winter Rye	20 lbs/ac
Winter Wheat	20 lbs/ac
Spring Oats	20 lbs/ac

3. Cool-season grass and legume mix for well drained sites:
(This is a non-competive mix and can be used to stabilize areas where trees and shrubs will be planted.)

Name		Lbs/Ac	Planting Date
CREEPING RED FESCUE	Festuca rubra	10	early spring or fall
HARD FESCUE	Festuca longifolia	10	early spring or fall
WHITE CLOVER	Trifolium repens	2	early spring or fall
Cool-season grass and legume mix for poorly drained sites:			
REED CANARY GRASS	Phalaris arundinacea	10	spring
BIRDSFOOT TREFOIL	Lotus corniculatus	6	

4. Cool-season grass mix for moderately well drained sites

Name		Lbs/Ac	Planting Date
KENTUCKY BLUEGRASS	Poa pratensis	25	spring or fall
PERENNIAL RYEGRASS	Lolium perenne	15	spring or fall
RED TOP	Argostis gigantea	5	spring or fall

5. Cool-season grass & wildflower mix for moderately well to excessively drained sites

Name		Lbs/Ac	Planting Date
CHEWINGS FESCUE	Festuca rubra L. Ssp. falax	10	spring or early fall
HARD FESCUE	Festuca longifolia	10	spring or early fall
WILDFLOWER SEED MIX (Choose 4 or more species from wildflowers in mix 2)		6	

OPERATION AND MAINTENANCE

The following actions shall be carried out to insure that this practice functions as intended throughout its expected life. These actions include normal repetitive activities in the application and use of the practice (operation), and repair and upkeep of the practice (maintenance):

The riparian forest buffer will be inspected periodically, protected and restored as needed, to maintain the intended purpose from adverse impacts such as excessive vehicular and pedestrian traffic, pest infestations, pesticide use on adjacent lands, livestock damage and fire.

Replacement of dead trees or shrubs and control of undesirable vegetative competition will be continued until the buffer is, or will progress to, a fully functional condition.

As applicable, control of concentrated flow erosion or mass soil movement shall be continued in the up-gradient area immediately adjacent to zone 2 to maintain buffer function.

Any removals of tree and shrub products shall be conducted in a manner that maintains the intended purpose and is consistent with state and local law.

For purposes of moderating water temperatures and providing detritus and large woody debris, riparian forest buffer management must maintain a minimum of 50 percent canopy cover. To achieve benefits provided by large woody debris, natural mortality of trees and large shrubs may need to be supplemented by periodically falling and placing selected stems or large limbs within water courses and water bodies to reach original design specifications.

For providing habitat and corridors for wildlife, manage the buffer to favor food, shelter and nesting cover that would satisfy the habitat requirements of the indicator or target wildlife species. Refer to MD Wildlife Biology and Management Handbook for more information.

For purposes of reducing excess pollutants in surface runoff and shallow groundwater (zone 1 and 2), or providing habitat and corridors for wildlife (zone 1 at a minimum), manage the dominant canopy to maintain maximum vigor of overstory and understory species.

Weeds should be controlled for 2 - 3 years after planting. Any use of fertilizers, mechanical treatments, prescribed burning, pesticides and other chemicals to assure buffer function shall not compromise the intended purpose. *Biological control of undesirable plant species and pests (e.g., using predator or parasitic species), shall be implemented where available and feasible.*

Additional operation and maintenance requirements shall be developed on a site-specific basis to assure performance of the practice as intended.

DATA AND SUPPORTING DOCUMENTATION

The following is a list of information to be recorded in the case file.

1) Purpose of riparian forest buffer

2) Field location and plan view

3) Size of planting
   - width of floodplain (ft)
   - width of planting (ft)
   - length of stream (ft)
   - acres of riparian forest buffer

4) Planting details
   - date planted
   - species planted
   - spacing of planting

5) Operation and maintenance plan

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U.S. Fish and Wildlife Service, Chesapeake Bay Field Office with the Natural Science Center and Adkins Arboretum, 1995. Native Plants for Wildlife Habitat. Annapolis, MD.

NRCS Standards - Pennsylvania

Pennsylvania is currently in the process of developing a state NRCS standard for riparian forest buffers. Until the state standard is finalized, the following national standard will be used in Pennsylvania. For more information, contact the Pennsylvania NRCS office listed below.

Natural Resources Conservation Service
Suite 340
One Credit Union Place
Harrisburg, PA 17110-2993
Phone: (717) 782-2206
FAX: (717) 782-4469

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NATURAL RESOURCES CONSERVATION SERVICE
CONSERVATION PRACTICE STANDARD

RIPARIAN FOREST BUFFER

(Acre)
CODE 391

DEFINITION

An area of trees and/or shrubs located adjacent to and up-gradient from water bodies.

PURPOSES

- Create shade to lower water temperatures to improve habitat for aquatic organisms.
- Provide a source of detritus and large woody debris for aquatic organisms and habitat for wildlife.
- Reduce excess amounts of sediment, organic material, nutrients and pesticides in surface runoff and reduce excess nutrients and other chemicals in shallow ground water flow.

CONDITIONS WHERE PRACTICE APPLIES

On areas adjacent to permanent or intermittent streams, lakes, ponds, wetlands and areas with ground water recharge.

CRITERIA

General Criteria Applicable To All Purposes Named Above.

The location, layout and density of the riparian forest buffer will accomplish the intended purpose and function. The buffer will consist of a zone (identified as zone 1) that begins at the normal water line, or at the top of the bank, and extend a minimum distance of 15 feet, measured horizontally on a line perpendicular to the water body.

Dominant vegetation will consist of existing or planted trees and shrubs suited to the site and the intended purpose. Occasional removal of some tree and shrub products such as high value trees is permitted provided the intended purpose is not compromised by the loss of vegetation or harvesting disturbance.

Necessary site preparation and planting shall be done at a time and manner to insure survival and growth of selected species. Only viable, high quality, and adapted planting stock will be used. Site preparation shall be sufficient for establishment and growth of selected species and be done in a manner that does not compromise the intended purpose.

Livestock shall be controlled or excluded as necessary to achieve and maintain the intended purpose.

Harmful pests present on the site will be controlled or eliminated as necessary to achieve and maintain the intended purpose.

Additional Criteria To Reduce Excess Amounts of Sediment, Organic Material, Nutrients and Pesticides in Surface Runoff and Reduce Excess Nutrients and Other Chemicals in Shallow Ground Water Flow.

An additional strip or area of land, zone 2, will begin at the edge and up-gradient of zone 1 and extend a minimum distance of 20 feet, measured horizontally on a line perpendicular to the water body. The minimum combined width of zones I and 2 will be 100 feet or 30 percent of the geomorphic flood plain whichever is less, but not less than 35 feet.

Criteria for zone 1 shall apply to zone 2 except that removal of tree and shrub products such as timber, nuts and fruit is permitted on a periodic and regular basis provided the intended purpose is not compromised by loss of vegetation or harvesting disturbance.

Conservation practice standards are reviewed periodically, and updated if needed. To obtai the current version of this standard, contact the Natural Resources Conservation Service.

Concentrated flow erosion or mass soil movement shall be controlled in the up-gradient area immediately adjacent to zone 2 prior to establishment of the riparian forest buffer.

CONSIDERATIONS

The severity of bank erosion and its influence on existing or potential riparian trees and shrubs should be assessed. Watershed-level treatment or bank stability activities may be needed before establishing a riparian forest buffer.

Where ephemeral, concentrated flow erosion and sedimentation is a concern in the area upgradient of zone 2, consider the application of a vegetated strip consisting of grasses and forbs.

When concentrated flow erosion and sedimentation cannot be controlled vegetatively, consider structural or mechanical treatments.

Favor tree and shrub species that are native and have multiple values such as those suited for timber, biomass, nuts, fruit, browse, nesting, aesthetics and tolerance to locally used herbicides.

Avoid tree and shrub species which may be alternate hosts to undesirable pests. Species diversity should be considered to avoid loss of function due to species-specific pests.

Woody phreatophytes and hydrophytes that deplete ground water should be used with caution in water-deficit areas.

The location, layout and density of the buffer should compliment natural features.

PLANS AND SPECIFICATIONS

Specifications for this practice shall be prepared for each site. Specifications shall be recorded using approved specifications sheets, job sheets, narrative statements in the conservation plan, or other acceptable documentation.

OPERATION AND MAINTENANCE

The following actions shall be carried out to insure that this practice functions as intended throughout its expected life. These actions include normal repetitive activities in the application and use of the practice (operation), and repair and upkeep of the practice (maintenance):

The riparian forest buffer will be inspected periodically and protected to maintain the intended purpose from adverse impacts such as excessive vehicular and pedestrian traffic, pest infestations, pesticide use on adjacent lands, livestock damage and fire.

Replacement of dead trees or shrubs and control of undesirable vegetative competition will be continued until the buffer is, or will progress to, a fully functional condition.

As applicable, control of concentrated flow erosion or mass soil movement shall be continued in the up-gradient area immediately adjacent to zone 2 to maintain buffer function.

Any removals of tree and shrub products shall be conducted in a manner that maintains the intended purpose.

Any use of fertilizers, pesticides and other chemicals to assure buffer function shall not compromise the intended purpose.

NATURAL RESOURCES CONSERVATION SERVICE
CONSERVATION PRACTICE STANDARD

RIPARIAN FOREST BUFFER

(Acre)
CODE 392

DEFINITION

An area of trees and/or shrubs located adjacent to and up-gradient from water bodies.

PURPOSES

* Create shade to lower water temperatures to improve habitat for fish and other aquatic organisms.
* Provide a source of detritus and large woody debris for fish and other aquatic organisms and riparian habitat and corridors for wildlife.
* Reduce excess amounts of sediment, organic material, nutrients, pesticides and other pollutants in surface runoff and reduce excess nutrients and other chemicals in shallow ground water flow.

CONDITIONS WHERE PRACTICE APPLIES

On areas adjacent to permanent or intermittent streams, lakes, ponds, wetlands and areas with ground water recharge.

CRITERIA

General Criteria Applicable To All Purposes Named Above

The location, layout, width, and woody plant density of the riparian forest buffer will accomplish the intended purpose and function. See General Specifications for required plant densities for buffer plantings. The buffer will consist of a zone (identified as zone 1) that begins at the bank full water line, or at the upper edge of the active channel or shore, and extend a minimum distance of 15 feet, measured horizontally on a line perpendicular to the water course or water body.

NOTE: Reduction of sediment, organic material, nutrients and pesticides will be limited if only Zone 1 is established.

Dominant vegetation will consist of existing or planted trees and shrubs suited to the site and the intended purpose. Selection of locally native species will be a priority when feasible. Plantings will consist of two or more species with individual plants suited to the seasonal variation of soil moisture status of individual planting sites (see Figure 1 and Table 1). Plant types and species shall be selected based on their compatibility in growth rates and shade tolerance. Select species from the Plant List, Table 1, located in General Specifications.

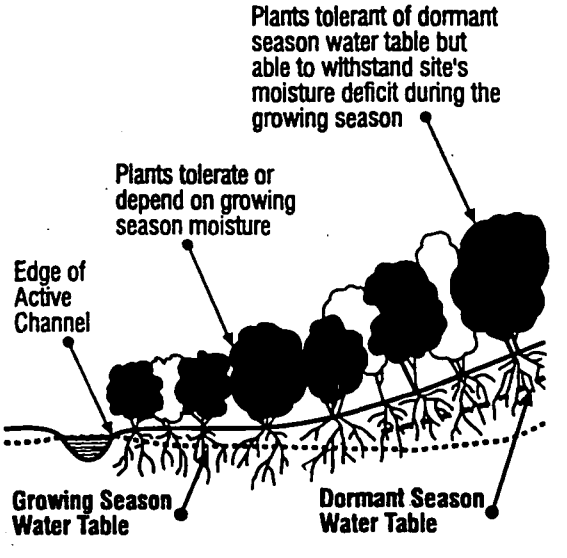

Figure 1. Plant adaptation to soil moisture.

Conservation practice standards are reviewed periodically, and updated if needed. To obtain the current version of this standard, contact the Natural Resources Conservation Service.

Occasional limited removal of some tree and shrub products such as high value trees is permitted provided the intended purpose is not compromised by the loss of vegetation or harvesting disturbance. Felling and skidding of trees shall be directed away from the water course or water body. Skidding will be done in a manner to prevent creation of ephemeral channels perpendicular to the stream.

An adequate upstream or adjacent seed source must be present when using natural regeneration to supplement or establish a buffer. Generally planting is preferred over natural regeneration due to control of plant species present and reduced time for woody plants to reach maturity.

Necessary site preparation and planting for establishing new buffers shall be done at a time and manner to insure survival and growth of selected species. Refer to General Specifications for care, handling, and planting requirements for woody planting stock.

Only viable, high quality, and adapted planting stock will be used. Refer to General Specifications for size and quality requirements for woody planting stock.

The method of planting for new buffers shall include hand or machine planting techniques, be suited to achieving proper depths and placement of planting stock roots, and not impair the intended purpose and function of the buffer.

Site preparation shall be sufficient for establishment and growth of selected species and be done in a manner that does not compromise the intended purpose. See General Specifications for detailed site preparation procedures. Supplemental moisture will be applied if and when necessary to assure early survival and establishment of selected species.

Livestock shall be excluded except for designed stream crossing and livestock watering sites. These stream access areas shall be located and sized to minimize impact to buffer vegetation and function. (See Fencing [Code 382] and Stream Crossing [Code 232] Standards.)

Harmful pests present on the site will be controlled or eliminated as necessary to achieve and maintain the intended purpose.

ADDITIONAL CRITERIA TO REDUCE EXCESS AMOUNTS OF SEDIMENT, ORGANIC MATERIAL, NUTRIENTS, AND PESTICIDES IN SURFACE RUNOFF AND REDUCE EXCESS NUTRIENTS AND OTHER CHEMICALS IN SHALLOW GROUND WATER FLOW.

An additional strip or area of land, zone 2, will begin at the edge and up-gradient of zone 1 and extend a minimum distance of 20 feet, measured horizontally on a line perpendicular to the water course or water body. The minimum combined width of zones 1 and 2 will be 100 feet or 30 percent of the geomorphic flood plain whichever is less, but not less than 35 feet. (Note: The geomorphic flood plain may be narrower than the valley bottom if the valley formed under different hydrologic conditions.) Figure 2 illustrates examples of zone 1 and 2 widths for water courses and water bodies.

Criteria for zone 1 shall apply to zone 2 except that removal of tree and shrub products such as timber, nuts and fruit is permitted on a periodic and regular basis provided the intended purpose is not compromised by loss of vegetation or harvesting disturbance.

Concentrated flow erosion, excessive sheet and rill erosion or mass soil movement shall be controlled in the up-gradient area immediately adjacent to zone 2 prior to establishment of the riparian forest buffer (see figure 3).

ADDITIONAL CRITERIA TO CREATE SHADE TO LOWER WATER TEMPERATURES TO IMPROVE HABITAT FOR FISH AND OTHER AQUATIC ORGANISMS.

A buffer for lowering warm-season water temperatures shall consist of at least zone 1 for water course reaches or water bodies less than

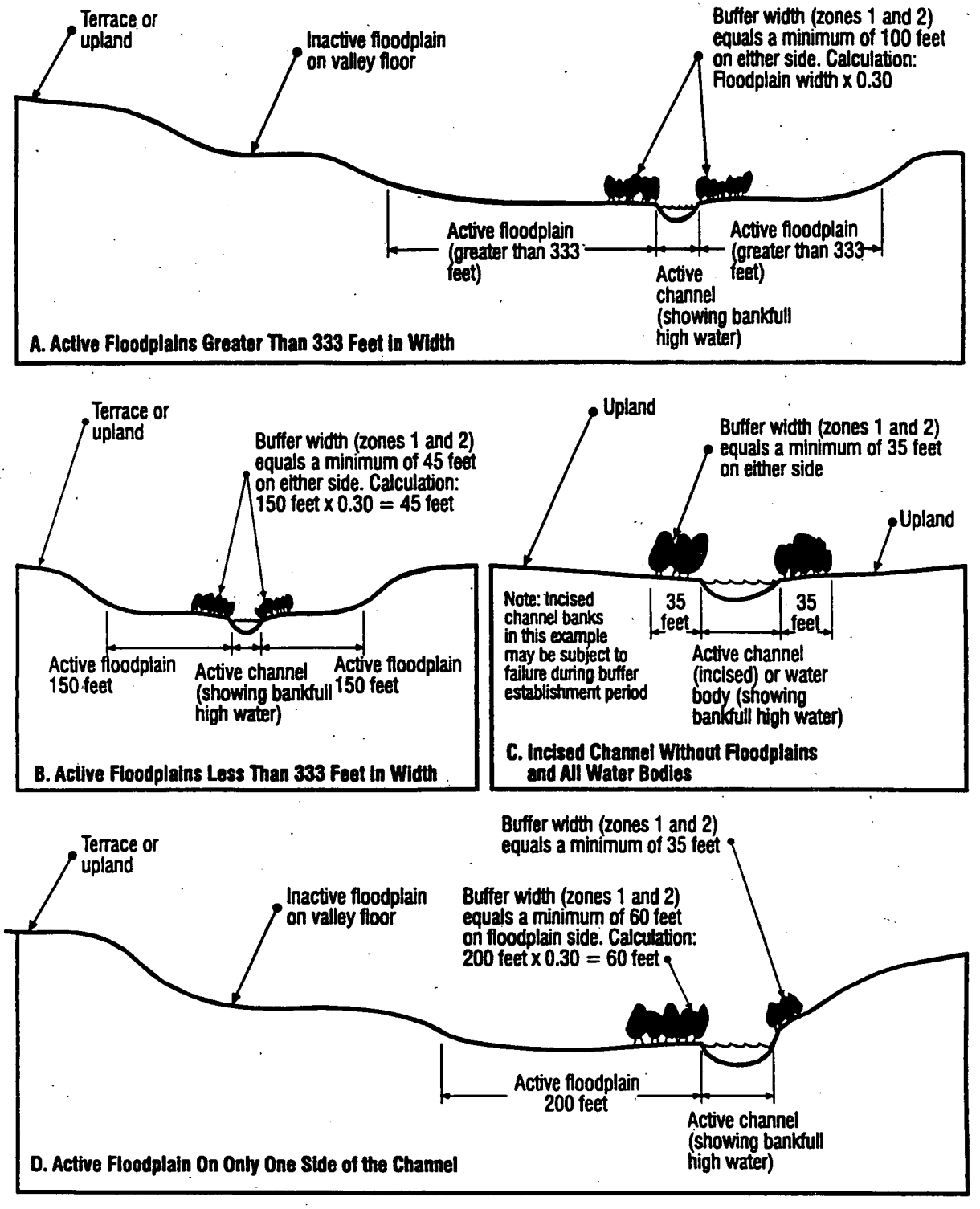

Figure 2. Examples of riparian forest buffer widths for water courses and water bodies.

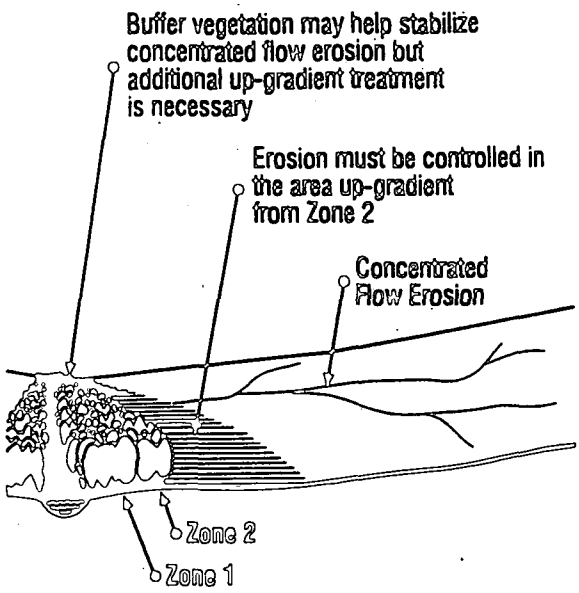

Figure 3. Control of concentrated flow erosion.

or equal to 30 feet in width or water bodies greater than 30 feet wide but less than 1 acre in size. (Note: Buffers for wider water courses or larger water bodies may be valuable but will have only site-specific effects.) Buffers shall be established or maintained on south and west sides of water courses and bodies insofar as practical. The buffer canopy shall be established to achieve at least 50 percent crown cover with average canopy heights equal to or greater than the width of the water course or 30 feet for water bodies. See figure 4.

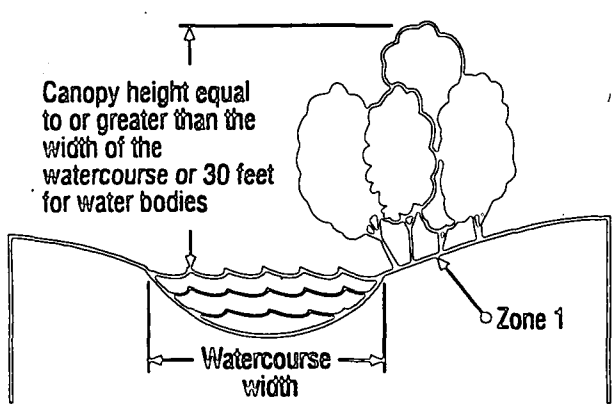

Figure 4. Canopy height for water temperature control.

Suggested buffer species shall include those species listed in the Plant List, Table 1, General Specifications, with sufficient height potential. Place drooping or wide-crowned trees and shrubs nearest the water course or body. Shoreline or channel relief (e.g., deeply incised channels) and topographic shading will be taken into account in selecting species.

Additional Criteria to Provide a Source of Detritus and Large Woody Debris for Fish and Other Aquatic Organisms.

Within zone 1 as a minimum, establish, favor or manage species capable of producing stems and limbs of sufficient size to provide an eventual source of large woody debris for in-stream habitat for fish and other aquatic organisms.

Considerations

The severity of bank erosion and its influence on existing or potential riparian trees and shrubs should be assessed. Watershed-level treatment or bank stability activities may be needed before establishing a riparian forest buffer. Refer to Streambank Protection Standard (Code 580) and Chapter 18 of NRCS Engineering Field Handbook on Bioengineering.

Complex ownership patterns of riparian areas may require group planning for proper buffer design, function and management.

Where ephemeral, concentrated flow or sheet and rill erosion and sedimentation is a concern in the area up-gradient of zone 2, establish or maintain where practical a vegetated strip consisting of grasses and forbs. A minimum width of 20 feet is needed. Stiff-stemmed grasses, such as switchgrass, established at the up-gradient edge of zone 2 will accelerate deposition of sediment. See figure 5. When concentrated flow or excessive sheet and rill erosion and sedimentation cannot be controlled vegetatively, establish structural or mechanical treatments.

Joining of existing and new buffers increase the continuity of cover and will further moderate water temperatures. A mix of species with growth forms that are tall and wide-crowned or drooping will increase moderation effects. For water courses, buffers established on both sides will enhance multiple values.

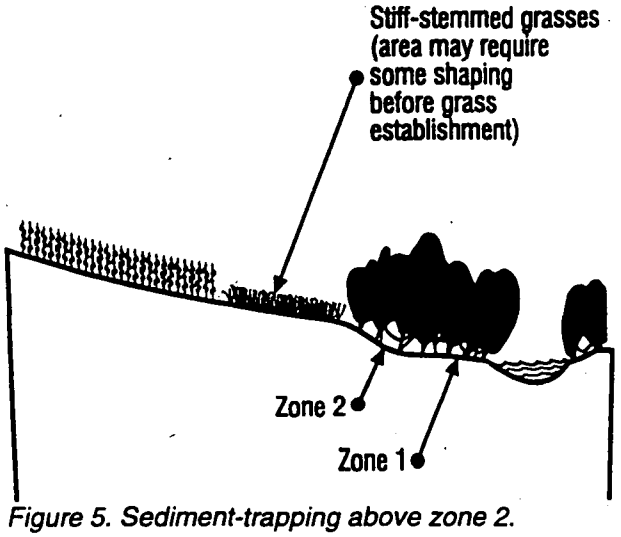

Figure 5. Sediment-trapping above zone 2.

Favor tree and shrub species that are native and have multiple values such as those suited for timber, biomass, nuts, fruit, browse, nesting, aesthetics and tolerance to locally used herbicides. Consider species that resprout when establishing new rows nearest to water courses or bodies.

Avoid tree and shrub species which may be alternate hosts to undesirable pests or that may be considered noxious or undesirable. Species diversity should be considered to avoid loss of function due to species-specific pests.

The location, layout and density of the buffer should complement natural features. Avoid layouts and locations that would concentrate flood flows or return flows. Low, flexible-stemmed shrubs will minimize obstruction of local flood flows.

Consider the positive and negative impacts beaver, muskrat, deer, rabbits and other local species may have on the successful management of the riparian and stream system. Temporary and local population control methods of these kinds of local species should be used cautiously and within state and local regulations.

Consider the type of human use (rural, suburban, urban) and the aesthetic, social and safety aspects of the area to determine the vegetation selection, arrangement and management. For example, avoiding shrubs that block views and pruning low tree branches near recreation trails allows for ease of patrolling.

Species selection criteria to improve aesthetics include seasonal foliage color, showy flowers and fruit, foliage texture, form and branching habit. The layout and design should be appropriate for the setting as determined by adjacent land uses.

PLANS AND SPECIFICATIONS

Specifications for this practice shall be prepared for each site. Specifications shall be recorded using approved specifications sheets, job sheets, narrative statements in the conservation plan, or other acceptable documentation. Requirements for operation and maintenance of the practice shall be incorporated into site specifications.

OPERATION AND MAINTENANCE

The following actions shall be carried out to insure that this practice functions as intended throughout its expected life. These actions include normal repetitive activities in the application and use of the practice (operation), and repair and upkeep of the practice (maintenance):

The riparian forest buffer will be inspected periodically, protected and restored as needed, to maintain the intended purpose from adverse impacts such as excessive vehicular and pedestrian traffic, pest infestations, pesticide use on adjacent lands, livestock damage and fire.

Replacement of dead trees or shrubs and control of undesirable vegetative competition will be continued until the buffer is, or will progress to, a fully functional condition. Consideration will be given to retaining snags and den trees for wildlife use.

As applicable, control of concentrated flow erosion or mass soil movement shall be continued in the up-gradient area immediately adjacent to zone 2 to maintain buffer function.

Any removals of tree and shrub products shall be conducted in a manner that maintains the intended purpose.

Riparian Forest Buffer 392-6

For purposes of moderating water temperatures and providing detritus and large woody debris, riparian forest buffer management must maintain a minimum of 50 percent canopy cover.

For providing habitat and corridors for wildlife, manage the buffer to favor food, shelter and nesting cover that would satisfy the habitat requirements of the indicator or target wildlife species.

For purposes of reducing excess pollutants in surface runoff and shallow groundwater (zone 1 and 2 at a minimum), or providing habitat and corridors for wildlife and/or fish (zone 1 at a minimum), manage the dominant canopy to maintain maximum vigor of overstory and understory species.

Any use of fertilizers, mechanical treatments, prescribed burning, pesticides and other chemicals to assure buffer function shall not compromise the intended purpose. Biological control of undesirable plant species and pests (e.g., using predator or parasitic species) shall be implemented where available and feasible.

Additional operation and maintenance requirements shall be developed on a site-specific basis to assure performance of the practice as intended.

REFERENCES

U.S. Department of Agriculture, Forest Service Site Index Curves for Forest Tree Species in the Eastern U.S., Tech Report NC-128.

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NATURAL RESOURCES CONSERVATION SERVICE
CONSERVATION PRACTICE SPECIFICATIONS

RIPARIAN FOREST BUFFER

(Acre)
CODE 392

GENERAL SPECIFICATIONS

Procedures, technical details and other information listed below provide additional guidance for carrying out selected components of the named practice. This material is referenced from the conservation practice standard for the named practice and supplements the requirements and considerations listed therein.

PLANTING DENSITIES

Initial plant-to-plant densities for trees and shrubs will depend on their potential height at 20 years of age. Heights may be estimated based on: 1) performance of the individual species (or comparable species) in nearby areas on similar sites, or 2) predetermined and documented heights using the attached Table 1. Planting density specifications are:

Plant Types/Heights: (Potential in 20 Years)	Plant-to-Plant Spacing in feet:
• Shrubs and trees from 10 to 25 feet in height	5 to 8
• Trees greater than 25 feet in height	8 to 12

PLANT LIST

Table 1 lists some woody plant species (trees and shrubs) commonly associated with and suited to riparian areas. Key attributes are listed for each plant to assist with the design process for establishing new buffers.

CARE, HANDLING, SIZE AND PLANTING REQUIREMENTS FOR WOODY PLANTING STOCK

Planting stock will be stored in a cool, moist environment (34-38 degrees F) or heeled in. During all stages of handling and storage, keep stock tops dry and free of mold and roots moist and cool. Destroy stock that has been allowed to dry, to heat up in storage (e.g., within a bale, delivery carton or container), or that has developed mold or other pests. Live cuttings that will not be immediately planted shall be promptly placed in controlled storage conditions (34-38 degrees F) and protected until planting time.

Seedlings shall not be less than 1/4" in diameter at 1" above the root collar. For cuttings, avoid using material less than 1/2" - 3/4" in diameter, cut off tops with apical buds, remove side branches, and produce lengths long enough to reach adequate soil moisture required by the individual species during the growing season. Tops of dormant-season collected cuttings may be dipped into latex paint, paraffin or sealing wax to prevent desiccation and mark the up-end. Rooted planting stock must not exceed a 2:1 shoot-to-root ratio. See figure 1. Container stock shall normally not exceed a 1-gallon can size.

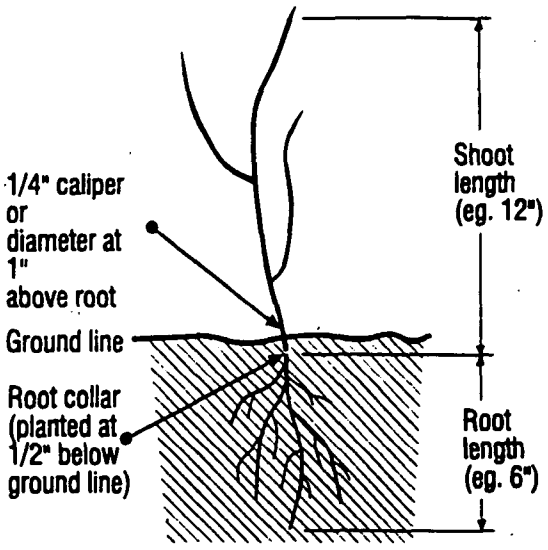

Figure 1. Plant or stock size requirements.

Roots of bareroot stock shall be kept moist during planting operations by placing in a water-soil (mud) slurry, peat moss, super-absorbent (e.g., polyacrylamide) slurry or other equivalent material. Rooting medium of container or potted stock shall be kept moist at all times by periodic watering. Pre-treat stored cuttings with several days of soaking just before planting. Stock shall not be planted when the soil is frozen or dry. Rooted stock will be planted in a vertical position with the root collars approximately 1/2-inch below the soil surface. Insert cuttings to the depth required to reach adequate soil moisture with at least 2-3 buds above ground. The planting trench or hole must be deep and wide enough to permit roots to spread out and down without J-rooting or L-rooting. After planting of rooted stock or cuttings, pack soil around each plant firmly to eliminate air pockets.

BUFFER WIDTH GUIDE TO IMPROVE SUITABILITY FOR SELECTED WILDLIFE SPECIES

Widths below include the sum of buffer widths on one or both sides of water courses or water bodies and may extend beyond riparian boundaries (in such cases refer to Tree/Shrub Establishment, 612, for design of upland forests).

Species:	Desired Width in feet:
• Bald eagle, cavity nesting ducks, heron rookery	600
• Pileated woodpecker	450
• Deer	200
• Amphibians, quail, rabbit, songbirds	100

PREPARATION OF PLANTING SITES

Planting sites shall be properly prepared based on the soil type and vegetative conditions listed below. For sites to be tilled, leave a 3-foot untreated strip at the edge of the bank or shoreline. Avoid sites that have had recent application of pesticides harmful to woody species to be planted. If pesticides are used, apply only when needed and handle and dispose of properly and within federal, state and local regulations. Follow label directions and heed all precautions listed on the container.

Fabric or other mulch may be used for weed control and moisture conservation for new plantings on all sites, particularly those with pronounced growing season moisture deficits or invasive, weedy species. Refer to Mulching, 484, for installation procedures.

Based on site conditions and predominant soil texture of the fine earth fraction, procedures include:

<u>Tillable sites with loamy/clayey soils</u>

- Sod and alfalfa sites

  Summer fallow 1 year to kill the sod or alfalfa. Till (moldboard plow, disk plow, rototiller or similar equipment) in the spring before planting the stock. A fall-sown crop of small grain may be used where needed to control erosion.

Sod may be killed by non-selective herbicides the year previous to planting stock. Plant stock in the residue. On heavy soils, tillage is usually necessary to achieve a satisfactory planting when a tree planting machine is used.

- Small grain or row crop sites

If the site is in row crop, till (moldboard plow, disk plow, rotiller or similar equipment) in the fall or in the spring prior to planting the trees or shrubs. If the site has a plow or hard pan in subsoil, perform a deep disking or ripping operation in the fall. A fall-sown crop of small grain may be used where needed to control erosion.

If the site is in small grain stubble, the stock may be planted in the spring without further preparation. If fabric mulch is to be installed, till in the spring before planting.

Tillage on steep slopes must be on the contour or cross-slope. A cover crop between the rows may be necessary to control erosion and sediment deposition on planted stock.

Tillable sites with sandy soils

- Sod and alfalfa sites

Till (moldboard plow, disk plow, rototiller or similar equipment) and plant to a spring cover crop (corn, grain, sorghum, etc.) the year prior to planting. Leave a stubble cover in which to plant. A light disking may be needed before planting if fabric mulch is used.

Sod may be killed by nonselective herbicides the year prior to planting. Plant trees or shrubs in the residue.

When hand planting, scalp or strip an area at least 3 feet in diameter and two-to-four inches deep. (place plants in the center of the scalped area.)

Rototill a 3-foot wide strip. (Place plants in the center of the tilled area.) Where a drip watering system will not be used, rototill the strip the year prior to planting.

- Small grain or row crop sites

If the site is in small grain, corn, or similar clean tilled crop, and it is reasonably free of weeds, plant stock in the stubble without prior preparation. It may be necessary to till a narrow strip with a disk or other implement to kill weeds or volunteer grain, or to prevent stalks and other residue from clogging the tree planter. If fabric mulch is used, disking may also be needed. A cover crop or stubble may be needed between the rows to protect the planting from water or wind erosion.

Non-tillable sites and/or erosive sites (including sites with undesirable brushy or herbaceous species)

On sites where it is not practical or possible to operate equipment (steepness, rockiness, etc.), where tillage of the site will cause excessive erosion, or where tillage of the site is impractical, the methods listed below may be used. Sites with undesirable brush will need initial treatments that physically removes and kills the brush species to facilitate planting of desired stock and prevent reencroachment of the brush. Suitable methods include hand-cutting and removal, brush hogging, brush-blading, or other equivalent procedure with repeated treatment or use of herbicides to control resprouting.

Machine or hand scalp an area at least 36 inches in diameter with subsequent plant placement in the center of the scalped area.

Rototill a strip at least 36 inches wide the year prior to tree planting with subsequent plant placement in the center of the tilled strip.

Kill the vegetation in a 36-inch diameter or larger area or in a 36-inch or wider strip with a non-selective herbicide the year prior to planting and plant in the center or along the center-line of the treated area.

Riparian Forest Buffer 392-4

TABLE 1. PLANT LIST.

Common Name	Scientific Name	1. 20 yr. ave. height (ft).	2. Shade Tolerance	3. Shade Value	4. Nutrient Uptake	5. Inundation Tolerance	6. Soil Saturation Tolerance	7. Native Species	8. Wildlife Value	9. Timber Value	L=Low M=Med H=High Y=Yes N=No
Tree (Deciduous)											
Black Walnut	Juglans nigra	35	L	M-H	L	L-M	L	Y	M	H	
Bitternut Hickory	Carya cordiformis	25	L	M	L	M	M	Y	M-H	M	
Green Ash	Fraxinus pennsylvanca	45	M	M	H	M	M-H	Y	M	M	
Oaks Cherry Bark	Quercus falcata var. pagodifolia (S.E. Va.) *	50	L	H	M-H	M	L-M	Y	M-H	H	
Pin	Q. palustris	30	L	M	M-H	M	M	Y	H	M	
Overcup	Q. lyrata (S.E. Va.) *	25	M	M	M-H	H	M-H	Y	M-H	M	
Swamp Chestnut	Q. michauxii (E. Pied./CP) *	25	L	M	M-H	M	L-M	Y	M-H	H	
Swamp White	Q. bicolor (Cent./No. Va.) *	25	M	M	M-H	M-H	M-H	Y	H	M	
White	Q. alba	25	M	H	M-H	L-M	L-M	Y	H	H	
Willow	Q. phellos (Pied./CP) *	25	L	H	M-H	M	M	Y	H	M	
Red Maple	Acer rubrum	28	H	M	M	H	H	Y	M	M	
Swamp tupelo	Nyssa sylvatica var. biflora (CP) *	40	H	M	L	H	H	Y	M	M	
Yellow Poplar	Liriodendron tulipifera	60	L	H	H	L	L-	Y	M	H	
Shrubs **											
Bankers Willow	Salix cottettii	15	L	L***	L	H	H	N	M	–	
Purple Osier Willow	Salix purpurea	15	L	L***	L	H	H	N	M	–	
Smooth Alder	Alnus serrulata	15	L	L***	L	H	H	Y	L	–	

* Best suited to indicated sections of Virginia (CP = Coastal Plain, Cent. = Central Va., Pied. = Piedmont)

** Place adjacent to water; especially useful in high velocity flood areas

*** Low due to small size

EXPLANATION OF TERMS - TABLE 1.

Species are grouped by plant type and arranged in alphabetical order by common name. Heights and attributes represent expected performance and characteristics of the individual plant at the reference age in dominant canopy positions on medium-textured, neutral pH soils. The reference age for trees is 20 years of age. The reference age for shrubs is 10 years.

Attributes: (codes include H = High, M = Medium, L = Low, Y = Yes, N = No)

1. 20 Yr. Ave. Height. The average height (in feet) that a plant is expected to reach in 20 years.

2. Shade Tolerance. The plant's capacity to grow in a shaded condition. H = can grow in the shade of an overstory; M = can grow in partial shade; L = needs full or nearly full sunlight.

3. Shade Value. The density or fullness of shade provided by an individual plant's crown in a full leaf-out condition. H = provides full shade; M = a partially open crown that provides patchy or incomplete shade; L = a very open crown that provides little shade.

4. Nutrient Uptake. The plant's general capacity to use excess nutrients such as nitrate-nitrogen. H = can use large amounts; M = some excess nutrients used; L = plant is a low-nutrient user.

5. Inundation Tolerance. General capacity of the plant to withstand standing water, low soil aeration conditions. H = can tolerate 5 or more days of inundation; M = can tolerate 2-5 day events; L = can tolerate 1-day or less of inundation.

6. Soil Saturation Tolerance. The plant's capability to grow in near or saturated soil conditions. H = plant can withstand "wet feet;" M = some tolerance to saturated conditions; L = little or no tolerance of water-saturated soil.

7. Native Species. Y indicates the plant is native to the state; N indicates it is introduced.

8. Wildlife Value. Relative capacity of the plant to provide food and cover to various wildlife species. H = High value by several species, M = Moderate to high value for few to several species, L = Little use or value to wildlife.

9. Timber Value. Relative monetary value of timber and other forest products. H = Generally brings high value under average site conditions, M = Medium value for average site conditions, L = Low value for average site conditions.

USDA FOREST SERVICE STANDARD

Source: Welsch, David J. 1991. *Riparian Forest Buffers.* USDA FS Publ. No. NA-PR-07-91. USDA FS, Radnor, PA.

SPECIFICATION
RIPARIAN FOREST BUFFER

Definition

An area of trees and other vegetation located in areas adjoining and upgradient from surface water bodies and designed to intercept surface runoff, wastewater, subsurface flow and deeper groundwater flows from upland sources for the purpose of removing or buffering the effects of associated nutrients, sediment, organic matter, pesticides or other pollutants prior to entry into surface waters and groundwater recharge areas.

Scope

This specification establishes the minimally acceptable requirements for the reforestation of open lands and renovation of existing forest to be managed as Riparian Forest Buffers for the purposes stated.

Purpose

To remove nutrients, sediment, animal-derived organic matter, and some pesticides from surface runoff, subsurface flow and near root zone groundwater by deposition, absorption, adsorption, plant uptake, denitrification, and other processes, thereby reducing pollution and protecting surface water and groundwater quality.

Conditions Where Practice Applies

Subsurface nutrient buffering processes, such as denitrification, can take place in the soil wherever carbon energy, bacteria, oxygen, temperature and soil moisture are adequate. Nutrient uptake by plants occurs where the water table is within the root zone. Surficial filtration occurs anywhere surface vegetation and forest litter are adequate.

The riparian forest buffer will be most effective when used as a component of a sound land management system including nutrient management and runoff, sediment and erosion control practices. Use of this practice without other nutrient and runoff, sediment and erosion control practices can result in adverse impacts on buffer vegetation and hydraulics including high maintenance costs, the need for periodic replanting and the carrying of excess nutrients and sediment through the buffer by concentrated flows.

This practice applies on lands:

1) adjacent to permanent or intermittent streams which occur at the lower edge of upslope cropland, grassland or pasture;
2) at the margins of lakes or ponds which occur at the lower edge of upslope cropland, grassland or pasture;
3) at the margin of any intermittent or permanently flooded, environmentally sensitive, open water wetlands which occur at the lower edge of upslope cropland, grassland or pasture;
4) on karst formations at the margin of sinkholes and other small groundwater recharge areas occurring on cropland, grassland or pasture.

   Note: In high sediment production areas (8-20 in/ 100 yrs.), severe sheet, rill and gully erosion must be brought under control on upslope areas for this practice to function correctly.

Design Criteria

Riparian Forest Buffers

Riparian forest buffers will consist of three distinct zones and be designed to filter surface runoff as sheet flow and downslope subsurface flow which occurs as shallow groundwater. For the purposes of these buffer strips, shallow ground water is defined as saturated conditions which occur near or within the root zone of trees and other woody vegetation and at relatively shallow depths where bacteria, oxygen, and soil temperature contribute to denitrification. Streamside Forest Buffers will be designed to encourage sheet flow and infiltration and impede concentrated flow.

Zone 1

Location

Zone 1 will begin at the top of the stream bank and occupy a strip of land with a fixed width of fifteen feet measured horizontally on a line perpendicular to the streambank.

Purpose

The purpose of Zone 1 is to create a stable ecosystem adjacent to the water's edge, provide soil/water contact area to facilitate nutrient buffering processes, provide shade to moderate and stabilize water temperature encouraging the production of beneficial algal forms and to contribute necessary detritus and large woody debris to the stream ecosystem.

Requirements

Runoff and wastewater to be buffered or filtered by Zone 1 will be limited to sheet flow or subsurface flow only. Concentrated flows must be converted to sheet flow or subsurface flows prior to entering Zone 1. Outflow from subsurface drains must not be allowed to pass through the riparian forest in pipes or tile thus circumventing the treatment processes. Subsurface drain outflow must be converted to sheet flow for treatment by the riparian forest buffer or treated elsewhere in the system prior to entering the surface water.

Dominant vegetation will be composed of a variety of native riparian tree and shrub species and such plantings as necessary for streambank stabilization during the establishment period. A mix of species will provide the prolonged stable leaf fall and variety of leaves necessary to meet the energy and pupation needs of aquatic insects.

Large overmature trees are valued for their detritus and large woody debris contributions to the stream ecosystem. Therefore, management of Zone 1 will be limited to bank stabilization and removal of potential problem vegetation. Occasional removal of extreme high value trees may be permitted where water quality values are not compromised. Logging and other overland equipment shall be excluded except for streamcrossings and stabilization work.

Livestock will be excluded from Zone 1 except for designed stream crossings.

Zone 2

Location

Zone 2 will begin at the edge of Zone 1 and occupy an additional strip of land with a minimum width of 60 feet measured horizontally in the direction of flow. Total minimum width of Zones 1 & 2 is therefore 75 feet. Note that this is the minimum width of Zone 2 and that the width of Zone 2 may have to be increased as described in the section "Determining the Total Width of Buffer" to create a greater combined width for Zones 1 & 2.

Purpose

The purpose of Zone 2 is to provide necessary contact time and carbon energy source for buffering processes to take place and to provide for long term sequestering of nutrients in the form of forest trees. Outflow from subsurface drains must not be allowed to pass through the riparian forest in pipe or tile thus circumventing the treatment processes. Subsurface drain out flow must be converted to sheet flow for treatment by the riparian forest buffer or treated elsewhere in the system prior to entering the surface water.

Requirements

Runoff and wastewater to be buffered or filtered by Zone 2 will be limited to sheet flow or subsurface flow only. Concentrated flows must be converted to sheet flow or subsurface flows prior to entering Zone 2.

Predominant vegetation will be composed of riparian trees and shrubs suitable to the site, with emphasis on native species and such plantings as necessary to stabilize soil during the establishment period. Nitrogen fixing species should be discouraged where nitrogen removal or buffering is desired. Species suitability information should be developed in consultation with state and federal forestry agencies, Soil Conservation Service, and Fish and Wildlife Service.

Specifications should include periodic harvesting and timber stand improvement (TSI) to maintain vigorous growth and leaf litter replacement and to remove nutrients and pollutants sequestered in the form of wood in tree boles and large branches. Management for wildlife habitat, aesthetics, and timber are not incompatable with riparian forest buffer objectives as long as shade levels and production of leaf litter, detritus and large woody debris are maintained. Appropriate logging equipment recommendations shall be determined in consultation with the state and federal forestry agencies.

Livestock shall be excluded from Zone 2 except for necessary designed stream crossings.

Zone 3

Location

Zone 3 will begin at the outer edge of Zone 2 and have a minimum width of 20 feet. Additional width may be desirable to accommodate land shaping and mowing machinery. Grazed or ungrazed grassland meeting the purpose and requirements stated below may serve as Zone 3.

Purpose

The purpose of Zone 3 is to provide sediment filtering, nutrient uptake and the space necessary to convert concentrated flow to uniform, shallow, sheet flow through the use of techniques such as grading, and shaping, and devices such as diversions, basins and level lip spreaders.

Requirements

Vegetation will be composed of dense grasses and forbs for structure stabilization, sediment control and nutrient uptake. Mowing and removal of clippings is necessary to recycle sequestered nutrients, promote vigorous sod and control weed growth.

Vegetation must be maintained in a vigorous condition. The vegetative growth must be hayed, grazed or otherwise removed from Zone 3. Maintaining vigorous growth of Zone 3 vegetation must take precedence and may not be consistent with wildlife needs.

Zone 3 may be used for controlled intensive grazing when conditions are such that earthen water control structures will not be damaged.

Zone 3 may require periodic reshaping of earth structures, removal or grading of accumulated sediment and reestablishment of vegetation to maintain effectiveness of the riparian buffer.

Determining need for protection

Buffers should be used to protect any body of water which will not be:

treated by routing through a natural or artificial wetland determined to be adequate treatment;
treated by converting the flow to sheet flow and routing it through a forest buffer at a point lower in the watershed.

Determining total width of the buffer

Note that while not specifically addressed, slope and soil permeability are components of the following buffer width criteria.

Each of the following criteria is based on methods developed or used by persons conducting research on riparian forests.

Streamside Buffers

The minimum width of streamside buffer areas can be determined by any of several methods suitable to the geographic area.

1) Based on soil hydrologic groups as shown in the county soil survey report, the width of Zone 2 will be increased to occupy any soils designated as Hydrologic Group D and those soils of Hydrologic Group C which are subject to frequent flooding. If soils of Hydrologic Groups A or B occur adjacent to intermittent or perennial streams, the combined width of Zones 1 & 2 may be limited to the 75 foot minimum.
2) Based on area, the width of Zone 2 should be increased to provide a combined width of Zones 1 & 2 equal to one-third of the slope distance from the stream bank to the top of the pollutant source area. The effect is to create a buffer strip between field and stream which occupies approximately one-third of the source area.
3) Based on the Soil Capability Class of the buffer site as shown in the county soil survey, the width of Zone 2 should be increased to provide a combined width of Zones 1 & 2 as shown below.

Capability Class	Buffer Width
Cap. I, II e/s, V	75'
Cap. III e/s, IV e/s	100'
Cap. VI e/s, VII e/s	150'

Pond and Lake-Side buffer strips

The area of pond or lake-side buffer strips should be at least one-fifth the drainage area of the cropland and pastureland source area. The width of the buffer strip is determined by creating a uniform width buffer of the required area between field and pond. Hydrologic Group and Capability Class methods of determining width remain the same as for streamside buffers. Minimum widths apply in all cases.

Environmentally Sensitive Wetlands

Some wetlands function as nutrient sinks and when they occur in fields or at field margins can be used for renovation of agricultural surface runoff and/or drainage. However, most wetlands adjoining open water are subject to periodic flushing of nutrient-laden sediments and, therefore, require riparian buffers to protect water quality.

Where open water wetlands are roughly ellipsoid in shape, they should receive the same protection as ponds.

Where open water wetlands exist in fields as seeps along hillslopes, buffers should consist of Zones 1, 2 & 3 on sides receiving runoff and Zones 1 & 3 on the remaining sides. Livestock must be excluded from Zones 1 & 2 at all times and controlled in Zone 3. Where Zones 1 & 3 only are used, livestock must be excluded from both zones at all times, but hay removal is desirable in Zone 3.

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Vegetation Selection

Zone 1 & 2 vegetation will consist of native streamside tree species on soils of Hydrologic Groups D and C and native upland tree species on soils of Hydrologic Groups A and B.

Deciduous species are important in Zone 2 due to the production of carbon leachate from leaf litter which drives bacterial processes that remove nitrogen as well as to the sequestering of nutrients in the growth processes. In warmer climates evergreens are also important due to the potential for nutrient uptake during the winter months. In both cases a variety of species is important to meet the habitat needs of insects important to the aquatic food chain.

Zone 3 vegetation should consist of perennial grasses and forbs.

Species recommendations for vegetated buffer areas depend on the geographic location of the buffer. Suggested species lists should be developed in collaboration with appropriate state and federal forestry agencies, the Soil Conservation Service and the Fish and Wildlife Service. Species lists should include trees, shrubs, grasses, legumes, forbs, as well as site preparation techniques. Fertilizer and lime, helpful in establishing buffer vegetation, must be used with caution and are not recommended in Zone 1.

Maintenance Guidelines

General

Buffers must be inspected annually and immediately following severe storms for evidence of sediment deposit, erosion or concentrated flow channels. Prompt corrective action must be taken to stop erosion and restore sheet flow.

The following should be avoided within the buffer areas: excess use of fertilizers, pesticides, or other chemicals, vehicular traffic or excessive pedestrian traffic and removal or disturbance of vegetation and litter inconsistent with erosion control and buffering objectives.

Zone 1 vegetation should remain undisturbed except for removal of individual trees of extremely high value or trees presenting unusual hazards such as potentially blocking culverts.

Zone 2 vegetation, undergrowth, forest floor, duff layer and leaf litter shall remain undisturbed except for periodic cutting of trees to remove sequestered nutrient and to maintain an efficient filter by fostering vigorous growth, and for spot site preparation for regeneration purposes. Controlled burning for site preparation, consistent with good forest management practice could also be used in Zone 2.

Zone 3 vegetation should be mowed and the clippings removed as necessary to remove sequestered nutrient and promote dense growth for optimum soil stabilization. Hay or pasture uses can be made compatible with objectives of Zone 3.

Zone 3 vegetation should be inspected twice annually and remedial measures taken as necessary to maintain vegetation density and remove problem sediment accumulations.

Stable Debris

As Zone 1 reaches 60 years of age, it will begin to produce large stable debris. Large debris, such as logs create small dams which trap and hold detritus for processing by aquatic insects thus adding energy to the stream ecosystem, strengthening the food chain and improving aquatic habitat. Wherever possible, stable debris should be conserved.

Where debris dams must be removed, try to retain useful, stable portions which provide detritus storage.

Deposit removed material a sufficient distance from the stream that it will not be refloated by high water.

Planning Considerations

1. Evaluate the type and quantity of potential pollutants that will be derived from the drainage area.
2. Select species adapted to the zones based on soil and site factors and possible commercial goals such as timber and forage.
3. Plan to establish trees early in the dormant season for maximum viability.
4. Be aware of visual aspects and plan for wildlife habitat improvement, if desired.
5. Consider provisions for mowing and removing vegetation from Zone 3. Controlled grazing may be satisfactory in Zone 3 when the filter area is dry and firm.

Environmental Land Planning Series

Site Planning for Urban Stream Protection

prepared by:
Tom Schueler
The Center for Watershed Protection
8737 Colesville Road, Suite 300
Silver Spring, Maryland 20910

prepared for:
Lorrie Herson-Jones
Project Manager
Department of Environmental Programs
Metropolitan Washington Council of Governments
777 N. Capitol Street, Suite 300
Washington, D.C. 20002

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Chapter 5

The Architecture of Stream Buffers

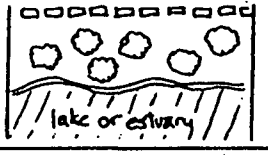
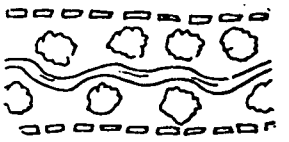
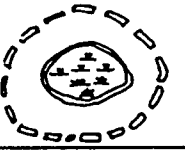
Introduction

This chapter emphasizes the importance of protecting key natural areas at the development site. This is done by delineating these areas and protecting them within a buffer system. This chapter provides detailed guidance on how to design and maintain effective buffer systems within a community.

Three primary aquatic areas provide the foundation for the buffer system. They include the *shoreline* of a lake or estuary, a delineated *wetland*, or a *stream* channel. Some of the common delineation criteria for each aquatic area are shown in Table 21.

Additional buffer width can be reserved around aquatic areas to provide further protection. These buffer areas may include sensitive habitats, steep slopes, floodplains and other important resource areas. The width and uses of the buffer zone also depend to some extent on the kind of aquatic area being

TABLE 21. DELINEATION CRITERIA FOR SHORELINE, WETLAND AND STREAM BUFFERS

BUFFER TYPE	SHORELINE BUFFER	STREAM BUFFER	WETLAND BUFFER
Delineation			
Main Objectives:	Separation of land development from aquatic areas, pollutant removal	Preserve stream ecology, prevent flood damage and bank erosion, habitat	Prevent wetland disturbance
Width varies by:	Water use class or designation of lake or estuary	Stream order, and adjacent slopes	Size, type and quality of wetland
Measured from:	Mean high water or high tide line	Bank or stream centerline	Edge of field delineated wetland
Stormwater management	Bypass or treat	Bypass, but some limited treatment	Avoid direct entry
View corridors	Important	Seldom important	Seldom important
Access	Water-dependent	Restricted	Prohibited
Median Width (from Heraty, 93)	75 ft. (lake) 50 ft. (ocean)	88 ft.	100 ft.

Each type of buffer - shoreline, stream and wetland - are different in their design objectives

considered for protection (see Table 19).

The remainder of this chapter explores the architecture of a buffer system, with a strong emphasis on how buffers can be applied to protect urban streams. With some subtle refinements, the same basic approach and concepts can also be applied to shorelines and wetland areas.

Some Buffer Geometry and Terminology

To design an effective stream buffer system, it is important to understand spatial connections between the stream and its watershed. A network of streams drain each watershed. Streams can be classified according to their order in that network (Fig. 21). A stream that has no tributaries or branches is defined as a first–order stream. When two first–order streams combine together, a second–order stream is created, and so on. *Headwater streams* are defined as first– and second–order streams. Although they are short in length and drain relatively small areas, these headwater streams comprise of roughly 75% of the total stream and river mileage in the United States (see Table 22).

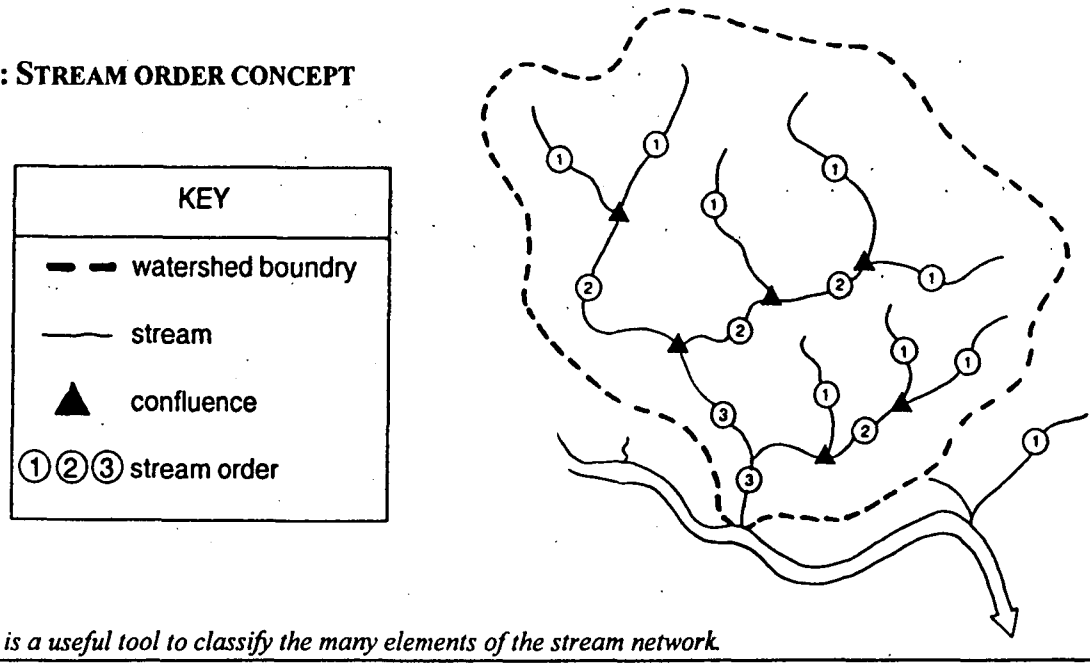
The next key concept is *drainage density* or the length of stream channel per unit area. A region with steep topography, poor cover, and less permeable soils tends to have more stream mileage than a region with less relief and more permeable soils. Geomorphic research has shown that drainage density is remarkably constant within the same physiographic region. Thus, for much of the eastern US, a one–square–mile watershed often has a total stream channel length of 1.4 miles (range 1.0–2.5).

Determining where a first–order stream actually begins in the landscape is not an easy matter. This is due to the complicated path that runoff follows to reach a stream channel. The total distance from the ridgetop (or watershed divide) to the stream channel is known as the *overland flowpath* (Fig. 22). Typically, this distance ranges from 750 to 1,500 feet in many regions of the country. Runoff begins as "*sheet flow*"—the flow is very shallow and spread uniformly over the land surface. Very quickly, however, this uniform flow concentrates to form shallow and then progressively deeper channels, usually within 300 feet of the ridgetop (Ferguson and Debo 1991). These channels only have running water during storm events and are known as *intermittent* channels.

At some point further downstream, groundwater supplies running water to the channel on a year–round basis—these streams are *perennial.* The transition from intermittent channel to perennial stream is not fixed. Indeed, it often moves up or downstream from season to season and year to year, in response to changes in the local water table.

The cross–sectional area of a perennial stream channel fixes that stream's capacity to convey runoff. Typically, an undeveloped stream channel can fully accommodate the peak discharge from a *two–year storm event*, but no more. When the peak discharge rate exceeds the two–year storm event, runoff volume exceeds the capacity of the channel and must

FIGURE 21: STREAM ORDER CONCEPT



Stream order is a useful tool to classify the many elements of the stream network.

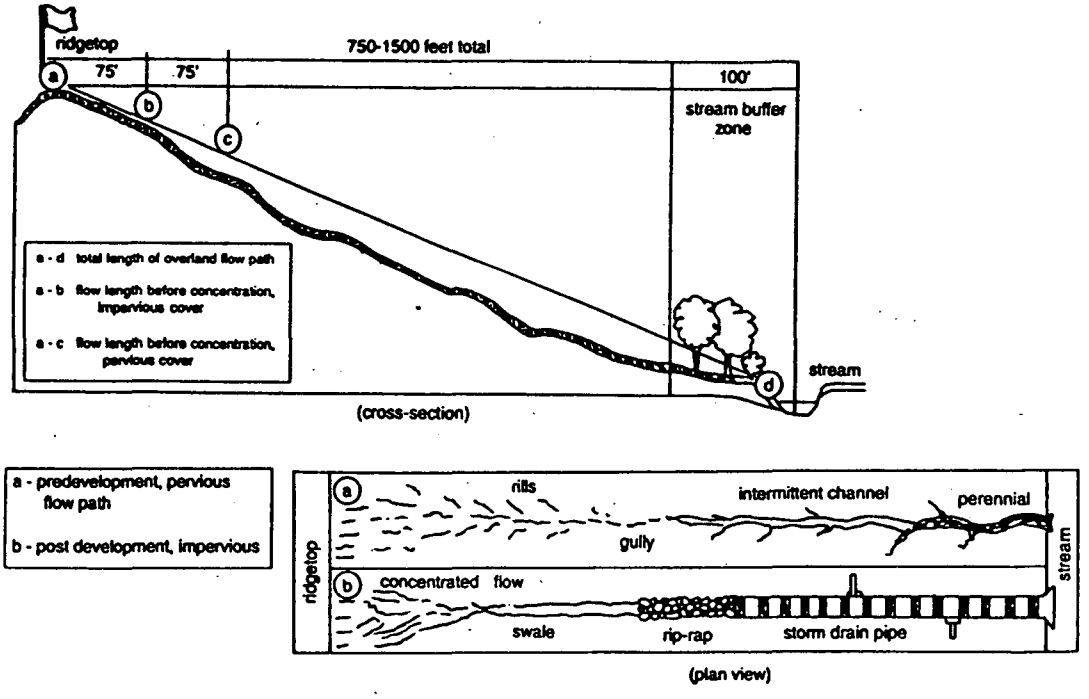
TABLE 22: PROPORTION OF NATIONAL STREAM AND RIVER MILEAGE IN HEADWATER STREAMS

Stream Order*	Number of streams	Total Length of Streams, miles	Mean Drainage Area (sq. miles) **
1	1,570,000	1,570,000	1.0
2	350,000	810,000	4.7
3	80,000	420,000	23
4	18,000	220,000	109
5	4,200	116,000	518
6	950	61,000	2,460
7	200	30,000	11,700
8	41	14,000	55,600
9	8	6,200	264,000
10	1	1,800	1,250,000
Total	2,023,400	3,250,000	N/A

* stream order based on Strahler method, analyzing maps at a scale of 1:24,000.
** cumulative drainage area, including tributaries.

Note: 75% of the total stream and river mileage in the country is in either first or second order streams

FIGURE 22: THE OVERLAND FLOW PATH TO A STREAM



The distance between the ridgetop and the stream is known as the overland flow path. Even in undisturbed watersheds, flow tends to quickly concentrate over a short distance (plan view, panel A). In urban watersheds, flow tends to concentrate even more quickly, requiring stabilization of the intermittent channel (panel B).

spill over the banks into the adjacent *floodplain* on either side of the channel (Fig. 23). By convention, the area and height of the floodplain is defined using the *100-year storm* event. The runoff from this event is determined from the maximum rainfall that has a probability of occurring once every 100 years. The width of the floodplain tends to be narrower in headwater streams and much broader in higher order streams and rivers.

A developed watershed has a remarkably greater rate and volume of runoff for a given storm event than an undeveloped one (cf Chapter 2). As a consequence, both the cross-sectional area of the stream channel and the elevation of the *100-year floodplain* (area immersed during the 100-year flood) are increased. In more practical terms, the stream channel erodes, becoming wider and/or deeper. During extreme floods, a larger land area is subject to flooding after development (see Fig. 23). The severity of the response is a direct function of the amount of *impervious cover* that is created in the watershed.

The geometry of streams and their floodplains is formed by rainfall and runoff. After development, more rainfall is translated into runoff, and the geometry of both the stream and the floodplain changes. A clear understanding of the dynamics of these variables is essential in designing an effective stream buffer scheme.

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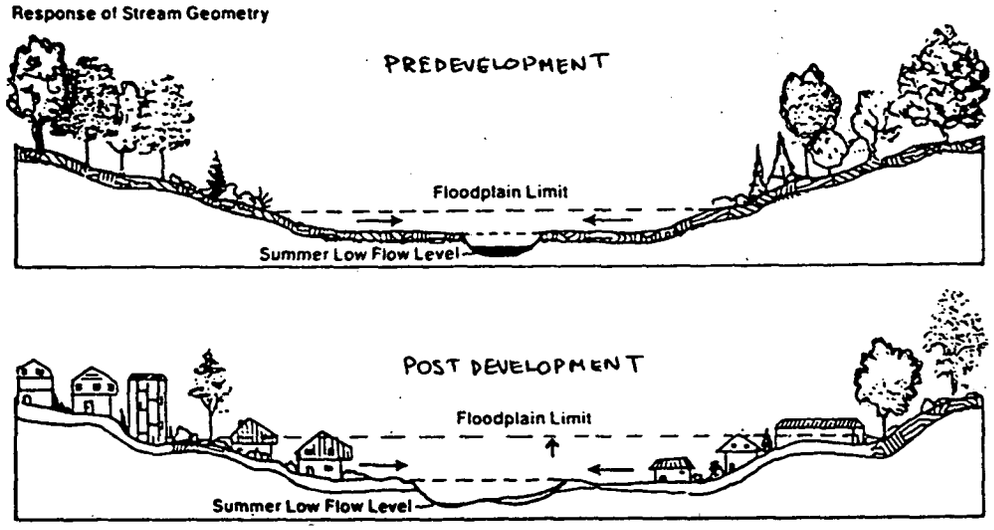
FIGURE 23: THE STREAM AND ITS FLOODPLAIN, BEFORE AND AFTER DEVELOPMENT



The increase in the peak discharge rates following urbanization shifts the elevation of the 100 year floodplain upward, which may put more property and structures at risk. (Source: Schueler 1987).

Benefits of Forested Stream Buffers

A wide forest buffer is an essential component of any local stream protection strategy. Its primary value is to physically protect the stream channel from future disturbance or encroachment. A network of buffers act as the right–of–way for a stream and functions as an integral part of the stream ecosystem. But a stream buffer also provides many other important benefits that contribute to the quality of the stream and the adjacent community. The many benefits of stream buffers are summarized in Table 23. In many regions, these benefits are amplified when the streamside zone is kept in a forested condition. Recent research indicates that forested stream buffers provide the following benefits:

1. Reduced watershed imperviousness

The use of stream buffers can indirectly reduce a site's impervious cover in several ways. To begin with, land within the stream buffer network cannot be developed, and thus will not have impervious cover. How much land does the stream buffer network consume? This question can be answered at the landscape scale by examining the drainage density relationship. In the East Coast, for example, a watershed with a drainage area of one square mile will have a total stream channel length of about 1.4 miles, on average.

TABLE 23: BENEFITS OF URBAN STREAM BENEFITS (*f*, BENEFIT AMPLIFIED BY OR REQUIRES FOREST COVER)

1. Reduces watershed imperviousness by 5%. An average buffer width of 100 ft protects up to 5% of watershed area from future development.
2. Distances areas of impervious cover from the stream. More room is made available for placement of BMPs and septic system performance is improved.(*f*)
3. Reduces small drainage problems and complaints. When properties are located too close to a stream, residents are likely to experience and complain about backyard flooding, standing water, and bank erosion. A buffer greatly reduces complaints.
4. Stream "right of way" allows for lateral movement. Most stream channels shift or widen over time; a buffer protects both the stream and nearby properties.
5. Effective flood control. Other, expensive flood controls not necessary if buffer includes the 100-yr floodplain.
6. Protection from streambank erosion. Tree roots consolidate the soils of floodplain and stream banks, reducing the potential for severe bank erosion (*f*)
7. Increases property values. Homebuyers perceive buffers as attractive amenities to the community. 90% of buffer administrators feel buffers have a neutral or positive impact on property values. (*f*)
8. Increased pollutant removal. Buffers can provide effective pollutant removal for development located within 150 feet of the buffer boundary, when designed properly.
9. Foundation for present or future greenways. Linear nature of the buffer provides for connected open space, allowing pedestrians and bikes to move more efficiently through a community. (*f*)
10. Provides food and habitat for wildlife. Leaf litter is the base food source for many stream ecosystems; forests also provides woody debris that creates cover and habitat structure for aquatic insects and fish. (*f*)
11. Mitigates stream warming. Shading by the forest canopy prevents further stream warming in urban watersheds. (*f*)
12. Protection of associated wetlands. A wide stream buffer can include riverine and palustrine wetlands that are frequently found near streams.
13. Prevent disturbance to steep slopes. Removing construction activity from these sensitive areas are the best way to prevent severe rates of soil erosion (*f*)
14. Preserves important terrestrial habitat. Riparian corridors are important transition zones, rich in species. A mile of stream buffer can provide 25-40 acres of habitat areas(*f*)
15. Corridors for conservation. Unbroken stream buffers provide "highways" for migrations of plant and animal populations.(*f*)
16. Essential habitat for amphibians. Amphibians require both aquatic and terrestrial habitats and are dependent on riparian environments to complete their life cycle (*f*)
17. Fewer barriers to fish migration. Chances for migrating fish are improved when stream crossings are prevented or carefully planned.
18. Discourages excessive storm drain enclosures/channel hardening. Prevents increases in runoff from impervious cover and subsequent eroding or overflowing of headwater streams.
19. Provides space for stormwater ponds. When properly placed, structural BMPs within the buffer can be an ideal location to remove pollutants and control flows from urban areas.
20. Allowance for future restoration. Even a modest buffer provides space and access for future stream restoration, bank stabilization, or reforestation.

If a 100–ft wide stream buffer is reserved on each side of the channel, then the buffer would consume about 34 ac or about 5% of the total watershed area. If the zoning density was fixed, this would reduce impervious cover by a like amount. While this represents a modest reduction in total imperviousness at a site, it can be combined with other techniques to achieve a significant watershed reduction.

The second way that stream buffers reduce imperviousness is by forcing a more clustered and compact development pattern. The linear nature of the stream buffer, along with the limitations on roadway crossings, make it nearly impossible to use traditional roadway networks that create needless imperviousness area. (see Chapter 6). Shorter and more economical branching or cul–de–sac road networks are often more feasible residential street designs.

2. Distance from imperviousness to the stream

A stream buffer is also useful in that it increases the distance from impervious areas to the stream. This allows more room to locate effective stormwater BMPs, or to utilize innovative stormwater conveyance systems, such as biofilters. In rural areas, the separation distance helps to improve the performance of on–site septic systems. The greater the distance that subsurface septic system effluent must travel, the greater the chance that soils and plants will remove harmful bacteria and nutrients.

3. Reduce small drainage complaints

Probably the most frequent complaints fielded by local public works agencies concern small residential drainage problems—backyard flooding, streambank erosion, standing water, clogged culverts and the like. The common root of these problems is that property is simply located too close to a stream. By reserving a forested buffer that creates more distance between the residents and the stream, the number of complaints should drop, giving much needed relief to local governments from this time–consuming maintenance burden.

Forest buffers, particularly those with a deep layer of organic matter, can have 10 times more runoff storage capacity and infiltration capacity than a grass or turf area (CBP 1993). This "spongy" quality helps the buffer forests absorb more runoff and should also help reduce drainage problems.

4. Space in which streams can move laterally over time

In a very real sense, a buffer is the right–of–way for a stream, and allows for the physical protection of the stream channel.

Stream channel location is not constant over time. Over the course of decades, the actual position of the channel may wander back and forth across the floodplain (Leopold et al. 1964). Some lateral movement of the stream can and should be expected, even in undeveloped streams.

In urban streams, the lateral movement becomes more rapid and unpredictable. To begin with, most urban stream channels have not yet adjusted to the increased frequency and rate of stormwater runoff generated by upstream development. It is therefore quite common for an urban stream to double or triple channel width before reaching a new equilibrium. Fallen trees from undercut banks can further accelerate the process, resulting in localized widening as much as five times the pre-development channel width.

Clearly, the existence of a wide buffer gives the urban stream the room to move laterally or widen over time, without threatening structures or developed property. When a stream is given room to move, communities often spend fewer dollars for expensive channel protection and stabilization methods that are required to keep a channel in a fixed place.

5. Effective flood insurance

Small stream flooding is a common occurrence in urban areas, even during moderate storm events. Floodwaters can extend far from the channel and damage property and structures. However, when the post-development 100–year floodplain is wholly contained within a stream buffer, the risks of flood damage are greatly reduced. Because structures are kept away from the floodplain, they do not need to be "floodproofed" with expensive protective measures. Thus a stream buffer is an effective form of flood insurance for a community and conforms with federal flood insurance requirements (FEMA).

In addition, the dedication of a buffer provides for temporary storage of floodwaters in headwater streams (for extreme floods greater than the two year event), thereby reducing the height of the flood crest for downstream areas (Karr and Schlosser 1978).

6. Protection against streambank erosion

A deep network of tree roots consolidate the soils of the floodplain, making them more resistant to erosive forces of runoff. The shallow roots of grass, on the other hand, provide little resistance to bank erosion (Karr and Schlosser 1978). When deep tree roots are absent, the toe of the streambank is very susceptible to rapid erosion. The bank then begins to undercut, and blocks of turf at the top of the bank begin to slump into the channel (Sweeney 1993). These eroded sediments are deposited in the channel, where they can smother the existing stream substrate. Also, deposited sediments temporarily reduce the cross–sectional area of the channel, thus leading to a new and more severe phase of bank erosion.

7. Increased property values

Forested buffers create a more natural and attractive sense of community. A national survey of 36 stream buffer program administrators indicated that stream buffers were perceived to have either a neutral or positive impact on adjacent property values (Heraty 1993). None of the respondents indicated that buffers had a negative impact

on land value.

This finding is consistent with numerous other studies that have found that greenways and buffers increase property values of adjacent homes (Correl et al. 1978, Seattle Office of Planning (1987) and Mazour (1988).

8. Increased pollutant removal

Urban stream buffers have the potential to remove pollutants that move through them, in groundwater or sheet flow. Soils and vegetation within the buffer act as a living filter. Pollutants in stormwater settle out, adsorb to soil, or are taken up by vegetation. Performance monitoring studies suggest that stream buffers can remove the majority of sediment and trace metals that are delivered to them, as long as even and uniform sheet flow is maintained across the outer edge of the buffer. Removal of phosphorus and nitrogen appears to be modest, and more unreliable (see Table 28).

It is important to note that stream buffers cannot be relied on as the sole urban BMP at most development sites. Most of the runoff produced in urban areas concentrates too quickly to be effectively treated by a buffer, and other, more structural, BMPs must still be installed (e.g., stormwater ponds, wetland infiltration or filtering system).

9. A foundation for greenways

At the landscape scale, a buffer network provides a connected system of open space that can link a community together. A buffer serves as the foundation of a greenway that can meet the recreational needs of adjacent urban residents. The greenway can contain foot trails, which allow for easier pedestrian movement through the community or to provide an opportunity for nature enjoyment. Surveys by Adams (1994) indicate that 58% of suburban residents actively engage in wildlife watching and nature enjoyment near their homes. Residents also exhibit a keen desire to live next to natural areas and are willing to pay a premium for homes located next to them (Adams et al. 1983)

Where the stream buffer is wide enough and publicly owned, it can also serve as the site of a bikeway that links the community together. Because bikepaths are impervious and require clearing of vegetation, they should be carefully located in the outer zone of a buffer.

10. Provision of food, cover, and stream habitat

Riparian forests are an integral part of the stream ecosystem. Trees supply the stream with leaf litter, which constitutes the major source of energy in headwater streams in most parts of the country. Leaf litter and woody debris literally form the base of the food chain. Bacteria and fungi colonize these packs of organic matter and are in turn consumed by aquatic insects, which are eaten by other insects and fish. Thus the annual leaf fall supplied from a forested buffer is the key energy source for every trophic level in the stream.

The adjacent forests also supply large woody

debris to the stream channel. These logs, branches and twigs create more structural complexity within the channel and thus more habitat area for aquatic insects. The woody material often forms natural debris dams that help a headwater stream retain more of its nutrients and organic matter. For example, Sweeney (1993) noted that forested streams had 17 times as much wetted benthic habitat area as unforested streams. In addition, forested streams had eight times as much woody debris and 38 times as much leaf litter as unforested streams. The presence of a forest buffer also appears to directly influence the quality and the diversity of the stream community. Both Steedman (1988) and Sweeney (1993) have extensively documented that a stream insect community declines in total area and diversity when the forest cover is lost.

11. Stream warming is mitigated

Mature forests provide shade that keeps stream temperatures from rising during the summer months. When the forest cover is removed, an urban stream will invariably heat up by as much as 5–10 degrees F (Greene 1950, Pluhowski 1970, Sweeney 1993, and Galli 1991). A temperature increase of this magnitude can seriously threaten the survival of trout and other salmonid fish species, as well, as well as some sensitive aquatic insects, such as stoneflies.

12. Wetland protection

Wetlands often are the surface expression of the underlying water table. Some type of wetland is almost always found where the water table is at or near the surface. Likewise, perennial streams are also an expression of the water table where it meets the lowest point in the local landscape. As such, streams are almost always associated with certain types of riverine and palustrine wetlands. Located near the stream channel or in the adjacent floodplain, these wetlands are often forested and of high functional quality. Clearly, by reserving a wide stream buffer, it is possible to more systematically protect these important wetlands from disturbance. In addition, extending the buffer network beyond the limits of a wetland provides a more effective transition zone between the wetland and upland urban areas.

13. Prevention of soil erosion from steep slopes

Steep slopes and streams are often located near each other, as the stream has historically been the erosional agent that creates sharp relief. Steep slopes pose the greatest risk of sediment delivery during construction. The combination of steepness and proximity to the stream make these slopes the most susceptible areas for erosion at any development site. Sediment loads from these areas can be exceptionally high, even when the best erosion and sediment control techniques are applied. Where stream buffers are expanded to fully include all adjacent steep slopes and thereby prevent their clearing and disturbance, they can be a very effective component of an erosion and sediment control plan.

14. Preservation of wildlife habitat

A continuous one–mile stream buffer that extends 100 ft outward on either side of the channel preserves about 25 ac of contiguous stream or riverine habitat. A stream buffer acts as a habitat "island," a transition zone between aquatic and terrestrial environments. Most ecologists have concluded that the total number of species of birds, mammals, reptiles, and amphibians, is strongly related to the area of a habitat island—as it gets larger, more species are recorded.

Studies of wildlife diversity in urban habitat islands suggest that a surprising number of bird, mammal and reptile species can be found in contiguous habitat island that are 25 ac or greater in area (Table 24).

15. Creation of wildlife corridors

In addition to their intrinsic value as wildlife habitat, stream buffers also create potential corridors for wildlife travel between larger habitat islands in the urban landscape (e.g., urban forest preserves, natural wetland complexes, stormwater wetlands and community parks). Not only do stream buffers increase the effective size of the total habitat island, but they provide source populations of organisms for future recolonization. To be most effective, a wildlife corridor should be 300–600 ft wide (Desbonnet et al. 1994).

16. Critical amphibian habitat

Amphibians have a terrestrial and aquatic life cycle and require both habitats in close

TABLE 24: URBAN WILDLIFE SPECIES DIVERSITY AS A FUNCTION OF HABITAT ISLAND SIZE

Habitat Island Size	5 acre	10 acre	20 acre	30 acre	40 acre	50 acre	75 acre	100 acre
Woodland Birds*	--	13	21	27	29	31	33	34
Woodland Birds*	24	27	31	33	36	37	40	43
Woodland Birds*	14	21	29	33	36	38	43	46
Chaparral Birds	2.5	3.4	4.3	4.8	5.2	5.5	6.0	6.4
Land Vertebrates	14	21	33	42	51	59	76	95
Beetles	--	6.6	7.7	8.5	9.0	9.5	10.4	11.2
* Studies from three different eco-regions around the world								

As Adams (1994) data illustrates, the number of bird, mammal and insect species increases as the area of the "habitat island" increases

proximity. Thus amphibian species are commonly found in greatest abundance within the stream buffer zone. Tree frogs, salamanders, spring peepers, and other species create the diverse musical chorus heard in the spring and summer riverine woods. Amphibians appear to be undergoing a world–wide decline in abundance, particularly in urban and suburban areas (Minton 1968, Cochran 1989). A number of researchers have noted the importance of stream buffers to support amphibian populations in urban areas.

17. Barriers to fish migration are discouraged

Stream buffer programs regulate the manner in which the stream channel is crossed by highways, utilities, and other linear development. When utilized properly, a stream buffer regulation can prevent the creation of unintentional barriers to upstream fish migration, such as roadway culverts, grade control structures, hardened utility crossings and the like.

18. Excessive storm drain enclosures/channel hardening avoided

Headwater streams are exceptionally vulnerable to physical elimination in urban watersheds. Once impervious cover in the watershed exceeds 30 to 60%, stormwater flow becomes so great that many natural channels cannot withstand them without severely eroding or overflowing (cf Chapter 2). As a consequence, many open channels and headwater streams are enclosed in storm drains to more quickly route stormwater runoff off the site and prevent temporary flooding of streets and parking lots.

The loss of headwater streams can be striking. In some highly developed urban areas, the majority of headwater streams have been enclosed by storm drains or hardened channels. While a stream buffer may not fully protect an urban stream channel from erosion (upstream BMPs are still needed), it may reduce the need for costly bank and channel protection techniques.

19. Good sites provided for stormwater ponds

A buffer system provides an excellent framework within which stormwater BMPs can be integrated. It is the most effective and economical place in the landscape to provide stormwater quantity and quality control. When carefully located and designed, these ponds can maintain the quality of the stream and the buffer network.

20. Allowance for future restoration

Stream buffers are a prerequisite for future watershed restoration. Most urban watershed restorationists have discovered that the best locations and opportunities for restoration projects are along the stream buffer. This relatively narrow strip of land provides numerous sites for riparian reforestation, access for stream restoration projects, and many candidate locations for stormwater retrofit projects. At its most fundamental level, the reservation of a stream buffer enables a community to fix in the future some of the mistakes it may have made in the past. Without a pre–existing stream buffer, such

restoration is seldom possible.

Local Experience with Buffer Programs

Communities have learned that they must go beyond merely drawing a line on a map during the development review process. They must also actively manage and protect a stream both during the construction process and over time in the changing landscape.

Our most detailed knowledge about the quality of local buffer programs comes from a detailed national survey of 36 local and state programs by Heraty (1993) The responses from planners and engineers suggest that most local buffer programs could stand significant improvement in how they are administered. Indeed, respondents in nearly 25% of all programs surveyed have already recognized this need and have revisited their buffer programs to improve their effectiveness. The survey results are supplied in Appendix B, and some of the key findings are provided below:

1. Buffer boundaries are largely invisible to local governments, contractors and residents.

Stream buffer boundaries may be drawn on development plans, but they often become invisible after the plans are approved. The survey indicated that over two–thirds of all communities that required buffers did not record their presence on their official maps. Without buffer maps, local governments cannot systematically inspect or manage their network of buffers. In addition, less than half of all communities required that the buffer boundaries be shown on construction plans, such as clearing and grading plans or erosion and sediment control plans. The absence of buffer limits on construction stage plans increase the risk that contractors will encroach upon or disturb the buffer during the construction phase.

The survey also revealed that 60% of property owners were largely unaware of the boundary or purpose of the stream buffer in their community. This ignorance could generally be traced to the lack of active notification by local governments about the boundaries of buffers to new property owners.

2. Buffers are subject to extensive encroachment in urban areas.

When boundaries are not well defined, buffers become an urban "commons" area, subject to encroachment pressures from adjacent property owners and other users. The pressures begin during the construction stage, where a buffer may be subject to illegal clearing and grading, compaction of soils, tree damage from heavy equipment, and sediment impacts due to poor erosion controls elsewhere on the site. Corish (1995) notes that over 50% of communities surveyed reported that site clearing and grading operations frequently do not protect preserve vegetated areas, and that 25% of all buffers are materially damaged during construction. Corish's finding is comparable to Heraty's, indicating that 26% of jurisdiction report frequent buffer encroachment during construction.

Encroachment pressures continue well after

the site has been developed. Some indication of the extent of these pressures can be gleaned from Cooke's 1991 study of 21 urban wetland buffers in the State of Washington (Table 25).

TABLE 25: ENCROACHMENT PRESSURES ON URBAN WETLAND BUFFERS IN WASHINGTON (COOKE 91)

Category of Disturbance	% of Buffers Disturbed
Dumping of Yard Wastes	76
Conversion of Natural Vegetation into Lawn or Turf	100
Tree Removal	50
Evidence of Fertilizer Impact	55
Evidence of Stormwater Short-Circuiting Buffer	28
Increased Dominance of Invasive/Exotic Plants	67
Evidence that Buffer had been Maintained	5
Trails Established in Buffer	29
Buffers Exhibiting Signs of Alteration	95
Severely Altered Buffers (Not Protecting Adjacent Wetland)	43

The buffers ranged in age from two to eight years. Ninety-five percent of the buffers showed visible signs of encroachment or disturbance, including mowing, dumping of yard wastes, tree removal, trails, and erosion. Those buffers located next to residential areas were often cleared of native vegetation and replaced with lawns (often with high fertilizer input).

3. Few jurisdictions have effective buffer education programs

The lack of awareness about stream buffers is not surprising since only 15% of all programs marked or posted buffer boundaries. Usually the only notification given about the existence of buffers was a one-time legal disclosure, such as recordation on the property deed, language in a homeowner association charter, or a written disclosure upon resale. Surprisingly, 47% of all buffer programs had no specific notification program for individual property owners at all.

Increasingly, communities are experimenting with new and innovative techniques to educate their residents about buffers, including pamphlets, boundary markers, buffer walks, regular homeowner's association meetings, and individual maintenance agreements. One promising approach involves enlisting residents to plant native trees and shrubs in their backyards to attract wildlife and save water. This "bufferscaping" effort not only increases the width of the buffer, but actively involves interested residents in the stewardship of the buffer and the stream environment.

4. Allowable and unallowable uses are seldom defined

In addition to the inexorable pressure from adjacent land owners, a buffer planner must reconcile what uses are to be allowed or denied within the buffer zone. Potential uses are bike trails, footpaths, BMPs, utility crossings, campgrounds, athletic fields, playgrounds,

gazebos, decks, streambank stabilization projects, parallel pipe systems, and many others (Table 26).

TABLE 26: ALLOWABLE AND UNALLOWABLE USES IN THE STREAM BUFFER ZONE (SOURCE: HERATY 1993)

Use	*Allowed*	*Denied*
Footpaths	60	8
Utility line crossings	52	5
Water dependent uses	45	10
Bike paths	30	15
Stormwater BMPs	28	10
Home additions/decks/gazebos	10	55
Maintenance for flood control	Often Allowed	
Pumphouses	Restricted	
Sewage treatment plants	Restricted	
Golf Courses	Restricted	
Campground	Restricted	
Timber Harvesting	Restricted	
Hydropower	Restricted	
Roads/Bridges	Restricted	
Athletic Fields	Restricted	
Playground Equipment	Restricted	
Compost/Yard Wasted	Unrestricted	
Landscaping	Unrestricted	
No Uses Permitted (30%)		
No Uses Denied (15%)		

Percentages of buffer programs that specifically allow or deny a given use. The "Restricted" and "Unrestricted" entries refer to other stream buffer uses that are not commonly addressed in local ordinances.

Many communities have revisited their stream buffer ordinance to make better decisions on the use of the buffer. In general, uses that create impervious surfaces, require extensive clearing, generate pollutants, or that can be located elsewhere are not allowed (MWCOG 1995). Uses that create minimal or temporary changes to the buffer, such as foot paths or stormwater BMPs, or that cannot be located away from the stream (utility crossings, water–dependent access) are generally allowed.

5. Few jurisdictions specified mature forest as a vegetative target

Few jurisdictions clearly specify a vegetative goal of mature forest for their stream buffer program. Heraty (1993) found that over two–thirds of all programs simply required that pre-development vegetative cover be maintained, regardless of whether it was trees, weeds, or turf. Indeed, 20% of all buffer programs failed to specify any vegetative goal at all. Given the importance of riparian forests in the ecology of headwater streams, the adoption of a specific vegetative target for the stream buffer would be wise.

6. Accuracy of buffer delineation seldom confirmed in the field

Local programs encounter a number of difficulties in accurately delineating buffer boundaries at individual development sites. For example, Heraty (1993) reported that nearly 50% of the buffer programs find that buffer widths are not measured from an appropriate baseline, or that consultants do not properly expand the buffer width to pick up floodplains, wetlands or critical habitats specified in their ordinance. One–third of the governments indicate that consultants fail to draw buffer boundaries on site plans or construction drawings, even when this has

been mandated. Some 30% of all respondents indicated that they did not have the time or resources to check the validity of the developer's buffer delineation on the plans at all. It is speculated that an even greater number failed to confirm stream and buffer boundaries in the field.

Twenty percent of jurisdictions had no mechanism to inform the contractor about buffer boundaries during construction. On the positive side, Corish (1995) reported that 75% of respondents did inspect the condition of the buffer at least once after construction had begun. In general, local governments consistently noted problems during the construction stage. For example, respondents reported that erosion control structures were not properly maintained (67%), cleared areas were poorly revegetated (56%), cleared slopes were not adequately stabilized (44%), cleared land was exposed for longer than the prescribed maximum time period (44%) and that soils were heavily compacted (28%). Indeed, only a mere 18% of all jurisdictions surveys concluded that "few problems were encountered in implementation" (Corish 1995).

7. Most buffers remain in private ownership

The vast majority of buffers (90%) remain in private ownership after development (Heraty 1993). Access and use is solely restricted to the property owner. In some subdivisions, the buffer is considered semi–private open space and is dedicated to a homeowner association, which manages the buffer and can control or restrict access. Only 10% of all communities require that the buffer be public open space, and dedicated to the local parks authority. In privately owned buffers, use restrictions are primarily spelled out in the property deed of record. A formal conservation easement is utilized in only about 11% of cases.

Residents appear to broadly support privately owned stream buffer programs in their community. Over 80% of local governments agreed with the statement "that a majority of our citizens think that the community is better off having stream buffers," and that the stream buffers had a neutral (54%) or positive (40%) influence on adjacent land values.

This is not to imply that buffers are popular with all residents. A sampling of the most frequently cited complaints about buffers from residents include:

- ☐ the buffer system gives strangers access to my backyard
- ☐ the buffer is a breach of my property rights
- ☐ access along the stream buffer is denied
- ☐ vagrants and teenagers use the buffer for illegal purposes
- ☐ trees obstruct water or scenic views
- ☐ I am taxed on land that I cannot develop
- ☐ buffers are a source of varmints, weeds, ticks, feral dogs, etc.
- ☐ the process for adding decks, sheds, gazebos is too restrictive
- ☐ the buffer is in an unsightly condition during early stages of forest growth
- ☐ unfair to those who owned land prior to the buffer law

By and large, resident complaints about stream buffers are uncommon and can be directly addressed through a concerted education program to inform residents of the many benefits buffers provide, as well as clear enforcement of trespassing laws. Interestingly, many communities often receive an equal number of complaints from residents that demand better stewardship of the buffer system.

8. The stream buffer program needs to be responsive to the interests of the development community

Although the stream buffer system is not likely to consume more than 5% of the land area of a watershed (much of which cannot be developed anyway because it is also a floodplain, wetland, or steep slope), it can consume a much larger proportion of an individual development site. Clearly, the potential exists to generate complaints about excessive regulation and property right issues. While only one community reported developer complaints that stream buffers actually stifled development activity (Heraty 1993), the development community does express strong concerns in several areas:

- ☐ inflexible buffer delineation
- ☐ inconsistent application of buffer guidelines
- ☐ lengthy approval process
- ☐ lost lots that could have been developed
- ☐ extra costs for development submittal
- ☐ buffer use are too restrictive (e.g., stormwater BMPS are not allowed)

While the philosophical issue of property rights infringement can never be satisfactorily resolved for all developers, local governments are encouraged to craft their programs to be responsive to the economic needs of the development community. After all, the primary purpose of the stream buffer program is to place some distance between development and the stream—and not to discourage development from taking place.

Pollutant Removal Capability of Stream Buffers

While an urban stream buffer provides many impressive benefits, it must be emphasized that they often have a limited capability to remove pollutants borne in urban stormwater runoff. This is a surprising conclusion for a number of reasons. First, many communities have cited pollutant removal as the key justification for establishing buffer programs (Heraty 1993). Second, high removal rates have been frequently reported for forested buffers in rural areas (Desbonnet et al. 1994). Why, then, do stream buffers have limited value to remove pollutants in stormwater runoff?

The primary reason relates to how flow reaches the stream buffer in urban watersheds. Buffers require the presence of sheet flow to be effective. Once flow concentrates to form a channel, it effectively short-circuits the buffer and no treatment occurs. Unfortunately, flow usually concentrates within a short distance in urban areas. It is doubtful, for example, whether sheetflow conditions can be

maintained over a distance of:

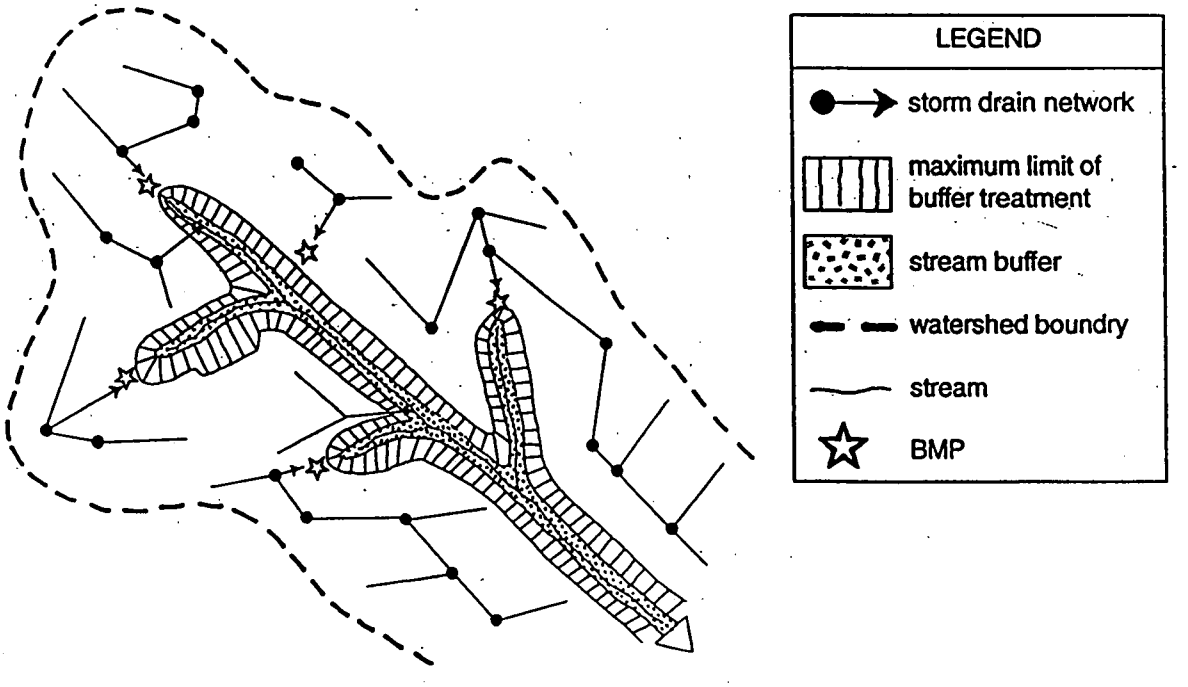
- ☐ 150 ft for pervious areas
- ☐ 75 ft for impervious areas

This constraint sharply reduces the percentage of a watershed that can be effectively treated by a stream buffer. This can be illustrated using the drainage density example that was used earlier. If we assume that (a) 1.4 miles of stream exist in a one square mile watershed, (b) a 100–ft buffer exists on each side of the channel and (c) that each side of the buffer serves the maximum limit of 150 ft of contributing pervious area, we would be able to directly treat about 50 ac total of pervious area. This acreage represents only 8% of the total drainage area to the stream (or 13% if we include the area in the stream buffer) This implies that the runoff from the remaining 87% of the total drainage area will be delivered to the stream in one of three ways:

- ☐ in an open channel
- ☐ within an enclosed stormdrain pipe, or
- ☐ a stabilized outfall channel from a BMP

In each case, the channel or pipe will cross the stream buffer before it discharges into the steam (Fig. 24) In addition, some kind of structural BMP will still be needed to provide water quality control for the runoff before it reaches the stream.

FIGURE 24: THE ENTRY OF STORMWATER RUNOFF INTO THE URBAN STREAM BUFFER NETWORK



Due to the rapid concentration of flow, most runoff enters the buffer in an open channel or stormdrain pipe. On a watershed scale, a buffer only receives 10% of the sheetflow.

The four basic options for providing stormwater quality control include:

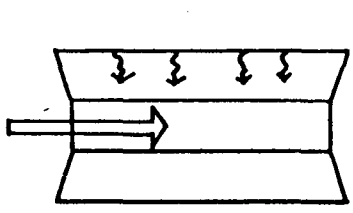
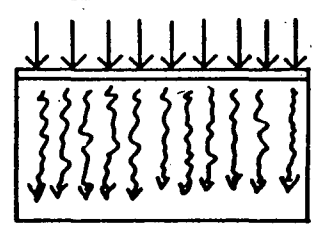
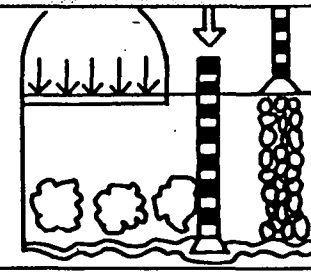
- ☐ stormwater ponds
- ☐ shallow wetlands
- ☐ infiltration practices
- ☐ filtering systems

Each practice must be fully integrated within the stream buffer system in order to maximize treatment efficiency and ensure that the largest possible contributing drainage area is captured.

Urban Vegetative Treatment Systems

Under some circumstances, an urban stream buffer can be employed as a vegetative filter to treat the quality of stormwater runoff. Indeed, a wide variety of vegetative filters have been used for this purpose. While each of these filters relies on the use of vegetation to slow runoff velocity and filter out pollutants, not all of them are comparable. Consequently, their design and pollutant removal performance are often quite different. The differences are often amplified by the diverse and conflicting terminology used to describe urban vegetative filter systems (Table 27).

TABLE 27: SOME STANDARDIZATION OF URBAN VEGETATIVE FILTERING SYSTEMS

	Open Channel Systems	Filter Strip Systems	Buffer Systems
FILTER			
FLOW	shallow flow occurs through a designed open channel, concentrated outflow	grass filter that accepts sheetflow from adjacent areas, no concentrated outflow	primarily used to protect stream, but can act as a filter under restricted conditions
TERMS	swale (wet or dry) grass channel grass swale bioswale biofilter bioretention swale	filter strip vegetated filter strip grass filter strip grass buffer bioretention area	forest buffer stream buffer riparian filter buffer strip urban buffer treatment

For example, as many as 15 different names have been given to these practices, and these are often used interchangeably. In reality, however, most vegetative filters can be grouped in one of three general categories:

Open Channels: designed to filter out pollutants in stormwater as they are conveyed through an open, grassy channel. Sometimes known as swales, the channel conveys stormwater runoff across the stream buffer and discharges directly into the stream. From a pollutant removal standpoint, there are four basic design options for the open channel, which are described in detail in Chapter 6 (Page 157).

Filter strips: designed as a grass filter that accepts sheetflow from impervious or pervious areas to pretreat it before it is delivered to a stream buffer or downstream BMP. As noted before, urban filter strips can treat runoff over a relatively short distance (usually 75 to 150 feet). Some design guidance for urban filter strips can be found on page 116.

Forested buffers: primarily designed to protect streams; forest areas may provide some treatment of stormwater runoff from nearby pervious or impervious areas but this is only a secondary benefit. In most cases, stormwater runoff from upland areas crosses the forested stream buffer in the form of an open channel or an enclosed storm drain. The pollutant removal benefit of stream buffers can be more significant in low-relief coastal areas, where groundwater interaction is strong.

Performance of urban vegetative practices: Our current knowledge about the pollutant removal capability of each of the three categories of urban vegetative practices is summarized in Table 28, and is described below:

Open Channels: the performance of grassed open channels has been reasonably well studied in a wide number of environments around the country. The studies indicate that grassed channels have a high capability to reduce sediment, hydrocarbon and metals in most situations (>50%). However, their ability to remove phosphorus and nitrogen is much more limited and unreliable, with removal rates averaging only 10 to 50%. Grassed channels have shown little capability to reduce bacteria, chlorides or nitrate, with zero or negative removal rates frequently reported.

Filter strips: only one study has assessed the capability of a grass filter strip to treat urban stormwater runoff. Yu et al. (1992) reported moderate to high removal rates for a 150–ft strip that treated runoff from a large parking lot, but mediocre performance in a shorter, 75–ft strip.

Stream buffers: at the present time, there is no performance data on the effectiveness of forest stream buffers to treat urban stormwater runoff. Some indication of their potential effectiveness can be inferred from the performance of forest and grass buffers from agricultural areas.

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TABLE 28: MEASURED POLLUTANT REMOVAL CAPABILITY OF SELECTED URBAN VEGETATED FILTERS

BMP System	TSS	TP	TN	Zinc	Lead
Grass Channel (1)	83	29	(neg) *	63	67
Grass Channel (2)	81	17	40	69	50
Grass Channel (2)	87	83	84	90	90
Grass Channel (3)	65	41	>20.	49	47
Grass Channel (3)	98	18	>50	81	81
Grass Channel (4)	72	54	ND	74	ND
Filter Strip-75' (5)	54	(-25)	(-27)*	47	(-16)
Filter Strip- 150'(5)	84	40	(-20)*	55	50
MEAN NON URBAN (6)	73	56	63	--	--
MEAN URBAN	78	32	25	66	53

***nitrate-N only**

REFERENCES

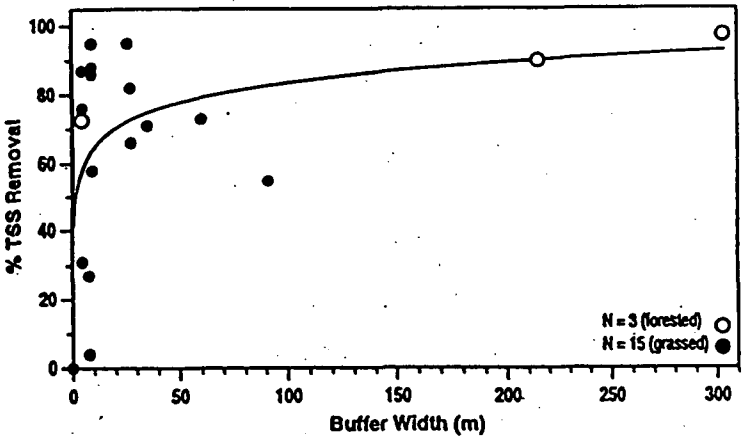
(1) Seattle METRO 1992 **(2) Harper 1988** **(3) Dorman et al. 1989**
(4) Yu et al. 1993 **(5) Yu et al. 1992** **(6) Desbonette et al. 1994**

While grass channels generally are reported to have a high capability to remove sediment, their ability to remove nutrients varies substantially, often due to soil, slope and other factors.

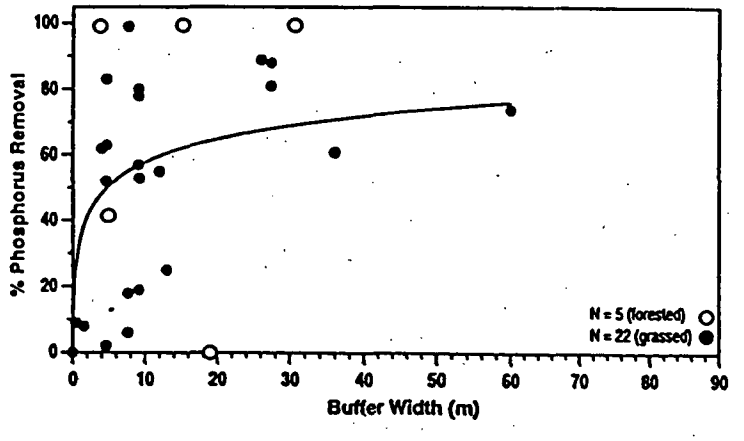
The moderate to high pollutant removal observed in rural and agricultural buffers appears to be due to the relatively slow transport of pollutants across the buffer in sheet flow or shallow groundwater flow. In either case, the relatively slow movement of water gives soil, roots and microbes more time to trap or remove pollutants. Desbonnet et al. (1994) recently reviewed over 35 monitoring studies that investigated the pollutant removal performance of rural and agricultural buffers (Fig. 25).

FIGURE 25: SURFACE POLLUTANT REMOVAL IN AGRICULTURAL FILTER STRIPS

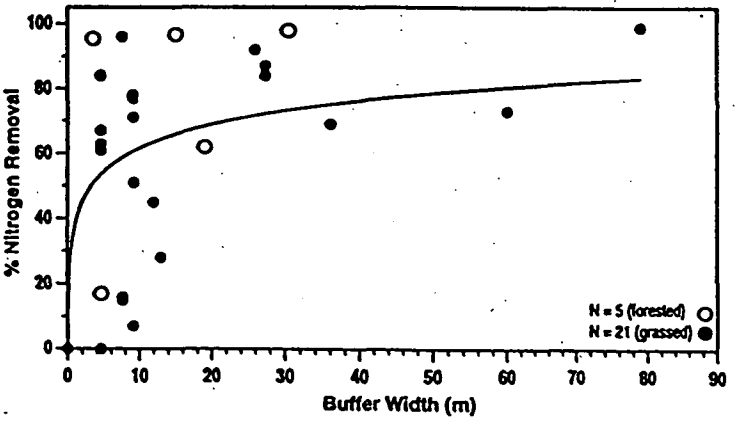
PANEL A
TOTAL SUSPENDED SOLIDS REMOVAL



PANEL B
TOTAL PHOSPOROUS REMOVAL



PANEL C
TOTAL NITROGEN REMOVAL



Desbonnet et al. (1994) compares the reported removal efficiency of 35 buffer strips, most of which were located in rural or coastal areas. The effect of buffer width on sediment, phosphorus and nitrogen removal are shown in panels a - c.

Although considerable variation was observed among the studies, several performance trends emerged:

- Buffers were generally capable of removing 75% of the suspended sediment delivered to them in surface runoff, even when the grass buffer was as narrow as 25 ft.
- Removal of nitrogen and phosphorus in surface runoff seldom exceeded 50 or 60%, even in widest buffers monitored. Further increases in nutrient removal required that buffers extend 300 to 600 ft long, a rather impractical length.
- Removal of nutrients in subsurface or groundwater flow was very inconsistent. Under ideal site conditions—poorly drained and organic rich soils, deep root systems and groundwater flow within two to six feet of the surface—buffers exhibited exceptional removal of nitrate–nitrogen—often 90% or more. When such conditions exist, buffers can be very useful in reducing the nitrogen effluent from rural septic systems.

In general, most researchers consider agricultural buffers to be a useful BMP, but only when they are combined with other practices (Magette et al. 1989). It is also widely recognized that many agricultural buffers fail to perform as designed after they are installed in the field (Dillaha et al. 1989). Field surveys indicate that many agricultural buffers lack good vegetative cover, are subject to excessive sediment deposition, or are short–circuited by channels formed by concentrated flow.

Summary: *Potential Pollutant Removal Capability of Urban Stream Buffers.*

On the basis of performance data from related vegetative systems, it is possible to estimate the pollutant removal capability of an urban stream buffer (i.e., explicitly designed to treat stormwater using the design procedure outlined in Buffer Criteria 7). The hybrid of the grass strip in the outer zone and the forested buffer in the middle and streamside zone has the *potential* to achieve the following removal rates:

▸ Sediment	75%
▸ Total Nitrogen	40%
▸ Total Phosphorus	50%
▸ Trace Metals	60 to 70%
▸ Hydrocarbons	75%

The ability of a particular buffer to actually *achieve* these rates depends on many site–specific factors that are outlined in Jordan (1995). The design procedure outlined in Criteria 7 is intended to restrict the use of the stream buffers for stormwater treatment only to those conditions where site–specific factors assure reliable pollutant removal (Table 29).

Performance Criteria for Urban Stream Buffers

The ability of a particular buffer to realize its many benefits depends to a large degree on how well it is planned, designed, and maintained. Ten practical performance criteria are offered to govern how a buffer is sized, managed, and crossed and how it is to

TABLE 29: SITE FACTORS THAT ENHANCE OR DETRACT FROM POLLUTANT REMOVAL PERFORMANCE IN URBAN VEGETATIVE FILTERING SYSTEMS

Factors that enhance performance	Factors that reduce performance
Slopes less than 5%	Slopes greater than 5%
Contributing flow lengths < 150 ft.	Overland flow paths over 300 feet
Water table close to surface	Groundwater far below surface
Check dams/level spreaders	Contact times less than 5 minutes
Permeable, but not sandy soils	Compacted soils
Growing season	Non–growing season
Long length of buffer or swale	Buffers less than 10 feet
Organic matter, humus or mulch layer	Snowmelt conditions, ice cover
Small runoff events	Runoff events > 2 year event
Entry runoff velocity less than 1.5 fps	Entry runoff velocity more than 5 fps
Swales that are routinely mowed	Sediment buildup at top of swale
Poorly–drained soils, deep roots	Trees with shallow root systems
Dense grass cover, six inches tall	Tall grass, sparse vegetative cover.

handle stormwater. The key criteria include:

1. Minimum total buffer width
2. Three–zone buffer system
3. Mature forest as a vegetative target
4. Conditions for buffer expansion or contraction
5. Physical delineation requirements
6. Conditions where the buffer can be crossed
7. Integrating stormwater and BMPs within the buffer
8. Buffer limit review
9. Buffer education, inspection, and enforcement
10. Buffer flexibility

Criteria 1. Minimum total buffer width.

Most local buffer criteria consist of a single requirement–that the buffer be a fixed and uniform width from the stream channel. Urban stream buffers range from 20 to 200 ft in width on each side of the stream according to a national survey of 36 local buffer programs, with a median of 100 ft (Heraty 1993). Most

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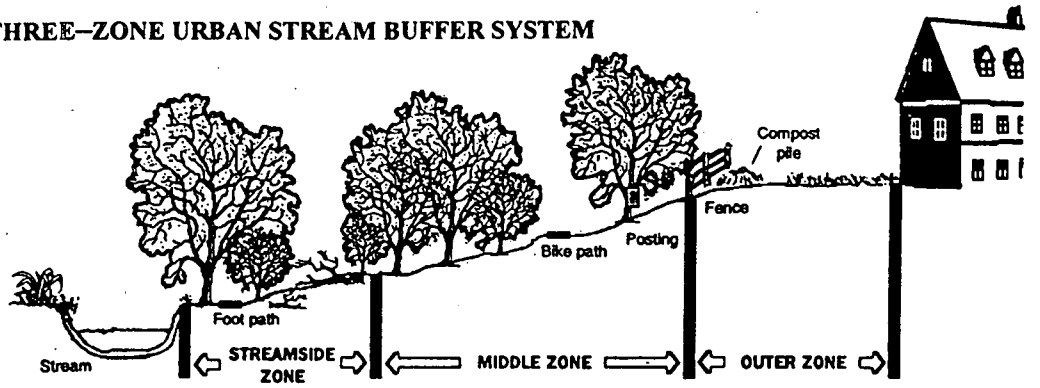
jurisdictions arrived at their buffer width requirement by borrowing other state and local criteria, local experience, and, finally, through political compromise during the buffer adoption process. Most communities require that buffers to fully incorporate all lands within the 100–yr floodplain, and others may extend the buffer to pick up adjacent wetlands, steep slopes or critical habitat areas.

In general, a minimum base width of at least 100 feet is recommended to provide adequate stream protection. In most regions of the country, this requirement translates to a buffer that is perhaps three to five mature trees wide on each side of the channel.

Criteria 2. Three–zone buffer system. Effective urban stream buffers divides the total buffer width into three lateral zones—streamside–middle zone and outer zone. Each zone performs a different function, and has a different width, vegetative target and management scheme, as shown in Figure 26 and described below:

The **streamside zone** protects the physical and ecological integrity of the stream ecosystem. The vegetative target is mature riparian forest that can provide shade, leaf litter, woody debris and erosion protection for the stream. The minimum width is 25 ft from each stream bank—about the distance of one or two mature trees from the streambank.

FIGURE 26: THE THREE–ZONE URBAN STREAM BUFFER SYSTEM



CHARACTERISTICS	STREAMSIDE ZONE	MIDDLE ZONE	OUTER ZONE
FUNCTION	Protect the physical integrity of the stream ecosystem	Provide distance between upland development and streamside zone	Prevent encroachment and filter backyard runoff
WIDTH	Min. 25 feet, plus wetlands and critical habitats	50 to 100 feet, depending on stream order, slope, and 100 year floodplain	25 foot minimum setback to structures
VEGETATIVE TARGET	Undisturbed mature forest. Reforest if grass	Managed forest, some clearing allowable	Forest encouraged, but usually turfgrass
ALLOWABLE USES	***Very Restricted*** e.g., flood control, utility right of ways, footpaths, etc.	***Restricted*** e.g., some recreational uses, some stormwater BMPs, bike paths, tree removal by permit	***Unrestricted*** e.g., residential uses including lawn, garden, compost, yard wastes, most stormwater BMPs

Three lateral zones comprise the foundation of an effective urban stream buffer zone. The width, function, management and vegetative target vary by zone.

Land use is highly restricted—limited to stormwater channels, footpaths, and a few utility or roadway crossings.

The **middle zone** extends from the outward boundary of the streamside zone, and varies in width, depending on stream order, the extent of the 100-yr floodplain, adjacent steep slopes and protected wetland areas. Its key functions are to protect key components of the stream and provide further distance between upland development and the stream. The vegetative target for this zone is also mature forest, but some clearing may be allowed for stormwater management, access, and recreational uses. A wider range of activities and uses are allowed within this zone, e.g., recreation, bike paths, and stormwater BMPs. The minimum width of the middle zone is about 50 ft, but it may be expanded based on stream order, slope or the presence of critical habitats.

The **outer zone** is the buffer's buffer, an additional 25 ft setback from the outward edge of the middle zone to the nearest permanent structure. In most instances, it is a residential backyard. The vegetative target for the outer zone is usually turf or lawn, although the property owner is encouraged to plant trees and shrubs, and thus increase the total width of the buffer. Very few uses are restricted in this zone. Indeed, gardening, compost piles, yard wastes, and other common residential activities are promoted within the zone. The only major restrictions are no septic systems cover, permanent structures, or impervious cover.

Criteria 3. Pre-development vegetative target.

The ultimate vegetative target for the streamside and middle zone of most urban stream buffers should be specified as the pre-development riparian plant community— usually mature forest. Notable exceptions include prairie streams of the midwest, or arroyos of the arid West, that may have a grass or shrub cover in the riparian zone. In general, the vegetative target should be based on the natural vegetative community present in the floodplain, as determined from reference riparian zones. Turfgrass is allowed for the outer core of the buffer and is mandatory if the buffer is used as a stormwater treatment system (see Criteria 7).

A vegetative target has several management implications. First, if the streamside zone does not currently meet its vegetative target, it should be managed to ultimately achieve it. For example, a grassy area should be allowed to grow into a forest over time. In some cases, active reforestation may be necessary to speed up the successional process. Second, a vegetative target implies that the buffer will contain mostly native species adapted to the floodplain. Thus, non-native or invasive tree, shrub and vine species should be avoided when revegetating the buffer. Removal of exotic shrubs and vines (e.g., multiflora rose or honey suckle) that are so prevalent along the buffer edge should be encouraged.

Criteria 4. Buffer expansion and contraction.
Many communities require that the minimum width of the buffer be expanded under certain conditions. Thus, while the streamside and outer zones of the buffer are fixed, the width of the middle zone may vary. Specifically, the average

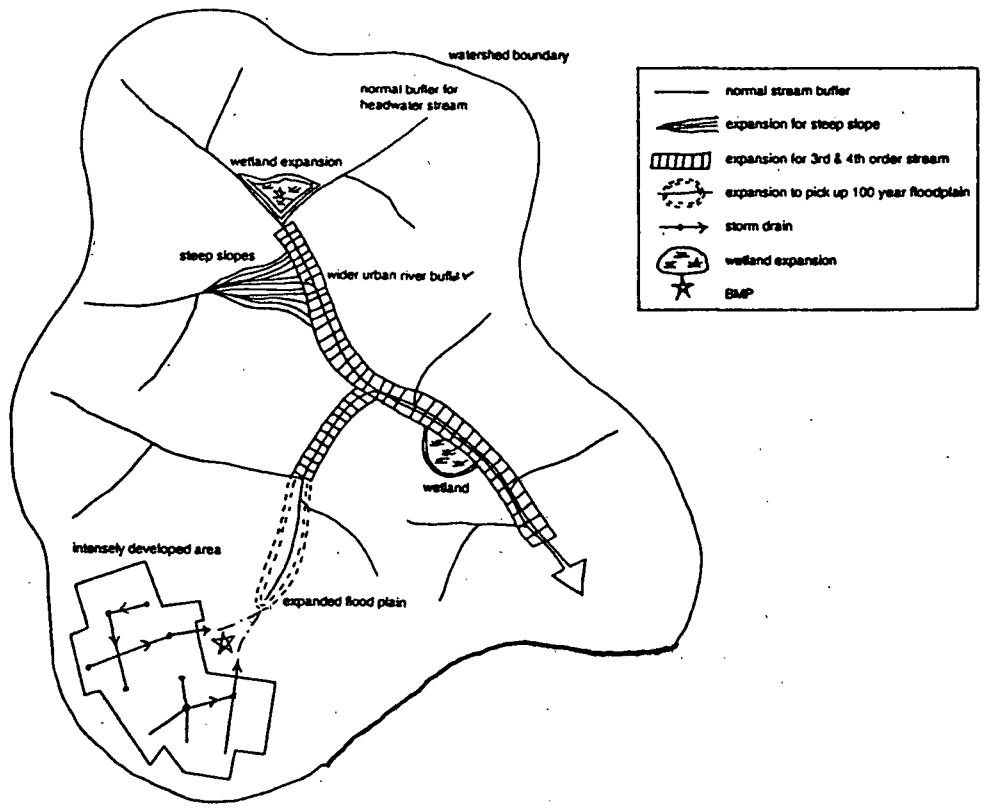
width of the middle zone can expanded to include:

- the full extent of the 100–yr floodplain
- all undevelopable steep slopes (greater than 25%)
- four additional ft of buffer for each one percent increment of slope above 5%
- any adjacent delineated wetlands or critical habitats

The middle zone also expands to protect streams of higher order or quality in a downstream direction (Fig. 27). For example, the width of the middle zone may increase from 50 ft (for first– and second–order streams) to 75 ft (for third– and fourth–order streams) and as much as 100 ft for fifth– or higher order streams/rivers. The width of the buffer can also be contracted in some circumstances to accommodate unusual or historical development patterns, shallow lots, stream crossings, or stormwater ponds (see Criteria 10).

Criteria 5. Buffer delineation. Three key decisions must be made when delineating the boundaries of a buffer. At what mapping scale will streams be defined? Where does the stream begin and the buffer end? And from what point should the inner edge of the buffer be measured?

FIGURE 27: EXPANSIONS TO THE WIDTH OF URBAN STREAM BUFFERS



The base width of the urban stream buffer may increase to pick up steep slopes, wetlands, and floodplains adjacent to the buffer. In addition, the base width often increases for larger streams and rivers.

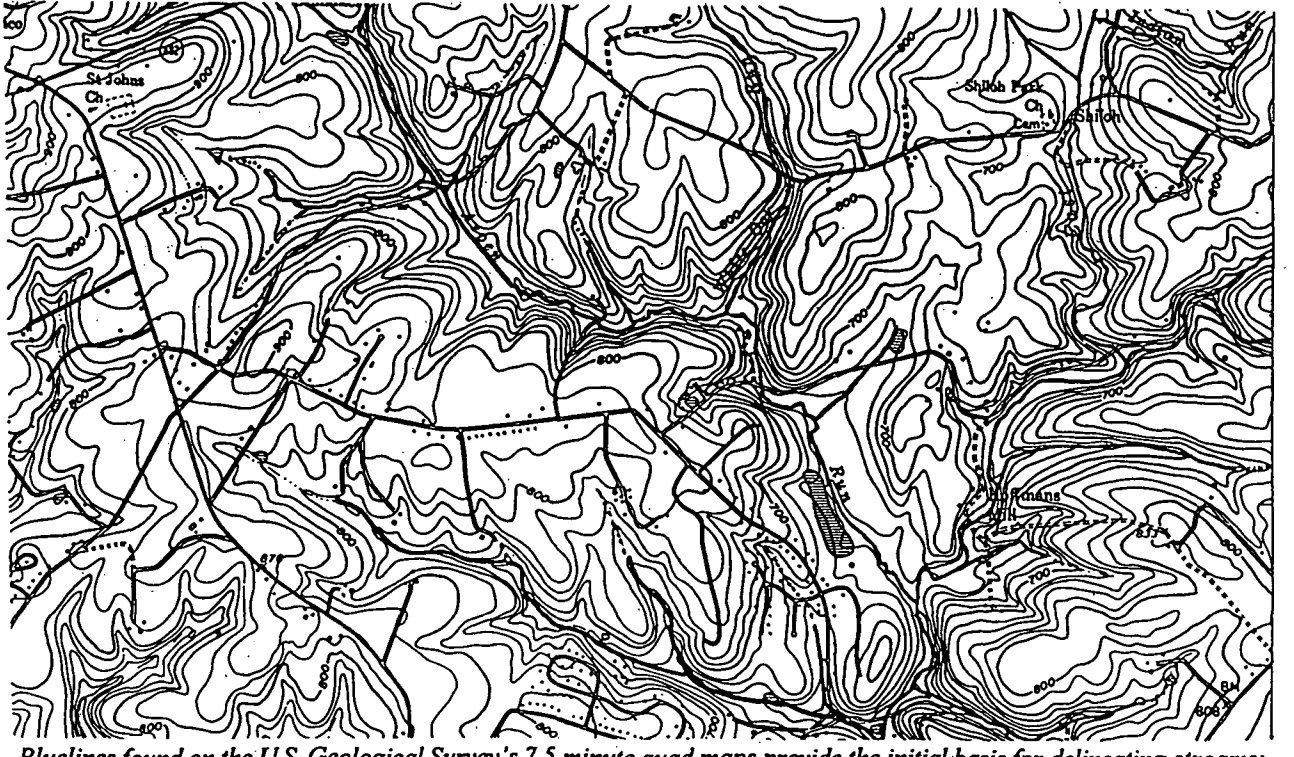
The mapping unit: the traditional mapping scale used to define the stream network are the bluelines present on USGS 7.5 minute quadrangle maps (1 inch=2,000 feet (Fig. 28)). It should be kept in mind that bluelines are only a first approximation for delineating streams, as this scale does not always reveal all first order perennial streams or intermittent channels in the landscape, or precisely mark the transition between the two (MOPS 1993 and Leopold et al. 1964). Consequently, the actual location of the stream channel can only be confirmed in the field.

The *origin of a first order stream* is always a matter of contention. As a practical rule, the origin of the stream can be defined as the point where an intermittent stream forms a distinct channel, as indicated by the presence of an unvegetated streambed and high water marks. Other regions define the origin of a stream as the upper limit of running water during the wettest season of the year.

Problems have frequently been reported in situations where the stream network has been extensively modified by prior agricultural drainage practices, such as ditching.

The *inner edge* of the buffer can be defined from the centerline of small first– or second–order streams. The accuracy of this method is questionable in higher order streams with wider channels. Thus, the inner edge of the buffer is measured from the top of each streambank for third and higher order streams.

FIGURE 28: USGS 7.5 MINUTE QUADRANGLE MAP



Bluelines found on the U.S. Geological Survey's 7.5 minute quad maps provide the initial basis for delineating streams; but final delineation often requires field confirmation.

Criteria 6. Buffer crossings. Two major goals of a stream buffer network are to maintain an unbroken corridor of riparian forest and maintain the upstream and downstream passage of fish in the stream channel. From a practical standpoint, it is not always possible to try to meet both goals everywhere along the stream buffer network. Some provision must be made for linear forms of development that must cross the stream or the buffer (Fig. 29), such as roads, bridges, fairways, underground utilities, enclosed storm drains or outfall channels.

It is still possible to minimize the impact to the continuity of the buffer network and fish passage. Performance criteria should specifically describe the conditions under which the stream or its buffers can be crossed. Some performance criteria could include:

Crossing width: minimum width right of way to allow for maintenance access.

Crossing angle: direct right angles are preferred over oblique crossing angles, since they require less clearing of the buffer.

Crossing frequency: only one road crossing is allowed within each subdivision, and no more than one fairway crossing is allowed for every 1,000 ft of buffer.

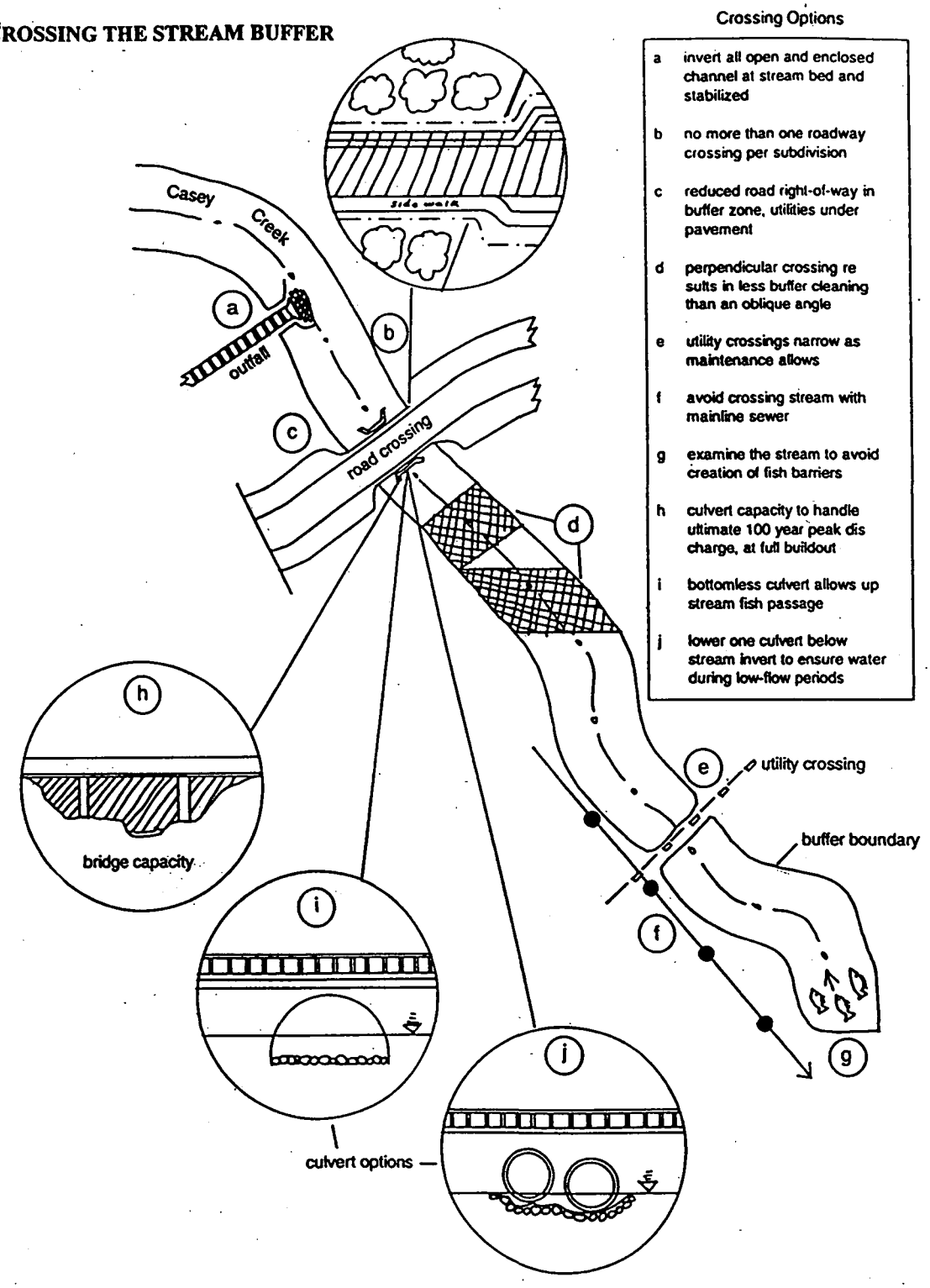
Crossing elevation: all direct outfall channels should discharge at the invert elevation of the stream. Underground utility and pipe crossings should be located at least three feet below the stream invert, so that future channel erosion does not expose them, creating unintentional fish barriers. All roadway crossings and culverts should be capable of passing the ultimate 100–yr flood event. Bridges should be used in lieu of culverts when crossings require a 72 inch or greater diameter pipe. The use of corrugated metal pipe for small stream crossings should be avoided, as these often tend to create fish barriers. The use of slab, arch or box culverts are much better alternatives. Where possible, the culvert should be "bottomless" to ensure passage of water during dry weather periods (i.e., the natural channel bottom should not be hardened or otherwise encased).

Criteria 7. Stormwater runoff. Buffers can be an important component of the stormwater treatment system at a development site. They cannot, however, treat all the stormwater runoff generated within a watershed (generally, a buffer system can only treat runoff from less than 10% of the contributing watershed to the stream). Therefore, some kind of structural BMP must be installed to treat the quantity and quality and stormwater runoff from the remaining 90% of the watershed. More often than not, the most desirable location for stormwater practices is within or adjacent to the stream buffer. The following guidance is recommended for integrating stormwater BMPs into the buffer:

a. The use of buffers for stormwater treatment. The outer and middle zone of the stream buffer may be used as a combination grass/forest filter strip under very limited circumstances (Fig. 30). For example:

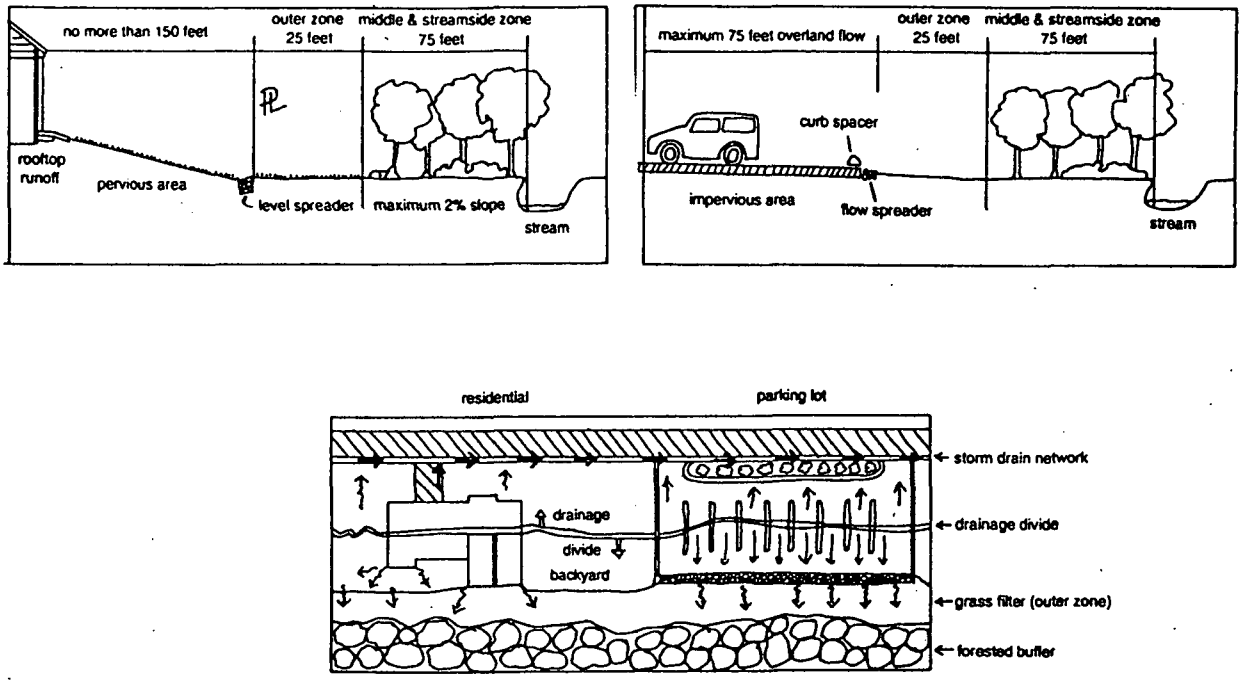
The buffer cannot treat more than 75 ft of

FIGURE 29: CROSSING THE STREAM BUFFER



Two major goals of a stream buffer are to maintain an unbroken riparian corridor and to allow for fish passage. Therefore, the conditions under which the buffer can be crossed should be clearly laid out.

FIGURE 30: DESIGN CRITERIA FOR USING A STREAM BUFFER FOR STORMWATER TREATMENT



Under some conditions, the stream buffer can be used to treat the quality of stormwater runoff from adjacent pervious and impervious areas.

overland flow from impervious areas and 150 ft of pervious areas (backyards or rooftop runoff discharged to the backyard). The designer should compute the maximum runoff velocity for both the six–month and two–year storm designs from each contributing overland flow path, based on the slope, soil, and vegetative cover present. If the computation indicates that velocities will be erosive under either condition (greater than 3 fps for 6–mo storm, 5 fps for 2–yr storm), the allowable length of contributing flow should be reduced.

When the buffer receives flow directly from an impervious area, the designer should include curb cuts or spacers so that runoff can be spread evenly over the filter strip. The filter strip should be located 3 to 6 inches below the pavement surface to prevent sediment deposits from blocking inflow to the filter strip. A narrow stone layer at the pavement's edge often works well to protect the strip from eroding.

The stream buffer can only be accepted as a stormwater filtering system if basic maintenance can be assured, such as routine mowing of the grass filter, and annual scraping and removal of sediments that build up at the edge of the impervious area and the grass filter. The existence of an enforceable maintenance agreement that allows for public

maintenance inspection is also helpful.

b. Locating stormwater ponds and wetlands in the buffer. A particularly difficult management issue involves where stormwater ponds and wetlands be located in relation to the buffer? Should they be located inside or outside of the buffer? If they are allowed within the buffer, where exactly should they be put? Some of the possible options are outlined in Table 30 and Figure 31.

A number of good arguments can be made for locating ponds and wetlands within the buffer or on the stream itself. Constructing ponds on or near the stream, for example, affords treatment of the greatest possible drainage area treated at a topographic point that makes construction easier and cheaper. Second, ponds and wetlands require the dry weather flow of a stream to maintain water levels and prevent nuisance conditions. Lastly, ponds and wetlands add a greater diversity of habitat types and structure, and can add to the total buffer width in some cases.

On the other hand, locating a pond or wetland in the buffer can create environmental problems, including the localized clearing of trees, the sacrifice of stream channels above the BMP, the creation of a barrier to fish migration, modification of existing wetlands, and stream warming. Locating ponds and wetlands in buffers will always be a balancing act. Given the effectiveness of stormwater ponds and wetlands in removing pollutants, it is generally not advisable to completely prohibit their use within the buffer. It does make sense, however, to choose pond and wetland sites carefully. In this respect, it is useful to consider possible performance criteria that restrict the use of ponds or wetlands to:

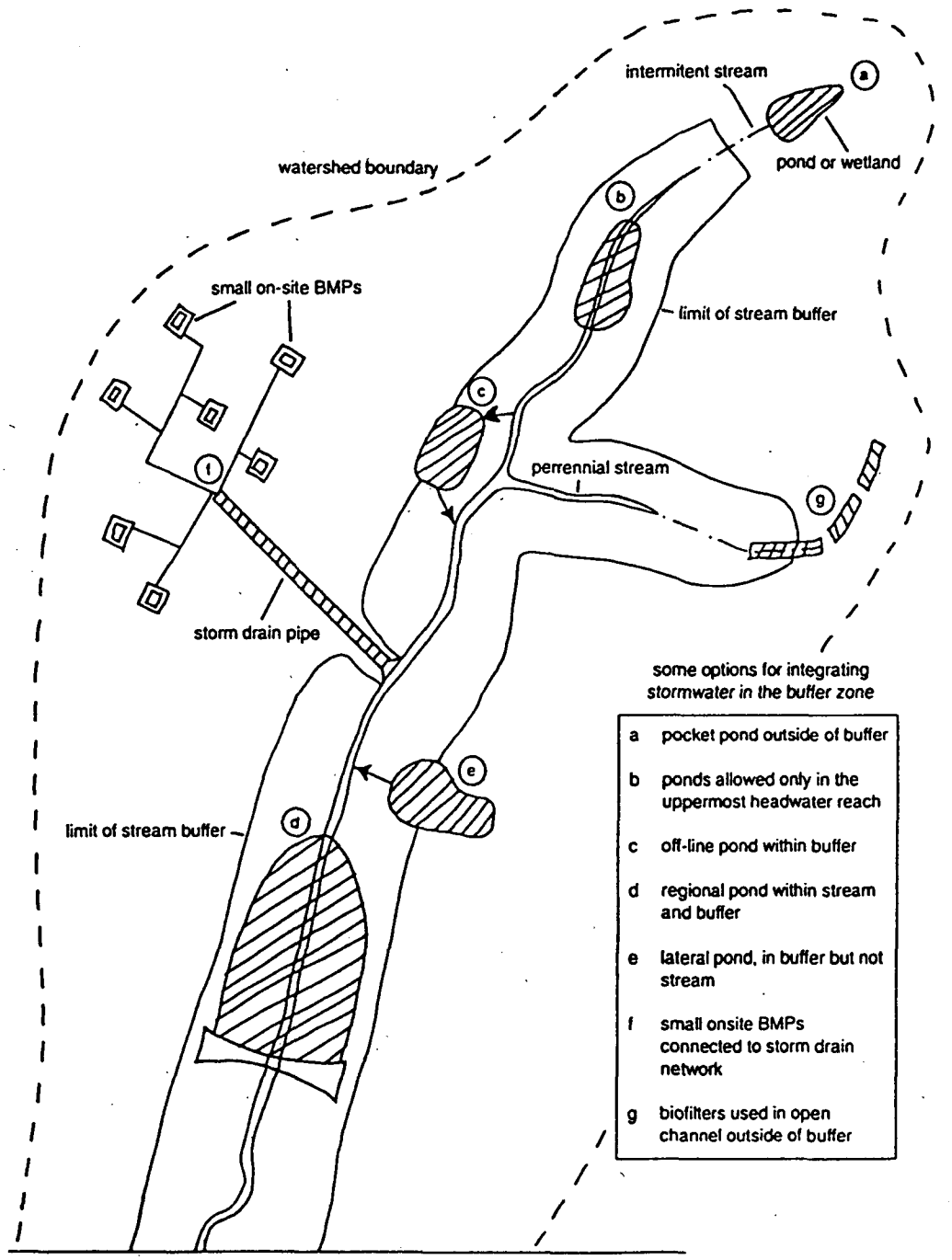
- ☐ a maximum contributing area (e.g., 100 acres), or
- ☐ the first 500 feet of perennial stream channel, or
- ☐ clearing of the streamside buffer zone only for the outflow channel (if the pond is discharging from the middle zone into the stream)

TABLE 30: OPTIONS FOR LOCATING STORMWATER BMPS WITHIN THE STREAM BUFFER ZONE

Location of the Stormwater BMP	Preferred Stormwater BMP to Use
1. outside of the buffer system	infiltration, sand filters, pocket ponds and wetlands
2. upper end of the buffer zone	Stormwater pond or wetland
3. in the outer core	filters, infiltration
4. in the middle core	off–line pond or wetland
5. in the conveyance system	biofilters, grassed swales
6. the outer core and middle zone	vegetated buffer treatment system

The preferred BMP option depends on where stormwater treatment is allowed within the stream buffer.

FIGURE 31: OPTIONS FOR LOCATING STORMWATER PRACTICES IN THE BUFFER



A range of options are available for locating stormwater practices within the stream buffer. Ponds or wetlands can be located only on (a) intermittent streams, (b) in the upper 300 feet of perennial streams, (c) off-line, (d) regional ponds or (e) laterally within the buffer. Alternatively, other BMPs can be located outside of the buffer; although their outfalls may still require a buffer crossing.

- ☐ off–line locations within the middle or outer zone of the buffer, or
- ☐ use ponds only to manage stormwater quantity within the buffer.

Criteria 8. Buffers during plan review and construction. The limits and uses of stream buffer systems should be well defined during each stage of the development process—from initial plan review through construction. The following steps are helpful during the planning stage:

- ☐ require that the buffer be delineated on preliminary and final concept plans
- ☐ verify the stream delineation in the field
- ☐ check that buffer expansions are computed and mapped properly
- ☐ check suitability of buffer for stormwater treatment
- ☐ ensure that the other BMPs are properly integrated in the buffer
- ☐ examine any buffer crossings for problems

Stream buffers are vulnerable to disturbance during construction. Steps to prevent encroachment during this stage include:

- ☐ mark buffer limits on all plans used during construction (i.e., clearing and grading plans, and erosion and sediment control plans)
- ☐ conduct a preconstruction stakeout of buffers to define limit of disturbance
- ☐ mark the limit of disturbance with silt or snow fence barriers, and signs to prevent the entry of construction equipment and stockpiling
- ☐ familiarize contractors with the limit of disturbance during a preconstruction walk–through.

Criteria 9. Buffer education and enforcement. The future integrity of a buffer system requires a strong education and enforcement program. Two primary goals of a buffer are to make the buffer "visible" to the community, and to encourage greater buffer awareness and stewardship among adjacent residents. Several simple steps that can accomplish these goals include:

- ☐ mark the buffer boundaries with permanent signs that describe allowable uses
- ☐ educate buffer owners about the benefits and uses of the buffer with pamphlets, streamwalks and meetings with homeowners associations
- ☐ ensure that new owners are fully informed about buffer limits/uses when property is sold or transferred.
- ☐ engage residents in a buffer stewardship program that includes reforestation and backyard "bufferscaping" programs
- ☐ conduct annual bufferwalks to check on encroachment

The underlying theme of education is that most encroachment problems reflect ignorance rather than contempt for the buffer system. The awareness and education measures are intended to increase the recognition of the buffer within the community. Not all residents, however, will respond to this effort, and some kind of limited enforcement program may be

necessary (Schueler 1994). This usually involves a series of correction notices and site visits, with civil fines used as a last resort if compliance is not forthcoming. Some buffer ordinances have a further enforcement option, whereby the full cost of buffer restoration is charged as a property lien (Schueler 1994). A fair and full appeals process should accompany any such enforcement action.

Criteria 10. Buffer flexibility. In most regions of the country, a hundred foot buffer will take about 5% of the total land area in any given watershed out of production. While this constitutes a relatively modest land reserve at the watershed scale, it can be a significant hardship for a landowner whose property is adjacent to a stream. Many communities are legitimately concerned that stream buffer requirements could represent an uncompensated taking of private property. These concerns can be eliminated if a community incorporates several simple measures to ensure fairness and flexibility when administering its buffer program. As a general rule, the intent of the buffer program is to modify the *location* of development in relation to the stream but not its overall *intensity*. Some flexible measures in the buffer ordinance include:

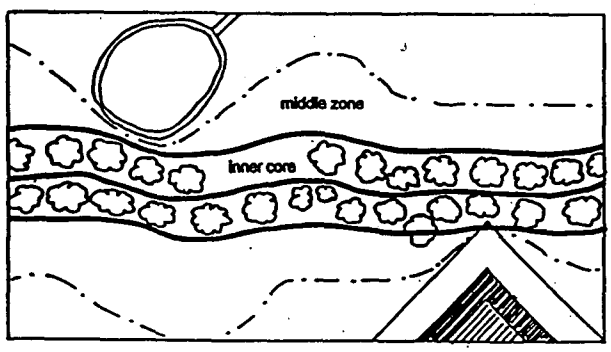
Maintaining buffers in private ownership. Buffer ordinances that retain property in private ownership generally are considered by the courts to avoid the takings issue, as buffers provide compelling public safety, welfare and the environmental benefits to the community that justify partial restrictions on land use. Most buffer programs meet the "rough proportionality" test recently advanced by the Supreme Court for local land use regulation (Hornbach 1993). Indeed stream buffers are generally perceived to have a neutral or *positive* impact on adjacent property value. The key point is that the reservation of the buffer cannot take away all economically beneficial use for the property. Four techniques–buffer averaging, density compensation, variances and conservation easements—can ensure that property owners are fully inoculated from this rare occurrence.

Buffer averaging. In this scheme, a community provides some flexibility in the width of the buffer. The basic concept is to permit the buffer to become narrower at some points along the stream (e.g., to allow for an existing structure or to recover a lost lot), as long as the *average* width of the buffer meets the minimum requirement (Fig. 32). In general, buffer narrowing is limited, such that the streamside zone is not disturbed, and no new structures are allowed within the 100–yr floodplain (if this is a greater distance).

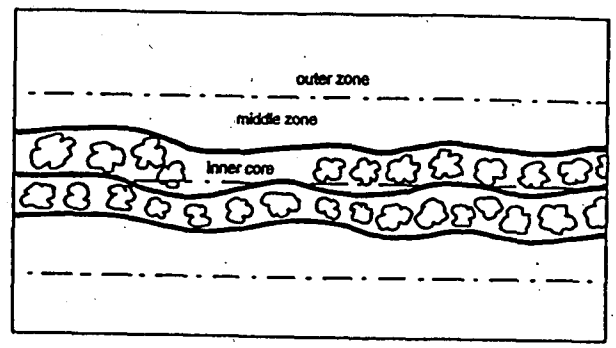
Density compensation. This scheme grants a developer a credit for additional density elsewhere on the site, in compensation for developable land that has been lost due to the buffer requirement. Developable land is defined as the portion of buffer area remaining after the 100–yr floodplain, wetland, and steep slope areas have been subtracted. Credits are granted when more than 5% of developable land is consumed, using the formula shown in Table 31. The density credit is accommodated at the development site by allowing greater flexibility in setbacks, frontage distances or

FIGURE 32: STREAM BUFFER DELINEATION: AVERAGING IN THE MIDDLE ZONE

"AVERAGED" BUFFER WIDTH



"FIXED" BUFFER WIDTH



Under buffer averaging, the width of the buffer can vary from point to point, as long as the average width in the parcel meets the local criteria. The streamside zone, however, should not be encroached on.

TABLE 31: DENSITY COMPENSATION FORMULA FOR STREAM BUFFERS

Percent of Site Lost to Buffers	Density Credit (*)
1 to 10 %	1.0
11 to 20%	1.1
21 to 30%	1.2
31 to 40%	1.3
41 to 50%	1.4
51 to 60%	1.5
61 to 70%	1.6
71 to 80%	1.7
81 to 90%	1.8
91 to 99%	1.9

* Additional dwelling units allowed over based density (1.0)

** Density credit may be transferred to a different parcel

This density compensation formula, loosely adapted from Burns (1992), is based on the premise that the purpose of a buffer is to maintain distance from the stream, and not to reduce allowable density.

minimum lot sizes to squeeze in "lost lots." Cluster development also allows the developer to recover lots that are taken out of production due to buffers and other requirements (cf Chapter 4).

Variances. The buffer ordinance should have provisions that enable a existing property owner to be granted a variance or waiver, if the owner can demonstrate severe economic hardship or unique circumstances make it impossible to meet some or all of the buffer requirements. The owner should also have access to an administrative appeals process should a request for a variance be denied.

Conservation Easements. Landowners should be afforded the option of protecting their portion of the buffer in a perpetual conservation easement. The easement conditions the use of the buffer, and can be donated to a land trust as a charitable contribution that can reduce an owner's income tax burden. Alternatively, an easement can be donated to a local government, in exchange for a reduction or elimination of property tax on the parcel.

Resources Needed for Implementation

To implement a stream buffer program, a community will need to adopt an ordinance, develop technical criteria, and invest in additional staff resources and training.

The buffer ordinance should contain the ten performance criteria described previously. A suggested checklist for the ordinance can be found in Table 32.

The real costs of instituting a buffer program for local government involve the extra staff and training time to conduct plan reviews, provide technical assistance, field delineation, construction and ongoing buffer education programs. Seventy percent of the governments surveyed by Heraty (1993) indicated that their staff expended no more than 10% more time to review buffers. In most cases, these economies were achieved by combining plan review and inspection functions with existing environmental design requirements. However, it should be noted that many of these programs did not contain all of the performance criteria recommended in this chapter, so that the stated costs are probably on the low side (i.e., many respondents did not devote staff resources to delineate stream boundaries in the field).

The adoption of a buffer program also requires an investment in training for the plan reviewer and the consultant alike. Manuals, workshops, seminars and direct technical assistance are needed to explain the new requirements to all the players in the land development business.

Lastly, very few local communities yet recognize the critical importance of buffer maintenance to the long–term success of their program. A relatively small staff commitment (often just one individual) to systematically inspect the buffer network before and after construction, and to work with their residents to increase and maintain awareness about buffers, can be an excellent investment in local stream protection.

TABLE 32: CHECKLIST FOR ADOPTING A STREAM BUFFER ORDINANCE

Providing Authority for the Stream Buffer

- ☐ Is it structured to comprehensively address all stream protection elements?
- ☐ Does it contain clear and simple performance standards?
- ☐ Does it utilize practical operating definitions and mapping units?
- ☐ Does the it support and unify the existing development review process?

Setting an Appropriate Threshold for Development

- ☐ Does it clearly define the activities that constitute "development?"
- ☐ Does it set forth reasonable exemptions?
- ☐ Does it contain provisions for waivers (and waiver fees) if a stream buffers are not feasible at the site?

Providing Funding Support for Program Administration

- ☐ Does it authorize the collection of plan review/inspection and other fees?
- ☐ Are initial operating funds committed to support review staff?

Reducing Potential for Future Conflict in Plan Review

- ☐ Does it require delineation of all resource protection areas before concept plans are considered?
- ☐ Does it specify the nature of submittal requirements for plan review?
- ☐ Does it contain a defined time–table for plan review action?
- ☐ Does it allow for buffer averaging and/or density compensation?

Ensuring Compliance

- ☐ Does it contain a rapid and unified enforcement process?
- ☐ Does it require the posting of performance bonds?

Avoiding Legal Landmines

- ☐ Does it contain a fair and timely appeals procedure?
- ☐ Does it address grandfathering of recorded plats?
- ☐ Does it make allowances for special or unusual developments?
- ☐ Does it contain a severability clause?
- ☐ Are variances included?
- ☐ Are technical criteria adequately supported and referenced?

Many communities focus on technical criteria when crafting a stream buffer ordinance. As this checklist indicates, successful buffer programs also emphasize institutional, review and enforcement aspects (adapted from Schueler 1994)

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STREAM CORRIDOR MANAGEMENT:

A BASIC REFERENCE MANUAL

New York State
Department of Environmental Conservation
Division of Water
Bureau of Water Quality
Albany, New York

January 1986
(second printing)

Henry G. Williams, Commissioner

CHAPTER 4: STEPS FOR SOLVING THE PROBLEM
(A PLANNING AND PROBLEM-SOLVING FRAMEWORK)

The purpose of this chapter is to present a planning and problem-solving framework for addressing critical stream corridor management issues, problems, and needs. Without such a planning framework, problems and issues may be addressed in piecemeal fashion, decision-making will be disjointed, and actions taken will tend to be fragmented and unrelated. Most important, actions taken without a planning overview or focus provide little or no assurance that critical natural and cultural resources within the stream corridor are being protected or enhanced. The planning and problem-solving framework in this chapter is presented in a step-by-step format as follows:

STEP 1: IDENTIFY THE PLANNING AREA

The first step is to identify the planning area. This may be accomplished by obtaining a base map of the principal drainages and subdrainage basins within the community. Planning area boundary lines then should be superimposed on the base map (see Figure 10). The planning area should include all that land area from which stream corridor management problems are perceived to arise. The planning area could include an entire watershed; it is suggested that it not be less than several hundred feet landward from both banks of a stream. Under no circumstances should it be less than the 100-year flood plain. At this stage, the planning area boundary should remain flexible. There will be ample opportunity to fine tune the planning area boundary and to establish stream corridor management boundaries as information is assembled and analyzed in subsequent steps.

STEP 2: INVENTORY AND ANALYSIS OF LAND USE AND ENVIRONMENTAL RESOURCES

In Step 2, existing land use and natural and cultural resources in the planning area should be mapped. The maps used for this work should be at the same scale as that used in establishing planning area boundaries. This will facilitate comparison of data in analyzing developmental trends and environmental constraints (See Figure 11).

Existing Land Use and Developmental Trends

Evaluate existing land use and county and local economic development trends in the planning area or that impact the planning area. Include in the evaluation such growth-inducing factors as current and anticipated major public and private capital investments; for example:

- — industrial expansion
- — major commercial development
- — suburban residential development
- — development of natural resources (e.g., forestry, mining, recreation, etc.)
- — other social and economic factors

The evaluation should include (a) development that has occurred over the past few years, (b) developmental activities which are currently influencing the patterns and magnitude of growth in the planning area, and (c) development now in the early stages of programming which may impact the stream corridor ten or twenty years hence. This evaluation should show patterns and intensity of land use in the planning area, including urban and non-urban uses in undeveloped areas. The relative density and classification of development, i.e., industrial, commercial, residential, etc., should be mapped.

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Figure 10. Base Map

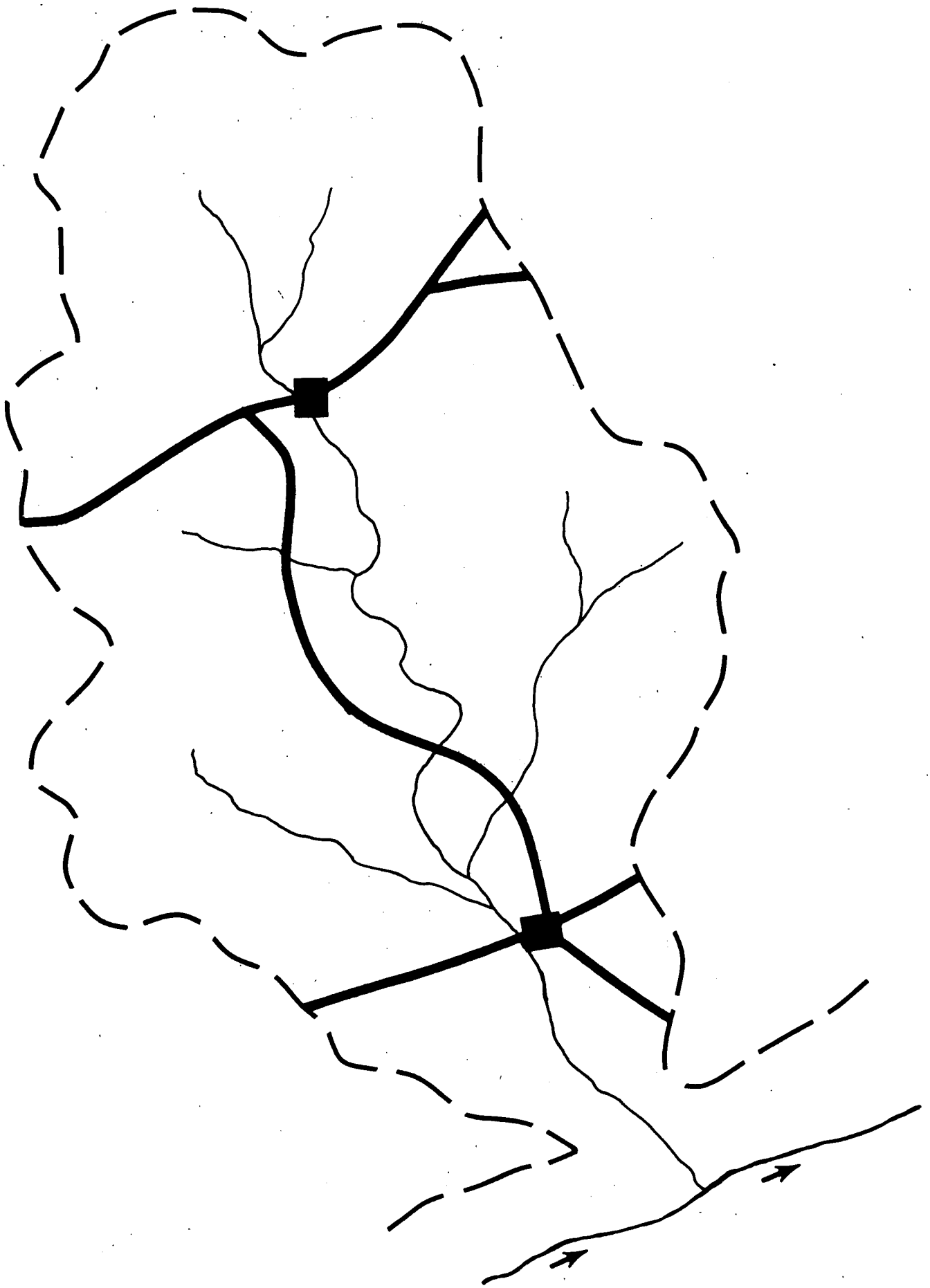
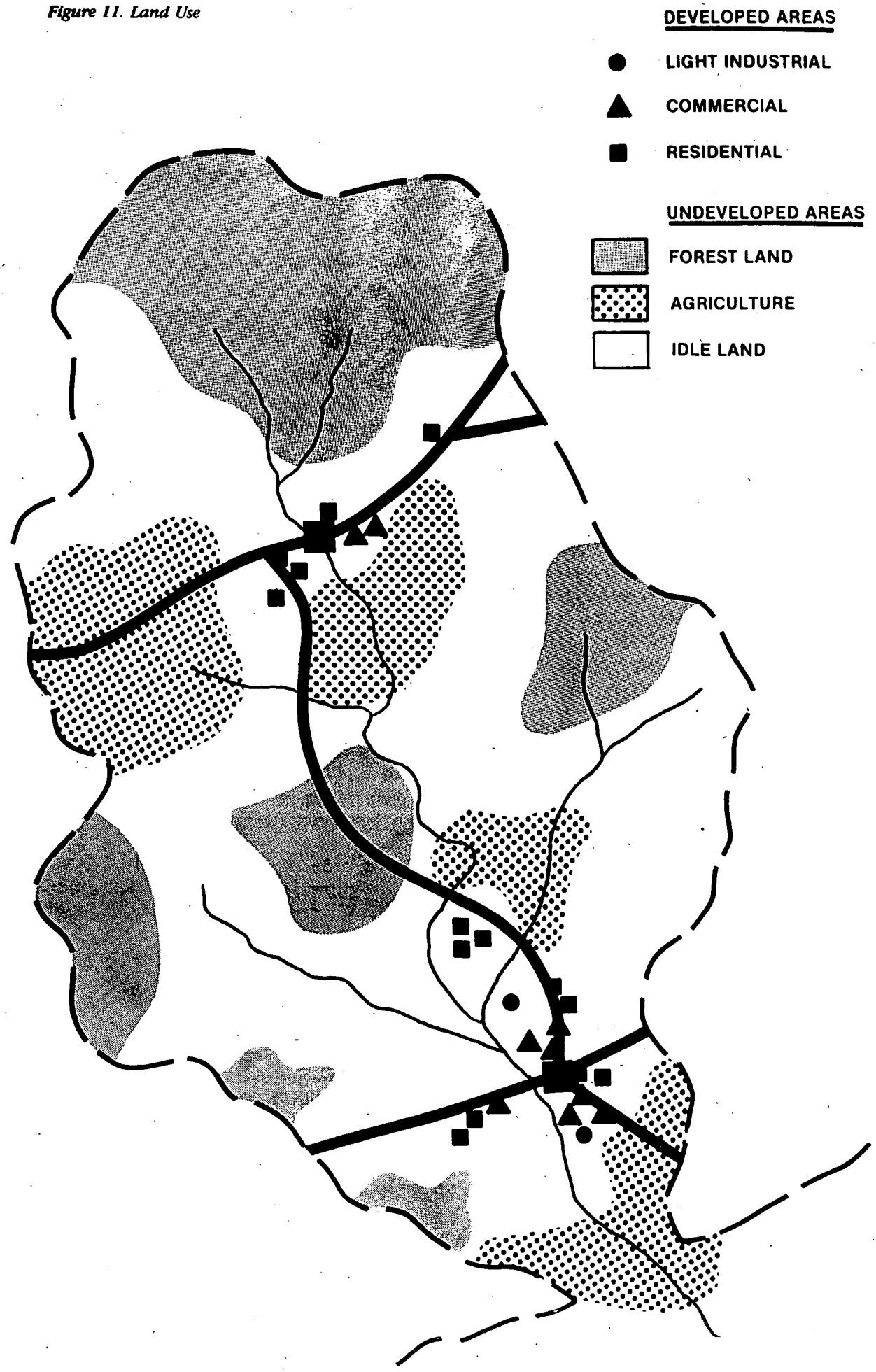


Figure 11. Land Use



Natural and Cultural Resource Inventory and Assessment

An inventory of natural and cultural resources in the planning area should be prepared. This inventory will involve acquiring, field checking (where appropriate) and mapping data, on overlays on the base map, the following kinds of information:[1]

- Surficial and bedrock geology.
- Soils and related information on development constraints and potentials, including soil depth, soil erodibility, soil structure, soil wetness, soil percolation, and slope.
- Major vegetative types.
- Surface and groundwater hydrology. (Include water quality classifications, known aquifers and aquifer recharge areas, and lakes).
- Historical and archeological sites and districts.
- Wetlands.
- Flood plains and areas of tidal inundation (including flood plains not identified on HUD maps).
- Agricultural lands.
- Fish and wildlife habitats by species.
- Rare or endangered plant and animal species in study area.
- Areas of outstanding scenic quality, e.g., waterfalls, scenic vistas, etc.

The preceding items are illustrative of factors that should be considered in the natural and cultural resources inventory. This list is not meant to be all-inclusive. Additional relevant factors, as may relate to the local situation, also should be identified in the inventory. Areas subject to special protective measures, such as park lands or rivers that have been designated in the State's Wild and Scenic River Program, and streams for which fishing easements have been acquired, should be identified and mapped (see Figure 12).

The resources inventory must be based on reliable and acceptable sources of information such as that which is available from county soil and water conservation districts, United States Geological Survey's research papers, and from federal and state flood plain maps. The Department of Environmental Conservation publication "Natural Resources Inventory: A Guide to the Process" may be helpful for identifying potential sources of information. Information also might be obtained from regional and local planning agencies, county environmental management councils, local conservation advisory councils, and conservation advisory boards. Many of these agencies have prepared natural resources inventories, open space indexes, and natural resource plans.

An assessment of the existing benefits that the natural and cultural resources in the planning area provide to the community should be made. The assessment should also examine the potential for restoring or rehabilitating a resource, a fishery, for example. This can be a descriptive statement which recognizes the importance of the resources to the community, i.e., whether the resource serves (or could serve) active recreational interests such as fishing, or passive recreational interests such as sightseeing, or water supply needs, etc. The assessment should be based on the natural and cultural resource inventory.

Environmental Constraints Analysis

Information from the resources inventory should be used to evaluate constraints to growth and development in the planning area such as flood plains, critical wildlife habitats, high soil erosion potential, historical landmarks, scenic vista, high groundwater table, wetlands, etc.

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[1] Map information may be obtained from the Map Information Unit, New York State Department of Transportation, Building 4, Room 105, State Campus, Albany, New York 12232, 518-457-4755.

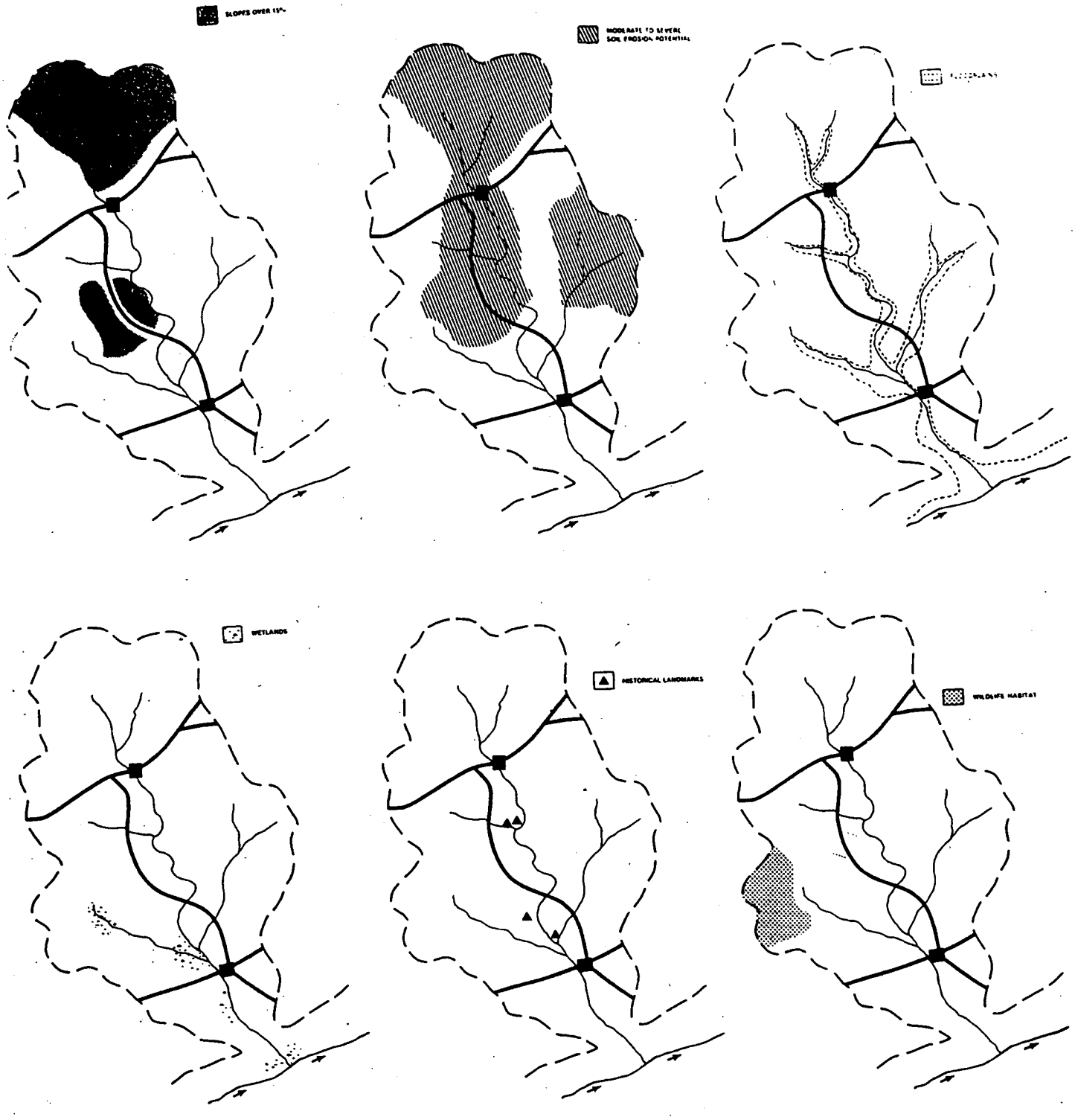


Figure 12. Natural Resources Data

For some situations, a three-element scale for rating constraints to development as "slight," "moderate," or "severe" might be useful. Transparent overlay maps of the various resource features can be superimposed upon one another and from this a summary map can be produced that can be used for making informed land use decisions in the planning area (see Figure 13).

In undertaking the constraints analysis, it will be useful to consult with other planning agencies, environmental management councils and conservation commissions and also, professional resource managers, to assist in the classification and interpretation of information in the natural resource inventory. The sources of data and methods used in the analysis should be included as part of the narrative in the report.

STEP 3: PROBLEM AND NEED ASSESSMENT

Identifying the water problems, needs, and opportunities for use or environmental enhancement is one of the most important steps of the evaluation process. Problems and needs should be separated into three categories: in-stream problems, stream corridor problems, and watershed problems as discussed below:

In-Stream Problems and Needs— Under this category problems directly related to the bed and banks of the stream, as well as to the stream proper, should be discussed. Problems, such as those described in Chapter 2 — for example, destruction of fisheries habitat through stream channelization, removal of streambank vegetation, sedimentation, and problems related to littering of streambed with trash or rubbish, including bottles, cans, or other debris — should be briefly discussed. The location of these problems and sources should be mapped on a base map overlay. As a corollary to the problems, management needs such as fisheries management, water quality management, flood plain management, recreational development, restoration or rehabilitation of scenic resources, etc., should be discussed.

Stream Corridor Management Problems and Needs — Aside from the direct impacts of various activities to the bed and banks of a stream, the stream corridor is the land unit that normally has the greatest influence on the quality and character of a stream. A stream is most vulnerable to sediment stemming from erosion and runoff which originates in the stream corridor, or to heat gain through removal of a stream corridor's vegetative canopy. Also, portions of a stream corridor may be flood prone. Thus, flood prone areas, and land use activities in the stream corridor which adversely affect a stream, whether they are related to agriculture, forestry, construction/urban encroachment, or mining activities, should be identified and mapped. A description also should be made of these activities and how they are impacting the stream, i.e., whether it is a quantity or quality relationship, or alteration of the biological structure of the stream. Professional resource managers from Regional Offices of the Department of Environmental Conservation, County Soil and Water Conservation Districts, and county and local planning agencies and environmental management councils should be consulted during this assessment to the extent necessary.

Watershed Management Problems and Needs — If local communities are to protect and conserve the resources of streams and creeks, they may have to look beyond the water course and stream corridor and consider the watershed in its entirety. Because of the cause/effect relationships of various processes inherent in land use to streams and creeks, water courses serve as an index of health of the entire watershed. Accordingly, stream management problems related to various land use activities that extend beyond the stream corridor, which are more of a watershed-wide concern, should be described and mapped. Here again the assistance of professional resource managers may be necessary.

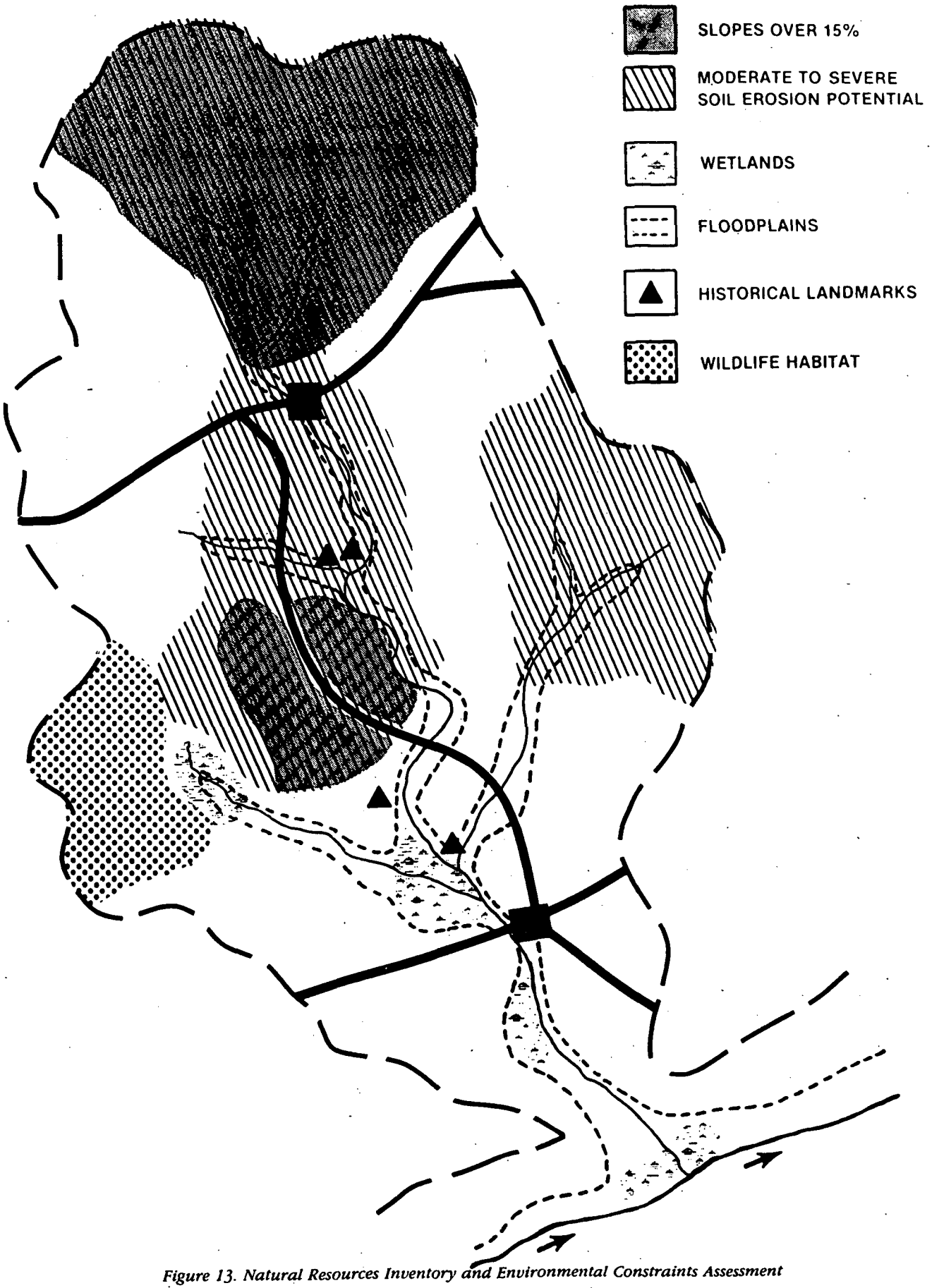


Figure 13. Natural Resources Inventory and Environmental Constraints Assessment

STEP 4: ESTABLISH THE STREAM CORRIDOR MANAGEMENT BOUNDARY

While there is no precise scientific formula for determining the optimum boundary location for any single stream corridor management unit, completion of the preceding steps should facilitate this process. The stream corridor management unit should have a "floating" boundary.

A floating stream conservation and management corridor varies in width according to the location of important natural resource features and environmental constraints which exert a strong influence on the character and quality of the stream and its surroundings. Wooded areas, wetlands, floodplains, scenic vistas, and areas having land use constraints, such as steep hillsides or soils having high erosion potential, should be included in the floating corridor (see Figure 14). Guidelines for establishing a stream corridor boundary are presented in Table 10.

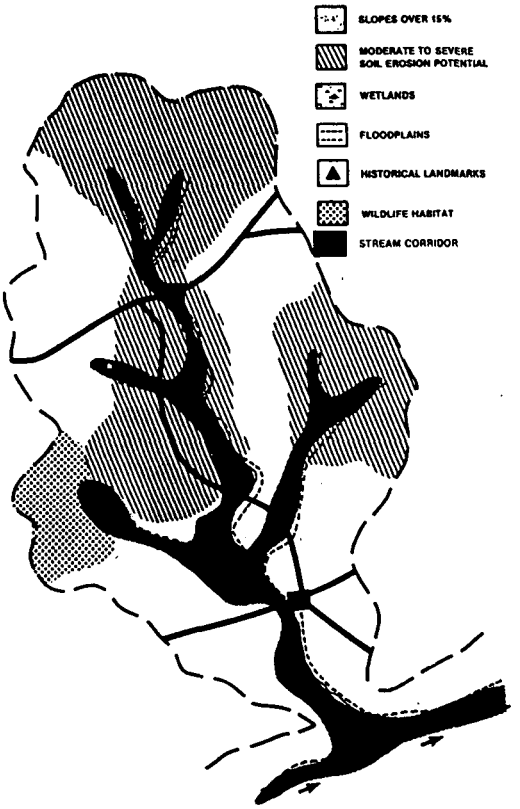


Figure 14. Floating Stream Corridor Boundary

Table 10

GUIDELINES FOR ESTABLISHING A FLOATING STREAM CORRIDOR BOUNDARY

1. A floating stream corridor management boundary should be delineated so as to include within the management area those natural, cultural, and historic features whose protection and preservation are important with respect to community stream conservation goals and objectives.
2. Such features may include, for example, scenic areas, natural, or historic landmarks, floodplains and wetlands, significant wildlife habitat, watershed and aquifer areas, ecologically important areas, and stream or waterway related outdoor recreational facilities. Such features should be identified on a list and briefly described in a narrative and, in addition, each feature should be referenced on an official map.
3. In establishing a floating stream corridor management boundary, consideration should be given to protecting natural and cultural features, such as the above, by establishing the boundary a reasonable distance landward, for example 100 feet for a wetland, to provide an adequate protective buffer area.
4. In defining the stream corridor management boundary, consideration should be given to the applicability of property boundaries, or regulatory boundaries, such as those on a zoning map, and to features such as roads or railroads which may parallel the stream and make the stream relatively easy to delineate and identify on a map.
5. By law (Environmental Conservation Law, Article 15, Title 27), the boundary width for a river (or stream) designated by the state as "Wild", "Scenic", or "Recreational" can be no farther landward than one-half mile from the mean high water mark in the river.

STEP 5: ESTABLISH GOALS AND OBJECTIVES

Goals and objectives must be established for the planning area. A goal is a general statement of policy focused on long-term accomplishments for the common good of the community; for example, to protect and enhance fisheries habitat, to protect soil resources, to protect drinking water supplies, to provide for increased recreational opportunity, or to protect the scenic and visual communities in the planning area. An objective is a specific, task-oriented statement which needs to be carried out in order to achieve a goal; for example, to establish a vegetative canopy in the stream corridor, or to ensure that development of the planning area is consistent with environmental constraints. Each goal is usually accompanied by two or more objectives which identify a variety of tasks that must be achieved in order to achieve the goal. Table 11 identifies several goals and a number of objectives which can either be adopted directly or modified to meet local stream corridor management needs.

STEP 6: ANALYZE PLANS, LAND USE CONTROLS, AND THEIR CONSISTENCY WITH GOALS AND OBJECTIVES

Land use and land-related plans, if implemented, can have a significant influence on the intensity and patterns of development in the stream corridor. Therefore, as factors of growth, each plan which has been adopted, or is expected to be adopted, should be evaluated to determine its potential for shaping growth patterns. Similarly, plan implementation mechanisms, both existing and proposed, should be evaluated.

Plan Review. Examine relevant state, regional, county, and local land use and land use-related plans and briefly describe their geographical area of coverage, and indicate the purpose of the plans through a summarization of their goals and objectives.

TABLE 11. GOALS AND OBJECTIVES

Goals and objectives reflect the vision and aspirations that a community has for the future. The following goals and objectives represent not only a vision, but also the state's aspirations for its streams and associated water resources. Communities across the State are encouraged to reflect upon these goals and objectives, tailor them to local problems and needs, and incorporate them into ongoing local planning efforts. Above all, local agencies are encouraged to serve as the driving force to ensure that programs to achieve adopted goals and objectives are effectively implemented.

Goal

- To restore, protect, and enhance water quality and associated aquatic resources and water supplies.

Objectives

- To minimize erosion and prevent sedimentation of waterways.
- To prevent the accelerated enrichment of streams and contamination of waterways from runoff containing nutrients, pathogenic organisms, organic substances, and heavy metals and toxic substances.
- To maintain or restore a natural vegetative canopy along streams where required to ensure that mid-summer stream temperatures do not exceed tolerance limits of desirable aquatic organisms.
- To maintain the stream or waterway free from litter, trash, and other debris.
- To minimize the disturbance of streambed and prevent streambank erosion and, where practical, to restore eroding streambanks to a natural or stable condition.
- To restore, rehabilitate, or enhance water quality and associated resources through the implementation of appropriate Best Management Practices on the land.

Goal

- To minimize the threat to life and the destruction of property and natural resources from flooding, and preserve (or reestablish) natural flood plain hydrologic functions.

Objectives

- To ensure that runoff from developing and urbanizing areas is controlled such that it does not unnecessarily increase the frequency and intensity of flooding at the risk of threatening life and property.
- To adopt appropriate land use controls and performance standards for controlling development of flood plains.

Goal

- To restore, protect, develop, and enhance the historic, cultural, recreational, and visual amenities of rural and urban stream corridors.

Objectives

- To ensure that environmental resource constraints are fully considered in establishing land use patterns in stream corridors.
- To retain and preserve open space and visual amenities in urban and rural areas by establishing and maintaining greenbelts along stream corridors.
- To ensure that development in the stream corridor is consistent with the historical and cultural character of the surroundings and fully reflects the need to protect visual amenities.

Table 11. (Continued)

- To ensure that the recreational and fisheries potential of a stream corridor are developed to the fullest extent practicable.
- To maximize the use of creative and imaginative resources to rehabilitate and transform urban stream corridors, which through neglect may represent a source of urban decay and blight, into attractive community assets consistent with historical or other cultural amenities.

Plan Implementation Effects on the magnitude, quality, direction, and timing of growth. Analyze, evaluate, and describe, in narrative and graphic form, how the proposals in the plans are expected to influence land use and growth in the stream corridor planning area, and describe how the proposed stream corridor management unit relates to various plans. For example, show, on a map overlay scaled to the stream corridor planning area base maps, how various land use planning activities and implementation strategies, such as zoning and other land use controls and infrastructure investment (e.g., water supply, transportation, sewers) will influence and direct growth, including timing, density, and magnitude. Questions to be answered include:

— Are emerging and potential growth and land use patterns in accord with stream corridor management goals and objectives?

— Do land use plans and implementation mechanisms, including zoning and other controls, provide adequate protection of environmentally critical areas within a stream corridor planning area such as: flood plains, wetlands, significant wildlife habitats, scenic and historical features, riparian vegetation, and agricultural areas? If not, explain the reasons therefore.

— Are the plans responsive to the physical conditions of the planning area, such as shallow or clay soils, topography, high water table, and poor drainage?

Plan Consistency. To avoid land use conflicts, it is important to ensure that stream corridor management plans are consistent with state, regional, and local plans and their implementation strategies. If they are not, adjustments or modifications to various plans may have to be made. Some existing county and local plans may be out-of-date or inadequate in other ways. Some may not be sensitive to physical or environmental resource conditions.

Land use and related plans that are inconsistent with the goals and objectives of the established stream corridor management planning area, may be updated, revised, or refined by the local agency or other agencies responsible for plan preparation, so as to ensure consistency.

CONSISTENCY WITH DEC STREAM
AND RIVER CONSERVATION PLANS AND PROGRAMS

In order to ensure greater planning consistency, local agencies and organizations are encouraged to contact DEC regional offices (listed on inside of back cover) to discuss stream corridor management goals and objectives, and implementation strategies. Such discussion should be helpful not only for learning about technical assistance which DEC may also be able to provide, but also to avoid potential planning conflicts and to ascertain whether or not permits may be required to implement any segment of the stream corridor management plan (See Chapter 6).

Plan Effectiveness. Indicate whether or not policies and plans and implementation strategies, including state and local land use controls and infrastructure investment, educational programs, incentive programs, etc., are likely to be effective in terms of meeting stream corridor management goals and objectives. Indicate whether or not the performance standards in zoning, subdivision, or site plan review regulations are adequate.

STEP 7: EXAMINE MANAGEMENT OPTIONS

Once the goals and objectives have been formulated, management options for achieving them should be arrayed and examined. The options will range from remedial and preventative land management measures and practices, for addressing existing problems and for preventing new ones from occurring, to opportunities for developing stream corridor resources to their fullest potential. The remaining chapters in this manual are devoted largely to a discussion of stream corridor management opportunities.

STEP 8: PREPARE STREAM CORRIDOR MANAGEMENT PLAN

A stream corridor management plan should be prepared in consultation with interested local, county, and regional agencies and affected property owners and private interest groups. The plan, which should be based on the analysis of information generated under the preceding steps, should:

- Contain a clear description and delineation in narrative and graphic form (maps and photographs) of the significant natural, cultural, and aesthetic resources and features of the stream corridor; existing land and water uses; land ownership; and existing land and water controls and management activities and programs.
- Set forth a detailed plan to address existing or potential issues, problems, and needs which impact, or may impact, resources and features in the stream corridor which are important to protect and preserve. The protection and enhancement of natural resources and cultural features may include the restoration of resources negatively impacted by previous or existing land use and development.
- Set forth land and water management goals and objectives, and specific policies, standards, and management guidelines to implement a definitive, long-range program of protection, enhancement, and compatible public uses.
- Set forth specific regulations, including standards and restrictions, that will govern the use of land and water resources. Standards and restrictions should include, as necessary and appropriate, provisions for forest management; provisions for construction of roads, trails, and bridges; motorized access; and subdivision, principal buildings, and other structures; water quality; refuse disposal; stream improvement; and signs and utilities, etc.
- Provide for the continuing involvement of the affected and interested public in the development, implementation, and administration of the plan.
- Contain a fiscal element which identifies funding sources and schedule for plan implementation.

STEP 9: IMPLEMENTATION AND FEEDBACK

It is during this step that stream management plans are implemented. As a function of this phase, implementation activities should be evaluated on an ongoing basis to identify program success and shortfalls. As program deficiencies become apparent, new strategies can be developed to achieve goals and objectives.

CHAPTER 5: STREAM CONSERVATION OPTIONS AND CHOICES FOR LOCAL GOVERNMENT

The purpose of this chapter is to discuss the opportunities available to local government through policy development, education, land acquisition, land use controls, floodplain regulations, tax incentives, governmental aid programs, and other options for protecting, conserving, and enhancing their streams and stream corridor resources.

STREAM CORRIDOR MANAGEMENT OPTIONS

- Policy Development
- Information and Education
- Land Acquisition
- Land Use Controls
- Tax Incentives
- Governmental Aid Programs
- Special Improvement Districts
- Watershed Rules and Regulations
- Wild, Scenic, and Recreational Rivers Program

POLICY DEVELOPMENT:

Counties, towns, cities, and villages can have a positive influence on streams and stream corridors within their political jurisdiction through the adoption of policies to guide the activities and actions of local program administrators. Stream conservation policy directives adopted by a local legislative body can be of particular significance in the following program areas:

Highway Construction and Maintenance

Local policies can be adopted which direct highway supervisors to adhere to and implement various stream conservation practices during highway planning, construction, and maintenance operations. Contractual arrangements for highway construction also can include requirements for taking proper safeguards and implementing proper "best management practices" (BMPs) during and following construction activities.

Stream conservation practices and measures (BMPs) are contained in Chapter 6 of this manual. These range from providing guidance to properly locating stream crossings and proper culvert installation techniques to locating areas for properly disposing of spoil material from a stream channel clearing operation.

Additional site-specific guidance on the selection and design of appropriate management practices, for example seeding mixtures for road bank stabilization, may be obtained from County Soil and Water Conservation Districts. County highway department engineers also can provide substantial guidance on site-specific measures for protecting streams from highway construction and maintenance activities.

Building Inspection and Zoning Enforcement

Building inspectors and zoning enforcement officials have significant influence over the manner in which development proceeds in a community, particularly in terms of guiding the behavior of developers. Through development of policies, local legislators can direct inspectors and zoning officials to assist community efforts to achieve stream corridor conservation goals and objectives. Policy development in this regard can occur essentially in the following three areas:

- Designated Priority Area — Building inspectors can be advised through a policy memorandum that the legislative body considers streams and stream corridors to be of special significance to the community and, as such, building inspectors and zoning officers are to give priority attention to projects within a stream corridor. They can direct inspectors to ensure that developers are in close compliance with local zoning laws designed to protect stream corridors and they can insist that such laws be rigorously enforced. Local boards also can direct inspectors and zoning officers to work closely with developers to ensure that appropriate BMPs (many of which are contained in Chapter 6) are implemented as needed.
- Training — A local legislative body may adopt a policy which seeks to ensure that building inspectors and zoning officers receive the proper training to perform their tasks. A block of time in a training program could be devoted to stream corridor management. Regional and county planning agencies have the potential to structure such a training program for communities within their jurisdiction.
- Increased Staffing — A local legislative board may find it necessary and desirable, particularly in rapidly expanding communities, to expand the staff of building inspectors to assist in the administration of a variety of regulatory activities including those related to stream corridor management.

Mobilize Service Organizations

Local officials can mobilize the resources of community service organizations by encouraging their participation in stream corridor conservation projects, such as litter removal and tree planting along stream banks. For example, boy and girl scouts, youth groups, and other organizations have been extremely effective in tree planting projects and removing litter from streams. Inmates from many state and county correctional facilities often are available for community projects such as streambank fencing and tree planting.

Implementing the State Environmental Quality Review Act (SEQRA)

On November 1, 1978, local governments became responsible for implementing SEQR (Article 8 of the New York State Environmental Conservation Law). Local officials can adopt policies and procedures to ensure full implementation of SEQR as mandated.

SEQR applies to the following local (and state) actions:

- **projects** affecting the environment that:
  - — are directly undertaken by an agency
  - — are funded by an agency, or
  - — require one or more permits or approvals from an agency
- **planning activities** that affect future choices
- the making of **rules, regulations, procedures, or policies**
- any combination of the above.

Under the Act, local agencies include: any local board, agency, authority, district, commission, or governing body, including any city, county, or other political subdivision of the state.

SEQR is of particular significance to stream corridor management as it creates a process by which decision-makers can identify, measure, and interpret the potential impacts of a proposed action at the earliest possible time in the planning of a project, communicate this information to others, and utilize this information in making their decisions. The law emphasizes the importance of protecting the natural environment and requires environmental factors to be considered along with social and economic considerations when decisions are being made. Table 12 provides criteria for determining whether or not a proposed project within a stream corridor is of environmental significance. Additional guidance on implementing SEQR may be obtained from Regional Offices of the Department of Environmental Conservation listed inside the back cover.

TABLE 12

CRITERIA FOR DETERMINING ENVIRONMENTAL SIGNIFICANCE

This list is designed to aid lead agencies in determining whether impacts which may be expected to result from a proposed action will have a significant effect on the environment. It should be consulted for Type I and Unlisted Actions. The list is not exhaustive, but these criteria are definite indications of significant environmental effects:

- A substantial adverse change in existing air quality, water quality, or noise levels; a substantial increase in solid waste production; a substantial increase in potential for erosion, flooding, or drainage problems.
- The removal or destruction of large quantities of vegetation or fauna; the substantial interference with the movement of any resident or migratory fish or wildlife species; impacts on a significant habitat area; or substantial adverse effects on a threatened or endangered species of animal or plant or the habitat of such a species.
- The encouraging or attracting of a large number of people to a place or places for more than a few days compared to the number of people who would come to such place absent the action.
- The creation of a material conflict with a community's existing plans or goals as officially approved or adopted.
- The impairment of the character or quality of important historical, archeological, or aesthetic resources or of existing community or neighborhood character.
- A major change in the use of either the quantity or type of energy.
- The creation of a hazard to human health or safety.
- A substantial change in the use or intensity of use of land or other natural resources or in their capacity to support existing uses.
- The creation of a material demand for other actions which would result in one of the above consequences.
- Changes in two or more elements of the environment, no one of which has a significant effect on the environment, but which when taken together result in a substantial adverse impact on the environment.
- Two or more related actions undertaken, funded, or approved by an agency, no one of which has or would have a significant effect on the environment, but which cumulatively meet one or more of the criteria in this section.

Source: Johnson, T.H., **et.al.**, 1979

INFORMATION AND EDUCATION

Information and education is an essential element of a stream corridor management program. If such a program is to be successfully implemented, the public will have to be fully informed about such factors as the problems and issues, goals and objectives, and implementation strategies. The information base which is developed in a series of steps for solving the problem (see Chapter 4) will be invaluable for purposes of educating the public about the stream corridor management program.

LAND ACQUISITION

Land acquisition is an important stream corridor management tool which is available to communities for protecting critical environmental areas or for acquiring recreational lands or public access thereto. A variety of land acquisition techniques, including their advantages and limitations, are presented in Table 13. Potential sources of funding for land acquisition, including the Land and Water Conservation Fund and "Return a Gift to Wildlife Fund", are identified in Section F (Governmental Aid Programs) of this chapter.Additionally, Section 247 of the General Municipal Law allows a municipality to acquire land for conservation of natural or scenic resources. The municipality can acquire outright title to the land or some lesser interest, such as an easement or a restrictive covenant.

TABLE 13
LAND ACQUISITION TECHNIQUES[1]

METHOD	EXPLANATION	ADVANTAGES	LIMITATIONS	AGENCY OR GROUP LIKELY TO BE INVOLVED
Fee Acquisition				
1. Purchase	Outright acquisition of entire interest to property (may be subject to existing easement(s))	Total ownership of property; management and public use facilitated; best protection afforded	High cost; possibly politically undesirable; possible cultural and community disruption	Local, State, and Federal governments; private trusts
2. Purchase and sellback with restrictions	Fee acquisition with subsequent sale of fee, with restrictions or retention of partial interest	Value of underlying fee established by market; possibly the best method of delineating the specific retained interests desired	Possibly politically undesirable as it may force removal of original landowner; public agency has burden of management until underlying fee resold	Same as above
3. Purchase and leaseback	Fee acquisition with subsequent lease of the property	Productive use and management of the property; income; more control over misuse of property than if only an interest was retained	Public use probably precluded; possibly politically disruptive	Same as above
Purchase and granting of life/term estate or other reservation of use	Fee acquisition but public use of property delayed until termination of a "lease" for specified term or until death of present owner	Smoother, phased transition from private ownership; politically more acceptable	Public use postponed; management of retained interest required	State and Federal governments; private trusts
5. Donation/bargain sales	Acquisition of full or partial interest in property at less than fair market value	Use of public funds maximized; some tax benefits to donor	Limited Federal tax benefits to donor (e.g., maximum tax reduced from 70% to 50%, making charitable contributions less attractive in 1982)	Local, State, and Federal governments; private trusts
6. Right of first refusal	Requirement of present owner to offer property to the government for purchase prior to sale to another private owner; right can either be purchased, legislated, or condemned; right may or may not be exercised	One method of selectively controlling rate of growth; fair market value established by market	Currently unclear how this method may or may not violate public acquisition laws; mechanics for governmental use not fully delineated	State and Federal governments
Partial Interest				
1. Easement	Ownership of portion of the rights included in fee-simple ownership of property such as development, access, and timber rights	Private owner retains fee title and is responsible for management of property; less costly in most cases than fee acquisition; flexible	Cost may nearly equal fair market value of fee-simple in some cases; potentially very limited or no public use of property; possible management problems; limitations on charitable contributions of easements	Local, State, and Federal governments; private trusts
2 Leases	"Rental" of all or portion of property for contractual period	Continued private use and ownership of property; often involves shorter time period to achieve desired use; does not commit public entity to site in perpetuity	Lack of public ownership can limit public expenditures and restricts long-term site planning; annual lease fees	Local, State, and Federal governments
3. Combination of Both Full Fee Purchase and Partial Interest	For example, purchase of full fee on one portion of a site and an easement purchase on the remainder	Allows for creative land uses and a great deal of flexibility in negotiation with landowner	Can involve complex rights and uses; can also be timeconsuming to package land protection scheme	Same as above

1 Source: U.S. Department of Interior, *Draft Environmental Impact Statement for the River Management Plan: Upper Delaware*, (National Scenic and Recreational River/New York–Pennsylvania) National Park Service, Denver. October 1982.

LAND USE CONTROLS

SAMPLE LAND USE CONTROL PROVISIONS
AND PERFORMANCE STANDARDS
APPLICABLE TO STREAM
CORRIDOR MANAGEMENT

Sample land use control provisions and performance standards which can be used in a stream corridor management context are available from the Bureau of Water Resources, New York State Department of Environmental Conservation, 50 Wolf Road, Albany, New York 12233. The Appendix provides a list of sample provisions available.

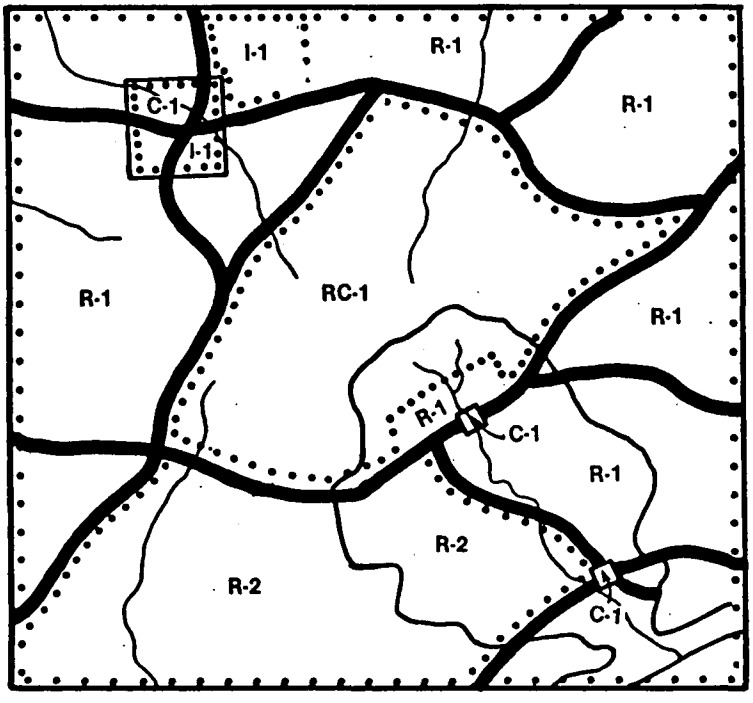
Local government can draw upon a variety of regulatory techniques to control land use activities for the purpose of protecting and enhancing streams and stream corridor resources. The approaches which should find most widespread application are briefly described as follows:

Zoning

Zoning is the most widely used tool for controlling land use and managing community growth which local governments have at their disposal. Basically, zoning entails the division of a community into sections or districts and prescribes what uses can be made of the land therein. Zoning also prescribes the density of development in a community through provisions which establish minimum setback distances, percentage of lot that may be occupied, and minimum lot size which applies to entire districts. Figure 15 is illustrative of a traditional zoning map.

Without the inclusion of provisions which specifically respond to stream conservation needs, zoning as described above may be inadequate to respond to the stream corridor management task for the following reason. Regulatory standards for each land class or zoning district are uniformly applied; therefore, landscape features within a stream corridor are treated the same as land for the entire zoning district. As a result of this uniformity, zoning may not take into consideration such development constraints as steep hillsides, scenic vistas, erosive sites, natural drainage, and many other environmental features. In recognition of this limitation, several variations of zoning have evolved which have specific application to stream corridor planning and management. These include zoning provisions for establishing *stream conservation districts* and *incentive zoning*.

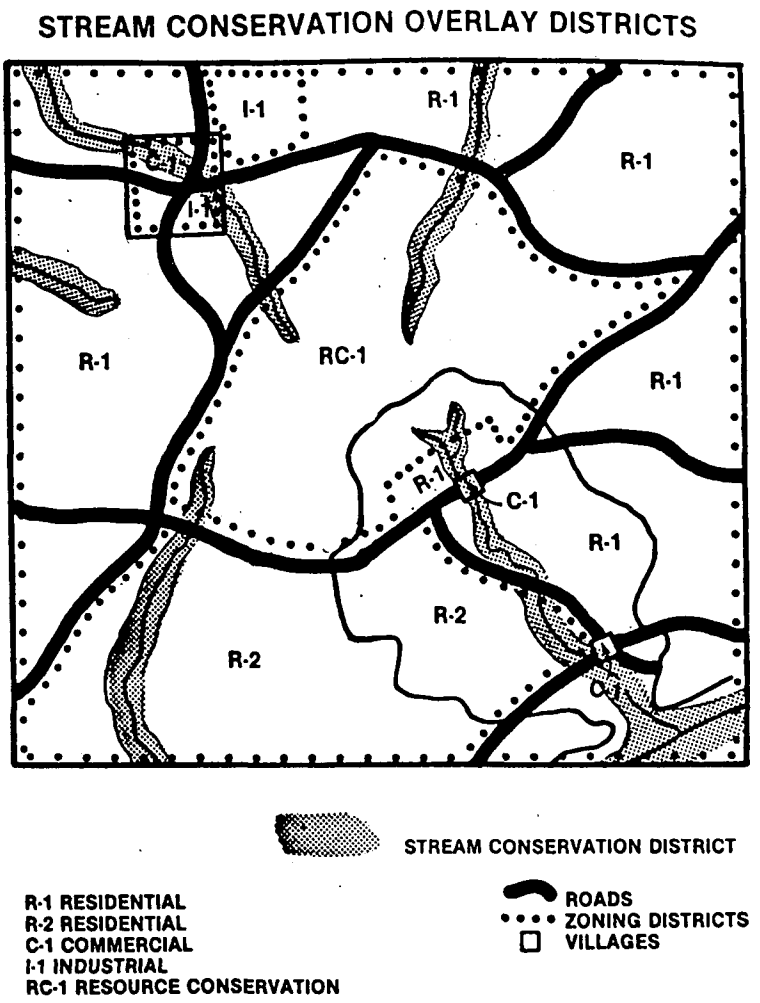
Figure 15. **TRADITIONAL ZONING MAP**



R-1 RESIDENTIAL
R-2 RESIDENTIAL
C-1 COMMERCIAL
I-1 INDUSTRIAL
RC-1 RESOURCE CONSERVATION

ROADS
ZONING DISTRICTS
VILLAGES

Figure 16.



Stream Conservation Districts — Communities can elect to establish stream conservation districts to protect and enhance streams and stream corridors. This can be accomplished through overlay zoning where zoning already exists or through the creation of a special stream conservation district in communities which have not enacted zoning ordinances. Performance standards excerpted from the state Wild, Scenic, and Recreational River (draft) regulations are available from the Department of Environmental Conservation upon request (see Appendix R). These standards may be used directly or tailored for application to a stream conservation district.

Overlay Zoning — Overlay zoning is the basic approach that a community can take to control land use activities within the stream corridor. As applied to stream corridors, overlay zoning delineates a stream conservation district through mapping and superimposes a set of regulations or standards and requirements on existing zoning (see Figure 16). Overlay zoning is particularly suited to stream corridor management where there is a special public interest such as the need for floodplain management, conserving erosive soils on steep hillsides, and protecting historic sites, scenic vistas, or other natural resource features in a geographic area (i.e., the stream corridor) that does not coincide with the underlying zoning boundary (see Appendixes C and R).

No Community-wide Zoning — A community which has not adopted a community-wide zoning ordinance may wish to protect its stream corridor through the adoption and enforcement, by local law, of a special stream conservation district regulation. Such a district would be applicable only to those parts of the community within established stream corridor district boundaries. This approach would re-

quire the local governing body to designate an enforcement officer, for example, the town clerk. Stream conservation district regulations would be required, and an appeals procedure would have to be established. The site plan review process described below could serve as the project review mechanism.

Incentive Zoning — Incentive zoning, or bonus zoning, as it is often referred to, provides another approach to stream corridor management. Essentially, incentive zoning provides for a trading arrangement between the community and the property owner. In exchange for the developer providing something that the community feels is in its interest, for example, the protection of a stream corridor, more open space, and the use of cluster development designs rather than conventional lot-by-lot development, the developer is given a bonus. The bonus usually is permission to build at greater density, for example more floor area or more dwelling units. A common use of incentive zoning is found in Planned Unit Development Regulations described in a later section of this chapter (see Appendix F).

Subdivision Regulations

Subdivision regulations are a tool to fashion development in defined ways and by prescribed methods so as to regulate the use of private land in the public interest. Within recent years, the exercise of subdivision regulation has become increasingly broadened by incursions into the area of timing of development, wetlands and floodplain protection, reservation of land for recreational use and other purposes and mandatory dedications of open space, and for protection against environmental degradation.

Viewed in this context, the relationship between stream corridor management and subdivision regulation should be obvious. A prime example is the ability and necessity to control development in areas where the replacement of the natural vegetation and undisturbed soil — which would normally absorb stormwater runoff — by artificial concrete, asphalt, and steel construction would lead to increased problems of flooding (see Figure 17).

The state's planning laws permit cities, villages, and towns (and in certain cases, counties and regional planning boards, if authorized by the counties) to review subdivisions to ensure that good subdivision design is obtained through compliance with established standards of performance. Communities with or without zoning may enact subdivision regulations.

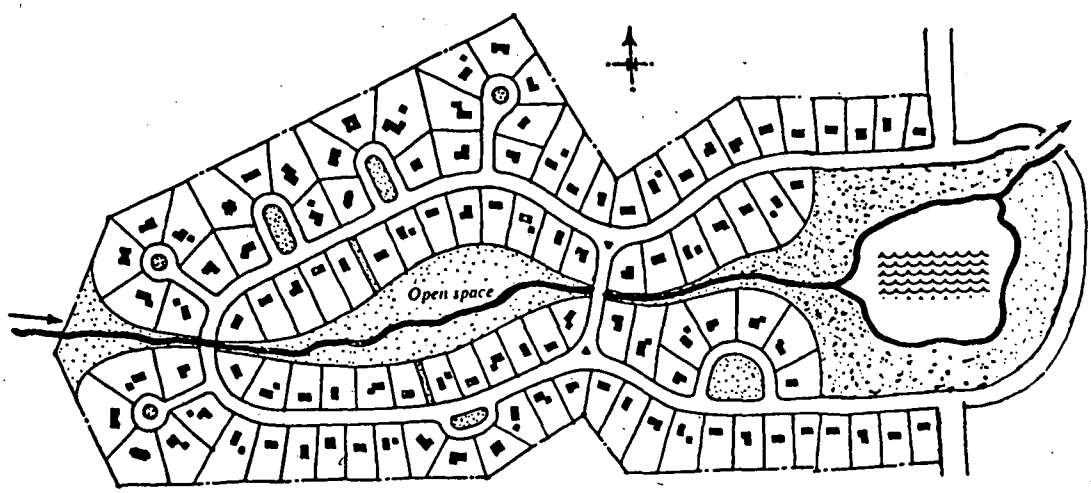


Figure 17. Subdivision Configuration. A well maintained stream can serve as a focal point to a subdivision. (Adopted from "Control of Land Subdivision", 1974)

Other Regulatory Techniques

Several other regulatory techniques, which have evolved out of zoning and the regulation of subdivisions, are applicable to stream corridor management. These include: cluster zoning, planned unit development (PUD), transfer of development rights (TDR), and site plan review.

Cluster Zoning — Cluster zoning is a means to permit the transfer of density, in conjunction with the approval of a subdivision plat, from a preset standard by grouping or concentrating the building units on a reduced area of land. For example, if a given tract of land of 100 acres is zoned in such a way that 100 dwellings could be built on individual lots of one acre apiece, cluster development would permit these 100 dwellings to be grouped on, say, twenty acres, while the 80 acres remaining could be devoted to open space preservation.

The clustering concept provides community officials with an opportunity for negotiating with the developer over the location and density of clustering on developable portions of the tract so as to leave natural areas, the stream corridor, for example, and areas more difficult to develop virtually unobstructed.

It is important to note, however, that unless provisions are contained in the zoning ordinance for incentive zoning or planned unit development (PUD), state enabling legislation for cluster development does not permit a violation of the overall density ceiling otherwise applicable for the particular tract under the zoning ordinance.* Thus if the land could be used for 100 homes on one-acre plots, the clustered development on the same tract could not exceed 100 homes (see cluster zoning example in Figure 18).

Planned Unit Development (PUD) — A PUD is a diversified development project which does not fit the standard zoning regulations of a municipality and which is built as a "planned unit". This feature permits variation in many of the traditional controls related to density, land use, setbacks, open space, and other design elements. It differs from the cluster development concept in that it is easily amenable to any mixture of uses and is not subject to any of the underlying zoning for the land involved. For example, a single PUD permits: flexibility in site design that allows buildings to be clustered; mixtures of housing types such as detached houses, townhouses, or garden apartments; combining housing with such other ancillary uses as neighborhood shopping centers; better design and arrangement of open space — including the protection and preservation of streams and the stream corridor; and retention of such natural features as flood plains, steep slopes, or wetlands (Meshenberg, J., 1976).

PUD regulations typically are included within the district regulations of the zoning ordinance, i.e., the use requirements, development standards, and procedures are spelled out in the ordinance text (see Appendix E).

Transfer of Development Rights (TDR) — The "transfer of development rights" permits all or part of the density potential (established in the zoning ordinance) of one tract of land to be transferred to a noncontiguous parcel or even to land owned by someone else. The development rights become a separate article of property, which can be sold to a landowner whose property is better suited to greater densities of development. After selling the development rights, a landowner still retains title and all other rights to the land. These other rights permit farming, forestry, some recreational uses, and other nonintensive uses such as stream corridor conservation, open space preservation, and preservation of buildings or neighborhoods of historical or architectural significance (see Appendix H).

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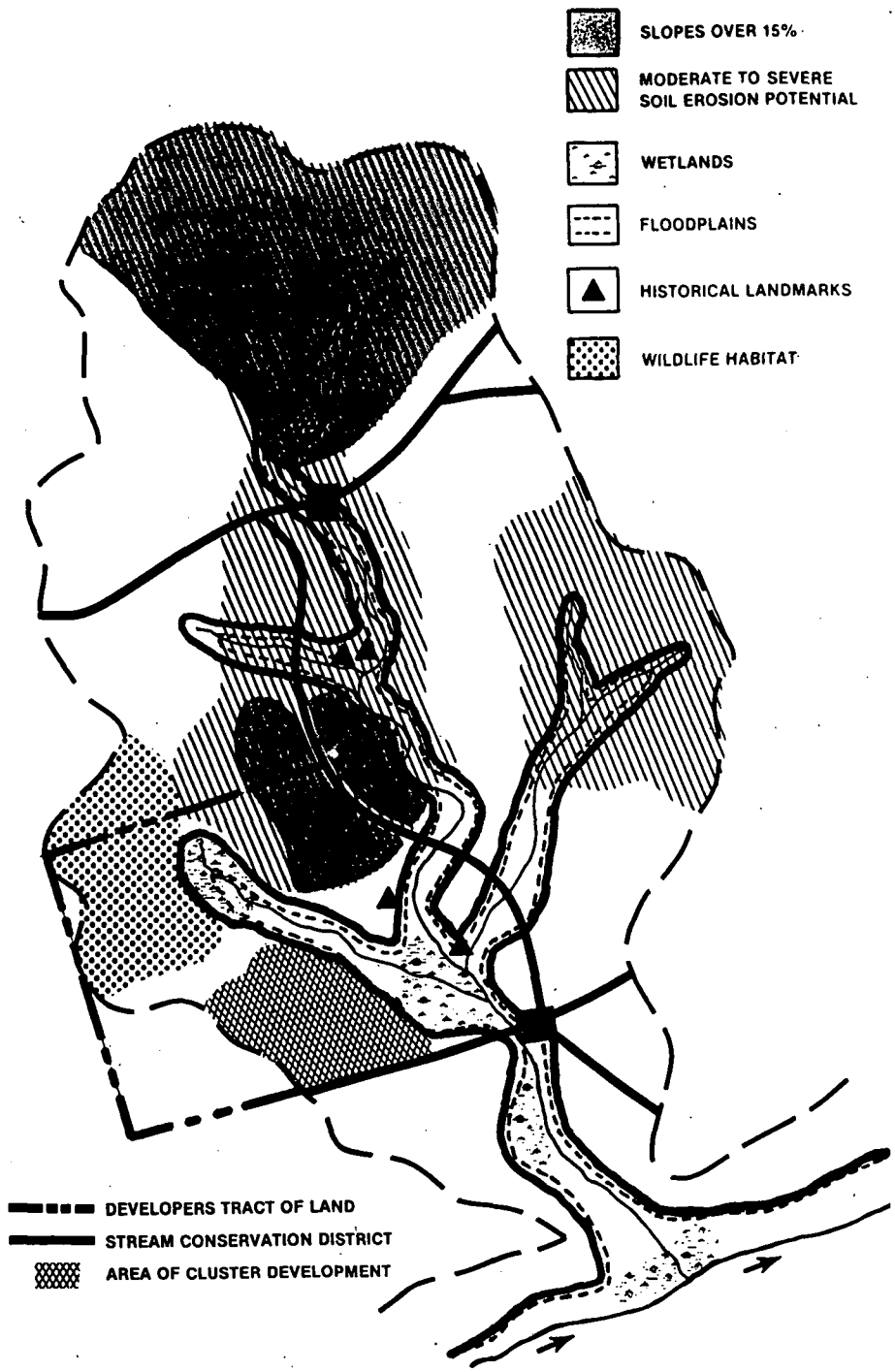
* The enabling statutes permitting clustering are in General City Law §37, Village Law §7-738, and Town Law §251.



EXAMPLE: *Cluster zoning concept on a 100 acre tract of land*

Assume—tract contains 24 acres in stream conservation district zoned at 1 unit per 4 acres for a total of 6 allowable units

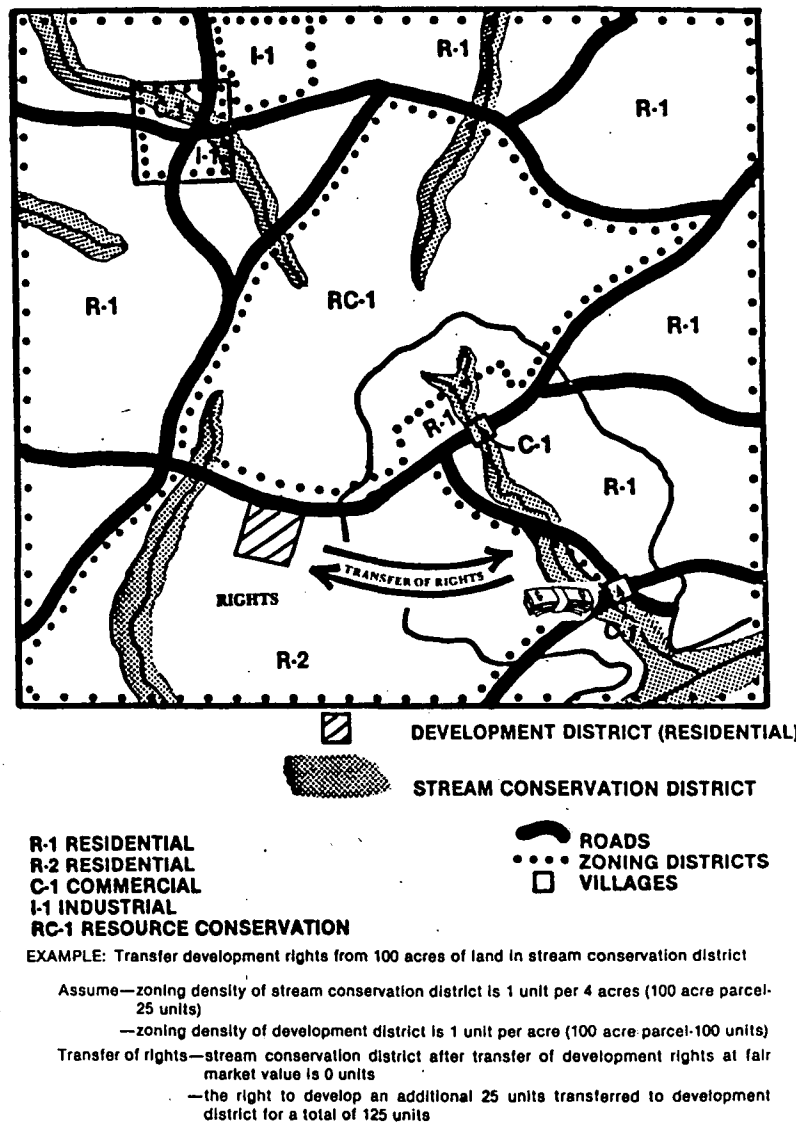
—the remainder of the tract-76 acres-consists of open space, forest and agricultural land having a zoning density of 1 unit per acre (76 acre parcel-76 units)

Cluster Development—cluster zoning provisions seek to encourage efficient development in areas having few environmental constraints to development. In this example, the total number of units permitted through clustering is 6 + 76 = 82.

Figure 18. Cluster Zoning

There are several significant benefits of TDR: it permits preservation of lands where further development is undesirable for a variety of reasons; it compensates the owner of preserved land financially by allowing him to sell his unused development rights; it reduces the impact that the exercise of the community's police power can have on property owners; it provides a reasonable economic return to landowners selling development rights; it involves minimal loss of revenue to the community in that the total economic base does not change and tax revenues remain at the same level — on the one hand the owner who sells his unused development rights also reduces the assessed value of his land and so lowers his taxes; on the other hand, the landowner who purchases the development rights increases the assessed use value of the land and so pays higher taxes. Finally, there is no loss of new development to the community. Figure 19 illustrates how TDR works (NYS Zoning Technical Series, 1981).

Figure 19. **TRANSFER OF DEVELOPMENT RIGHTS**



EXAMPLE: Transfer development rights from 100 acres of land in stream conservation district

Assume—zoning density of stream conservation district is 1 unit per 4 acres (100 acre parcel-25 units)

—zoning density of development district is 1 unit per acre (100 acre parcel-100 units)

Transfer of rights—stream conservation district after transfer of development rights at fair market value is 0 units

—the right to develop an additional 25 units transferred to development district for a total of 125 units

Site Plan Review — Site plan review is a process that can be used by decision-makers in communities with or without zoning to evaluate the potential impact that a land development proposal has on a community. Such a review focuses attention on a site development plan. Site development plans have two functions:

(1) they illustrate the intended design, arrangement, and uses of the land to be developed

(2) they describe the proposal's physical, social, and economic effects on the community

Site plan reviews can include both small and large scale proposals ranging from gas stations, drive-in facilities, and offices to complex ones such as multifamily housing, shopping centers, and planned unit developments. Within the sites, the prime concerns might include, among other factors, minimizing ecological disturbances, management of stormwater runoff, and preservation of open space and historic and cultural features in the stream corridor.

The site plan review process may be conducted over the following three phases:

(1) Presubmission Phase — which provides an opportunity for the community to learn of the developer's intent and for the developer to learn of the community's requirements and standards for development

(2) Preliminary Site Development Plan Phase — which includes the submission of an application for preliminary site development plan approval for a developer. The application should be accompanied by information about the proposal including legal data, impact on the environment, natural features, existing development and infrastructure, and site development proposal. Because it is a preliminary action and not final, board action on the proposal should be given as tentative approval with modifications or disapproval.

(3) Final Site Development Plan Phase — If approval or approval with modification is tentatively given in the preliminary site development phase, the next step will be submission of a final application, including the necessary documentation for final approval. In this case, the requested modification should be satisfied in the final application (NYS Zoning Technical Series, 1979).

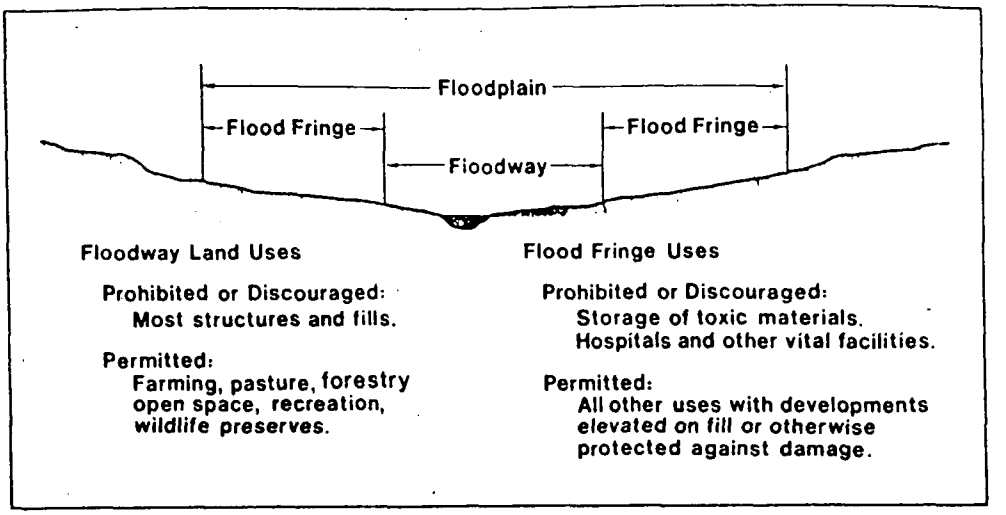
Floodplain Regulations

Floodplain regulation is a form of overlay zoning which designates flood-prone areas and limits their uses to those compatible with the degree of risk. It serves several purposes including:

- preventing new development in flood-prone areas that could result in loss of life and excessive damage to property, or reducing the potential for such losses and damages
- protecting unwary buyers from purchasing land or homes in flood-prone areas
- preventing encroachments that decrease the flood-carrying capacity of flood plains, increase flood heights, or otherwise aggravate flood problems
- reducing need for future expenditures for construction, operation, and maintenance of reservoirs, levees, and other flood control measures
- preserving natural floodplain values, including water quality (U.S. Water Resources Council, 1981).

Figure 20 contains a cross-sectional diagram of a floodplain and shows how floodplain regulations can be employed to limit uses in an area to those which are consistent with the flood hazard.

Local governmental jurisdictions, including towns, cities, and villages, must adopt floodplain regulations to enable landowners to obtain flood insurance. Model floodplain regulations which satisfy the eligibility requirements of the federally sponsored flood insurance program are available upon request from the Bureau of Flood Protection, Room 422, New York State Department of Environmental Conservation, 50 Wolf Road, Albany, New York 12233. Over 95 percent of all communities in New York State have adopted floodplain regulations. Flood plain development permits are



Source: U. S. Water Resources Council, 1981

Figure 20. Land Use Considerations in Floodway and Flood Fringe Areas

managed by the Department of Environmental Conservation in those areas where local government is not administering the program. Permit applicants should contact the appropriate regional office listed on the inside back cover of this manual for DEC administered flood plains.

Single Purpose Ordinances

Towns, cities, and villages having no zoning may adopt single purpose ordinances to control off-site damages to streams from construction and related development activities. For example, communities may adopt an erosion and sediment control ordinance or a stormwater management ordinance (or a combination thereof) to protect streams and lakes from sedimentation, nutrient loading, and other nonpoint source contaminants, and from stormwater runoff in urbanizing areas. Model local erosion and sediment control ordinances and sample laws for controlling stormwater runoff may be obtained from the Bureau of Water Resources, Room 328, New York State Department of Environmental Conservation, 50 Wolf Road, Albany, New York 12233 (see Appendix). Communities in which zoning already exists need only extract the relevant provisions, from the model local laws referred to above, and incorporate them into the appropriate sections of their zoning ordinance.

TAX INCENTIVES

Tax incentives may be offered by local government to riparian landowners to protect and enhance stream corridors. A locally administered tax incentive program may appear in the form of:

1. Tax Exemptions. Tax exemptions can be offered to landowners who retain land for public benefit such as a scenic vista in a stream corridor, historic places, public access areas, or other similar public uses in a stream corridor.
2. Preferential Assessment. Under this approach, land may be assessed at current open space values so as to remove tax pressure on owners to sell at a speculative price for profit.
3. New York's Agricultural Districts Law and Forest Tax Law can provide tax incentives to motivate landowners to retain farmland and forest land in an undeveloped condition.

The above approaches to providing tax incentives normally have the following feature in common; often a lower artificial assessment is levied on the property to achieve a jurisdictions long-term land use goal for a given area until the land is subjected to an undesired use, at which time a tax pay-back penalty clause is invoked. The major advantage of a tax incentive approach is that it assists those landowners who desire to retain the present land use but cannot because of increasing tax burdens. On the other hand, long-term protection goals may not be met unless the land is retained in the desired use in perpetuity.

GOVERNMENTAL AID PROGRAM

Planning, technical, and funding assistance to implement an effective stream conservation program is potentially available to local government from various federal, state, and county agencies. For example, many projects which have benefitted streams have been partially funded through Land and Water Conservation Grants, and various Soil Conservation Service Programs. The Agricultural Conservation Program of the Agricultural Stabilization and Conservation Service provides funding assistance to private landowners to implement various agricultural practices.

Some key agencies and the type of assistance they provide are identified in Table 14. There are numerous federal, state, and local laws, programs, and activities which are directly applicable to the protection and management of resources and land use

TABLE 14
AGENCIES AND ASSISTANCE OFFERED

Agency	Program	Type of Assistance	Address of Assisting Agency
Federal			
1. Department of Housing and Urban Development	— Community Planning and Development (cities having a population over 50,000)	— Funding (Construction Grants)	— U.S. Department of Housing and Urban Development, Community Planning and Development Division, 107 Delaware Avenue, Buffalo, New York 14202
	— Urban Development Action Grant	— Funding (Construction Grants	
2. Department of Interior	— State and Local River Conservation Program	— Technical Assistance	— National Park Service — Office of Recreational Programs
	— Land and Water Conservation Grant	— Funding (Land Acquisition)	— National Park Service — Office of Recreational Programs
	— Historic Preservation Grants-In-Aid	— Funding (Property Acquisition and Building Rehabilitation)	— Office of Cultural Programs Mid-Atlantic Region, 143 S. 3rd St., Philadelphia, PA 19106
3. Soil Conservation Service	— Soil and Water Conservation Program	— Conservation Planning and Technical Assistance	— Contact County Soil and Water Conservation Districts
	— Resource Conservation and Development	— Funding and Technical Assistance (Construction Cost Sharing)	
	— PL 566 (Flood and Erosion Control)	— Funding (Construction Cost Sharing)	
4. Agricultural Stabilization and Conservation Service (ASCS)	— Agricultural Conservation Program	— Funding assistance to private landowners for erosion control and other land treatment measures	— Consult County Soil and Water Conservation District or Local Telephone Directory
State			
5. Office of Parks, Recreation, and Historic Preservation	— Environmental Quality Bond Act of 1972	— Funding (Land Acquisition)	— New York State Office of Parks, Recreation, and Historic Preservation; Nelson A. Rockefeller Empire State Plaza; Agency Bldg. #1; Albany, NY 12238
6. Department of State	— Small Cities Program	— Funding (Construction Grants)	— New York State Department of State, 162 Washington Avenue, Albany, NY 12231

TABLE 14
AGENCIES AND ASSISTANCE OFFERED

Agency	Program	Type of Assistance	Address of Assisting Agency
7. Department of Environmental Conservation	— Stream Conservation/Non-point Source Planning — Local Community Assistance Program	— Funding (Planning Grants)	— Office of Community Affairs/Division of Water, New York State Department of Environmental Conservation, 50 Wolf Road, Albany, NY 12233
Regional/County			
8. Regional Planning Board	— Local Planning Assistance and Regional Coordination	— Planning and Technical	— Refer to NYS Environmental Conservation Directory
9. County Planning Department	— Local Planning Assistance and County-wide Coordination	— Planning and Technical	— Refer to NYS Environmental Conservation Directory or Local Telephone Directory
10. County Soil and Water Conservation Districts	— Technical Assistance Program	— Planning and Technical	— Refer to NYS Environmental Conservation Directory or Local Telephone Directory

within the stream corridor. It is important for those who have initiated a stream corridor management planning process to become well-informed about all such laws and programs so as to take full advantage of the legal authority and financial or technical assistance that is available for the task at hand. A full partnership should be developed with those agencies and organizations, at all levels of government and in the private sector, that have an ongoing or potential role to play.

Funding assistance usually is the most difficult type of assistance to obtain. Often there is considerable competition among communities for such assistance. Because of competition, funding agencies generally establish priorities as a basis for funding. Therefore, as a general rule, communities seeking funding assistance for a stream conservation program should design projects to produce a multiplicity of benefits as a way of promoting the proposal. Two sources of information, the Funding Resources Center and a "Guide to Resources", are available for identifying sources of funding which might potentially be used for stream corridor management purposes.

FUNDING RESOURCE CENTER

The Economic Development Unit within the Division of Community Affairs, NYS Department of State, 162 Washington Avenue, Albany, New York 12231 has computer capability to assist local agencies in identifying potential sources of funding that can be used for stream conservation and management purposes. This is a very important service which local government should take every opportunity to utilize, not only for stream conservation projects, but for other community development projects as well.

also:

A STEP-BY-STEP
GUIDE TO RESOURCES
FOR ECONOMIC DEVELOPMENT
2ND EDITION
STATE OF NEW YORK
DEPARTMENT OF STATE
DIVISION OF COMMUNITY AFFAIRS
162 WASHINGTON AVENUE
ALBANY, NEW YORK 12231

SPECIAL IMPROVEMENT DISTRICTS

A special improvement district, for example a park district which has a stream corridor as its focal point, may be established. Under a special improvement district, taxes can be levied to finance park operation and maintenance requirements. Currently, there are over 100 park districts in the state.

WATERSHED RULES AND REGULATIONS

Many communities protect their water supplies with watershed rules and regulations. These regulations, which are enacted through the New York State Department of Health, usually contain setbacks and other standards for salt storage, pesticide use, sewage discharges, solid waste disposal, and the storage and handling of toxic chemicals. Watershed regulations carry the weight of State regulations, and they may extend across municipal boundaries if necessary.

Any community with a municipal water supply may prepare these regulations. Model regulations are available from the Health Department and technical assistance is usually available from state health engineers or from county officials where county health departments exist. Once a municipality completes a draft of the regulations, it is submitted to the Health Department for approval and promulgation. Legal notices are subsequently published in local newspapers and public hearings are held when necessary. When approved by the Health Department, the regulations are filed with the Secretary of State and become enforceable standards for protecting the community's water supply.

The municipality must then appoint an official who is responsible for watershed inspections, serving notice to violators and reporting noncompliance to the Health Department. The Health Department in turn, investigates reports and may direct the local board of health to enforce compliance or take direct enforcement action.

> Today most surface water supplies serving over 5,000 people and all supplies serving over 10,000 people are protected by Watershed Rules and Regulations.

Watershed rules and regulations can be used effectively to protect water supplies from chemicals which may be spilled or leaked from bulk storage facilities. Unfortunately, most existing rules and regulations were passed prior to our knowledge of trace concentrations of chemicals in water supplies and do not adequately protect waters from contamination caused by poor bulk storage practices. A recent review of such regulations found that most of the rules and regulations now in use are archaic. They are concerned solely with human and animal waste disposal practices and use language of decades past. Only the rules and regulations enacted or revised since 1970 address current environmental concerns. The greatest threats to water supply today besides sewage disposal are synthetic or organic chemicals, radioactive materials, heavy metals, chlorides, nutrients, sediment and petroleum products.

Watershed regulations provide municipalities in New York State with an excellent means of protecting water supplies. However, the regulations must contain provisions which address the storage of petroleum and other hazardous chemicals. Those communities with watershed rules and regulations should be sure that they include controls over bulk storage facilities. Communities without rules and regulations should consider the benefits of using them. Guidance for establishing watershed rules and regulations may be obtained from State or County Health Department offices.

NEW YORK STATE'S WILD, SCENIC, AND RECREATIONAL RIVERS PROGRAM

One of the most important State programs to protect and enhance rivers and streams and their corridors, was established in 1972 through the enactment of the State Wild, Scenic, and Recreational River Systems Act (Environmental Conservation

Law S15-2701). This law encourages maximum local initiative in the development, implementation, and administration of river conservation studies and plans. It also provides fundamental regulatory protection for rivers that are designated in the system.

Communities may find the state's Wild, Scenic, and Recreational Rivers Program to be an attractive option for protecting and enhancing a stream or river corridor. The Wild, Scenic, and Recreational River Systems Act is designed to protect, preserve, and enhance significant rivers (and streams) throughout the state, including the important natural and cultural resources that are associated with shoreland environs of such rivers. Rivers are designated into the Wild, Scenic, and Recreational River System by act of the legislature, after an eligibility study has been completed.

In order to give detailed attention to the natural and cultural resources and land use conditions that are unique to the corridor of each designated river (or stream), a management plan should be prepared after designation. This plan may be prepared locally, in cooperation with the Department of Environmental Conservation (or the Adirondack Park Agency for rivers and streams on private land within the Park). The resources and land use management recommendations that are set forth in the plan then provide the basis for future local and state decisions and actions. The plan, therefore, must be adopted by DEC (or APA) as well as by affected local governments.

At the local level, the river corridor plan usually will be incorporated as a detailed element in the local comprehensive plan, to be implemented, in part, through local subdivision and zoning ordinances. When this is done, state protective responsibilities for designated rivers may be delegated to local government, specifically in the area of land use regulation.

The cooperative intergovernmental approach that is embodied in the state Wild, Scenic, and Recreational River System Act ensures that a reasonable negotiation process is set in motion whereby firm and lasting agreements can be reached by all interested parties on the means for achieving conservation and development objectives.

If a river is designated in the system, the law requires that actions of all State agencies must be consistent with its river conservation objectives. This is a major benefit of designation. For example, State-sponsored projects may be precluded from being located within a designated river corridor. Designation also means that the river will be maintained in its present natural free-flowing condition. No new dams may be constructed and no new diversions of water will be allowed. Water quality must be maintained or improved. The present natural, scenic, historic qualities of the landscape will be protected and land uses that are compatible with the purpose of the Act will be continued and encouraged.

Framework provisions of the act together with the regulations and standards of performance for rivers (or streams) designated either "wild", "scenic", or "recreational" are available upon request (see Appendix P).

SECTION 6:
PANEL PROCESS

RIPARIAN FOREST BUFFER PANEL

As requested by the signatories to the Directive, a Panel was convened to develop a comprehensive riparian forest buffer policy. The charge of the Riparian Buffer Panel was to consider and make recommendations, where appropriate, on a number of policy actions related to riparian forests. One of the Panel's challenges was to propose definitions of forest buffers which balance ecological criteria needed to protect water quality and habitat in streams with the accommodation of appropriate land uses within the riparian zone. The Panel was also charged with establishing time-sensitive, quantifiable goals which can serve as a long-term target for maintenance and restoration. Finally, the involvement of all stakeholders was considered essential to the final policy implementation. To ensure broad public input, the Panel included a diverse membership and conducted a series of meetings to reach out to a broader constituency. This helped strengthen communication and partnerships necessary for success.

Panel Focus

Riparian Stewardship. First, healthy streams are critical to restoring the Bay. Riparian buffers and other stream protection and restoration measures, provide tools for enhancing water quality and fish/wildlife habitat. Therefore, the Panel sought to make recommendations which enhance the overall commitment to the stewardship of streams, rivers, shorelines and riparian areas.

Emphasis on Riparian Forest Buffers. Forested riparian buffers deliver the greatest range of environmental benefits of any type of stream buffer. Current program efforts are limited. Therefore, additional actions are needed to increase the retention and establishment of riparian forests.

Shared Assumptions

- Natural riparian areas are critical to healthy streams and rivers
- Focus should be on voluntary incentive-based approaches
- Education and training are important to success
- Both Public and private roles are important in implementation
- Flexibility in approach is essential
- Shared goals among agencies and interests are needed

Panel Mission

"To recommend to the Chesapeake Bay Executive Council a comprehensive policy and strategy for implementation that will enhance overall riparian stewardship and emphasize the retention of riparian forests where they exist and restoration where they are needed."

Principles

Each of the following principles shaped the Panel's policy recommendations:

- Develop measurable goals based on sound science.
- Recommend flexible implementation strategies that consider the differences in landscape, existing policy, environmental conditions, and landowner objectives.
- Focus first on existing regulatory and incentive programs, enhancing their ability to accomplish the intent of the Directive and incorporate additional voluntary efforts as needed.
- Build a policy that increases private and non-profit participation.
- Recognize the important roles of education, technical assistance, training and continued research.
- Be responsive to landowner needs and ensure stakeholder involvement.

PANEL MEMBERS

To ensure broad public input, the panel included scientists, land managers, citizen, farming, forest industry, development, and environmental interests and federal, state and local government. Mr. James Garner served as Chair, and Dr. Louis Sage served as Vice-Chair.

JAMES GARNER	✦ *Virginia Department of Forestry*
LOUIS E. SAGE	✦ *Scientific and Technical Advisory Committee*
BILL ADAMS	✦ *Pennsylvania Farm Bureau*
JERI BERC	✦ *USDA Natural Resource Conservation Service*
BILL BOSTIAN	✦ *The Nature Conservancy*
DAVID BRUBAKER	✦ *Citizen's Advisory Committee/PennAg Industries*
SEAN DAVIS	✦ *LDR International*
MIKE ECKERT	✦ *Maryland Farm Bureau*
CARSON LEE FIFER, JR.	✦ *McGuire, Woods, Battle & Booth*
KENT FOX	✦ *Pennsylvania Hardwood Lumber Manufacturing Association*
VICTOR FUNK	✦ *Pennsylvania Bureau of Land & Water Conservation*
JAMES GRACE	✦ *Pennsylvania Bureau of Forestry*
MARCIA HANSON	✦ *Local Government Advisory Committee/Fairfax County Supervisors*
IAN HARDIE	✦ *Scientific and Technical Advisory Committee/University of MD*
RON HEDLUND	✦ *Virginia Department of Conservation & Recreation*
KATHLEEN LAWRENCE	✦ *VA Chesapeake Bay Local Government Assistance Department*
PAUL SCHWARTZ	✦ *Susquehanna River Basin Commission*
PETER MILLER	✦ *Westvaco*
ROBERT PENNINGTON	✦ *U.S. Fish & Wildlife Service*
ROYDEN POWELL	✦ *Maryland Department of Agriculture*
MICHAEL RAINS	✦ *USDA Forest Service*
ERIC SCHWAAB	✦ *Maryland DNR Forest Service*
TOM SIMPSON	✦ *MD Dept. of Agriculture/University of MD Extension*
WILMER STONEMAN	✦ *Virginia Farm Bureau*
ANN SWANSON	✦ *Chesapeake Bay Commission*
DENICE TAPPERO	✦ *Stone Forest Products*
MIKE THOMAS	✦ *V irginia Office of the Governor*
CAROLYN WATSON	✦ *Maryland Department of Natural Resources*
JAMES WHEELER	✦ *PA Association of Township Supervisors*
SYLVIA WHITWORTH	✦ *DC Environmental Regulation Administration*

TECHNICAL TEAM

The process for implementation of the Riparian Forest Buffer Directive approved by the Chesapeake Bay Program's Implementation Committee also provided for the establishment of a technical team. The primary role of this group was to provide the technical information and analysis needed to carry out the mission of the panel and to assist the Alliance for the Chesapeake Bay in facilitating the Panel's meetings and issue deliberations. Albert Todd, US Forest Service, State and Private Forestry, Northeastern Area served as Team Leader.

RICHARD COOKSEY	✦ *USDA Forest Service*
SCOTT CRAFTON	✦ *VA Chesapeake Bay Local Assistance Department*
PATTY ENGLER	✦ *USDA Natural Resources Conservation Service*
J. MICHAEL FOREMAN	✦ *Virginia Department of Forestry*
ALEXANDRA GAGNON	✦ *Chesapeake Research Consortium*
CAREN GLOTFELTY	✦ *PA State University/School of Forest Resources*
STEVEN KOEHN	✦ *Maryland DNR Forest Service*
LOUISE LAWRENCE	✦ *Maryland Department of Agriculture*
JOHN LIPMAN	✦ *Chesapeake Bay Commission*
BOB MERRILL	✦ *Pennsylvania Bureau of Forestry*
BOB TJADEN	✦ *University of Maryland Extension*
ALBERT TODD	✦ *USDA Forest Service*
LAUREN WENZEL	✦ *Maryland Department of Natural Resources*

EXISTING PROGRAM ANALYSIS

SUMMARY

Analysis

Recommendations to modify existing programs must be based on an assessment of how well a program or type of program contributes to the intent of the Directive. By looking at program accomplishment data where available, analyzing case studies, and talking to program managers, additional policy steps can be identified. The analysis posed a number of broad qualitative questions:

- *Do the programs have a riparian forest emphasis?*
- *Are regulatory programs being adequately enforced?*
- *Are incentives in non-regulatory programs adequate to encourage landowner participation?*
- *What are the barriers to riparian forest stewardship?*
- *Are programs adequately funded?*
- *How permanent are actions taken by incentive programs?*

Findings

Because of differences between jurisdictions and individual programs, approaches, and data collection methodology, a full spectrum of comparative data useful in making comparisons was not available. The following is a synopsis of the interim findings from this analysis:

1) Very few programs provide a specific riparian forest buffer focus; it is more common that protecting, establishing, or maintaining RFB's is an ancillary benefit to some other programmatic goal.

2) Federal and state incentive funds for RFB's are unstable or on the decline adversely affecting such programs as SIP, FIP, 319 grants, and CZMA § 6217.

3) New partnerships or new sources of funds must be sought to expand potential funding and enlist other forms of in-kind support.

4) Many programs are unnecessarily bureaucratic, complicated to understand and participate in, and cumbersome to administer due to burdensome paperwork.

5) A general lack of awareness of the various existing RFB programs that exist is a serious impediment increasing the level of participation.

6) State regulatory programs are implemented locally with varying degrees of consistency.

7) There are many agencies and conservation organizations involved with riparian forest

buffer retention and/or restoration, but with varying degrees of support. A consensus or shared goal for riparian forests would help reduce competition and stimulate joint actions among these organizations.

8) Cost-share rates and caps, grants and/or tax breaks are not sufficient to encourage riparian landowners to initiate RFB activities. Any restructuring of economic incentives must ensure that local governments, likely to implement RFB programs, will not suffer an unreasonable loss to local tax base.

9) Various incentives programs have requirements such as entry fees, minimum acreage or time commitments which can discourage participation in RFB programs.

10) RFB programs provide varying levels of protection ranging from the duration of the regulated activity to 25 plus years for easements.

11) Existing efforts do not effectively utilize the capabilities of non-profit and private groups.

12) RFB programs on the federal and state level consist of delivery of technical and financial assistance (including easement programs) and various types of income and property tax breaks.

13) Most RFB programs on the local (county and municipal) level consist of comprehensive planning and zoning and the institution of development and conservation ordinances.

14) Accomplishment report data are unavailable or inconsistent between and within the states.

15) Not all programs have a specific buffer component or otherwise have the ability to differentiate between administrative overhead and implementation relative to RFB's establishment, protection and maintenance.

16) Programs which mandate mitigation for the loss of forest land or the designation of set aside acreage often have requirements which do not recognize the establishment of RFB's as a legitimate way of complying with the mandate.

17) Some RFB programs need to be more flexible allowing landowners to perform needed maintenance, conduct pest control measures and judiciously harvest timber to recover some economic return from the land on a periodic basis.

RIPARIAN FOREST BUFFER PANEL
PROGRAM AND GAPS ANALYSIS REPORT
HALL OF THE STATES, WASHINGTON DC
October 2, 1995

This "gaps analysis" focuses on two kinds of programs: Those that promote forests in the riparian zone and those programs promote general forest management or non-forest stream protection measures but where opportunities exist to increase the emphasis on riparian forest maintenance and restoration. This approach will help decision makers better identify where the riparian forest "gaps" are and how to best fill those gaps.

Modifying the existing programmatic structure requires that decision makers first assess how well each program or type of program is working to achieve riparian forest objectives. How many acres or stream miles has a program maintained or restored? How well are programs being implemented or enforced? How cost-effective are these programs? How do we define and measure "riparian forests"? While we cannot answer all of these questions, we can use a "case study" approach for examining the most significant of these programs. By looking at what programmatic data we have available, we can get an idea of which programs are effectively maintaining and restoring riparian forest buffers, and which programs can be modified to do so.

There are a number of key factors and issues that can influence the success of riparian forest maintenance and restoration programs. A number of issues must be considered for guiding discussions on how to coordinate and modify existing riparian programs. These issues, detailed in the discussion section below, are central to an analysis of programmatic gaps.

DISCUSSION

Do the programs have a riparian forest emphasis?

A number of programs designed to protect streams and riparian areas may lack the essential forest emphasis that the Riparian Forest Buffer Panel is trying to promote. Riparian forests deliver a host of ecological benefits to the stream system that other non-forest riparian protection measures may not provide. Even programs that promote trees in the riparian zone may not deliver these benefits if the program is not managed for forest benefits. For example, the types of trees planted may not provide the appropriate mix of leaf litter necessary to provide food for aquatic insects, or the density, age, and location of trees may be insufficient to provide adequate shading or large woody debris. Thus, ensuring the presence of trees in riparian areas does not by itself ensure the ecological integrity of the stream.

Pennsylvania's Streambank Fencing Program is a case in point. Although the program is laudable in that it affords a very substantial measure of stream protection from the impacts of livestock, it places no specific emphasis on the restoration of trees. Virginia's Chesapeake Bay Preservation Act, which requires landowners near streams and rivers to protect forested areas, also allows the clearing of trees to improve vistas and the removal of large woody debris from the riparian forest and stream shallows, where it serves a useful ecological purpose. If the maintenance of riparian forest buffers is to be accomplished in these and other programs, then riparian forest objectives -- and the package of benefits riparian forests provide -- must be a central emphasis of these programs.

Are regulatory programs being adequately enforced?

Regulatory programs are an essential tool in maintaining and restoring riparian forest buffers and protecting water quality throughout the Bay region. As with all regulatory programs, enforcement is critical to ensuring that the law provides its fullest measure of protection and that the regulated community is treated equitably. It is especially important to consider whether enforcement of existing regulations is adequate prior to promulgating any additional regulations. Policy makers may find that there are ample regulatory "tools" available, and that strengthening the enforcement of existing laws may be the most economical and politically practical means of accomplishing riparian forest maintenance and restoration.

Are the incentives adequate in non-regulatory programs?

Because so much protection of riparian land relies on voluntary and contractual programs, a central element of riparian forest policy involves incentives -- cost-share programs, fee payments for land taken out of production, subsidized seedlings, and so on. These incentives are delivered through a host of agencies such as the Natural Resource Conservation Service, the Agricultural Stabilization and Conservation Service, the Forest Service, state and local natural resource agencies, private industry, and citizen groups. Pennsylvania's Streambank Fencing Program is exemplary in that it provides fencing to restrict livestock access to streams free of charge to farmers. This has resulted in the installation of over 100 miles of fencing. Timber corporations such as Westvaco, Chesapeake, and Glatfelter provide subsidized seedlings to landowners for reforestation, and countless private businesses are involved in community forest buffer replanting programs. But the question remains as to how effective various incentive programs are in meeting the economic needs of landowners while maintaining and restoring riparian forests rather than other non-forest stream protection efforts.

The financial benefit a landowner receives can have a significant impact on his or her willingness to participate in riparian forest programs. For example, Maryland's

Buffer Incentive Program used to have a backlog of applicants when the program offered landowners a one-time $500-per-acre payment to maintain minimum 50-foot forested buffers. A legislative modification to the program in 1994 lowered the payment to $300 per acre; the result was a steep decline in the number of applicants. More research needs to be done to determine what levels of cost-share are economical to landowners in differing land-use scenarios. Some relatively minor adjustments to funding levels or structures could result in significant changes in the willingness of landowners to participate in incentive programs.

Similarly, there may be opportunities in other resource-land incentive programs to increase the focus on riparian protection where little or none currently exists. For example, all three states have some type of preferential tax assessment program for land kept in various resource uses or open space, such as prime agricultural land or private woodlots. These programs reduce the assessed value of the land, so that the landowner pays lower property taxes. Yet these programs often lack any special provisions for protection of the riparian zone, and none have specific conditions for maintaining riparian forests. Thus where incentives exist to protect resource land in general, opportunities to promote riparian forest stewardship could be considered.

What are the barriers to riparian forest stewardship?

It is important to examine aspects of other regulatory programs that might hinder participation in riparian forest stewardship. In Maryland, one landowner reported frustration with state permitting requirements for constructing stream crossings for livestock, when the alternative (allowing unrestricted livestock access to the stream) is entirely unregulated. Thus there may be instances where a regulatory process, justified in certain land-use situations, may act as a disincentive to better riparian stewardship on the part of a landowner in a different situation.

Buffer restoration may present perceptual disincentives to landowners as well. When some of the trees closest to the stream in a recently restored forest buffer are washed away during a flood event, questions about the benefits of these efforts are inevitably raised. In many cases, this kind natural widening of the stream bed is an expected outcome in a recovering riparian forest. Viewed as desirable to the stream ecologist, this change in the stream bank can be perceived by the landowner as a failure of the practice to protect the stream and stabilize land. Thus addressing disincentives may also involve developing strategies to better communicate with landowners, so that landowners understand the ecology of stream systems and scientists and agency personnel understand landowner needs and expectations.

The complexity of state and federal cost-share practices and other payment programs can also act as a barrier. There is a bewildering array of cost-share programs and practices available for both agriculture and forestry uses. Many of these financial incentives affect the riparian zone. Although this "menu" of practices can provide flexibility in meeting the landowner's needs, it can also be confusing and result in a piecemeal approach to riparian stewardship. In addition, a landowner may be referred to two or three different agencies in order to implement a combination of riparian protection measures. This involves a great deal of time and paperwork, and may be perceived as a barrier to riparian forest stewardship.

There may also be conflicts among landowner assistance programs which act as a barrier to riparian stewardship as well. For example, the Commodity Set-Aside program makes price-support payments to farmers based on the number of acres in or available to production. If a farmer removes part of his land from production for long-term uses such as riparian forest buffers, he risks losing some of that subsidy.

Decision makers in resource agencies should consider ways to strengthen the emphasis on riparian forest buffers while streamlining cost-share programs, where appropriate, so that individual practices for riparian forest stewardship are more comprehensive and consistent with one another. This will help landowners seeking to implement riparian forests to do "one-stop shopping." The Bay Program's efforts to implement a Total Resource Management (TRM) approach to conservation planning may be highly instructive in making landowner stewardship more user friendly.

How will programs be funded?

Inadequate funding for programs is an ever-present concern. This can be a problem not only for enforcement manpower in regulatory programs but also for providing technical assistance needed to implement cost-share programs. Most agricultural agencies on both the state and federal levels report being unable to accommodate a long waiting list of clients who would like to implement riparian forest buffer practices. Thus, even when cost-share funding is available, there is a dearth of technical assistance personnel needed to write conservation plans for landowners.

Clearly, more funding will be needed to enhance riparian forest buffer efforts throughout the Bay region. In an era of fiscal austerity, however, public funds alone cannot supply the resources needed. Decisions makers must consider exploring alternative financing mechanisms, as well as seeking the involvement of private industry, businesses, local governments, citizen groups, and volunteers. Both the Maryland Blue Ribbon Panel, which recently issued its report on financing alternatives for Maryland's tributary strategies, and Pennsylvania's Stream Corridor Protection Workgroup may provide some ideas for financing riparian forest buffers.

How permanent are riparian protections in incentive programs?

Most cost-share practices are contracted for 10 years. Now is the time to begin thinking of additional incentives to maintain buffers permanently, in a way which provides for resource uses but also maintains the long-term ecology of the stream. Otherwise, riparian forest buffers, to which years of money and effort have been devoted, may be converted to other land uses.

EVALUATING RIPARIAN FOREST BUFFER PROGRAMS

In order to begin this analysis, we need to establish criteria which will be used to evaluate the effectiveness and efficiency of each program. The greatest hurdle is that many of these programs may be missing some of the data that we want to evaluate. Therefore, the analysis will be, to some extent, data limited. Although this limitation will prevent us from coming up with any sort of "ranking" of the effectiveness of riparian forest programs, it will allow us to draw some general conclusions about which programs are working most effectively and how to modify other programs to increase the emphasis on riparian forest buffers.

There are a number of criteria with which we can evaluate the efficacy of our programs. The following list will help guide the analysis of programmatic gaps. The actual criteria used will vary between programs, as certain data may not be available for any given program. Ideally, the kind of criteria that could be used are:

- Number of Acres/Stream Miles Planted with Trees
- Number of Acres/Stream Miles of Forest Protected
- Cost per Acre of Riparian Forest
- Cost per Stream Mile of Riparian Forest
- Number of Program Participants Served
- Number of Program Participants Awaiting Service
- Density/Type of Trees

PROGRAMMATIC ANALYSIS

The following describes some of the key programs -- federal, state, local, and private -- with riparian forest protection components. Some of these programs very actively promote riparian forests; others are more marginal in this respect. This section will conclude with a discussion of those programs which have no specific riparian protection provisions, but where the potential to introduce a riparian forest emphasis exists. These programs are a subset of the larger universe of stream protection efforts underway in the Bay region. This comparative approach will be instructive in providing us some insight into what riparian stewardship programs are available and how well they are working to maintain and restore riparian forests.

Riparian Forest Buffer Panel (Bay Area Regulatory Programs)

Program	Chesapeake Bay Critical Area Act	Forest Conservation Act	Nontidal Wetlands Act
Type	Regulatory, State (MD)	Regulatory, State (MD)	Regulatory, State (MD)
Purpose	Controls development within 1,000 feet of tidal waters. 100-foot mandatory buffer required for all tidal waters, tidal wetlands, and tributary streams in Critical Area. Exemptions for agricultural/silvicultural land.	Protects forest cover from development by limiting forest clearing. Requiring replanting where needed. "Priority areas" for retainment/replanting include 50-foot buffer areas streams.	Mandatory 25-foot naturally vegetated buffer required around all nontidal wetlands greater than 5,000 square feet. Provides forested/naturally vegetated buffer in cases where wetland exists within/adjacent to stream.
RFB Emphasis	Yes	No	No
Prot. Level	Indefinite	Indefinite	Duration of the regulated activity
Admin. Agency	Critical Area Commission, MD DNR	Local counties and municipalities with planning and zoning authority and MD DNR - Forest Service.	MD Department of the Environment - Water Resources Administration
Participation	Mandatory	Mandatory	Mandatory
Enforcement	Adequate	Adequate	Adequate to Poor
Barriers	Inconsistent implementation and interpretation by local jurisdictions. Does not enjoy universal acceptance at the local level	Requires more preconstruction planning. Inconsistent implementation at the local level. Needs to be streamlined to better recognize local development regulations and standard forest management practices.	Spotty enforcement due to insufficient personnel.
$ Level/Source	Varies by local county	Varies by local county. DNR-Forest Service General Fund @ $80,000/yr	Water Resources Administration General Fund
Benefits	Protects the riparian forests on the 60 Timber Harvest Plans submitted to local Forest Conservancy District Boards annually. Protects riparian forests by restricting development in the 1000' Critical Area. Creates zoning with limits on lot size, etc. Requires an approved Timber Harvest plan for all harvests within the Critical Area. The first 50' from mean high tide is a no cut buffer; the next 50' may be thinned selectively or clear-cut in the cases of Loblolly pine and yellow-poplar if a Buffer Management Plan is prepared by a licensed forester as part of the Timber Harvest Plan.	Conserves the forest land base. Prioritizes forest mitigation by encouraging riparian buffer planting. Riparian forests are considered high priority areas for forest retention. Provides long-term protection and management of riparian forest buffers at part of the tract.	Allows for management of forested wetlands through the use of BMPs. Conserves riparian as well as other non-tidal wetland values.

Program	Economic Growth, Resource Protection, and Planning Act	Reforestation	Chesapeake Bay Preservation Act
Type	Regulatory, State (MD)	Regulatory, State (MD)	Regulatory, State (VA
Purpose	Encourages riparian protection as part of each county's requirement to develop "sensitive areas element" in comprehensive plans.	Minimizes forest loss, replaces unavoidable losses from highway construction projects. Highest priority on forests near/adjacent to streams	Establishes "preservation areas" that comprise between 50% - 60% of Virginia's coastal plain. Stream areas, wetlands, tributaries require a 100-foot buffer around tributary streams. Exemptions for agricultural land. Prevents indiscriminate tree cutting.
RFB Emphasis	No	No	Yes, where there are trees
Prot. Level	Indefinite	Indefinite	Indefinite
Admin. Agency	Local counties and municipalities that have planning and zoning authority with approval of Maryland Office of Planning.	MD DNR-Forest Service	Chesapeake Bay Land Assistance Department working with local jurisdictions through local ordinances.
Participation	Mandatory	Mandatory	Mandatory
Enforcement	Adequate	Adequate	Inadequate local enforcement
Barriers	Inconsistent implementation at the local level. Needs to be streamlined to better recognize local development regulations and standard forest management practices. Insufficient support resources at the local level ($ & people).	Requires more preconstruction planning Differences between forest values and riparian buffer values is not distinguished.	Public perception of ordinances being inflexible and a form of a "taking".
$ Level/Source	Varies by local county	MD DNR-Forest Service General Funds @ $30,000/yr	State General Funds @ $2.3 million/yr. $1.1 million made available to local jurisdiction through 50/50 matching grants. Local jurisdictions generate Special Fund revenue for plan review.
Benefits	Conserves the forest land base by allowing for a comprehensive review of the forest resource. Prioritizes forest mitigation by encouraging riparian buffer planting. Riparian forests are considered high priority areas for forest retention. Provides long-term protection and management of riparian forest buffers at part of the tract.	Mitigated the loss of forest land including riparian areas. Encourages mitigation to occur in riparian areas as a priority.	Improved land use planning. Improvement in oversight of development and conservation planning on forest lands. Reduces NPS pollution by protecting and conserving riparian forest buffers.

Program	Dams Safety and Encroachments Act	Local Zoning Ordinances	Forest Harvest Guidelines	Water Quality Law ("Bad Actor" Law)
Type	Regulatory, State (PA)	Regulatory, State (MD, VA, PA)	Regulatory, State (MD)	Regulatory, State (VA)
Purpose	Regulates development in wetlands, stream areas by requiring permit from the Department of Environmental Protection. Applicants must avoid, minimize, or mitigate impacts. No specific buffer requirements.	Forty-two percent of counties in Maryland have regulations requiring stream buffers of 50 to 100 feet on developed land (exclusive of Critical Areas). All tidewater counties in Virginia have adopted Chesapeake Bay Preservation Act regulations into local zoning ordinances, which extends the designation of protection areas to all other areas of the county. Some municipalities in Pennsylvania have ordinances which restrict timber harvesting altogether.	Minimum 50-foot forested, selective-cut buffer required around all perennial streams. 60% crown cover or 60 square feet of basal area per acre must be evenly retained.	State guidelines recommend minimum 50-foot forested, selective-cut buffer required around all perennial streams and retention of 50% crown cover or 50 square feet of basal area per acre. Alternative practices that provide equivalent water quality protection may be permitted.
RFB Emphasis	No	Yes (MD, VA), No (PA)	No	No
Prot. Level	Indefinite	Indefinite	Duration of regulated activity	Duration of regulated activity
Admin. Agency	Department of Environmental Protection, Bureau of Land and Water Conservation, and local soil and water conservation districts.	Local counties	Local Soil Conservation Districts, local counties, and the Maryland Department of the Environment.	VA Department of Forestry
Participation	Mandatory	Mandatory	Mandatory	Mandatory
Enforcement	Adequate	Adequate	Adequate	Adequate
Barriers	Burdensome paperwork	N/A	Varying requirements by county. Inconsistent implementation by county. Burdensome paperwork.	Lack of public awareness
$ Level/Source	Department of Environmental Protection, Bureau of Land and Water Conservation, and local soil and water conservation districts.	Varies by local county	Local Soil Conservation Districts, local counties, and the Maryland Department of the Environment. Information not available for forest harvesting.	Va Department of Forestry
Benefits	Reduced NPS pollution	Protect and Maintain riparian forest buffers Conserves forest land base.	Reduce nonpoint source pollution. Protect and maintain stream integrity and bank stability.	Reduce nonpoint source pollution

Program	Special Protection Streams
Type	Regulatory, State (PA)
Purpose	Mandatory forested buffers required for commercial logging operations on state forest lands around streams designated for "special protection" by the Bureau of Water Quality Management (100-foot selective-cut buffer) or as Wilderness Trout Streams by the Pennsylvania Fish and Boat Commission (200-foot no-cut buffer).
RFB Emphasis	Yes
Prot. Level	Indefinite
Admin. Agency	Bureau of Water Quality Management or Fish and Boat Commission
Participation	Mandatory
Enforcement	Adequate
Barriers	N/A
$ Level/Source	Bureau of Water Quality Management or Fish and Boat Commission
Benefits	Reduced NPS pollution. Maintain water quality for fish habitat.

Program	Buffer Incentive Program	Virginia Agricultural BMP Cost-Share Program	Virginia Agricultural BMP Cost-Share Program	Streambank Fencing Program
Practice	N/A	*Woodland Buffer Filter Area*	*Loafing Lot Management System*	N/A
Type	Incentive, State (MD) technical and financial assistance.	Incentive, State (VA) technical and financial assistance	Incentive, State (VA) technical and financial assistance.	Incentive, State (PA) technical and financial assistance.
Purpose	One-time payments of $300 per acre for planting and maintenance of minimum 50-foot forested buffers along streams/shorelines.	One-time payments of $100 per acre to establish minimum 50-foot forested buffers along streams. Permitted only on crop and pasture land that has recently been in production.	Cost-share for rotational grazing system. Requires a minimum 25-foot fenced buffer around streams.	Fencing with minimum 12-foot buffer free to rural landowners by PA Game Commission in exchange for allowing public hunting. Department of Environmental Resources implementing parallel program that omits hunting requirement.
RFB Emphasis	Yes	Yes	No	No
Prot. Level	10 year practice lifespan	10 year practice lifespan	10 year practice lifespan	10 year practice lifespan, PA Game Commission Maintains
Admin. Agency	MD DNR-Forest Service	VA Department of Conservation and Recreation through the soil and water conservation districts.	VA Department of Conservation and Recreation through the soil and water conservation districts.	Department of Environmental Protection - Game Commission through the local soil and water conservation districts.
Participation	Voluntary, 30 sites/yr, averaging 175 acres.	Voluntary, 3/yr for 15 acres	Voluntary, 10/yr @ 75% c/s up to $7,500 per applicant.	Voluntary (highly supported)
Enforcement	Adequate	Adequate	Adequate	Adequate
Barriers	Burdensome paperwork; payment insufficient for commercial farm owner/operators.	Lack of information and education to improve public awareness. Perceived risk of practice loss due to flood risk.	Expensive to install. With the cap, the cost-share is often not even 50% of the total actual cost.	Perception of giving up use of fenced land for 10 years. Insufficient funds, a limiting factor for participation.
$ Level/Source	MD DNR-Forest Service @ 111,000/yr	VA Department of Conservation and Recreation via Federal Funds through a CBI Grant, average $1.1 million/yr	VA Department of Conservation and Recreation via Federal Funds through a CBI Grant, average $1.1 million/yr	Department of Environmental Protection - Game Commission through an CBI Grant.
Benefits	Creation and maintenance of RFBs for 10 years. Reduction of NPS pollution.	Creation of riparian forest buffers. Reduction of NPS pollution. Payment can be "piggybacked" onto other cost-share practices.	Stream bank stabilization from livestock. Improved heard health. Creation of riparian forest buffers. Reduction of NPS pollution.	Stream bank stabilization from livestock. Reduced NPS pollution.

Program	Agricultural Conservation Program	Agricultural Conservation Program	Agricultural Conservation Program	Conservation Reserve Program
Practice	Permanent Vegetative Cover (SL1)	Stream Protection (WP2)	Riparian Forest Buffer Establishment (WP7)	N/A
Type	Incentive, Federal (MD, VA, PA) technical and financial assistance.	Incentive, Federal (MD, VA, PA) technical and financial assistance.	Incentive, Federal (CFSA) technical and financial assistance.	Incentive, Federal (CFSA) technical and financial assistance.
Purpose	Cost-share for establishing trees, grasses, shrubs in eroding areas, including riparian zone.	Cost-share for establishing permanent vegetative cover, which can include trees, along the banks of streams, as well as related items such as remote watering systems, stream crossings for livestock, and stream fencing.	Provides a number of cost-share practices designed to solve soil, water, and related environmental problems in agricultural areas, including small woodlands. Most notably: Minimum 95-foot forested Riparian Buffer Strips.	Takes highly erodible land out of production for at least ten years. Cost-share for tree establishment, other vegetative cover. Annual rental payments on land taken out of production.
RFB Emphasis	No	No	Yes	No
Prot. Level	10 year practice lifespan.	10 year practice lifespan.	10 year practice lifespan.	10 year practice lifespan.
Admin. Agency	Consolidated Farm Services Agency	Consolidated Farm Services Agency	Consolidated Farm Services Agency	Consolidated Farm Services Agency
Participation	Voluntary, MD 35 farms for 613 acres. PA 265 farms for 3,165 acres	Voluntary, MD 8 farms for 191 acres/yr PA 30 farms for 360 acres/yr VA 4 farms for 81.2 acres/yr	Voluntary	Voluntary
Enforcement	Adequate	Adequate	Adequate	Adequate
Barriers	Insufficient funds. Burdensome paperwork	Insufficient funds. Burdensome paperwork.	Buffer requirements perceived as too wide. Insufficient funding. Burdensome paperwork.	Insufficient funding. Burdensome paperwork.
$ Level/Source	Consolidated Farm Services Agency, funds vary from year to year.	Consolidated Farm Services Agency, funds vary from year to year.	Consolidated Farm Services Agency, funds vary from year to year.	Consolidated Farm Services Agency, funds vary from year to year.
Benefits	Reduce nonpoint source pollution.	Reduce nonpoint source pollution. Establish and protect riparian forest buffers.	Reduce nonpoint source pollution. Establish and protect riparian forest buffers.	Reduced NPS pollution. Riparian forest buffers may be established if HEL was recently cropped.

Program	Wetlands Reserve Program	Woodland Incentive Program	Virginia Agricultural BMP Cost-Share Program	Forest Stewardship Program
Practice	N/A	N/A	Woodland Erosion Stabilization	N/A
Type	Incentive, Federal (CFSA) technical and financial assistance.	Incentive, State (MD) technical and financial assistance	Incentive, State (VA) technical and financial assistance	Incentive, Federal (USFS) technical assistance
Purpose	Allows farmers to sell permanent or 30 year easements to U.S.D.A. Cost-share to restore altered wetlands to natural condition. Eligible land includes prior converted cropland, farmed wetlands, riparian areas along streams or water courses that link protected wetlands	Cost-share provided to non-industrial private woodland owners for tree planting, including riparian forest buffer establishment.	Cost-share to establish permanent vegetation on eroding areas. on forest harvesting sites.	Provides technical assistance to private landowners for implementing conservation practices while meeting harvesting needs. Forest Stewardship Plans required for participation in other federal cost-share programs for forestry.
RFB Emphasis	No	No	No	No
Prot. Level	Indefinite	15 year practice lifespan	5 year practice lifespan	N/A
Admin. Agency	Natural Resources Conservation Service	MD DNR-Forest Service	Department of Conservation & Recreation, through the local soil and water conservation districts	US Forest Service through State forestry agencies
Participation	Voluntary	Voluntary (Tree planting not distinguished from buffer planting)	Voluntary, 20-30/yr for 65-80 acres.	Voluntary, MD 570 yr for 40,000 acres
Enforcement	Adequate	Adequate	Adequate	Adequate
Barriers	Long term nature of agreement Insufficient funds, not available in all states Burdensome paperwork	Cost-share payment 15% less than other available programs.	Some sites no longer eligible because they are now captured by the "Bad Actor" Law. Public Awareness	Availability of service personnel or others qualified to provide technical advise.
$ Level/Source	Natural Resources Conservation Service, varies year to year	MD DNR-Forest Service @ $60,000/yr General Funds	VA Department of Conservation and Recreation via Federal Funds through a CBI Grant, average $1.1 million/yr.	USFS through state forestry agencies, MD $136,000/yr.
Benefits	Protects wetlands and riparian forests	Establishment and maintenance of riparian forest buffers	Reduce nonpoint source pollution Improved wildlife habitat.	Sustainable multiple use management. BMPs used during forest harvesting. Establishment and maintenance of riparian forest buffers recommended.

Program	Forestry Incentive Program	Stewardship Incentive Program	Special Rivers Project	Tree-Mendous Maryland
Type	Incentive, Federal (CFSA) technical and financial assistance	Incentive, Federal (USFS/CFSA) technical and financial assistance	Incentive, Federal (EPA, Bay Program) technical assistance	Incentive, State (MD)
Purpose	Cost-share for tree planting, including in forested wetlands and riparian areas on private, non-industrial forest land.	Cost-sharing for tree planting, stream fencing, riparian and wetland improvement, tree shelters, and fisheries habitat improvement on non-industrial private forest land.	Fosters forest stewardship and best management practices in both rural and urban watersheds to improve water quality. Limited to the Susquehanna, Monocacy, and Anacostia river basins.	Local businesses, regional corporations, citizen groups, and local governments conduct community plantings on public land. Also trains people to lead tree-planting efforts in their communities.
RFB Emphasis	No	Yes, for SIP 6	No	No
Prot. Level	10 year practice lifespan	10 year practice lifespan	N/A	N/A
Admin. Agency	Consolidated Farm Services Agency and the State Forestry Agencies.	US Forest Service and the Consolidated Farm Services Agency through the State forestry agencies.	Environmental Protection Agency through the Maryland Department of the Environment and the DNR- Forest Service.	DNR-Forest Service
Participation	Voluntary, MD 60/yr for 2,300 acres	Voluntary SIP 6: MD 3.5 applications for 25 acres/yr VA 4.0 applications for 20 acres/yr PA 3.0 applications for 16.6 acres/yr	Voluntary	Voluntary, 42,000 volunteers/yr, plant 800,000 trees/yr on 1,200 acres.
Enforcement	Adequate	Adequate	N/A	N/A
Barriers	Insufficient funding. Lack of stable fund source. 10 acre minimum requirement	Insufficient funding. Lack of stable fund source. Burdensome paperwork	Insufficient funding via a CBI Grant Limited personnel due to high turnover.	Securing protection and maintenance for long-term (vandalism) Insufficient resources (e.g. funding and personnel)
$ Level/Source	Consolidated Farm Services Agency, MD FY94 $126,000 FY95 $ 63,000.	SIP 6 MD average $6,000/yr	Environmental Protection Agency through the Maryland Department of the Environment and the DNR- Forest Service @ $190,000/yr	DNR-Forest Service @ $150,000/yr Special Funds
Benefits	Establishment and maintenance of riparian forest buffers. Vigorous growth promoting increased nutrient uptake and an increase of buffer effectiveness.	Riparian forest buffer and wetland establishment. Reduce nonpoint source pollution. Protect and maintain stream integrity and bank stability.	Sustainable multiple use management. BMPs used during forest harvesting. Riparian forest buffer and wetland establishment. Reduce nonpoint source pollution. Protect and maintain stream integrity and bank stability.	Increases fores land base in urban areas. Prevents and reduces NPS pollution. Decreases Impervious surface area. Educates people to the value of trees and forests and their relationship to water quality.

Program	Forest Conservation and Management Program	Reforestation/Timber Stand Improvement Tax Deduction (TAXMOD) Program	Agricultural Use Assessment	Use-Value Taxation
Type	Incentive, State (MD)	Incentive, State (MD)	Incentive, State (MD)	Incentive, State (VA)
Purpose	Special tax assessments on forest land, if the landowner agrees to adhere to a forest stewardship plan.	Allows landowners of small forestry operations to deduct double the costs associated with reforestation activities, including those in the riparian zone.	Preferential assessment on value of land used for agriculture. Woodlots can also receive an agricultural assessment. No specific requirements for riparian areas.	Counties provide preferential assessments on use value of agricultural and forest land. No specific requirements for riparian areas.
RFB Emphasis	No	No	No	No
Prot. Level	15 year agreement	15 year maintenance requirement	3 years with compliance checks and verification	Duration of participation
Admin. Agency	DNR-Forest Service and Department of Assessment and Taxation	DNR-Forest Service and Office of Treasurer	Department of Assessment and Taxation	Virginia Department of Agriculture and Consumer Services through the local tax assessors.
Participation	Voluntary, 60/yr for 1,500 acres	Voluntary	Voluntary	Voluntary
Enforcement	Adequate	Adequate	Adequate	Local Departments of Taxation
Barriers	Fees and penalties. Short-term ownership trend. Burdensome paperwork.	Lack of public awareness. Burdensome paperwork.	Lack of public awareness. Little or no demand in rural areas where agricultural use assessment is common.	No clearly defined conservation requirements. Local jurisdictions experience loss of tax base. Not available in all counties (65 of 95)
$ Level/Source	Program funded by participants.	N/A	N/A	N/A
Benefits	Protects forest land base. Reduced carrying costs for participants. Sustainable multiple use management. BMPs used during forest harvesting. Establishment and maintenance of riparian forest buffers recommended.	More tree planting and riparian forest buffer establishment. Reduced carrying costs.	Protects forest land base. Reduced carrying costs for participants. Sustainable multiple use management. BMPs used during forest harvesting. Establishment and maintenance of riparian forest buffers recommended.	Reduced carrying costs. Encourages preservation of open space.

Program	Farmland and Forest Land Assessment Act ("Clean and Green Act")	Public Law 96-451
Type	Incentive, State (PA)	Incentive, Federal (IRS)
Purpose	County can grant a preferential assessment for ten or more contiguous acres of land devoted to agricultural, forest reserve, or open space purposes. Can apply to land in the riparian zone, although no specific requirements in riparian areas.	Federal tax incentives to reduce reforestation costs. Can include reforestation efforts in riparian areas.
RFB Emphasis	No	No
Prot. Level	10 year agreement	N/A
Admin. Agency	Pennsylvania Department of Agriculture through local jurisdictions.	Internal Revenue Service
Participation	Voluntary	Voluntary
Enforcement	Adequate	Adequate
Barriers	Perception of loss of property rights Penalties for non-compliance	Lack of public awareness. Burdensome paperwork.
$ Level/Source	N/A	N/A
Benefits	Conservation of Open Space Protects forest and agriculture land base. Reduces carrying costs.	More tree planting and riparian forest buffer establishment. Reduced carrying costs.

GENERAL OBSERVATIONS and SUGGESTIONS

- Programs often lack specific RFB focus, rather protecting, establishing or maintaining RFBs is an ancillary benefit to some other programmatic goal.

- Federal and state support funds for RFBs are unstable or on the decline adversely affecting such programs as SIP, FIP, CBI grants, and CZMA § 6217.

- Given the current political and fiscal climate, new partnerships must be sought to expand potential sources of additional funding and other forms of in-kind support.

- Many programs are unnecessarily bureaucratic, complicated to understand and participate in, and cumbersome to administer due to burdensome paperwork. Streamlining would improve the participation in many existing programs and be essential for any new programs.

- A general lack of awareness of the various existing RFB programs is a serious impediment to more satisfactory levels of participation. Other programs suffer from unfounded misconception by the land owning public. More needs to be done to increase the awareness of program availability, dispel myths, and tout the benefits of RFBs and program participation.

- Many state regulatory programs are implemented by local jurisdictions with varying degrees of consistency. Many counties or municipalities add additional restrictions, require different levels of compliance, or have varying abilities to adequately provide program enforcement. A greater effort must be made to ensure overall consistency for program implementation at the local level.

- There are many agencies and conservation organizations involved with riparian forest buffer retention and/or restoration, but with varying degrees of support. A consensus for making RFBs a priority concern must be forged and pursued by all stakeholders. The commitment for RFBs must be effectively communicated to all personnel and supported by dedicating the time necessary to ensure success.

- Cost-share rates and caps, grants and/or tax breaks may not be sufficient to encourage forest landowners to initiate RFB supporting activities. In other cases incentives may be very popular, with the

limiting factor being the availability of funds to meet the demand for participation. Adjustments to cost-share rates, raising of program caps, and enhancing tax abatements can dramatically improve program participation and the ability to service program applicants. Any restructuring of economic incentives must ensure that local governments, likely to implement RFB programs, will not suffer a net loss to the local tax base.

- Various incentives programs have requirements such as entry fees, minimum acreage or time commitments which can discourage participation in RFB programs. Reducing minimum acreage, providing flexible or amendable time commitments, and waving fees for certain program delivery can improve program acceptability and participation.

- RFB programs provide varying levels of protection ranging from the duration of the regulated activity to 25 plus years for easement type programs. The majority of cost-share programs provides for 10-15 years of protection through practice maintenance requirements.

- Most RFB programs on the federal level consist of funds for technical and financial assistance and various types of income tax breaks.

- Most RFB programs on the state level consist of service delivery for technical and financial assistance (including easement programs) and various types of income and property tax breaks.

- Most RFB programs on the local (county and municipal) level consist of comprehensive planning and zoning and the institution of development and conservation ordinances.

- RFB accomplishment reporting is not consistent between and within the states. Common units of measure by county or watershed will allow for the tracking of progress and the analysis of trends. Each state should work toward establishing baseline data for the presence and adequacy of RFBs by which future progress can be judged.

- RFB funding comes from a myriad of sources at the federal, state and local levels. Not all programs have a specific buffer component or otherwise have the ability to differentiate between administrative overhead and implementation relative to RFBs establishment, protection and maintenance. Accounting procedures must be put in place to allow for tracking expenditures relative to RFB activities specifically and to facilitate cost-benefit analysis for program effectiveness and accountability.

- Programs which mandate mitigation for the loss of forest land or the designation of set aside acreage often have requirements which do not recognize the establishment of RFBs as a legitimate way of complying with the mandate. These kinds of conflicts need to be corrected so that such programs can be supportive of RFB establishment.

- Some RFB programs need to be more flexible allowing landowners to perform needed maintenance, conduct pest control measures and judiciously harvest timber to recover some economic return from the land on a periodic basis. Natural forests must be thinned by man or nature periodically to encourage new growth and the vigor and health of the existing resource.

CASE STUDIES

- Baltimore county Riparian Buffer Initiatives (MD)

BALTIMORE COUNTY RIPARIAN BUFFER INITIATIVES

Baltimore County, Maryland, exemplifies a proactive local approach to the protection of its water resources and management of its riparian forest buffers. With a population of 712,000 and 2,000 miles of streams that drain to the Baltimore region's three drinking water reservoirs, tidal creeks, and the Chesapeake Bay, the County has employed multiple mechanisms for the management of riparian ecosystems. These mechanisms include regulation, restoration, and citizen education and participation.

The County first established protection of stream systems through its Resource Conservation zoning in the 1970's, which included the RC4 Watershed Protection zone on more than 70,000 acres or 18% of the County land that drains to the three public reservoirs. RC4 zoning has density of .2 dwelling units per acre and 3 acre minimum lot sizes. It was applied to extensive areas adjacent to the reservoirs and along major tributary stream systems, with widths of 300 feet and greater where steep slopes exist. Performance controls include a prohibition on clearing more than 25% of the forest cover of a site and the establishment of more than 10% impervious surfaces.

With the increasing recognition of the importance of protecting streams which drain directly to non-reservoir receiving waters, including the Chesapeake Bay, and of the beneficial functions provided by riparian ecosystems, Baltimore County initiated broader riparian buffer measures in the mid 1980's. The Department of Environmental Protection and Resource Management (DEPRM) implemented County-wide buffer regulations by Executive Order starting in June 1989. In January 1991, they were codified as regulations for the Protection of Water Quality, Streams, Wetlands, and Floodplains. As implied in the title, the regulations provide for the delineation and reservation of areas along streams and their associated floodplains, wetlands, and steep or erodible slopes. The legislation intends that the riparian areas be left undisturbed to the extent possible in order to encourage regeneration or continued growth of existing vegetation. Termed "forest buffers," the sensitive riparian areas are protected through post-construction of developments through delineation of buffer areas on record plats and recordation of standard no-disturbance restrictive covenants.

There are four aspects of Baltimore County's buffer regulations that are distinctive or innovative. First, the concepts contained in the legislation were developed over several years by the Baltimore County Water Quality Steering Committee through a process of negotiation and consensus building. The Steering Committee consisted of representatives from the engineering, home building, and environmental communities, as well as representatives from County agencies. Second, the standards for forest buffers apply to all streams, including intermittent and perennial, and mapped and unmapped streams. Because the smallest 1st and 2nd order headwater streams represent approximately 50% and 25% of the County's stream network, respectively, the regulations protect the reaches most essential to the ecological health of river systems.

A third feature of the regulations is that the degree to which forest buffers are applied to a site is dependent on the environmental sensitivity of that site. Buffers are field delineated to include the greater of existing flood plain and non-tidal wetlands associated with streams and extensions in areas of steep or erodible slopes, or minimum buffer widths of 75 feet or 100 feet on each side of streams based on State-designated beneficial uses. Finally, the legislation is an integral part of Baltimore County's overall strategy for water resource management which includes watershed management planning; water quality monitoring; citizen education and volunteer activities; and a 24 million dollar, six year capital program for stream restoration, stormwater retrofits, wetland creation, forest establishment, waterway clean-ups, dredging, and shore erosion control.

The resource management planning underway by Baltimore County is providing invaluable information on resource conditions as well as effectiveness of regulatory and restoration components. Digitization of stream systems from 200-scale photogrammetric maps into a Geographic Information System revealed that the County has approximately 2100 miles of streams, or twice the mileage determined previously through State management programs based on USGS 2000-scale topographic maps. Further GIS analysis was conducted of land cover and 100 foot minimum buffers, which would apply to any development in the northern two-thirds of the County where natural or recreational trout waters are designated. Of the 70,000 acres potentially covered by these buffers, slightly less than one-half of the acreage is presently forested. For the County's 14 major watersheds, the percentage of stream buffers in forest cover ranges, however, from a low of 10% to a high of 63%. These coverages compare to a total county-wide forest cover of approximately one-third, with sub-watershed forest cover ranging from 10% to 50%. For the watersheds of the three drinking water reservoirs, which total 46% of Baltimore County, overall forest cover is 43% with 48% of hypothetical 100 foot buffers in forest cover. Further analysis will evaluate riparian buffers by stream order and will attempt to correlate subwatershed resource conditions with the six years of macroinvertebrate monitoring conducted as part of the Baltimore County Citizens for Stream Restoration Campaign.

Additional evaluation of the effectiveness of the County's stream buffer regulations is on-going based on a resource tracking database developed for land development projects reviewed by DEPRM. Although there are hundreds of projects of varying sizes and resource characteristics, for one sample of 10 projects varying from of 50 to 165 acres, and totaling 832 acres with 19,650 feet of streams, 198 acres of buffers were protected. Another sample of 10 development projects ranging from 10 to 50 acres and totaling 243 acres with 9300 feet of streams, 45 acres of buffers were identified. These data suggest that Baltimore County's riparian forest buffer regulations are effective in protecting stream systems.

Chesapeake Bay Commission

ISSUES AND ACTIONS

A legislative commission serving Maryland, Pennsylvania and Virginia.

AN ANALYSIS OF RIPARIAN FOREST BUFFER POLICIES IN MARYLAND, VIRGINIA, AND PENNSYLVANIA ADOPTED JANUARY 6, 1995

Introduction

In June 1994, the Chesapeake Bay Commission adopted the *Resolution Supporting the Development of a Riparian Forest Buffer Policy.* The resolution states that it will be the policy of the Commission to work to maintain riparian forests where they exist and restore them where they have been lost. It also urges the Chesapeake Bay Program to develop a comprehensive, watershed-wide policy, with input from a broad cross-section of stakeholders, to maintain and restore riparian forests. Finally, the resolution commits the Commission to an examination of existing state and federal programs, policies, and regulations to determine their effectiveness in promoting the maintenance and restoration of these forests.

This paper presents the findings of that examination. Information was gathered by contacting key decision makers in state and federal agencies, talking with landowners, private industry and private citizens, and reviewing literature, laws and regulations in the Bay region. A compendium of local, state, and federal laws and programs in Maryland, Virginia, and Pennsylvania that have riparian maintenance and restoration elements can be found in Appendix A of this paper. The Commission's resolution can be found in Appendix B.

The paper focuses on programs that promote forests in the riparian zone, rather than the larger universe of stream protection efforts. This focus helps highlight those issues unique to the implementation of riparian forests. The analysis does, however, adopt a great deal of latitude in defining riparian "forest" programs. Some of the programs examined revealed very strong forest elements, while some revealed only limited or incidental riparian forest maintenance and restoration opportunities. Looking at a broad range of programs, even the ones where forests play a very small part, helps to identify where the forest "gaps" are, and helps decision makers think about how to increase the programmatic emphasis on riparian forests.

Issues in Riparian Forest Buffer Maintenance and Restoration

As the Chesapeake Bay Program has shifted its focus to addressing the impact of nutrients in the tributaries of the Chesapeake Bay, riparian forests along the streams, rivers, and

shorelines of the watershed have become an increasingly important component of the strategy to reduce nutrients and provide living resource habitats. Riparian forests can protect water quality in streams by mitigating nutrients in both surface and groundwater, by settling out sediments in runoff, and by decreasing stream velocity and energy during storm events that might otherwise increase streambank erosion. These forests are also critical to ensuring a host of living resource habitat benefits for organisms in the stream. The forest canopy provides shade, thereby moderating water temperature, and provides leaf litter, which serves as the basis of the riparian food chain. Forests also supply large woody debris, such as fallen logs, which form protected pools for the propagation of fish eggs and insect larvae and habitat for species in tidal shallow water areas. This debris creates variations in stream flow as well, which promote a diversity of in-stream habitats for aquatic organisms.

From a policy perspective, riparian forests are crucial to the restoration of migratory fish species, such as shad, herring, and striped bass. Without the ecological benefits afforded by riparian forests, many streams and rivers, including some of those currently targeted for the construction of fish passages, may not attain the water quality or the habitat requirements necessary to support populations of migratory fish. Thus the success of the Bay Program's fish passage efforts is tightly linked to riparian forest maintenance and restoration.

Largely in response to the Commission's resolution, the Chesapeake Executive Council recently adopted the Riparian Forest Buffer Directive (see Appendix C). The Directive commits the signatories to developing a comprehensive, watershed-wide policy to enhance the maintenance, restoration, and stewardship of riparian forests. Specifically, the Directive calls for a panel to be convened to develop a policy for Executive Council consideration.

The Riparian Forest Buffer Panel will consider and make recommendations, where appropriate, for a number of policy items. One of the Panel's primary challenges is to propose accepted definitions of forest buffers which balance the ecological criteria needed to protect water quality and habitat in the stream with the accommodation of resource management activities appropriate within the riparian zone. The Panel also has been charged with establishing time-sensitive, quantifiable goals, measured in acres, stream miles, or other appropriate terms, to serve as long-term targets for the maintenance and restoration of riparian forests.

In addition, the Panel will examine ways to strengthen communication and partnerships between federal, state, and local governments, private landowners, and the public. An interim report from the Panel outlining the major policy findings will be submitted to the Executive Council in 1995, with final recommendations for a riparian forest buffer policy due in 1996.

While the Directive was being developed, the staff of the Chesapeake Bay Commission began its examination of existing state and federal programs, policies, and regulations in Maryland, Virginia, and Pennsylvania, as called for in the Commission's resolution. This preliminary programmatic analysis revealed how widely riparian protection measures are dispersed across different laws, programs, land uses, and issues. There are components of

riparian forest maintenance and restoration in development regulations, agricultural programs, forestry programs, and even tax policy. Some measures are mandatory while others are voluntary. Some expressly advocate the maintenance and restoration of riparian forests, while others provide more limited, even incidental protection of these forests.

This array of programs is advantageous in that it provides a number of different riparian protection "tools." The disadvantage, however, is that the current policy framework represents a fragmented approach to riparian forest maintenance and restoration. There is no overarching policy guidance to better coordinate these discrete efforts. A comprehensive policy is needed which articulates the benefits of riparian forests and then integrates these concepts into the implementation of existing programs. With a more consistent policy direction, programs can be better coordinated and the emphasis on riparian forest objectives can be enhanced, while still providing landowners and agencies with the flexibility that a "menu" of programs provides.

Modifying the existing programmatic structure, however, requires that decision makers first assess how well each program or type of program is working to achieve riparian forest objectives. How many acres or stream miles has a program maintained or restored? How well are programs being implemented or enforced? How have landowners reacted to these practices? How cost-effective are these programs? How do we define and measure "riparian forests"? These questions call for a much more extensive programmatic assessment than Commission staff alone were able to provide. Taking this analysis to the next level of detail requires the resources of a broad range of technical stakeholders who can produce and assess empirical data.

Partnerships on Pennsylvania's Conodoguinet Creek

Conodoguinet Creek flows 101 miles through Pennsylvania's Cumberland Valley to the Susquehanna River, through a mix of forests, agricultural lands, and development. The Alliance for the Chesapeake Bay, the Pennsylvania Bureau of Forestry, the U.S. Geological Survey (USGS), a local watershed organization, local governments, and volunteers are working on several projects, including one to restore riparian forests along the creek. Groups of citizen volunteers, trained by a professional forester from a major paper company, recently conducted a riparian inventory on randomly selected sites.

With the Bureau of Forestry providing technical assistance, restoration plans were designed and volunteers were organized to begin planting trees at selected sites. Funding for seedlings and other materials was provided by the U.S. Department of Agriculture Forest Service, the Pennsylvania Bureau of Forestry, and the Alliance for the Chesapeake Bay.

The Alliance for the Chesapeake Bay also has plans to conduct training workshops throughout the Susquehanna watershed to spread the word about riparian forest stewardship. The workshops would teach citizen groups, landowners, agency officials, and local governments about the importance of riparian forests and how to work riparian forest stewardship objectives into local planning. The emphasis is not simply on planting trees but on planting ideas -- teaching the general public that riparian forests matter and empowering communities to initiate their own riparian maintenance and restoration efforts.

The Riparian Forest Buffer Panel is an appropriate forum for continuing this analysis. The Panel is charged with developing a comprehensive, watershed-wide policy on riparian forests, which will include adopting accepted definitions of riparian forest buffers and establishing quantifiable goals to serve as a watershed targets for riparian forest maintenance and restoration. The Panel is thus well positioned to coordinate the programmatic assessment in a manner consistent with the accepted buffer definitions and to recommend programmatic changes that will achieve the established goals.

The Commission's preliminary analysis, however, has revealed a number of key factors and issues that can influence the success of riparian forest maintenance and restoration efforts. The Commission's analysis provides a starting point for a more detailed programmatic assessment, and raises a number of issues which will be important for guiding discussions on how to coordinate and modify existing riparian programs. These issues, detailed below, should be considered by the Riparian Forest Buffer Panel as a watershed-wide riparian forest policy is developed.

Specifying Riparian Forest Objectives

There are a number of riparian programs in which the maintenance and restoration of trees plays an important role. Yet even these programs sometimes fall short of delivering the full range of ecological benefits that riparian forests can provide. For example, a program that does not specify the types of trees that should be maintained may not provide the appropriate mix of leaf litter necessary to supply food for aquatic insects or to maximize water quality improvements. Some tree-planting and tree-maintenance programs may not address forest stand structure issues -- density, age classes, understory vegetation -- which can affect water quality and stream habitat. Thus simply ensuring the presence of trees in riparian areas does not by itself ensure the ecological integrity of the stream. Programs need to address forests more comprehensively.

There are many examples of forest "gaps" in riparian maintenance and restoration programs. Sometimes one or more of the ecological benefits of riparian forests are simply omitted from a law or program, as with Pennsylvania's Streambank Fencing Program. Although the program is laudable in that it affords a very substantial measure of stream protection from the impacts of livestock, it places no specific emphasis on the restoration of trees. Other times, there may be provisions of a law which work against certain ecological benefits, such as Virginia's Chesapeake Bay Preservation Act. Although the law requires landowners near streams and rivers to protect forested areas, it also allows the clearing of trees to improve vistas and the removal of large woody debris from the riparian forest and stream shallows, where it serves a useful ecological purpose. Finally, the gap may take the form of an exemption to the law for certain land uses, as is the case with Maryland's Critical Area Law, which often permits grass-only buffers for agricultural land. If the maintenance of riparian forest buffers is to be accomplished in these and other programs, then riparian forest objectives -- and the package of benefits riparian forests provide -- must be clearly defined in the language of the programs.

This does not mean that inflexibility should be advocated. Different resource uses and values can and must be accommodated in riparian forest stewardship programs. But by re-examining our current approach to programs like the ones described above, we may be able to fine-tune riparian programs to increase the emphasis on forest values without compromising the basic needs of landowners. This requires identifying and communicating to agency managers and landowners alike the full range of riparian forest objectives that policy makers would like to achieve.

Enforcement

There are many examples in the Chesapeake Bay region of regulatory programs that maintain riparian forests. Some of these programs, such as riparian forest requirements for commercial forestry operations in Maryland and Virginia, address a large percentage of riparian land in each state. Other programs, such as Virginia's Chesapeake Bay Preservation Act and Maryland's Critical Area Act, cover more limited regions but protect those stream areas nearest the Bay and its tributaries, and reduce the impacts of development, where the loss of riparian forests may be permanent. In Pennsylvania, land managers require maintenance of riparian forests on state lands, thereby protecting some of the state's most pristine streams. These regulatory programs are essential to maintaining and restoring riparian forest buffers and protecting water quality throughout the Bay region.

As with all regulatory programs, enforcement is critical to ensuring that the law provides its fullest measure of protection and that the regulated community is treated equitably. The preliminary analysis performed by the Chesapeake Bay Commission did not empirically assess the success of enforcement efforts, although the sentiment was often expressed that greater enforcement resources were needed. A watershed-wide analysis of enforcement needs would help determine if regulatory programs are working properly. It is especially important to conduct this assessment prior to consideration of any additional regulations. Policy makers may find that there are ample regulatory "tools" available, and that strengthening the enforcement of existing laws may be a more economical and politically practical means of accomplishing riparian forest maintenance and restoration than the promulgation of additional regulatory measures. Also, it would be instructive to compare regulatory efforts to voluntary guidelines in order to assess the relative advantages and disadvantages of each approach in maintaining riparian forests.

Incentives and Disincentives

Because so much of the protection of riparian land relies on voluntary and contractual programs, a central element of riparian forest policy involves incentives -- cost-share programs, fee payments for land taken out of production, subsidized seedlings, and so on. These incentives are delivered through a host of agents such as the Natural Resources Conservation Service (NRCS), the Consolidated Farm Service Agency (CFSA), the U.S. Department of Agriculture Forest Service, state and local natural resource agencies, private industry, and citizen groups. Pennsylvania's Streambank Fencing Program is exemplary in that it provides fencing to restrict

livestock access to streams free of charge to farmers. This has resulted in the installation of over 100 miles of fencing. Forestry corporations such as Westvaco, Chesapeake, and Glatfelter provide subsidized seedlings to landowners for reforestation, and countless private businesses are involved in community forest buffer replanting programs. But the question remains as to how effective various incentive programs are in meeting the economic needs of landowners while maintaining and restoring riparian forests.

One-on-One Forestry in Virginia

Virginia's *Water Quality Law* gives the Department of Forestry legal authority to protect streams from sedimentation on any forestry operation. The state's voluntary best management practice (BMP) guidelines, usually recommended as the best way to achieve compliance with the law, specify the maintenance of a minimum 50-foot forested buffer along streams and retention of at least 50% of the crown cover or 50 square feet of tree trunk cover (known as "basal area") per acre. In addition, the State Forester can institute a stop-work order, implement corrective measures, and impose civil fines for water quality violations.

But what makes this regulatory program unusual is its flexibility. The law allows the State Forester to permit unconventional best management practices if they are found to be equivalent to the state's guidelines in protecting water quality. This motivates industry to comply with the law while searching for cost-effective, innovative alternatives to standard forestry guidelines. Thus both a stick and a carrot are employed to encourage landowners and foresters to work together to find mutually agreeable means of protecting streams.

The law also authorizes the State Forester to provide technical assistance to counties, municipalities, corporations, and individuals for the protection of trees, woodlots, and timber tracts, and the establishment and preservation of urban forests. Says James Garner, State Forester for Virginia, "We're not just out there telling industry what to do. We communicate with them, one-on-one. Actually, there are a lot of things *we* are learning from *them* about how to protect streams."

The financial benefit a landowner receives can have a significant impact on his or her willingness to participate in riparian forest programs. For example, Maryland's Buffer Incentive Program had a backlog of applicants when the program offered landowners a one-time $500-per-acre payment to establish and maintain minimum 50-foot forested buffers. A recent legislative modification to the program lowered the payment to $300 per acre; the result was a steep decline in the number of applicants. A more detailed, formal analysis of economic incentives could help determine what levels of cost-share are economical to landowners in differing land-use scenarios. Some relatively minor adjustments to funding levels or structures could result in significant changes in the willingness of landowners to participate in incentive programs.

Similarly, there may be opportunities in other resource-land incentive programs to increase the focus on riparian protection where little or none currently exists. For example, all three states have some type of preferential tax assessment program for land kept in various resource uses or open space, such as prime agricultural land or private woodlots. These programs reduce the assessed value of the land, resulting in lower property taxes. Yet these

programs often lack any special provisions for protection of the riparian zone, and none have specific conditions for maintaining riparian forests. Thus where incentives exist to protect resource land in general, opportunities to promote riparian forest stewardship could be considered.

It is equally important to examine aspects of regulatory programs that might hinder participation in riparian forest stewardship. In Maryland, one landowner reported frustration with state and federal wetland permitting requirements for constructing stream crossings for livestock, when the alternative (allowing unrestricted livestock access to the stream) is entirely unregulated. Thus there may be instances where a regulatory process, even one geared toward stream protection, may be perceived by the landowner as a disincentive to better riparian stewardship.

Disincentives may exist as well because of conditions in other landowner assistance programs. For example, some federal subsidy programs, such as the Commodity Set-Aside program, make payments to farmers based on the number of acres in or available to production. If that farmer permanently removes part of his land from production for uses such as riparian forest buffers, he risks losing some of that subsidy. Decision makers need to examine other resource-use assistance programs to identify disincentives to riparian forest implementation, and see if there are ways in which those programs could be adjusted to benefit both the landowner and the riparian area.

Finally, buffer restoration may present perceptual disincentives to landowners. When some of the trees closest to the stream in a recently restored forest buffer are washed away during a flood event, questions about the benefits of these efforts are inevitably raised. In some cases, this kind of natural widening of the stream bed is an expected outcome in a recovering riparian forest. Viewed as desirable to the stream ecologist, this change in the stream bank can be perceived by the landowner as a failure of the practice to protect the stream and stabilize land. Landowners may also view riparian forest establishment efforts as "preservation-only" encroachments, when in fact many successful riparian forest programs permit and even encourage active forest management and other resource-use activities in the riparian zone. Thus addressing disincentives may also involve developing strategies to better communicate with landowners and land managers, so that they understand the ecology of stream systems and scientists and agency personnel understand landowner or land manager needs and expectations.

Complexity of Federal and State Cost-Share Practices

There is a bewildering array of cost-share programs and practices available for both agriculture and forestry uses. Many of these financial incentives affect the riparian zone. Although this "menu" of practices can provide flexibility in meeting a landowner's needs, it can also be confusing and result in a piecemeal approach to riparian stewardship. There are many overlapping and sometimes conflicting practices available in different state and federal agencies. Even virtually identical practices, with identical names, sometimes have different provisions, conditions, and requirements. For example, the Agricultural Conservation Program (ACP) and

the Conservation Reserve Program (CRP) are both administered by the CFSA. According to Pennsylvania's CFSA manuals, both programs provide cost-share for the establishment of permanent vegetative cover on critical areas, both have provisions for planting trees, and both require livestock exclusion from the stream area for these practices. But whereas ACP provides cost-share at a rate of 75 percent, authorizes payment for livestock fencing, and has a contract life of 10 years, CRP provides cost-share at a rate of 50 percent, does not authorize payment for livestock fencing, and has a contract life of 15 years. Often agency personnel have trouble sorting out these differences and remaining current on similar practices offered in other programs and agencies. It is likely that landowners may see this complexity as a barrier to riparian stewardship. Thus what is intended as an incentive may be perceived as a disincentive.

One way in which the Bay Program could address this problem is to involve federal and state agencies in examining how to strengthen the emphasis on riparian forest buffers while streamlining cost-share programs, where appropriate, so that the individual practices for riparian forest stewardship are more comprehensive and consistent with one another. One illustrative example of streamlining may soon occur on the federal level. The U.S.D.A. Forest Service's Forestry Incentive Program, which has traditionally been oriented toward timber production, is scheduled to sunset in 1995. Rather than reauthorize the program, the federal government will instead focus its efforts on the Forest Service's Stewardship Incentive Program, which addresses both ecological and production values while promoting enhanced coordination with state-level agencies.

Another barrier to participation in cost-share practices is the time and paperwork involved in applying to these programs. A landowner may be referred to two or three different agencies in order to implement a combination of riparian protection measures. For example, stream fencing for livestock combined with tree planting in the buffer requires a Maryland farmer to visit both the Soil Conservation District and the Department of Natural Resource's Forest Service, which may be located miles apart. Decision makers in resource agencies should consider ways to better coordinate practices and programs so that a landowner seeking to implement riparian forests and other conservation practices can do "one-stop shopping." The Bay Program's efforts to implement a Total Resource Management (TRM) approach to conservation planning may be highly instructive in making landowner stewardship more user friendly.

Program Funding and Financing

Throughout the Commission's analysis, concern over inadequate funding for programs was repeatedly expressed by agency personnel. This appeared to be true not only for enforcement manpower in regulatory programs, as mentioned above, but also for providing technical assistance needed to implement cost-share programs. Many agricultural agencies on both the state and federal levels report being unable to accommodate a long waiting list of clients who would like to implement conservation practices, which may include riparian forest buffers. Thus, even when cost-share funding is available, there is a dearth of technical assistance personnel needed to write conservation plans for landowners.

Community Forestry in Maryland

In cities like Baltimore and in other urban and suburban locations throughout Maryland, state and local governments, citizens, businesses, and non-profit organizations are working as teams to improve the physical and social environments of public land while protecting stream corridors and other vital ecosystems. The *Tree-mendous Maryland* program encourages communities to plant trees on public property throughout the state and designates stream areas as priority planting sites.

The Maryland Forest service relies on the partnership of local businesses, regional corporations, and citizen groups to make the program financially self-sufficient. The program works with local governments and volunteers to identify sites and conduct community plantings. Trees are purchased at a discount from the Department of Natural Resources by individuals, clubs, associations, schools, businesses, and communities. During the first six years of the program, nearly six million trees were planted around the state by volunteers. The program has also trained 2,000 people to lead tree-planting efforts in their communities. Over 250,000 people have been involved in the program since its inception.

The *Revitalizing Baltimore* program is working to simultaneously restore stream quality and urban quality of life through community action, hands-on environmental assessment, riparian tree planting, technical assistance, and community leadership conferences. The program combines environmental protection with community development to make urban Baltimore more aesthetically and ecologically desirable. Groups such as Save Our Streams and the Trust for Public Land are working with urban planning departments and local businesses to teach young people about responsibility and community development through tree planting and citizen water quality monitoring. The Maryland Forest Service provides technical assistance. The program demonstrates that environmental protection can play an important role in teaching people to care about their communities and in developing skills and responsibilities that will help them lead more productive lives.

Clearly, more funding will be needed to enhance riparian forest buffer efforts throughout the Bay region. In an era of fiscal austerity, however, public funds alone cannot supply the resources needed. Decisions makers must consider exploring alternative financing mechanisms, as well as seeking the involvement of private industry, businesses, local governments, citizen groups, and volunteers. Both the Maryland Blue Ribbon Panel, which recently issued its report on financing alternatives for Maryland's tributary strategies, and Pennsylvania's Stream Corridor Protection Workgroup may provide some ideas for how to finance riparian forest buffers.

Lack of Consistency

There is enormous variability in the width, density, and diversity of riparian forest criteria across the range of existing riparian forest programs. Target definitions and ecological standards need to be specified in order to develop clear policy goals for riparian forests. This does not mean that a rigid standard should be applied to all streams, for the ecological requirements needed to optimize water quality and living resource habitats will vary according to the stream type and adjacent land uses. Some range of definitions, however, should be applied so that minimum ecological criteria are met in each given situation. This will be one of the primary tasks which the Riparian Forest Buffer Panel will undertake, as called for in the Riparian Forest Buffer Directive.

Lack of Data

Although a great deal of scientific data has been collected concerning riparian forest buffers, decision makers often lack important *programmatic* data -- the kind of data that tell us how many acres of riparian forest have been restored or how many dollars have been devoted to riparian restoration efforts. Many programs that affect the riparian zone, even those with riparian forest components, do not maintain readily available programmatic data on riparian forest implementation. Sometimes the data are buried in programmatic records, and limited personnel resources prevent this information from being readily available. In other cases, there may be no way to separate the riparian forest data from general forest data, because the program's data collection methods were not designed to differentiate between the two. Both of these examples clearly illustrate why it is important to integrate a riparian forest policy into the current framework of resource assistance programs. Moreover, as policy makers reorient these programs to emphasize riparian forest stewardship, it is critical that a comprehensive, watershed-wide forest buffer tracking system be developed so that this kind of data can be maintained in the future.

Impermanence of Incentive Programs

Most cost-share practices are contracted for 10 years. Now is the time to begin thinking of additional incentives to maintain buffers permanently, in a way which provides for resource uses but also maintains the long-term ecology of the stream. Otherwise, riparian forest buffers, to which years of money and effort have been devoted, may be converted to other land uses.

Recommendations

The issues raised by the Chesapeake Bay Commission's analysis point to the need for more information about riparian forest programs and the involvement of a broader community of stakeholders in developing strategies to enhance riparian forest maintenance and restoration. The Riparian Forest Buffer Panel, convened to develop a broad-based, watershed-wide policy on riparian forest buffers, is the appropriate forum for addressing these challenges and summoning the resources necessary to ensure that analyses are thorough and policy decisions are technically and politically feasible. Therefore, as the Riparian Forest Buffer Panel carries out the responsibilities specified in the Riparian Forest Buffer Directive, the Chesapeake Bay Commission recommends that the Panel consider undertaking the following tasks to support its work.

1. **The Riparian Forest Buffer Panel should continue a watershed-wide analysis of laws and programs.**

   This would involve taking the preliminary analysis by the Chesapeake Bay Commission to the next level of detail. The Panel could work with Bay Program subcommittees and agency staff from local, state, and federal governments to ask how

many acres or stream miles of riparian forests each program has maintained or restored, and what benefits those buffers provide. Then the Panel can analyze which programs are working most effectively and how programs can be modified to more efficiently use existing funds and administrative structures.

Given limited funds and time on the part of agency and Bay Program staff, there will likely be some limit on how detailed this type of analysis can be. As mentioned above, programmatic data on riparian forest buffers is not always easily available or standardized from one program to another. Yet simply convening key programmatic stakeholders to examine current programs and discuss programmatic changes would be an extremely useful step, as pieces of this analysis may have already been carried out by various state and federal agencies and the research community.

The Chesapeake Bay Commission would also like to re-emphasize those items from its *Resolution Supporting the Development of a Riparian Forest Buffer Policy* that would be an essential component of this analysis, including:

- An examination of what landowners perceive to be obstacles to the implementation of riparian forest buffers, through a landowner survey and/or a landowner roundtable.

- An analysis of economic incentives and disincentives for implementing riparian forest buffers, in order to assess the effectiveness of existing riparian buffer programs.

2. The Riparian Forest Buffer Panel should develop a forest buffer tracking system.

As mentioned above, information on the amount of riparian land maintained or restored by various programs is often not readily available from those agencies conducting the programs. Currently there is no watershed-wide tracking effort. The programmatic analysis would likely reconstruct some of this information from the past. Thus it is important to develop a coordinated, watershed-wide tracking system, in which different riparian programs would cooperatively maintain standardized data on the implementation of riparian forest buffers. This system would ensure easy and timely access to programmatic information on riparian forest buffers in the future. It would also help the Bay Program measure its progress toward any goals or related objectives determined by the Panel.

3. The Riparian Forest Buffer Panel should explore alternative financing mechanisms, including tax incentives and public/private partnerships.

Recommendations for programmatic changes should address how programs will be financed. The Commission's analysis revealed that there are a number of existing programs, such as preferential tax assessment programs for land kept in conservation,

where the emphasis on riparian protection could be enhanced. There also exist examples of successful public/private partnerships, such as timber industry cost-share programs, Tree-mendous Maryland, and riparian restoration efforts on Conodoguinet Creek. In addition, the Bay Program can look to Maryland's tributary strategy Blue Ribbon Panel or Pennsylvania's Stream Corridor Protection Workgroup for ideas on financing alternatives.

APPENDIX A

RIPARIAN FOREST BUFFERS: LAWS AND PRACTICES IN THE CHESAPEAKE BAY STATES

A Compendium of Riparian Protection Programs in Maryland, Virginia, and Pennsylvania.

Introduction

This compendium briefly describes the laws and programs that protect or address riparian forests in Maryland, Virginia, and Pennsylvania. It focuses on riparian forests, rather than the larger universe of stream protection efforts. A broad view of riparian forest laws and programs is presented, illustrating a range of protection efforts, from stream fencing to tree planting and maintenance. Although some of these programs don't have specific forest components, they are worth noting because they provide opportunities for increasing the emphasis on forests in their riparian protection elements.

Riparian forest protection has been divided into five basic areas: Development-related laws, agriculture, forestry, cross-land uses, and tax programs. This will impart to the reader a sense of how many ways riparian forest maintenance and restoration can be applied. It will also convey a sense of how dispersed these approaches are. Clearly, riparian forest policy does not fall into a neat category or a single law. Working toward a more comprehensive policy will require greater consistency and better coordination among these approaches.

I. DEVELOPMENT

Maryland

Chesapeake Bay Critical Area Act: This act controls development within 1,000 feet of tidal waters, measured from the heads of tide or the landward side of tidal wetlands. A mandatory 100-foot, naturally vegetated buffer is required for all tidal waters, tidal wetlands, and tributary streams in the Critical Area, including both perennial and intermittent streams. Exemptions exist for lots platted before the law was passed and for lots that would otherwise be rendered unbuildable by the law's requirements. For agricultural land, the buffer may be reduced to 25 feet with natural vegetation. It may be reduced further and grass may be permitted if an approved Soil Conservation and Water Quality Plan with Best Management Practices is in place. For silvicultural land, a 50-foot buffer is required.

Forest Conservation Act: This act protects forest cover from development throughout the state by limiting forest clearing for residential and commercial development and by requiring replanting where needed. The Act designates "priority areas" for retainment of forests and replanting, including 50-foot buffer areas around both perennial and intermittent streams. This area must remain undisturbed, unless an applicant has demonstrated to the satisfaction of the state or local authority that reasonable efforts have been made to protect such areas and that plans cannot reasonably be altered.

Nontidal Wetlands Act: A mandatory 25-foot naturally vegetated buffer is required around all nontidal wetlands greater than 5,000 square feet. This provides a forested or naturally vegetated buffer in cases where a wetland exists adjacent to a stream.

Reforestation Act: This is basically a "no-net-loss" scenario for highway construction. The law seeks to minimize forest loss and replace unavoidable losses from highway construction projects, placing the highest priority on forests near or adjacent to streams.

Economic Growth, Resource Protection, and Planning Act: This act does not regulate the riparian area per se, but does encourage such protection as part of each county's requirement to develop a "sensitive areas element" in their comprehensive plans. The Act, however, permits the local governments to define each sensitive area and its level of protection. Among the environmentally sensitive areas that are specifically mentioned in the act as needing protection are streams, stream buffers, and 100-year floodplains.

Revitalizing Baltimore: This program is working to restore stream quality through community action, hands-on environmental assessment, riparian tree planting, technical assistance, and community leadership conferences. The program combines environmental protection with community development to make urban Baltimore more aesthetically and ecologically desirable. Citizen groups work with urban planning departments and local businesses to teach young people about responsibility and community development through tree planting and citizen water quality monitoring. The Maryland Forest Service provides technical assistance.

Local Zoning Ordinances: Forty-two percent of the counties in Maryland have regulations requiring stream buffers of 50 to 100 feet on developed land (exclusive of Critical Areas). The characteristics of the buffer required may vary from simple setbacks to native vegetation.

Virginia

Chesapeake Bay Preservation Act: This act establishes "preservation areas" that comprise between 50% and 60% of Virginia's coastal plain. The "Resource Protection Areas" require a 100-foot buffer around tributary streams. Exemptions allow reduction of the buffer to 50 feet in cases where a lot would otherwise be rendered unbuildable. Exemptions also allow reduction of the buffer to 25 feet for agriculture land if an approved Soil and Water Quality Conservation Plan is in place.

Local Zoning Ordinances: All the tidewater counties have adopted Chesapeake Bay Preservation Act regulations into their local zoning ordinances, which extends the designation of protection areas to all other areas of the county. In addition, one other county outside of tidewater Virginia (Albermarle) has incorporated Chesapeake Bay Preservation Act regulations into their zoning ordinances to protect sensitive areas.

Pennsylvania

Dams Safety and Encroachments Act: This act regulates development in both wetlands and stream areas by requiring a permit from the Department of Environmental Resources. Although there are no specific buffer requirements, applicants must avoid, minimize, or mitigate impacts to these areas that would degrade water quality.

Local Zoning Ordinances: There are several thousand individual municipalities in Pennsylvania. A small number of them have ordinances which restrict timber harvesting altogether, although there are few specific protections for the riparian zone.

Federal

National Flood Insurance Program: All three states have counties that participate voluntarily in the National Flood Insurance Program. In Maryland, counties and towns that adopt the state's Model Floodplain Management Ordinance require a 100-foot flood protection setback from streams with floodplains designated on FEMA maps. In Virginia, participating counties curtail development in the floodway. Pennsylvania state law *requires* flood-prone municipalities to participate in the national program, and adds some technical requirements above federal standards.

II. AGRICULTURE

All Three States

Permanent Vegetative Cover: Cost-share is provided for establishing trees, grasses, and shrubs in order to stabilize soil on eroding areas, including riparian areas.

Grazing Land Protection: Cost-share is provided for spring development, trough, and tanks so as to provide watering sites for livestock away from the stream area.

Stream Protection: Cost-share is provided for establishing permanent vegetative cover, which can include trees, along the banks of streams, as well as related items such as remote watering systems, stream crossings for livestock, and stream fencing.

Maryland

Buffer Incentive Program: One-time payments of $300 per acre are provided for the planting and maintenance of minimum 50-foot forested buffers along streams and shorelines on private land of 5,000 acres or less.

Virginia

Woodland Buffer Filter Area: One-time payments of $100 per acre are provided to establish minimum 50-foot forested buffers along streams. This practice is permitted only on crop and pasture land that has recently been in production.

Loafing Lot Management System: Cost-share is provided for a rotational grazing system. This practice requires a minimum 25-foot fenced buffer around streams. Vegetation is not specified.

Pennsylvania

Streambank Fencing Program: Fencing with minimum 12-foot buffer is provided free to rural landowners by the Pennsylvania Game Commission in exchange for allowing public hunting on

their land. The Department of Environmental Resources is currently in the process of setting up a parallel program that omits the hunting requirement.

Federal

Agricultural Conservation Program (ACP): This program provides a number of cost-share practices designed to solve soil, water, and related environmental problems in agricultural areas, including small woodlands. Many practices are similar to those in state cost-share programs. Most notably, there is a Riparian Buffer Strips practice, which requires a minimum 95-foot buffer consisting of diverse, undisturbed forest nearest the stream and managed forest, shrubs, and grasses farther out. Also authorized under ACP are forestry cost-share practices. The program is administered by the Consolidated Farm Service Agency.

Conservation Reserve Program (CRP): This program takes highly erodible land out of production for at least ten years, preferably permanently. Cost-share is provided for tree establishment and other vegetative cover. Annual rental payments on the land are provided for the years that the practice is being maintained. The program is administered by the Consolidated Farm Service Agency.

Wetlands Reserve Program (WRP): The WRP allows farmers to sell permanent easements to the U.S.D.A. and receive cost-share to restore previously altered wetlands to their natural condition. Eligible land includes prior converted cropland, farmed wetlands, and riparian areas along streams or water courses that link wetlands which previously have been protected by an easement or similar agreement. The program is administered by the Natural Resources Conservation Service.

III. FORESTRY

Maryland

Forest Harvest Guidelines: A minimum 50-foot forested, no-cut buffer is required around all perennial streams. If a Buffer Management Plan is implemented, selective harvesting is allowed, so long as 60% crown cover or 60 square feet of basal area per acre is evenly retained.

Buffer Incentive Program: The Buffer Incentive Program (see Agriculture) can also be applied to non-commercial timber land.

Woodland Incentive Program: Cost-share is provided to non-industrial private woodland owners for tree planting, including riparian forest buffer establishment, as well as other forest management activities.

Virginia

Water Quality Law ("Bad Actor" Law): Gives the Department of Forestry enforcement powers to implement corrective measures on any forestry operation being conducted in a manner causing or likely to cause pollution. The state's voluntary best management practice (BMP) guidelines, usually recommended as the best way to achieve compliance with the law, specify the maintenance of a minimum 50-foot forested buffer along streams and retention of at least 50% of the crown cover or 50 square feet of tree trunk cover (known as "basal area") per acre. The Department may allow a reduction in the width of the buffer so long as equivalent water quality protection is provided.

Woodland Erosion Stabilization: Cost-share is provided to establish permanent vegetation on eroding areas on forest harvesting sites, although grass and legumes are used.

Pennsylvania

Voluntary Guidelines: There are no mandatory requirements in the riparian zone on private forest land, although a 50-foot buffer is recommended.

Special Protection Streams: Mandatory forested buffers are required for commercial logging operations on state forest lands around streams designated for "special protection" by the Bureau of Water Quality Management or as a Wilderness Trout Stream by the Pennsylvania Game Commission. A 200-foot no-cut buffer is required around Wilderness Trout Streams (all of which are also designated as "exceptional value" streams) and a 100-foot selective-cut buffer is required around "high quality" streams. Virtually all perennial streams on state forest land are designated at least "high quality." Some intermittent streams receive this designation as well, so long as there is a defined stream bed and stream bank.

Federal

Forest Stewardship Program: This federally funded program, which is administered by the states, provides technical assistance to private landowners for implementing conservation practices while meeting harvesting needs. Forest Stewardship Plans are required for participation in the federal cost-share programs for forestry (see FIP and SIP below). Funding comes from the U.S. Forest Service.

Forestry Incentive Program (FIP): This program is designed to increase the future supply of timber on private non-industrial (between 10 and 1,000 acres) forest land. Cost-share is provided for tree planting, including in forested wetlands and riparian areas. The program is funded by the Consolidated Farm Service Agency.

Stewardship Incentive Program (SIP): This program addresses a broad range of ecological enhancements on non-industrial private forest land. Cost-sharing is provided for tree planting, stream fencing, riparian and wetland improvement, tree shelters, and fisheries habitat improvement. The program is funded by the U.S. Forest Service.

IV. CROSS-LAND USES

Maryland

Special Rivers Project: This project fosters forest stewardship and best management practices in both rural and urban watersheds to improve water quality, although its geographic scope is limited to the Susquehanna, Monocacy, and Anacostia river basins. In rural settings, the program establishes Forest Stewardship Plans, riparian forest buffers, and agricultural BMPs. In urban areas, the program works with local planning agencies to implement urban forestry practices.

Greenways Program: This program provides long-term planning assistance to protect public lands and coordinate with federal and local governments and the private sector on a statewide greenways network, of which stream and river valleys are an essential part. The Greenways Program also prepares scenic river plans and assists local governments in developing long-term management strategies through the Scenic and Wild Rivers Program.

Program Open Space: This program uses funds from the state realty transfer tax to help local governments purchase open space. Many of the lands purchased are adjacent to or contain streams and rivers.

Tree-Mendous Maryland: This program works with local businesses, regional corporations, citizen groups, and local governments to conduct community plantings on public land. Trees are purchased from the Department of Natural Resources by individuals, clubs, associations, schools, businesses, and communities. The program has also trains people to lead tree-planting efforts in their communities.

Maryland Environmental Trust: This program helps landowners establish conservation easements. Requirements for riparian land in easement areas include a minimum 50-foot vegetative buffer strip.

Virginia

Conservation Easements: Soil and Water Conservation Districts in Virginia may use part of their funding to purchase conservation easements in eroding areas or areas of important ecological value, including the riparian zone. A number of Districts currently hold easements on riparian forests.

Pennsylvania

Easement Purchase Program: Counties or the state may purchase farmland easements for a minimum of 25 years. Part of the easement purchase decision is based on the level of stewardship and use of best management practices.

Federal/States

Scenic and Wild Rivers Program: All three states participate in this federal program, and also have parallel state-funded programs. These programs can be effective tools in preserving existing forest buffers and restoring areas to attain Scenic River designation. Pennsylvania, for example, has its own Scenic Rivers Act, in which a river seeking scenic designation must meet or be in the process of restoring scenic, ecological, and recreational standards. In the past, the program has funded riparian forest restoration efforts.

V. TAX PROGRAMS

Maryland

Forest Conservation and Management Program (FCMP): This program provides special tax assessments on forest land, if the landowner agrees to adhere to a forest stewardship plan for 15 years. In return, the tax assessment is frozen, usually at the agricultural rate or better.

Reforestation/Timber Stand Improvement Tax Deduction (TAXMOD) Program: This program allows landowners of small forestry operations to deduct from their adjusted gross income double the costs associated with reforestation activities, including those in the riparian zone.

Agricultural Use Assessment: This program provides a preferential assessment on the value of land that is used for agriculture. Woodlots can also receive an agricultural assessment. There are no specific requirements for riparian areas.

Virginia

Use-Value Taxation: Counties voluntary participate in this program, which provides preferential assessments on the value of agricultural and forest land consistent with its use. Although popular in urbanizing counties, it can have a negative impact on the tax base in rural counties. There are no specific requirements for riparian areas.

Pennsylvania

Covenant-Preserving Land Uses: This law authorizes a county to enter into covenants with landowners for the preservation of farmland, forest land, water supply land, or open space. The real property tax is reduced to reflect the fair market value of the land with the covenant restrictions. The covenant is good for ten years, and can be extended with the agreement of both parties for one year at a time.

Farmland and Forest Land Assessment Act ("Clean and Green Act"): The county Board of Assessment can grant a preferential assessment for ten or more contiguous acres of land devoted to agricultural, forest reserve, or open space purposes. Land is assessed at the use value rather

than the prevailing market value. This can apply to land in the riparian zone as well, although there is no requirement for forests in the riparian zone.

All Three States (Federal)

Public Law 96-451: This program provides federal tax incentives to reduce reforestation costs. The law permits up to $10,000 of capitalized reforestation costs each year to be eligible for an investment tax credit and a 7-year amortization. This can include reforestation efforts in the riparian zone.

ISSUES

Streams and their riparian areas cut across ownerships, interest groups, and scientific disciplines. They are an important part of our larger landscape but can also form our property lines and backyards. Workshops with landowners,environmental groups and government professionals, have helped to identifyissues that may present barriers to implementation of a riparian forest buffer policy. These issues fall into four main categories:

1. **Perceived threat to landowners/developers**

Discussion of riparian buffers can generate fear and resistance from landowners, farming interests, developers, and industry. These fears may represent a broad-based resistance to government programs, resistance to change or fear that a voluntary agreement to establish a buffer may lead to permanent regulation of land. Some landowners believe that designation of a buffer may lead to unrestricted public use, habitation by endangered species, or loss of use or property value.

2. **Economic loss**

As with other BMP's, landowners and developers may experience a loss of income associated with installation or retention of a forest buffer. For farmers, the amount of land removed from production may be small but the level of impact may vary. For a land developer, it may mean realignment of a subdivision plan, including roads and utilities, or may change the density of development. Tax laws may not recognize buffers favorably, thereby failing to encourage their retention. Economic benefits and tradeoffs of forest buffer retention and establishment are not well understood or documented. Farmers, developers or local governments, may also lack the time, ability, funds, or desire to plant and maintain forest buffers.

3. **Capability of existing programs**

Very few incentive programs are targeted to riparian forest buffer establishment or retention. Buffers, stream fencing, and other stream protection measures are often not eligible for cost-share programs. Programs are scattered throughout government, are complex, present bureaucratic hurdles, and may have significant regional differences. Competition between agencies/programs creates a lack of coordination and common goals. Some administrative or regulatory policies create disincentives to riparian forest buffers. Successful programs are sometimes poorly funded. Private and non-profit groups are underutilized as partners in riparian buffer efforts.

4. **Scientific/technical information needs**

Although the scientific foundation of riparian forest buffer function is substantial, experience and technical guidance for establishment and maintenance is limited. Information transfer and technical training is needed for landowners and field professionals. Monitoring of demonstration sites is limited.

CHALLENGES AND OPPORTUNITIES

Throughout the watershed, people are working to conserve and restore riparian areas through a wide variety of approaches. Actions which build on successes, reduce landowner and business fears, and generally enhance a stewardship ethic focussed on riparian forests are needed. The ultimate goal is to enhance water quality and habitat in our rivers and streams and along the shorelines of the Bay. Achieving forested buffers is desired, however, it is recognized that some landowners will limit their riparian stewardship to basic stream protection, filter strip measures, or forest buffers of minimal width.

Overall, the Chesapeake Bay Program can set quantifiable goals and policy guidelines to direct their accomplishment. A holistic view of the benefits of forest buffer and stream restorationwill help communicate the effectiveness of this approach and demonstrate its success. Furthermore, establishing Bay-wide riparian forest retention and restoration goals and tracking progress towards these goals will increase public awareness, commitment and involvement. Flexibility and innovation through guidelines customized for various federal, state, and local purposes, will be necessary if we expect to meet these goals. Therefore, meeting the challenge of retaining and restoring riparian forest buffers will require approaches that:

1. **Build commitment among riparian landowners**

A more aggressive stream and riparian stewardship program/policy requires a strong commitment by all levels of government, clear and coordinated goals and objectives, adoption of a sound riparian stewardship ethic among landowners. Such an ethic should focus on retaining and restoring the integrity and ecological health of streams and rivers through promotion of naturally functioning riparian systems, such as forests. Riparian landowners are essential partners in this effort. Practical steps that will assist us in this effort include:

- promoting the benefits/importance of RFBs to landowners
- developing and using demonstration sites
- developing information/promotional materials on RFB benefits and on technical and financial assistance available
- incorporating RFBs into the "menu" of best management practices through existing natural resource protection programs
- setting available goals for RFB establishment
- retaining the existing voluntary approach for RFB implementation on rural lands

2. **Increase technical knowledge about the effectiveness, establishment and management of riparian forest buffers**

In the past, the lack of consensus and understanding about how buffer function has been a significant barrier to their adoption. The recently released EPA Chesapeake Bay Program report entitled, "*Water Quality Functions of Riparian Forest Buffer Systems in the Chesapeake Bay Watershed*", provides a foundation for understanding buffers' impact on water quality. Future steps must be taken to develop management guidance for RFBs that will allow landowners and natural resource managers to successfully establish and conserve buffers. These steps include:

- Addressing short and long-term maintenance concerns under varying conditions
- Developing and refining establishment techniques and design standards

- Refining nutrient load calculations for site conditions and land use variability
- Developing "rule-of-thumb" management evaluation techniques to help natural resource managers determine the best design of RFBs for site conditions (either by themselves or in combination with other measures)
- Incorporation of RFBs in Tributary Nutrient Reduction Strategies
- Monitoring RFBs to provide site specific evaluations on effectiveness
- Quantifying the economic benefits to the landowner for RFB establishment

3. Increase knowledge of landowners and technical staff

The value of riparian forests for habitat has been recognized for some time. However, the water quality function of forests has only recently been quantified in the scientific literature. Training in using the forest as a nonpoint source pollution control BMP is not yet common for those who provide landowner assistance. Foresters rarely interact with agricultural or urban conservation planners or are unfamiliar with challenges of working in these areas. Technical information like that described in #2, must be disseminated to the landowners and technical staff responsible for making resource management decisions. For example, some managers may be familiar with agricultural or forestry best management practices, but lack sufficient background on the ecological importance of RFBs. These outreach efforts could include:

- Providing RFB training and cross-training among technical staff (ag, foresters, stream geomorphologists, engineers, biologists) to improve understanding of technical and practical issues related to stream protection and RFB establishment
- Develop education tools such as fact sheets, handbooks, and videos for landowners
- Developing and using demonstration sites for promotion of RFBs
- Developing landowner "peer" education such as "neighbor to neighbor" and "Master Conservationists" programs used to promote agricultural BMPs.
- Integrate RFB's into Clean Water Farm and other environmental awards programs

4. Coordinate and enhance existing programs and policies

While some existing programs incorporate riparian corridors as part of nonpoint source reduction or land conservation programs, very few focus specifically on RFB. Many agencies or commissions have specific but limited responsibilities for activities with the riparian area consequently management or restoration of this resources can be complicated and confusing. Suggestion for improving coordination to enhance riparian areas include:

- Increasing the flexibility of natural resources protection programs (Stormwater management, Nontidal Wetlands, Forest Conservation, etc.) to allow mitigation funds to be used for RFBs and stream protection measures.
- Addressing USDA set-aside programs that are a disincentive to removing land from production for RFB establishment
- Encouraging interagency natural resource professionals to cooperate to identify and install comprehensive projects using RFBs
- Further integrating state forestry and wildlife/fishery agencies into Bay program efforts and agricultural conservation agency programs
- Encouraging public and private partnerships to provide buffer plantings (school, community, non-profit groups)

5. Provide adequate incentives

The vast majority of riparian areas are on private lands. Greater attention must be placed on the essential role of private landowners as partners in managing, conserving and restoring riparian resources, especially for reducing nonpoint source loads to the Bay and its tributaries. There is a general consensus that government will be more successful in attracting citizen participation in riparian stewardship if their programs are primarily voluntary. Ideally, landowners should be presented with a range of options linked to incentives and disincentives. As with most concepts, gaining landowner acceptance and participation may take some time. A range of incentive programs should be explored, including:

- Establishing forest buffer programs or refining other incentive programs specifically for RFB establishment
- Extending and strengthening tax reductions, credits, or incentives which reduce tax liability for retention and establishment of forest buffers. Reducing real estate taxes through use-value rate eligibility, forest/agriculture districts, etc.
- Linking RFB establishment to existing land trust, mitigation, easement and set aside programs through purchase of easements, support payments for establishment and grants for planting and management
- Providing cost-share support for RFB maintenance and establishment of related stream protection practices
- Developing revolving loan funds for local government riparian programs
- Create Riparian Land Banks and increase RFB emphasis in CRP and WRP criteria
- Establish recognition programs for landowners, developers, agencies, etc. who contribute significantly to meeting RFB goals
- To overcome the fear of "takings", inform the public about appropriate uses in forest buffers
- Reducing stormwater utility fees by giving credit for buffer areas as on-site BMP

ECONOMICS

Economics Issue Forum

On March 26, 1996, the Riparian Forest Buffer Panel conducted a forum on economic issues related to forested buffers. The objectives of the meeting were to present to the Panel an array of issues related to the costs, benefits, and policy impacts of riparian forest buffers and to highlight current and innovate incentive strategies that could encourage riparian buffer retention, establishment and management. The outcomes and information shared at this forum were intended to show analysis performed to assess the cost impacts and benefit contributions of riparian forest buffers, context policy alternatives in an economics framework, and to add to the knowledge base that the Panel used to form its policy recommendations. Below are the key points of each of the seven speakers who presented to the Panel.

Doug Lipton, University of Maryland, Sea Grant College
Economics of a Basin-wide Riparian Forest Buffer Policy
Dr. Lipton presented a discussion of the economic tools that could be used in developing recommendations on riparian forest buffer policy. He suggests that economic analysis tools that can help answer the question "will this policy make us better off?" are the right ones and include benefit/cost analysis and cost-effectiveness analysis. However, the difficulty in using these techniques is in quantifying the value of benefits. Measuring the value of cleaner water, more wildlife and fish, and aesthetics is hard to do. Lipton recommended the Panel develop a policy that seeks to create/maintain forest buffers where there is high impact for low cost but stresses that the policy must be flexible enough to allow alternative buffers to be applied that provide some positive environmental impact and are less costly than forest buffers.

Ian Hardie, University of Maryland, Department of Agricultural Economics
How Do We Maximize Riparian Forest Buffers in the Bay Region?
Dr. Hardie suggested that the best way to develop practical policy recommendations, and to decide where to implement riparian forest buffers, is to use a cost-effectiveness approach. If the Panel chose to maximize environmental benefits, than forest buffers on all streams on all land uses would yield the greatest benefit. However, this objective is too expensive and probably not feasible. The costs of implementation rise when considering idle land (lowest cost) to forestry lands to agricultural lands to developed lands (highest cost). Dr. Hardie recommends that using a least-cost method should be carried out by selecting a target level of environmental benefits and seeking to achieve that target at the lowest cost. However, he warns that there may be equity problems with this method. Because developed lands have buffers that are at higher land use value, owners of developed land that might otherwise be targeted for buffer retention or restoration would likely be not be targeted because of the high cost. Most of the burden would fall on the agricultural community due to the lower cost of land to put into a riparian forest buffer. Ultimately, Dr. Hardie advocates a flexible buffer system which allows variance or exemptions to any buffer standard or policy. He strongly supports a voluntary approach and believes that cost-benefit assessments need to include all costs, direct, opportunity, education, and perceived loss of value due to permanence of forest. (See attachment.)

Rick Cooksey, U.S. Forest Service / Chesapeake Bay Program

Economic Accounting: Impacts of Riparian Forest Buffers on Four Land Use Scenarios

Mr. Cooksey presented the potential economic impacts of conserving or restoring riparian forest buffers for four typical land use scenarios in the Chesapeake Bay basin. The scenarios are : (1) agriculture - coastal plain; (2) agriculture - piedmont; (3) forestry - coastal plain; and (4) development - Richmond vicinity (See attachment). The scenarios presented were snapshots of impacts from removing the land area from current or intended production and establishing or retaining a stream side forest. They were intended to illustrate the "average" cost of riparian buffer establishment to a landowner, and how current state and federal programs could be used in conjunction with one another or "piggybacked" to reduce those impacts. The figures presented are actual dollar amounts calculated for each hypothetical field scenario showing variable costs (seeding, planting, fertilizing, harvest, hauling, labor, and taxes), but not fixed costs (mortgage, equipment loans). They utilized market prices and USDA agency cost share/commodity crop payment figures supplied by the Natural Resources Conservation Service and Farm Service Agency. Mr. Cooksey's impact scenarios suggest the following:

1. In agricultural areas, the costs of establishing or retaining riparian buffers in Maryland could be completely covered by existing programs or even provide a net gain to private landowners. In Virginia, current programs may meet establishment and maintenance costs. In Pennsylvania, existing programs do not cover these costs and would constitute a net loss to landowners. Current programs need to be better integrated and adequate incentives should be developed to encourage buffer establishment.
2. In forestry settings, Maryland landowners can expect to completely cover the cost of retaining or establishing forest buffers. In Virginia and Pennsylvania, loss of forest production to retain forest adjacent to streams would impose a net loss on landowners.
3. In the Richmond development example, the developer would lose buildable lots to retain a forest buffer on the site. According to current zoning, that loss would reduce profits. However, the use of a density compensation could be employed to recover those lots and might actually increase the market value of the home next to the buffer.

Ms. Jackie Geohagan, University of Maryland

Residential and Other Developed Land Values in Anne Arundel County, MD

Ms. Geohagan presented the preliminary results of her research project at the University of Maryland, which is focused on developing a mathematical model to predict land use change. The purpose of this work is to describe how landscapes evolve and land use conversion occurs as a result of different policy scenarios, land use controls, and nonpoint source regulation. The model is intended to be a tool that can assist managers in predicting change and can also be a useful mechanism for targeting areas where efforts to implement buffers should be focused. The initial research focuses on Anne Arundel County in Maryland. The unique aspect of this work is the attempt to link economic considerations, human activities on the land, and ecological features in one management tool.

Steve Koehn, Maryland Forest Service

Tax Strategies

Mr Koehn discussed two areas of taxation that impact forest buffers - income and property taxes.

Property taxes: Mr Koehn described a Maryland tax program that allow landowners with professional forest management plans to receive a preferential tax assessment. In this program the

landowner's property tax will be abated to the agricultural use rate of assessment. There is an entry fee for the program and an inspection fee every fifth year.

Income taxes: Mr Koehn discussed several tax programs that apply to forest buffers:

- Under the Maryland Tax Modification Program, a landowner can deduct two times the expenses of creating a buffer from state income tax.
- Under the Agriculture, Forestry Incentive and Stewardship Incentive programs, private users. It was noted that in Pennsylvania, the public perceives the benefits of buffers to be local, not improvements somewhere downstream in the Bay.
- Under the Reforestation Tax Credit, a landowner can take a tax credit of up to 10% of the expense of installing a buffer and amortize the remainder of the expense over the next 8 years.
- The capital gains tax rate on timber is 28% versus the normal 36%. There is a current proposal before Congress to allow a shelter of 50% of timber income from taxes.

John Hutson, Maryland Environmental Trust

Conservation Easements

MET's Conservation Easement Program accepts charitable contributions of land easements. The perpetual easement agreement is voluntary and flexible but prohibits commercial activity and promotes open space including forestry and agriculture. The result of an easement agreement is to limit or eliminate development potential. These easements supersede local zoning. The financial benefit of an easement to the landowner is that the program meets the IRS guidelines for a charitable contribution. An appraisal is taken of the value of the development rights to determine the value of the contribution. The charitable deduction is limited by a 30% rule, a rule that limits the maximum annual charitable deduction a donor can take to 30% of his or her adjusted gross income. If the value of the easement exceeds that level, the excess can be carried forward for up to five years. The landowner can also apply for 15 year tax credit on unimproved land.

Mr. Huston stated that it could be possible to increase the value given for the donated land if the landowner agreed to establish a buffer. However, the success of this program may depend on whether the landowner perceives it as a government program or not. Currently, MET does not require conservation plans on agricultural lands but does require a 50 foot vegetated strip along streams for lands on which pesticides and manure are used actively. The Maryland Agricultural Preservation Program , on the other hand, not only requires a nutrient management plan on donated land but the existence of a plan helps in the application process. Mr. Huston also stated that land trusts would probably be interested in a program in which federal money is provided to state foresters to obtain easements, which are then donated to land trusts.

Elizabeth Hickey, University of Maryland - Environmental Finance Center

Creative Financing Techniques

Ms. Hickey discussed a list of techniques for achieving forest buffer goals. She suggested that this list be viewed as a menu from which some mix of methods could be selected based on the situation (See attachment). The techniques are ranked according to cost and the degree to which they bind the landowner.

1) Notification Program: This method is the least costly and least binding. It simply alerts the landowner via letter that a resource (i.e. buffer) exists on the property and why it is important.

The letter encourages the landowner to maintain and protect the resource.

2) Management Agreements: In this non-binding written agreement, the landowner agrees to manage a resource on the property for a particular purpose over a stated period of time. Some compensation may be paid for expenses.

3) Financing Arrangements: These methods may be used to generate funds to pay for projects. Some examples include:
A) Loans - Special low interest loans are available if the project meets certain guidelines;
B) Revolving Loans - Initial grant money forms the base for loans; loan payments are used for future loans;
C) Environmental Mini-bonds - These bonds are sold in small denominations, such as $500, to the general public, and proceeds are designated for specific programs or activities; and
D) Stormwater utilities - Special districts are set up to finance a government service that benefits the residents of that district only.

4) Easements: Transfer of Development Rights (TDR) is one type of easement program whereby a government body facilitates the sale and purchase of development rights between private buyers and sellers. Some hurdles TDR systems face are assigning monetary rights, developing rates of exchange, and the resulting piecemeal approach to development.

5) Acquisition: This involves purchasing property outright or purchasing some percentage of ownership and, thus, a stake in management decisions. A variation is "right of first refusal," whereby the landowner agrees to notify the interested organization that the property will be offered for sale. The organization may, but is not obligated to, purchase the property.

Ms Hickey stated that a good "package" for a buffer program might include an environmental inventory, revolving loan fund on a watershed basis, and a combination of notification program and nonbinding agreements with an education component.

Patty Engler & John Long, Natural Resources Conservation Service

Cost-Share Programs

The speakers discussed a menu of existing financial and technical assistance programs available to private landowners that could be used to establish forest buffers. In practice, some of these programs may be combined in order to provide a more comprehensive package of assistance to the landowner. Most of these programs are reimbursable and, thus, require an initial cash outlay by the recipient. Through various combinations of these programs, it is not unusual for a landowner to make a profit on forest buffer installation.

Buffer Incentive Program (BIP) - tree planting and maintenance along streams and shorelines - one-time $300/acre grant up to 50 acres; must maintain trees for 10 years; 50 foot minimum buffer width; payment after first season contingent on 65 percent tree survival rate

Stewardship Incentive Program (SIP) - forest management plan development, tree planting, riparian and wetland improvement, recreation and wildlife habitat improvement - up to 65 percent cost-share; requires at least one but less than 1,000 acres nonindustrial private forest land; requires existing Forest Stewardship Plan for contiguous forested acreage; must maintain for at least 10 years

Forest Incentive Program (FIP) - increase future sustainable supply of saw timber - can be up to 65

percent cost-share capped at $10,000; requires at least 10 acres with capability of producing 20 cubic feet/acre/year; requires forest management plan

Woodland Incentive Program (WIP) - financial assistance for tree planting, stand improvement, and management to private, nonindustrial woodland owners - requires between 10 and 500 contiguous wooded acres capable of producing 20 cubic feet/acre/year; up to 50 percent cost-share capped at $5,000 for one year or $15,000 for three year project; requires a forest stewardship plan prepared or approved by licensed forester; must maintain practice for at least 15 years; access must be allowed for inspections

Agricultural Conservation Program (ACP) - agricultural best management practices
- pays up to 75 percent of installation costs of most BMPs but capped at $3,500/year; in Maryland, requires approval by State Conservation Review Group

Partners for Wildlife
* used to retain, create or manage wetland habitat for wildlife
* used mainly by horse farms
* seen as program of last resort

Maryland Agricultural Cost Share (MACS) - popular cost-share program for agricultural producers; and 87.5 percent cost-share capped at $10,000; can include trees

Wetland Reserve Program (WRP) - purpose is to restore wetlands on agricultural lands; can be used to connect 2 wetland sites (including the establishment of a forest buffer) separated by no more than one mile. And, easement purchased on the site of a restorable wetland but payment is capped at the agricultural value of the land; cost-share is currently 100 percent.

KEY POINTS of PANEL DISCUSSION:

- Create or designate one organization to coordinate the spectrum of programs and provide a menu/catalog that is brief, concise and specific. Agencies do not encourage participation in the entire range of programs; rather they focus on their own programs.

- Although there may not be enough emphasis on "civic duty" as an incentive, monetary subsidies are important because some landowners are "land rich, but cash poor" and need a financial boost to accomplish desired objectives.

- There is a need for a commitment by agriculture agencies to help "sell" forest buffers to landowners as a viable practice.

- Large landowners like tax programs, while small landowners like cost-share programs. This raises the issues about need for a menu of program options.

- A Blue Ribbon Panel was assembled to develop creative financing options for Maryland's Tributary Strategies. That Panel developed a menu of 36 ideas with case studies. These ideas should be

considered for applicability to a buffer program.

- Since so many existing programs reimburse the landowner, low-interest revolving loan funds could be used to fill the need for up-front cash outlays.

PANEL REQUESTS ADDITIONAL POLICY INSIGHT FROM ECONOMISTS

It was suggested that an additional policy team be formed to further develop incentive and financing ideas. However, since all existing policy workgroups were already discussing economic issues relative to their land use area, it was decided that a new policy team would not be formed. As an alternative, Ian Hardie was selected to contact each guest speaker at this issue forum and ask them for two ideas for effective incentive and tax programs. Ian Hardie and Rick Cooksey compiled these suggestions and distributed them to the Panel and Technical Team. Below are the suggestions presented as a result of their request.

List of Possible Incentive Recommendations

1. Provide a State matching or per-acre supplemental payment program to private organizations that get private landowners to establish and maintain or improve and maintain riparian forest buffers. Payment would go to the organization working with the landowner for acreage or miles of streamside actually buffered by landowner action. Payment would not be connected to any particular type of easement, agreement, method of negotiation, etc. Funds could pass to the landowner as part of a private agreement. Participating organizations would have to apply for and demonstrate fiduciary responsibility for the supplemental grants to the States.

✦ Existing Land Trusts and Environmental Trusts emphasize voluntary, donated easements, but purchase some easements or lands when this makes sense from an environmental viewpoint. Donated easements are often given by wealthier landowners who can obtain significant income tax benefits from making a charitable contribution. Easements may also reduce property values for estate settlement purposes or lower the net price to the buyer of a large property. Landowners with smaller parcels and lower incomes receive less tax benefits and, therefore, have less interest in these programs. The objective of this incentive would be to encourage private land trusts, citizen community improvement groups and other private organizations to promote establishment and maintenance of riparian forests buffers. Program flexibility would be maintained by tying the incentive payment to buffer production rather than type of private program or landowner agreement.

The listed potential recommendation is an alternative to the suggestion made on March 26 to John Huston of a program where federal money would go to state foresters to obtain easements which then be donated to the land trusts.

2. Expansion of Maryland Buffer Incentive Program to other parts of watershed.

✦ This possibility would satisfy the agricultural sub-panel consensus by endorsing an existing

program in Maryland but would require new legislation in Pennsylvania and Virginia. The Maryland program currently provides a one-time $300 per acre grant to landowners who plant and maintain forested buffers for a minimum of ten years. The grant can provide a substantial incentive since it can be packaged with cost-share assistance from federal cost-share programs. Relatively high incentive levels, the possibility of adjusting the level of the one-time grant, and the focus on establishing new buffers may make this the most effective of the listed alternatives for meeting the 40 percent nutrient reduction goal for the Bay. However, implementation would be more costly to state governments than that of other proposed recommendations. This type of program has the virtue of simplicity when compared to something like Conservation Reserve Program (CRP) and may have lower administrative costs as a consequence. Such a program may also raise some concerns due to the existing critical area and coastal zone regulations in Maryland and Virginia which force some landowners to establish or improve buffers without corresponding levels of compensation.

3. Supplement the tree planting component of Federal CRP or cost-sharing programs with State programs. Restrict supplemental efforts of planting and maintaining buffers.

✦ This option takes the viewpoint that existing Federal programs are effective (especially when packaged together) but lack sufficient funds. States in the Southeast have developed state programs that extend Federal FIP programs, so there is some precedent for this practice. This option may be very dependent on forest type. CRP tree planting incentives, which have provided about $160 per acre average net present value incentives to the landowner, have been available nationally for nearly a decade. But, actual planting has occurred almost exclusively in the southern pine forest. One drawback to supplementing federal programs is that they are re-established every five years, their budgets vary and a supplemental program could end up with nothing to supplement. Administrative costs also are likely to be higher than an one-time grant program if CRP and several cost-share programs are simultaneously supplemented. Direct costs to the states could also be high if new quantitative miles/acres goals require substantial expansion of the acreage being enrolled in these currently small programs.

4. Exempt acreage of forest buffer established and maintained from local property taxes. Include a tax repayment penalty for land from which buffers are subsequently removed.

✦ Note: exemption was chosen instead of reduction to match the no-tax suggestion from the forested land policy subgroup. Reduction to the land's agricultural assessed value is already part of the Maryland package. The Panel can easily substitute reduction for exemption in this listed alternative.

✦ Property tax exemptions would obviously be more attractive to landowners with lower income levels than existing tax incentives. Thus, this incentive could affect a different group of landowners. Property tax exemptions would also provide a continuing incentive that would supplement the one-time income tax events. The primary effect of the tax incentive might be to preserve existing buffers instead of establishing new ones, unless the incentive is

paired with cost-sharing, rent payment, one time grants or other means of getting new buffers established. A penalty of removing tax-exempted buffers might also be necessary to keep from subsidizing landowners who are simply holding land with established buffers for future conversion to another land use. The effect of such exemptions on local government revenues could vary substantially, depending on tax rates, tax revenue levels, and the acreage of stream sides to be buffered within each local jurisdiction. Considerable effort could be required to establish this option, given the large number of local governments and the existing variation in current property tax legislation and collection procedures. Some kind of education-coordination support would probably be needed to assist local governments if this option was recommended.

5. Revise existing land development regulations (e.g. disturbed site and stormwater management regulations) so that they integrate forest buffers. These may include allowing or requiring design of stormwater systems that disperse stormwater through buffers, introducing buffers as a component on site development plans and integrating buffers into open space requirements.

✦ Existing land development regulations do not consider forest buffer as a design component. Regulations often require stormwater to be piped directly into a stream, losing the water quality benefits that could be gained by dispersing this water through a stream side forest buffer. While site characteristics such as topography, size and shape can make it difficult to incorporate standardized buffers into development plans, many sites offer opportunities to make flexible buffers an important component in the overall site plan. A recommendation could stimulate potential revisions of existing regulations that would integrate water quality values from riparian forest buffers into the present development process.

6. Allow for compensating lot size adjustments in development plans that include forest streamside buffers, or create transferrable development rights that allow landowners who voluntarily establish forest buffers to offset lost development values on other properties.

✦ Density credits for buffers incorporated within specific site plans could be part of a revision of existing regulations. Transferrable development rights are appealing because they directly address landowner concerns that establishing buffers on undeveloped sites will "wipe-out" development values. The values at risk can be considerable: the average payment in Maryland for Purchases of Development Rights (a TDR "cousin" in which the government buys the right) was $756 per acre in 1987. Ignoring these values may create a significant barrier to the establishment or maintenance of forest buffers on land with significant development potential. Conversely, a review of existing TDR's by Pitt, Phipps, Bonsignore and Lessley indicates that they have complicated interactions with zoning regulations, seem to be suitable mostly for localities close to metropolitan areas, and have high administrative costs. It is also necessary for government to establish the development values as separate entities before they can be transferred.

7. Account more fully for nutrient reduction and sediment control values from riparian forest buffers in farm conservation (BMP) plans as they are developed.

- ✦ If credit is not given in farm conservation plans for the nutrient and sediment control benefits provided by riparian forest buffers, farmers have no incentive to include them. This recommendation simply calls for expansion of the definition of desirable BMPs and should not be difficult to implement.

8. Establish state revolving loan programs (or a watershed-wide program) to provide financing for landowners unwilling or unable to pay the immediate costs of establishing buffers. Payment of loans could be linked to the receipt of cost-share funds by the landowners.

- ✦ This recommendation was made by Elizabeth Hickey at the March 26 Panel meeting. It recognizes that existing cost-share programs would compensate for buffer establishment costs only after they are incurred. The landowner has to make the initial investment and then wait for compensation. Some may not be in the financial position to do so.

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Attachment - Ian Hardie

Economic Considerations for Riparian Forest Buffers in the Chesapeake Bay Watershed

Maximize Benefits from Forest Buffers?

Suppose the panel chose to recommend that the environmental benefits provided to the Bay watershed by riparian forest buffers be maximized. What would this cost (economically, not politically)?

The figure titled "Costs of Forest Buffers" represents these costs.

Notes:

Benefits are maximized by maximizing the miles of stream side buffered and by using a 3-zone or equivalent buffer.

Definition of "stream" is critical. Miles and benefits depend on order of streams included.

Features:

Segment 1: stream side that is already buffered on land that is not in commercial use (possibly floodplain or steep stream side). Slope and position of this segment indicates belief that costs of maintaining such buffers will be low and will not vary much across owners.

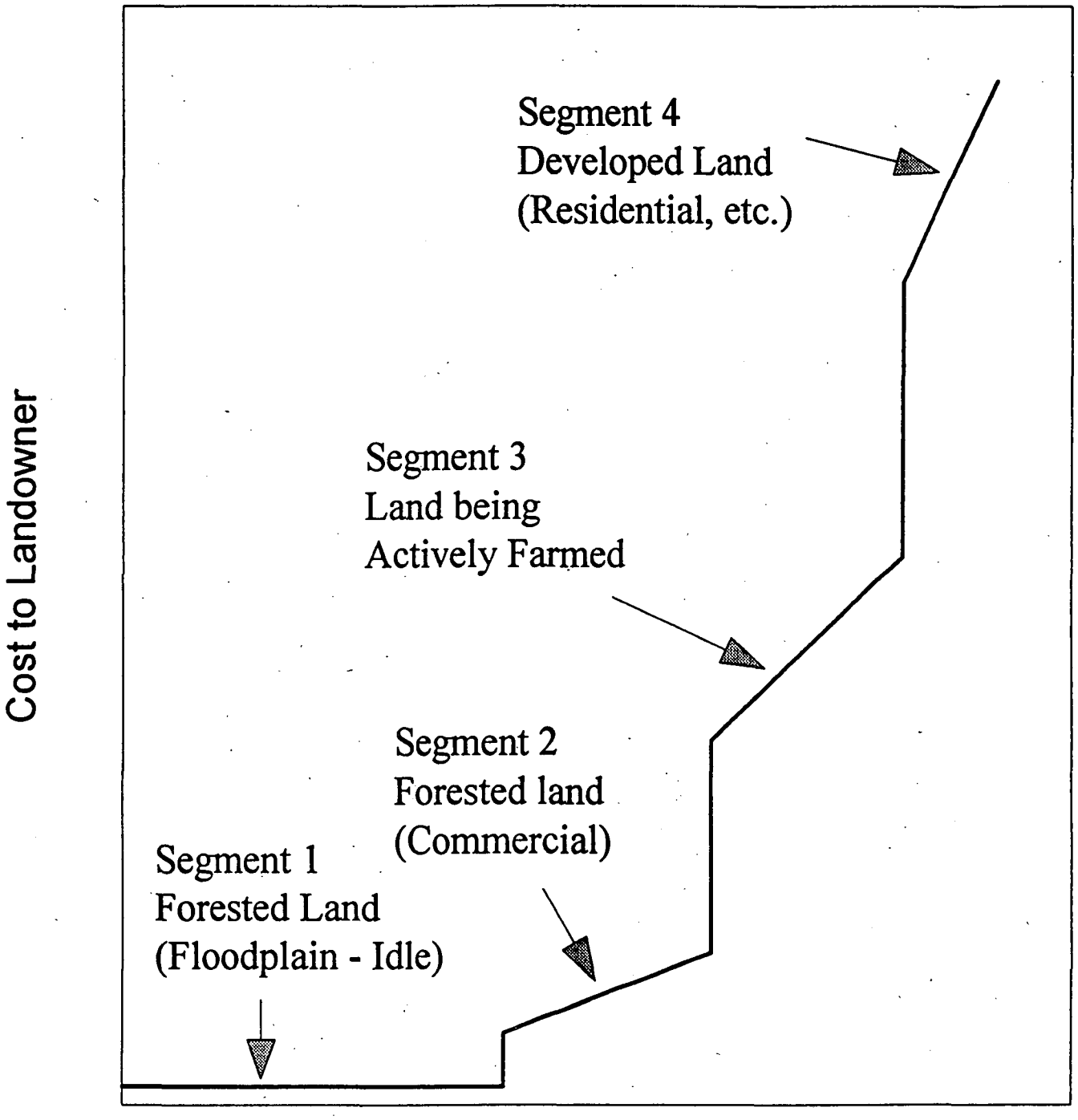
Segment 2: stream side that is already buffered on land that is used for commercial forestry. Level of segment is based on assumption that some timber harvests will be foregone. Buffer strips with more valuable timber are represented at upper end of line segment.

Segment 3: stream side that is currently being farmed. Level of segment is higher because buffers will have to be established. Slope is steeper because costs will vary more across farmers.

Segment 4: stream side that is already in a developed use. Level of segment is high and slope is steep. Costs of establishing buffers on this land could entail removal or reconstruction of existing structures.

Issue: Are costs too high for this to be an acceptable policy? (already resolved?)

Costs of Forest Buffers



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Develop a Cost-Effective Policy?

If costs of maximizing environmental benefits are too high, Panel could set a benefit goal (Imagine a vertical line at some specified stream side mileage).

Total costs of meeting this goal could be minimized by moving up the total cost curve from the origin:

(1) first preserve forest buffers on floodplain and "idle" land, then
(2) keep buffers on commercial forest land, then
(3) establish buffers on farmland, then
(4) establish buffers on developed land.

The goal would determine how far one went up the cost curve.

Such a cost-effectiveness approach raises an equity issue. High-cost owners are exempted. Most of the burden is placed on farmland owners.

Issues: Should the Panel establish an environmental benefit goal?

What role should cost-effectiveness play in Panel recommendations?

Is it important to distribute the burden of the buffer policy across all owners?

Flexible Buffers?

Setting and meeting prescribed goals becomes more difficult as policy becomes more flexible. Consider, for example, a flexible buffer policy with exemptions and variances to a prescribed buffer type.

Effect on total costs:

Exemptions from establishing buffers would shorten the length of the third and fourth line segments.

Variances such as a decreased buffer width would affect the slope of the segments. Level would be affected only if variance were granted to all owners (essentially a change in the definition of the prescribed buffer).

Total costs might increase. Variances can decrease buffer effectiveness and exemptions can remove lower-cost mileage. One might have to move further up the cost curve to meet a given benefit goal.

Effect on benefits:

Benefits will depend on variances and exemptions. Benefit goals must be established simultaneously rather than independently.

Issues: Should the Panel recommend a flexible buffer policy and forego an independent benefits goal?

Should such a policy be a process (such as a zoning board which rules case-by-case), or a set of rules that apply to a designated situation?

Examples of possible rules:

(1) narrow buffer if topography is such that buffer can only provide shade and in-stream habitat (no nutrient or sediment control).

(2) no buffer if its establishment significantly reduces landowner income.

(3) variable-width buffer if part of approved land development plan.

(4) narrow or no buffer if established or approved storm water management system renders nutrient and sediment control ineffective.

(5) grass buffer instead of forest buffer if view is important.

Voluntary Compliance?

Voluntary compliance policies require incentives because landowners must be encouraged to change from a preferred land use. Landowner benefits must outweigh the costs of making the change.

Four costs are relevant in a voluntary compliance program:

(1) Education costs: costs of learning about riparian forest buffers and what a landowner must do to establish and maintain them.

(2) Direct costs: costs of establishing buffers plus discounted costs of future maintenance minus discounted returns from any future timber harvests from the buffer.

(3) Opportunity costs: the present value of the net returns or private benefits given up by taking the stream side land out of its current use.

(4) Costs of losing ownership rights: possible costs of losing future rights to use land as desired or of having to conform to particular environmental stewardship laws (such as the endangered species or wetlands acts).

Some of the gains to the owner of having a cleaner bay, purer water, forested stream side, etc. can be netted from these costs. But some gains must remain to induce landowner participation.

Effect on Total Costs:

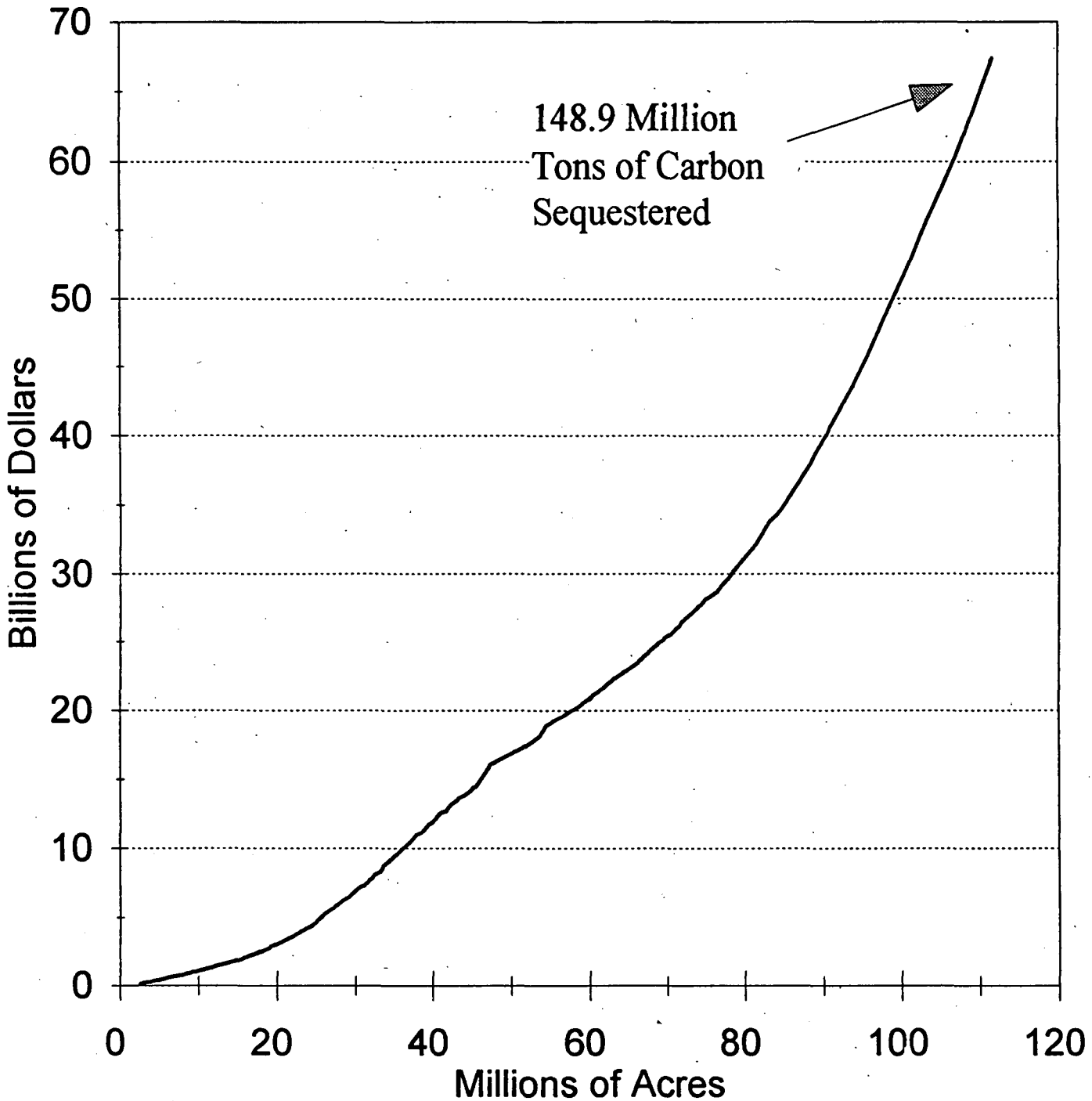
Length of the third and fourth cost segments may be greatly reduced. Miles of buffered stream side will be less. Total costs will decrease.

Figures titled "Total Cost of Carbon Sequestration"show this effect in another context. Policy represented there is to expand CRP program to get marginal farm land converted into forests that will sequester carbon and abate global warming. Incentives are 50% cost-sharing plus 10 years of rent at a level equal to average farm net return in the geographic area. One figure shows the total cost curve if all eligible farmers participate in the expanded CRP program. The other shows what happens if farmers participate at rates observed during the first 11 CRP sign-ups.

Same point about low participation was made about sediment control programs in Virginia by speaker in agriculture panel meeting (Jim Cox?, Jack Frye?) .

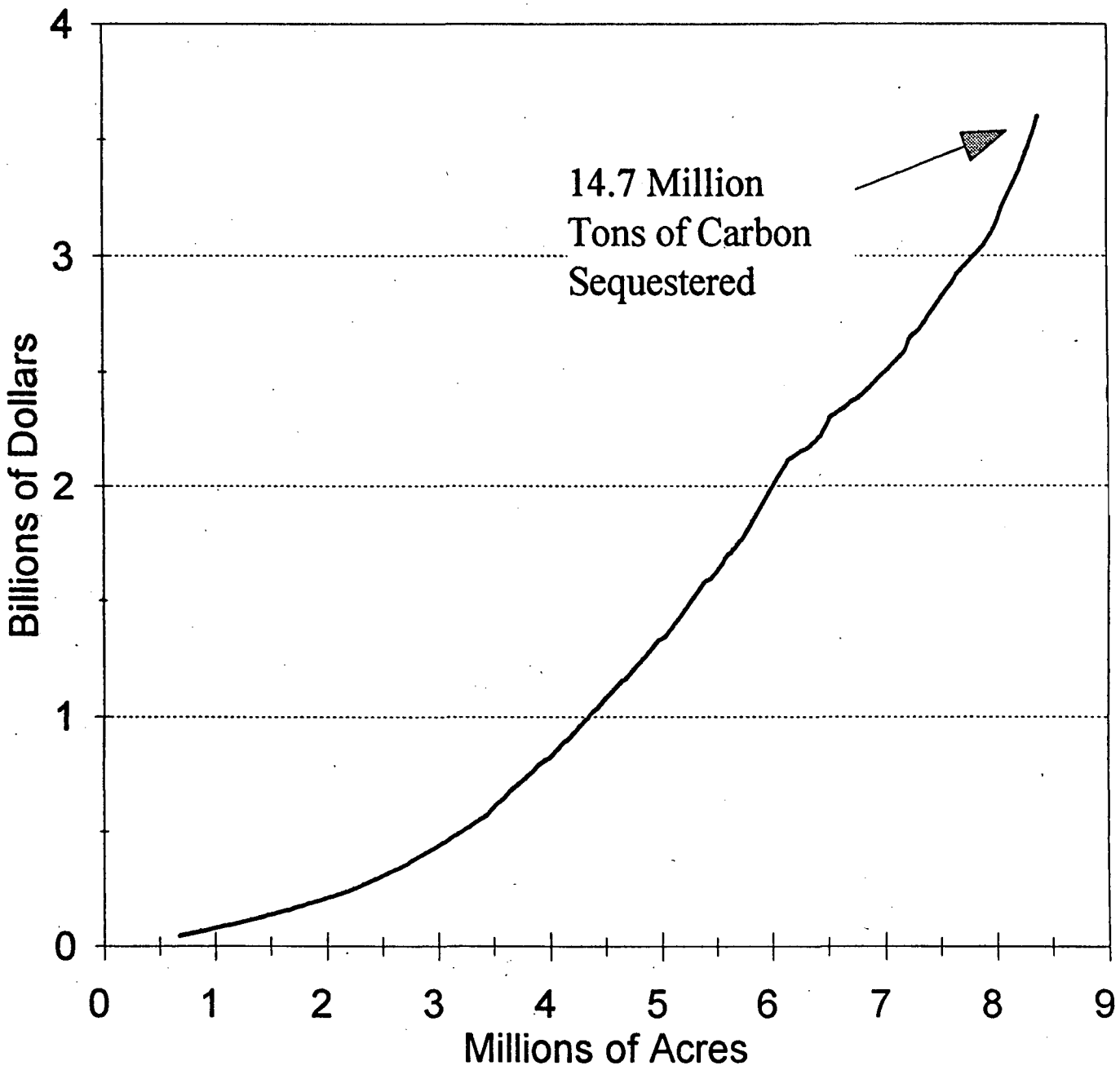
Total Cost of Carbon Sequestration

If All Eligible Owners Participate



Total Cost of Carbon Sequestration

If Past Participation Rates Continue



Issues: Can a voluntary incentives-based program add enough miles of buffered stream side to significantly improve water quality in the Bay and watershed?

Can the Panel successfully recommend a voluntary compliance program without figuring out the mix and level of incentives needed to meet an environmental benefits target? Will the Panel need to estimate the total costs of the program?

Possible incentives include:
- technical and educational assistance,
- property tax easements,
- cost-sharing,
- rent subsidies,
- purchase of use rights,
- purchase of land,
- exemptions from BMP's or other land use regulations.

How should the burden of incentive payments be apportioned between federal, state, local, and private sources? Does the Panel need to address this?

Preserve, Retrofit, or Target Change?

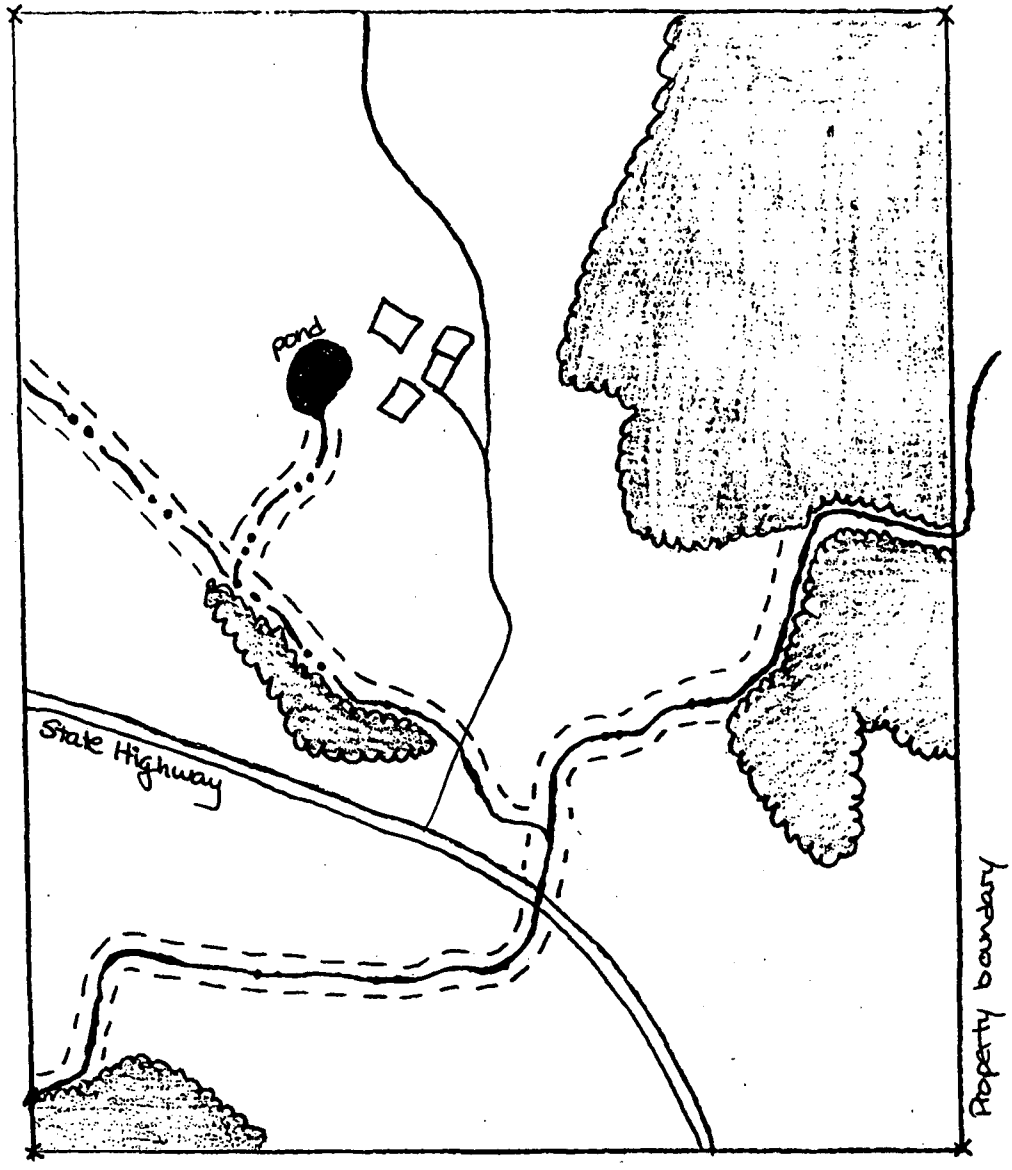
The static cost curve framework used above keeps land use and ownership fixed. The possibility of getting buffers established while land is being developed or use is being changed is left out.

Regulations are seemingly more acceptable when land ownership changes. Consider the existing zoning regulations, storm water and sediment regulations, etc. associated with land development. Contrast these with the incentives policies needed to change current land use decisions of existing owners. Note also that costs can be lower because buffers can be made a part of land use planning.

A Final Issue: Should the Panel develop distinct recommendations for preserving and establishing buffers on land that is being switched from one use or ownership to another?

Attachment - Cooksey

Example Farm: *Riparian forest buffer establishment*



Existing Forest
Perennial stream
Intermittent stream
Property boundary
Riparian forest buffer planting

AGRICULTURAL SCENARIO - COASTAL PLAINS

Two Crop, Two Year Rotation (Corn, Soybeans)

139 acre Field - 2640 ft. Buffer

Crop Production

1. Gross annual income per composite crop acre	$456.25
2. Annual production cost per composite crop acre	($330.00)
3. Net Annual Income - per composite crop acre	**$126.25**

Buffer Cost (per acre)

1. Buffer cost per square foot	= $ 0.0027	
Grass (orchard grass/ladino clover)	= $ 0.00021	
Trees (mixed hardwoods)	= $ 0.0026	
2. Net cost per acre of tree/grass buffer		$117.61
Buffer (trees-75'/grass25') - 100 foot width		
Buffer (trees-38'/grass-12') - 50 foot width		

TOTAL COST TO LANDOWNER PER ACRE	**$243.86**

Program Opportunities for BMP and Buffer Implementation

Virginia	
1. CRP (50% cs and 71/ac annually)	$129.81
2. Woodland Buffer Filter Area ($100/ac -one time)	$100.00
	$229.81
Maryland	
1. CRP	$129.81
2. Buffer Incentive Prg. ($300/ac- one time)	$300.00
	$429.81
Pennsylvania	
1. CRP	$129.81
2. Streambank Fencing Prg. (12-foot buffer fencing - free)	----
	$129.81

NET LOSS/GAIN (-/+)

Total net annual income for field	$17,586.63
Net Annual Income lost to Buffer	
100 feet (6 acs.)	$757.50
50 feet (3 acs.)	$378.75

Virginia

Total Cost to Landowner of Buffer with Programs	
100 feet	($84.30)
50 feet	($42.15)

Maryland

Total Cost to Landowner of Buffer with Programs	
100 feet	$1,115.70
50 feet	$557.85

Pennsylvania

Total Cost to Landowner of Buffer with Programs	
100 feet	($684.30)
50 feet	($342.15)

** *Figures are for first year with buffer establishment.*

** *Second year to end of CRP contract = net annual income - CRP payment* **($55.25)**

Resource Returns for Buffer

TREES	Net annual return per acre - loblolly pine - 35 year rotation	$67.27
WILDLIFE	Average hunting lease per year per acre	$3.00
WATER QUALITY	A public value - not measurable	

AGRICULTURAL SCENARIO - PIEDMONT

Three Crop, Two Year Rotation (corn, wheat, soybeans)
40 acres with 680 foot Buffer

Crop Production

1. Gross annual income per composite crop acre	$541.38
2. Annual production cost per composite crop acre	($455.00)
3. Net Annual Income - per composite crop acre	**$86.38**

Buffer Cost (per acre)

1. Buffer cost per square foot	= $ 0.0027	
Grass (orchard grass/ladino clover)	= $ 0.00021	
Trees (mixed hardwoods)	= $ 0.0026	
2. Net cost per acre of tree/grass buffer		$117.61
Buffer (trees-75'/grass25') - 100 foot width		
Buffer (trees-38'/grass-12') - 50 foot width		

TOTAL COST TO LANDOWNER PER ACRE **$203.99**

Program Opportunities for BMP and Buffer Implementation

Virginia	
1. CRP (50% cs and 71/ac annually)	$129.81
2. Woodland Buffer Filter Area ($100/ac -one time)	$100.00
	$229.81
Maryland	
1. CRP	$129.81
2. Buffer Incentive Prg. ($300/ac- one time)	$300.00
	$429.81
Pennsylvania	
1. CRP	$129.81
2. Streambank Fencing Prg. (12-foot buffer fencing - free)	-----
	$129.81

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NET LOSS/GAIN (-/+)

Total net annual income for field	$3,455.20
Net Annual Income lost to Buffer	
100 feet (1.6 acs.)	$138.21
50 feet (0.8 acs.)	$69.10

Virginia

Total Cost to Landowner of Buffer with Programs	
100 feet	$41.31
50 feet	$20.66

Maryland

Total Cost to Landowner of Buffer with Programs	
100 feet	$361.31
50 feet	$180.66

Pennsylvania

Total Cost to Landowner of Buffer with Programs	
100 feet	($118.69)
50 feet	($59.34)

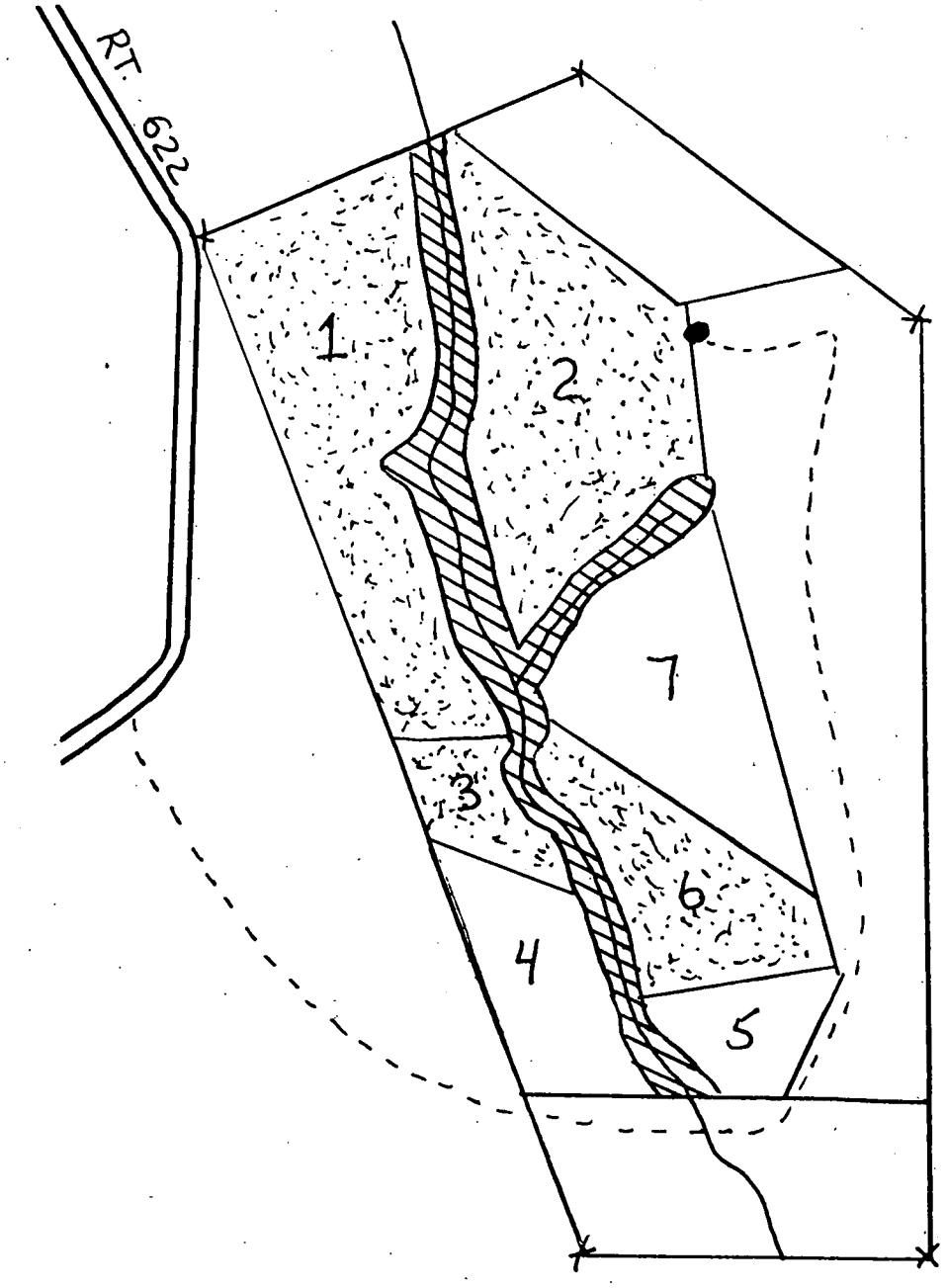
** *Figures are for first year with buffer establishment.*

** *Second year to end of CRP contract = net annual income - CRP payment*	**($15.38)**

Resource Returns for Buffer

TREES	Net annual return per acre - red oak - 60 year rotation	$16.00
WILDLIFE	Average hunting lease per acre per year	$3.00
WATER QUALITY	A public value - not measurable	

Example Forest: *Streamside Management Zone Designation*



Harvest area
Buffer Area
2 Cutting Units
Roads
Property Boundary

FORESTRY SCENARIO - COASTAL PLAINS

Non-industrial Private Landownership

54 Acres of Mixed Pine/Hardwood - 3000 ft. of 50'-wide Buffer

Timber Production

	$ per Acre
1. Gross income per acre	$1,268.00
2. Production cost per acre	
Harvest - payment to logger (labor,equip. maint., haul, ins., FOB)	$634.00
Planting - enhancement/management (optional)	$200.00
3. Net Income - (value of trees left in buffer)	**$434.00**

Buffer Cost (site)

Harvesting Alternatives within Buffer

	Total Return	Change	% Change
1. Total clearcut of entire area	$34,300		
2. Selective - All Sawtimber in Buffer (>50%ba)	$33,991	($309)	-10.00%
3. Selective - Hi Q. Sawtimber in Buffer (< =50%ba)	$31,602	($2,698)	-7.80%
4. No Harvest in Buffer	$28,531	($5,769)	-16.80%

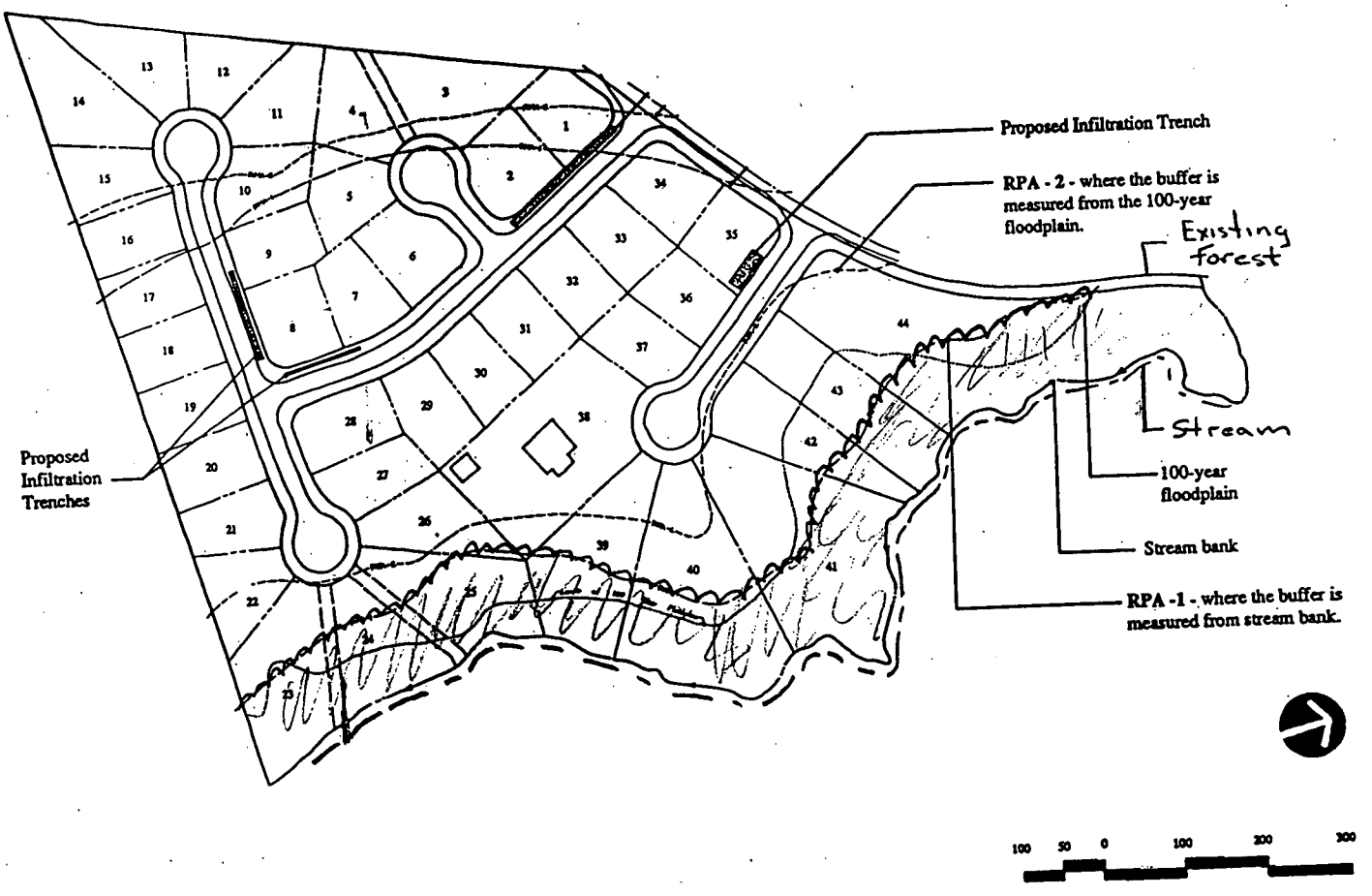
Program Opportunities for BMP and Buffer Implementation

Virginia:	Voluntary Participation - No programs for retention.		
	Fed. and state cost-share available for riparian zone enhancement:		
	• SIP - 75% cost-share (Practice 5, 6, 8)		$150.00
	• CRP - 50% cost-share		$100.00
	• ACP - 75% cost-share		$150.00
	• Va. BMP Cost-share Prg. - 75% cs		$150.00
	• Tax Incentive - Public Law 96-451 (10% credit up to $10m)		$20.00
		TOTAL	$170.00
Maryland:			
	• Fed. programs same as above		$150.00
	• MD Income Tax Mod. for Reforestation and Timber Stand Imp.		$400.00
	• Tax Incentive - Public Law 96-451 (10% credit up to $10m)		$20.00
		TOTAL	**$570.00**
Pennsylvania:			
	• Fed. programs same as above		$150.00
	• Tax Incentive - Public Law 96-451 (10% credit up to $10m)		$20.00
		TOTAL	$170.00

NET LOSS/GAIN (-/+)

Virginia	($264.00)
Maryland	$136.00
Pennsylvania	($264.00)

Example Development: *Riparian forest buffer Retention/Establishment*



DEVELOPMENT SCENARIO - RICHMOND VA VICINITY

Small Subdivision with Resource Protection Area (Bordering Stream)

17.6 Acre subdivision - 44 lots

Zoning Allowances

1. Minimum lot size allowed	9000 sq.ft.
2. Current number of buildable lots	44 lots
3. Finished lot price	$61,000.00

Implication of CBPA on Use of Platted Lots

100 foot buffer (lose three lots)	$183,000.00
50 foot buffer (lose one lot)	$61,000.00

Additional Cost Estimates for CBPA and Buffer

1. Site plan, erosion control plan (already required)	$0.00
2. Water quality stormwater management plan (engineering time)	$650.00
3. Installation and maintenance of erosion control devices (already required)	$0.00
4. Installation of required infiltration devices	$25,000.00
5. Reserve drainfield (served by public sewer)	$0.00
6. minimize land disturbance and natural vegetation removal (could show net savings)	$0.00
7. Review fees (could be $0)	$250.00

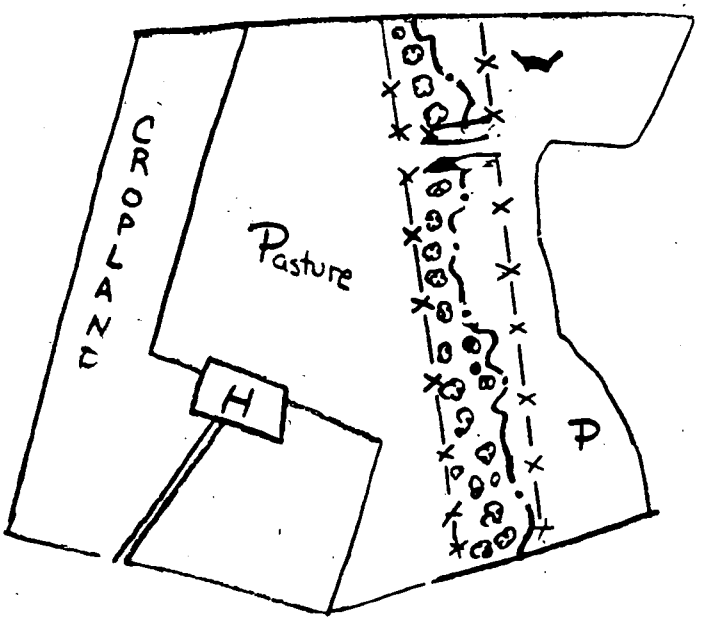
TOTAL COST TO DEVELOPER FOR COMPLIANCE	$25,900.00
* **Total per lot**	$589.00
* **Percentage of Total value**	1%

*** Estimate does not account for lost lots. Consultants suggest that innovative land use approaches such as clustering could reduce this type of loss.

*** Market research has indicated that lot values increase approximately 5% due to proximity to buffer.

Typical Stream Protection System

Practice	Cost
1000 feet of fence	$2600
1 livestock watering trough	2500
Stream Crossing	1200
1 acre forested buffer	400
	$6700



Ag BMP's2600 + 2500 + 1200	=	$6300.00
ACP Cost Share (75%)	=	3500.00
MACS Cost Share (87 1/2%)	=	2012.50
Cost to Producer		$ 787.50
Cost of Forest Buffer		$ 400.00
S.I.P (65%) Cost Share	=	260.00
B.I.P ($300/ac)	=	300.00
Cost to Procucer		-0-

ECONOMIC BENEFITS ASSOCIATED WITH RIPARIAN FOREST BUFFERS

What is the Value of Water Quality and Environmental Benefits?

Clean streams, rivers and the Bay offer many benefits. Riparian forest buffers help ensure those benefits and avoid costs to repair damaged and degraded natural systems. As a Best Management Practice (BMP), riparian forest buffers typically preform these functions for free.

Sediment Trapping - Urban retrofits and stormwater management technology are expensive. Studies indicate that urban stream systems may fail to function if the watershed is at 10% or greater impervious surface, resulting in "blown-out" streams that silt downstream areas and increase flood potential. Riparian forests help retain stream integrity.

- *Stormwater treatment options that integrate natural systems, such as grass swales and bioretention areas- like forest, are less expensive to construct than storm drain systems and provide better environmental results. In fact, costs of engineered stormwater BMPs range from $500 to $10,000 per acre, and will cost that much again over 20-25 years.*

- *After public outcry about degrading streams, Montgomery County, MD is spending $20,000-50,000 per housing lot in some areas to repair damaged streams and restore riparian forests.*

- *In Fairfax County, VA, a local bond issue provided nearly $1.5 million dollars to restore 2 miles of degraded stream and riparian area----that's over $750,000 per mile.*

Nutrient Removal - Adequate buffers can reduce costly water treatment.

- *Riparian forest buffers are a low maintenance and long-term solution. It is estimated that forest buffers can remove 21 lbs of nitrogen per acre each year for $.30 per pound, and about 4 lbs of phosphorus per acre every year for $1.65 a pound.*

- *The Interstate Commission for the Potomac River Basin (ICPRB) estimates that urban retrofit of BMPs to remove 20% of current nutrient runoff will cost approximately $200 per acre, or $643,172,600 for the Bay basin.*

- *In the same study, estimated costs of reducing runoff from highly erodible agricultural land are $130 per acre, or $68,758,430 for the basin.*

- *Wastewater treatment facilities in the Washington DC area have annual costs of $2-$10 million per year per facility, which equates to $3-$5 per pound of nitrogen removed.*

- *Maryland's Tributary Strategies show that, to reach a 40% reduction of nutrients by the year 2000, forest buffers and nonstructural controls are significantly more cost effective than engineered approaches. Where forest buffers are estimated to cost $617,000 and nonstructural shore erosion prevention/control $1.6 million per year, comparable structural techniques could cost $3.7 million to $4.3 million per year.*

Pollution Prevention - Air pollution and deposit of airborne pollutants are a multi billion dollar problem nationally that affects human health, damages vegetation, and reduces visibility. Trapping and filtering atmospheric pollution is a benefit that trees provide, as well as riparian buffers.

- *In 1991, trees in Chicago removed an estimated 17 tons of carbon monoxide, 98 tons of nitrogen dioxide, and 210 tons of ozone.*

- *Reducing air pollution by 20% would cut agriculture losses in half, saving Maryland farmers $20 million.*

- *In Fairfax, Va, open space trees and buffers are estimated to have reduced the cost of traditional air pollution controls by over $4.5 million in 1995.*

- *Energy savings of 10 percent can result by adding as little as 10% tree cover to buffers near buildings.*

- *Forest conservation has been estimated to reduce the amount of urban runoff generated from development in Utah by 17%.*

- *A single mature tree releases about 100 gallons of clean water per day into the atmosphere, and provides the cooling equivalent of nine room air conditioners operating at 8000 Btus per hour for twelve hours a day.*

Stream Temperature - The absence of streamside trees can have a dramatic effect on aquatic life through increased water temperature. Cold water trout streams were once common in the Mid-Atlantic states, but have been greatly reduced due to loss of riparian trees.

- *The relationship between stream shade and trout production has been found to firmly linked. Studies have shown that when stream surface shade is reduced to 35%, trout populations can drop by as much as 85%.*

- *In 1991, Maryland recreational fishers contributed $467 million to the state economy.*

The Value of Services Provided by a Wooded Stream Corridor

Erosion Control - Erosion and sediment control produces significant costs during development and in maintenance to communities down the road. Buffers mitigate some of these costs for free and add quantifyable and non-quantified benefits.

- *Current state and local requirements for erosion and sediment control (ESC) increase the cost of development. On a typical site, costs of ESC average $500-$1500 per cleared acre. Forest conservation, riparian buffers, and clustering sharply reduce ESC costs and provide services for free.*

- *Average costs for subdivision development include - clearing (forest) $4000 per acre; and sediment control $800 per acre. However, forest conservation keeps soil on site resulting in less time and labor re-grading, stabilizing, and re-landscaping the site.*

- *It costs $10-11.5 million annually to dredge and dispose sediments deposited into Baltimore Harbor to keep it navigable. Sediment produced by forest land is the lowest of all land uses.*

Flooding - When floods pass through a forested stream cooridor or floodplain, the roughness of the forest and its lush vegetation help to reduce the energy of the water flow and thereby reduce downstream flooding. Forests reduce the quantity of water for stormwater.

- *Retaining forest area and buffers has reduced stormwater costs in Fairfax County, Va by $57 million.*

- *Observations made after the 1993 floods in the Midwest showed that where forests were retained in the floodplain or where levees had overgrown with trees, damage to the levee system and the river were less than areas maintained in grass or farmland. Although these benefits are difficult to put a price on, property damage exceeded $50,000 - $250,000/mile.*

- *Similar observations of damage to river banks and adjacent farmlands were recorded following floods in Virginia in 1994-95 where statewide damage totaled more than $10 million.*

Increased Property Values - Frequently seen as a "loss," forests and buffers have been found to increase the value of property, as well as providing important environmental and recreation benefits.

- *Property values grow with trees. When surveyed by the Bank of America Mortgage, real estate agents say that homes with treed lots are 20 percent more salable.*

- *In Maryland, the Forest Conservation Act is working. Forest and buffers are being conserved and developers say that they are receiving 10-15% premiums for lots adjacent to forest and buffers.*

- *A recent economic study done for areas in southern California states that home prices increase an average of 17% because of trees and buffers.*

- *Builders in Amherst, Ma reported that added costs of forest retention on site are always recouped in increased sales prices.*

Recreational Greenways - Linear forests along are rivers are an important recreation resource to communities and attract revenue.

- *Housing prices were 32% higher when located next to a greenbelt buffer in Boulder, Colorado. In one neighborhood, increased property value of $5.4 million attributable to the greenway results in additional annual property tax revenues of over $500,000.*

- *Greenways offer business opportunities. Evidence shows that the quality of life of a community is an increasingly important factor in corporate relocation decisions. Greenways are often cited as contributors of quality of life.*

- *According to a 1995 attitude survey, 77% Maryland resident respondents said that it is important to have natural areas close to where they work and live. Almost half said that they would be inclined to move if existing open space in their community were lost.*

Wildlife Habitat - Buffers provide valuable wildlife habitat. Many species use riparian areas at various stages of their life cycles and as travel corridors. Organic matter produced by riparian trees is the foundation of the food web in most stream environments.

- *Each mile of 50 foot buffer on both side of a stream protects 12 acres of habitat along shorelines and creeks.*

- *Tourists and residents place a high premium on wildlife watching. A 1994 report says that nearly 60% of suburban residents actively engage in wildlife viewing near their homes, and are willing to pay premiums for locations in settings that attract wildlife.*

- *In 1989, the Maryland Department of Economic and Employment Development (DEED) estimated that the economic importance of the Chesapeake Bay to be $678 billion to the economies of Maryland and Virginia through commercial fishing, marine trade, tourism, port activities, and land values.*

- *Marylanders spent $270 million observing, feeding, and photographing wildlife in 1991 as reported by the U.S. Fish and Wildlife Service.*

- *The Department of Natural Resources of Maryland reports that $133 million was spent in the 1991-1992 season. Hunting related industries support an estimated 4,600 jobs in the state.*

Creative Financing Techniques for Establishing Riparian Forest Buffers in the Chesapeake Watershed

Elizabeth Hickey, Coordinator
Environmental Finance Center
University of Maryland

("Organization" in this menu refers to either a nonprofit conservation group or a governmental agency.)

Least Binding, Least Cost

- Notification Program

Owners who are made aware of important resources on their properties are often willing to protect them once they learn of their existence or significance. In this program, the organization might notify the property owner with a brief letter describing why the forest buffer and stream bank deserves protection with a follow-up visit to answer questions. Notification can be an important first step in establishing good will with a property owner—and may eventually result in a permanent commitment to protecting a significant resource.

- Recognition Program

A recognition program takes notification one step further by announcing publicly that a property or portion of a property is significant. Similar to the National Natural Landmarks Program, the idea is to play on the pride of the owner, who wants to maintain a respectable standing within the community and may have an inclination for stewardship. By presenting plaques or certificates to owners of significant property, the community as well as the owner gain from the publicity.

- Nonbinding Agreement Programs

A variation on a recognition program might require the property owner to agree, in writing, to protect certain specified features of their property. The owner's obligation to comply is strictly voluntary. The agreements are based on mutual trust, pride of ownership, recognition and appreciation of the resource.

Management Agreements

- Management Agreements

Under a management agreement, a property owner agrees to care for a significant resource on their property in a specified manner for a set period of time, or the owner

lets an organization carry out the management. Sometimes an owner receives compensation for expenses.

- Leases

Leases entitle the lessee to control the use of a property in return for rent, which may be nominal. An organization may lease the property from a property owner for a nominal fee or at market prices. On the other hand, an owner may agree in the lease simply to forgo destructive forestry or other practices that threaten the resource. In a lease-purchase agreement, the rents are applied toward an agreed-upon purchase price.

Financing Arrangements

- Agreements tied to Loans

Home buyers and owners have access, through their banks, to low-interest loans for homes that are built in desired areas and have environmentally sensitive features, such as a smaller footprint, more open space/undisturbed land, retention of forest buffers, etc. An agreement would be developed whereby a State and/or county government would place funds, in the form of the purchase of certificates of deposit, in local banks in exchange for certain criteria in loan agreements. Governments would accept a lower yield (interest rate) on the certificate with the understanding that the bank would pass the rate savings on to the home buyer/owner.

This program could also be designed for the development community as well. Developers would have access, through their banks, to low-interest loans for homes that are built in desired areas and have environmentally sensitive features

- State Revolving Loan Program

The SRF was established through the Water Quality Act of 1987 to replace the U.S. EPA Construction Grants Program for wastewater treatment facilities. The objective of the program is to improve water quality. Grant funds are appropriated by Congress to states, who then make loans to communities. Many states leverage their federal grant and provide state matching funds to increase the amount of money available for loans. Loans to communities are made at or below market interest rates for up to 20 years. Repaid principal and interest are then used for new loans.

An idea is to extend the SRF program to the private sector so that private and public/private partnerships can use and leverage program funds to engage in environmental activities. Projects such as stormwater management, erosion and sediment control, stream restoration, structural shore erosion controls and agricultural runoff control would be considered for loans. SRF loans can be provided for up to 100% of the project costs, including planning, design and construction, to finance

private sector capital projects. The criteria of water quality benefits and the capacity to repay are the most important factors in project qualification.

- Environmental Mini-bonds

Mini-bonds are bonds issued in small denominations (e.g.$500) available for purchase by the general public. Proceeds of mini-bonds could be designated for specific programs or activities, such as stream restoration and forest buffers.

Maryland has issued mini-bonds twice, raising $24.2 million in 1990 and $11.8 million in 1991. Unfortunately, the cost of issuing mini- bonds can be a significant barrier to their use. Typically, the cost of issuance per $1,000 of bond is $6-8. In 1990, the state-issued mini-bonds cost $11.80 per $1,000, and in 1991, the cost was $17.10. These costs include the cost of bond council, charges by rating agencies, and the administrative costs of printing and distributing official statements. Administrative costs are the largest component due to the large number of bond holders. These costs could be potentially reduced by soliciting donations of time and services from bond service departments of banks and bond counsels.

- Stormwater Utilities

A stormwater management utility is a form of a special assessment district. A special assessment district is an independent government entity formed to finance governmental services for a specific geographic area. They can range in size from a city block to a multi-jurisdictional arrangement. Special districts focus the costs of enhanced services on the beneficiaries of those services by separating benefited taxpayers from general taxpayers. Residents of special districts pay taxes (usually in the form of increased tax rates) to finance improvements from which they will benefit.

Special districts have the power to levy taxes, fees and special assessments in order to pay for the debt incurred in developing the service as well as to pay for the ongoing upkeep of the project. Special districts can issue debt independent of state or county government, reducing the burden on general debt capacity.

Easements

- Conservation Easements

◊ Donation
◊ Purchase— *Purchase of Easements or Development Rights*--the purchase of development rights by a local or state government. This necessitates the community assigning "development rights" to all parcels of land, and then purchasing those rights, to be used in designated "receiving" areas, usually in urban or already developed areas. Rights can also be extinguished or held in perpetuity.

◊ Transfer— *Transfer of development rights*--permits property owners in development-restricted areas to sell their development rights to property owners in designated receiving areas. This requires a community to have designated "sending" and "receiving" areas (resource or rural areas and developed or urban areas, respectively). It allows landowners in sending areas to realize the market value of their land without developing it. Developers who purchase these rights can increase their marginal profits by increasing the density of their development.

Acquisition of Land

- Acquisition of Undivided Interests in Land

Purchase of a percentage ownership in a property, which allows for a legal interest in its management.

- Outright Acquisition of Property

◊ Land Banks (Program Open Space and transfer taxes)

◊ Rights of First Refusal—guarantees the organization the opportunity to purchase important properties, but does not obligate it. By granting a right of first refusal, a property owner agrees to notify an organization that the property has been offered for sale and invites the organization to match the offer. This allows the organization to identify prospective buyers and negotiate with the potential new owner protection an agreement to protect the property (using one of the methods discussed here). This right may be donated to an organization of sold for a nominal fee.

◊ Option to purchase—involves paying the landowner for the guarantee that the landowner will reserve a property at an agreed-upon price for a set period of time (typically ninety days to one year).

FOREST LANDS

The following information was developed as part of the forest lands policy team - a subcommittee of the RFB Panel

Implementing RFBs within the context of existing forested land use requires a different starting point than either agricultural or urban land uses. Since the land is already forested, efforts to maintain are more important than efforts to restore. Clear accepted guidelines for management already exist within the stream corridor and are widely practiced by industry and private landowners. The strategy for implementing RFBs in existing forested landscapes is based on the following understandings:

1. Forest management is compatible with maintaining the functions of RFBs. A wide range of managment objectives are appropriate within RFBs, including timber harvesting options. Many landowners will be unable to maintain RFBs without the opportunity to derive income from forest management. In order to assure and to demonstrate this an auditing process should be created which includes implementation and effectiveness monitoring of BMPs.

2. It is essential to the success of a RFB strategy that a favorable climate is created and maintained for continued forest land use ownership. Important to creating this favorable climate will be:

   a. Education of and voluntary compliance by landowners and forest professional with RFB criteria.

   b. Recognition by the general public that the forest use is the most beneficial for water quality and habitat.

   c. Appropriate technical and financial incentives, for at least some forest owners, are critical for RFB retention and restoration.

3. The RFB strategy should rely on and expand as necessary existing educational and assistance programs such as the Forest Stewardship Program, the SFI Sustainable Forestry Initiative, etc.

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RIPARIAN FOREST BUFFER PANEL
U.S. FISH & WILDLIFE OFFICE
FORESTRY ISSUES
13 February 1996

AGENDA

1. INTRODUCTIONS AND ANNOUNCEMENTS

Sandy Saige, Panel Co-Chair, announced that a final report for the Executive Committee is due October 1996. The first draft of the report is due in April, public comments should be in by June and July, the final draft is due to the EC by August and the final report should be completed by early September.

2. WORKGROUP UPDATES

Developed Lands: Sean Davis
The WG met on 31 January in Fairfax, VA. At the meeting, WG members developed an outline which covers the planning, management and assistance of maintaining buffers where they exist and restoring them where they do not. This WG will differentiate between developed and developing lands, as such, there will be two different goals. The outline was distributed to the WG members and they were asked to complete it out and return to Sean Davis The next meeting date has not been determined.

Agricultural lands: Fran Flanigan
The WG met on 6 February in Annapolis, MD. At the meeting, the WG preferred adopting a stream corridor management approach to developing the Policy. The WG also recommended incorporating into the Policy a site specific approach that would allow for flexibility. The outline, developed by the Developed Lands WG, was presented to the Ag WG who felt that 90 percent of the outline would work well for the agricultural recommendations. They were asked to complete the outline and send to Alex Gagnon. The next meeting is scheduled for 1 March.

3. RIPARIAN FOREST BUFFERS ON COMMERCIAL FOREST LANDS

Jonathan Keyes, University of MD Cooperative Extension Service, discussed the issue of riparian forest buffers on commercial forest lands. In commercial forest lands the riparian forest buffers are maintained primarily for sediment and erosion control with secondary benefits of wildlife habitat. There are differences with buffers located in agricultural and urban. The discharge of nutrients in a forested system is relatively minor when compared to the discharges in agricultural and urban setting. Forestry is in its second generation dealing with policies regarding streamside zones, while the agricultural community has never had buffer policies. Forestry applications in buffers zones are regulated more strictly than in agricultural activities. Certain components of the buffer need to be protected during harvesting including soil structure, organic litter layer, vegetative cover and hydrology. Research has shown that it is not the cutting of trees that cause sedimentation but rather the building of logging roads.

BMPs consist of streamside management zone, stream crossings, skid roads, pall roads, landings and log decks and soil stabilization techniques. BMPs in some states are regulatory while other states maintain voluntary compliance. Studies have shown that actual compliance of these controls is not dependent on where they are voluntary or regulatory.

4. STATE PROGRAMS

Pennsylvania - Bob Merrill

Of the 28 million acres of forest land in Pennsylvania, 17 million acres are commercial. Of these 17 million acres, 21 percent is publicly owned by the State of Pennsylvania (i.e., BOF, Game Commission), 5 percent is owned by industry and 74 percent is privately owned. On private lands, PA recommends a 50' forest buffer. PA has sold the concept of riparian forest buffers to loggers by sponsoring Forestry and Conversation Together (FACT) workshops. These are one day workshops for forest operators or anybody else who is going into the forest to withdraw resources (i.e., minerals, oil gas). The workshops specifically cover the development and implementation of soil erosion and sedimentation plans. In addition, PA does have a logger certification program which covers safety, erosion, first aid, silviculture, ecology and maintenance skills.

The regulation of soil erosion and sedimentation plans is the responsibility of the County Conservation District. If there are violations, the County Conservation Districts and the Land and Water Bureau intercedes. On state forest lands, there is a mandatory 200' no-cut zone buffer along Special Protection Waters (i.e., trout streams). While, on High Quality Streams, which includes perennial and some intermittent streams, there is a 100' selection-cut buffer which also requires a crowd cover. Lastly, on most intermittent streams there is a 25-50' selective type-cut zone on state forest managed lands. PA sponsors a Forest Stewardship Program which helps to develop plans for landowners for the management of their land and its resources. In these plans, harvesting recommendations are suggested and guidelines for timber removal are provided. PA provides a guide called Timber Harvesting Issues for municipalities to use if they want to establish a forest ordinance within their jurisdiction.

Virginia - Mike Foreman

VA DOF's number one objective is to improve water quality. To achieve this objective, their goal is to institute a set of standards for conducting activities in an environmentally sound manner within a non-regulatory framework. In 1988, VA DOF adopted specific goals including: reduce sedimentation from silvicultural activities by 40 percent by the year 2000; have pre-harvest plans for 90 percent of the forest products by 1995, implement educational programs for loggers, landowners and foresters and monitor sediment and nutrient loads within select watersheds. Virginia believes that instituting pre-harvest plans will help achieve these other goals. VA DOF has been success in meeting some of these goals, but not all of them. Sediment loads have been reduced by 28-30 percent instead of the desired 40 percent. Only about 50 percent of products have pre-harvest. VA DOF has successfully instituted educational programs such as workshops and training days for loggers. Another success is that within Virginia there are eight watersheds that are being monitored for sediment and nutrient loads.

For every timber tract five acres or more, Virginia conducts two inspections once when the harvesting begins and once when it is finished. These inspections are performed by the Public Works Department and the BOF. Once the inspections are completed the compliance for BMPS is recorded. Of the 2,800 harvested tracts per year in Virginia, roughly 10 percent of those tracts have problems with BMPs. Virginia DOF believes that SMZs are the most important BMP.

Within Virginia there is 50' buffer guidance recommendation, with increased buffer width if it is located adjacent to a trout stream. Partial harvesting is allowed within 50 percent of the crown cover. VA DOF has a Bad Actor Law which allows for recommending corrective action, initiating civil penalties or as a last resort, project shut down if water quality degradation is observed. VA's Chesapeake Bay Act has designated Resource Protection Areas (RPA) within which BMPs are mandatory; while in Resource Management Areas (RMA) BMPs are voluntary.

Maryland - Steve Koehn
The major law that directly impacts riparian forest buffers in Maryland is the Chesapeake Bay Critical Areas Act. This law established a 1,000 Critical Area measured from mean high tide. The first 50' is a no-cut buffer zone except if there is Loblolly pine or Yellow Poplar. The second 50' can be managed, however the thinning cannot reduce basal area below 60 square feet BA. The buffer can be extended landward by the presence of Habitat Protection Area, Natural Heritage Protection Areas, Wetlands of Special State Concern and sensitive features (i.e., steep slopes).

Maryland's Forest Conservation Act requires a Forest Stand Delineation which identifies sensitive retention areas to be avoided in the development process (i.e., 50' riparian forest buffer).

Sediment and Erosion Control Regulations are mandatory in the state of Maryland. A Sediment and Erosion Control Plan is required when harvesting disturbs over 5,000 square feet. There are two types of sediment control plans: standard and custom. The standard has a set of requirements which are dependent on the site conditions. If one cannot meet the conditions of a standard plan, than a custom plan is used. One of the standards under this regulation establishes a no-cut using the 50 + 4 formula. SMZ restrictions include: no equipment, roads, trails or landings within the buffer zone, no tops in the creek, a residual BA of 60 square feet of well distributed growing stock in stems 6" or greater must be maintained, only permitted crossings are allowed and a distributed forest floor must be repaired immediately.

Maryland supports logger training which requires that the logger go through a sediment and erosion control course. They also have a recognition program for superior loggers called the Master Logger program which is funded through Coastal Zone Management Grants and the Maryland Forest Association. Lastly, Maryland is streamlining the permitting process through their TEAM program.

5. PRIVATE SECTOR VIEWPOINT

Stone Container - Denice Tappero
Stone Container's primary focus is writing management plans for landowners. They believe that the Panel needs to be reasonable when asking landowners to leave buffers; as such, their right to derive income from their buffer needs to be preserved. However, most people are easily persuaded to leave buffers because they are not changing the use of the property and eventually money will be derived from the buffer. Stone Container has noticed that landowners are less receptive to maintaining a buffer if there is no scientific reason provided to them for not harvesting the buffer.

Westvaco - Pete Miller
Westcavo is looking to be ahead of the game with research and development that supports water quality improvements. Westvaco supports the Sustainable Forestry Initiative (SFI) which they will continue to follow even if it is no longer embraced nationally. The main difficulty with regulatory programs is their lack of flexibility. The Panel should develop a plan for selective, effective harvesting along riparian areas and standardize the riparian forest buffer protection plans within the Bay states.

Glatfelter - Charles Brown
Glatfelter owns 100,000 acres of timber land in the Bay watershed, about 3/4 of this amount managed for pine species. In addition, they manage 25,000 acres of private land primarily in Pennsylvania. Their objective is to reinforce the notion that timber is a natural resource that can be renewed for economic value today and in the future; thereby managing their base. Two of the most important things Westvaco wants is to maintain flexibility within the buffer and provide economic incentives to the landowner.

Chesapeake - Larry Walton
In 1971, Chesapeake adopted their Environmental Guidelines which is intended to provide for wildlife diversity, timber management, etc. Essentially the BMPs are working and improvements have been seen. There needs to be guidelines for managing riparian forest buffers for economic value and establishing woodlands. The group was cautioned to make sure there was a problem before we intended to act, especially considering that land uses changes undoubtably have greater impacts on buffers than forestry activities. Too many regulations might result in increased incidents of non-compliance because landowners and loggers will be overwhelmed by the laws and will not follow them. Therefore if it is decided that there is a problem than pursue education and training versus regulations.

5. ISSUES FOR STATE FORESTS AND SMALL LANDOWNERS

State Forest Management - Bob Merrill PA Bureau of Forestry
There are two million acres of state forest in Pennsylvania. State forests are managed for timber but also for wildlife, recreation and watershed protection. If after an evaluation a timber area is deemed to be acceptable for harvesting, a proposal for the logging is submitted and examined. Once approved, the site is inspected frequently during the harvesting and the loggers have to follow strict erosion and sediment control provisions to ensure the protection of the resources. When the sale is complete, the area is returned to its original condition. State forest land management is highly supervised and controlled. Pennsylvania does allow selective harvesting in riparian forest zones, with selective harvesting allowed in exceptional value/trout streams. Eighty percent of the states exceptional streams reside in the state forests. Last year, the state of Pennsylvania made 14 million dollars in timber sales and that was cutting half of what the sustainable limit would allow.

6. DISCUSSION GROUPS

1. Riparian Forest Buffers in Forestry Land Use

- because of the nature of forestry activities there is a different starting point than other land uses
    - clear guide lines and recommendations already exist
    - low nutrient and sediment loadings for forests
    - history of implementation by industry
- is the 3-zone system applicable in a forestry setting? Since the land is forested there really is an extended buffer, but still a need to manage carefully adjacent to the stream.
- industry would like recommendations to reflect a positive statement about their role and the benefits of commercial forest land
- focus of the recommendation should be on maintaining and properly managing RFBs and then protecting them when the land use changes

2. Education and Voluntary compliance is important

- Foresters will implement willingly if they are educated and trained
    - ensure that water quality principles are included in training as a reason for implementing buffers
- need stable and continuous effort
- setting goals such as
    - number of loggers trained, workshops held, education sessions
    - tree harvesting/erosion and sedimentation plans
    - compliance audits as a way to measure progress

- educating the public about forest practices is important
- Sustainable Forestry Initiative (SFI) is an important opportunity and may yield good results for streams and the Bay
- focus on what we want to achieve
- include statements in recommendations that increase assurance that forests can manage within RFBs.
- relate the recommendations to current forestry practices, not the past.
- promote responsible management of riparian forest buffers and all the values that entails

3. Enforcement capacity needed

- foresters needed on-site reviews/visits
- voluntary approach backed up by regulations that ensure implementation
- feedback from enforcement to education - what is education program missing
- SFI umbrella has the potential to create a "green market" that will force companies to comply

4. Refine the Program

- learn from previous experience
- flexibility is important including harvest requirements
- need to retain management within the buffer as an option
- need to periodically assess if performance standards are having the desired effect - refine as needed.
- pre-harvest planning for sediment and erosion control is important
- link erosion and sediment control planning to a desired outcome (do not plan for the sake of planning)
- make a distinction between forest harvest and land clearing
- do not use forest management ordinances to control growth and development - use development ordinances
- make state or regional guidelines that maximum limit - prevents local governments from making them more stringent and thus unreasonable
- must have a way to demonstrate the value of forested land ($ and otherwise)

5. Economic Incentives

- look at inheritance taxes
- link buffers on agricultural lands to the forest industry
- look at taxes based on land use - give equity for forested land
- in forestry you must consider a longer time frame than is typical for agriculture - time frame varies with tree species
- when agriculture land is converted to forest buffer, is there a way to offset the loss of regular income from the land
- retain working forest landscapes
    - bureaucratic and regulatory relief
    - need legislative champions
- economic loss can be minimal if RFB is managed appropriately and with flexibility
- reduce/streamline the regulatory environment
- link cost-share money to baseline requirements

AGRICULTURAL LANDS

The following information was developed as part of the agricultural lands policy team - a subcommitttee of the RFB Panel.

Agricultural areas also offer substantial opportunities for the establishment of riparian forest buffers. The promotion of riparian forest buffers should be a part of routine farm conservation planning efforts, and standards for their use should be consistent with a Bay-wide Natural Resource Conservation Service (NRCS) standard.

In addition to Agricultural Policy Team meetings, the Panel sponsored an Agricultural Policy Forum on January 16. At this meeting, various issues regarding riparian forest buffers on agricultural lands were discussed. The Agricultural Policy Team adopted a stream corridor management approach when developing their recommendations, while deciding not to define a stream. The Policy Team also suggested when targeting their objectives that it was more important to target specific watersheds, rather than stream order, thereby maximizing limited money and manpower. The Policy Team supported adopting specific quantitative goals for buffers in agricultural lands. The group proposed establishing goals for restored acres/miles, implementing training courses, providing incentives, establishing watershed teams and improving landowner participation. Farmers and landowners have numerous concerns and questions regarding buffers. Major concerns farmers share about buffers include shading of crops, creating habitat for wildlife (specifically engaged species) which damages crops, obstructing views, reducing acreage available for crops, limiting livestock access to water and maintenance of the buffer. Several common themes emerged from these meetings, including:

- Consolidation of incentives so there is less bureaucracy and paperwork
- Better communication of the value of buffers to farmers and landowners
- Allow for flexibility and site-specific planning
- Communicate the voluntary nature of the Policy
- Stress the economic returns that forested buffers can provide as well as their role in improving water quality

Lloyd Casey, US Forest Service, provided the RFB Panel with a menu of buffer programs and incentives that could be used at the local, state and federal level.

Local Level

- Purchase conservation easements
- Purchase buffer corridors
- Reduce the tax rate on land in a buffer to compensate for the cost of maintaining the buffer
- Delay tax payment on land in a buffer until the harvest of trees grown in that buffer

State Level

- Purchase conservation easements
- Reduce income tax from buffer-related income
- Special license plate program to generate funds
- zone buffers
- Reduce the cost of sport licenses in exchange for buffers
- Reduce or limit the landowner's liability from public use
- State rents the buffer corridor from the landowner, landowner pays the state some percentage of tree harvest revenue.

Federal Level

- Federal tax credit for buffer implementation
- Index for inflation
- No tax on buffer-related income
- Tax imported forest products

The keys to successful implementation are planning on a farm and watershed scale, improving education and coordination of existing programs and offering a variety of incentives. In order to sell these recommendations to the agricultural community, the "package" must allow for flexibility. Flexible, site-specific conservation or stewardship plans will incorporate landowner objectives and a range of practices necessary to achieve healthy and functional streams.

STANDARDS AND GUIDELINES

There may be some need to separate maintaining buffers and restoring them. Characteristics of successful stream corridor management in agricultural areas include:

- Reducing random cattle access to streams and wetlands
- Removing livestock holding areas from stream corridors
- Eliminating cropping activities directly adjacent to streams and shorelines
- Maintaining permanent vegetation, and promoting natural forests within the stream corridor.
- Controlling accelerated channel erosion through use of natural channel approaches

Proper stream corridor management is broadly recommended, and riparian forest buffer activities should receive additional emphasis and targeting in priority watersheds.

- Reduce the conversion of existing riparian forests to agricultural uses.
- Establish or enhance natural forest cover in stream corridors to decrease nutrient losses and improve stream corridor habitat.
- Ensure that a "package" of priority programs are in place to adequately support the efforts to improve.
- Increase landowner participation in stream corridor management.
- Through an interdisciplinary team, define levels of stream corridor management, and establish quality criteria which rank practices by value to stream and riparian health.
- Identify a "model" stream buffer and minimum corridor width.
- Establish a set of "quality criteria" in order to prioritize areas for protection.
- Support the enforcement of existing laws and regulations such as the MD Critical Areas and Forest Conservation Acts and VA Chesapeake Bay Preservation Act.
- Increase the use of riparian corridor easements.

- ✦ Flexible stream corridor and buffer widths related to watershed objectives, site-specific conditions and landowner needs.
- ✦ Identify "levels" of stream corridor protection with appropriate BMP's, and place focus on promoting forested stream corridor.

DEFINITION OF A STREAM

The Policy Team decided not to define a stream in agricultural lands because the individual planner and willing landowner might be receptive to planting riparian forest buffers regardless of whether a particular stream would qualify under an adopted definition.

PLANNING

Planning and implementing a stream corridor management program should take place at both the individual farm level and the watershed scale. Protecting water quality at a site can be accomplished by the various practices described above; however, restoration of degraded conditions and long term success also require looking at the stream in the context of its watershed and considering upstream impacts and the linkages with other farms and properties.

Farm Scale

Utilize existing mechanisms of Conservation Districts and Landowner Assistance

At the farm scale, the concepts of stream corridor management and the promotion of forests as a preferred vegetation have to be a part of routine farm conservation efforts. Assistance provided by NRCS conservationists and District personnel, as well as state and consulting foresters, are the vehicle for this planning action. Conservation Plans should specifically address how to integrate the concept with other farm practices. This will require increasing the priority for these actions within existing conservation programs.

Watershed Scale

Assess Current Watershed Conditions

Summarize existing riparian corridor condition by the type of vegetation and use of the land. Identify the potential natural vegetation for riparian area (recommended natural vegetation). Using existing inventories where possible, identify the location, extent, and type of degraded streams in the watershed. Quantify impacts such as loss of riparian soils, nutrient inputs, thermal impacts, and benefits such as increased herd health, injuries to livestock and fish enhancement.

Prioritize Watersheds for Riparian Corridor Management Activities

Identify key scientific/technical decision criteria such as type, extent, and location of degradation, land use and potential for change, and assess the potential effectiveness of RFB's and other stream corridor practices as tools. In addition, other criteria, such as level of landowner or community interest and participation, should be identified.

GOALS

The Agricultural Policy Team discussed and supported a numeric goal of miles or acres of riparian forest buffer as part of stream corridor management (to be determined as a portion of the overall goal for the Riparian Forest Buffer Directive). The Policy Team suggested that this goal be set based on a combination of the inventory results tempered with the reality of existing programs and some provisions for targeting priority areas identified by a scientific approach. Additional goals are needed related to education, program coordination, incentive programs and research and monitoring.

Programmatic Goals

Establish and implement an ongoing training and education program in each jurisdiction to communicate the importance of riparian forests and stream corridor management, methods of protection and establishment, and resources available to resource professionals and decision makers.

Each jurisdiction will develop and implement mechanisms to increase interagency coordination, implementation, and monitoring of stream corridor management and riparian buffer programs.

Each jurisdiction and federal agency will review, enhance, and update the implementation of a "package" of priority programs and incentives for stream corridor management.

Establish a recognition program which reward the practice of stream corridor management.

NRCS will establish a specific stream corridor management system which includes forest buffers that can be implemented as a component of Farm Conservation Plans.

Establish riparian forest buffer/stream corridor demonstration streams in each of the major tributary watersheds of the Chesapeake Bay.

States will ensure that local governments have the authority to provide preferential property tax treatment for protected or enhanced streamside forest buffers or corridors.

URBAN AND DEVELOPING LAND ISSUES

The following information was developed as part of the developed lands policy team - a subcommittee of the Riparian Forest Buffer Panel.

It is important to recognize that implementation of riparian forest buffers (RFB) in developed and developing areas are different from their implementation in agricultural and forestry settings. First, the changes resulting from impervious cover of buildings, streets, and other infrastructure are permanent and typically result in cumulative changes in the hydrological regime. In contrast, the changes resulting from farming and forestry can be reversed. Second, the per-unit value of developed and developing lands is significantly greater than the per-unit value of farm or forest land.

Ideal RFB conditions are rarely found in developed or developing watersheds due to the stresses associated with development. Accepting this reality and allowing for flexibility and site-specific adaptations will be critical for effective implementation in a developed or developing landscape.

A policy team composed of public and private sector participants identified a variety of issues that should be considered in RFB policy recommendations. These issues include:

1. Flexibility is critical. "One size fits all" approaches, technical or programmatic, must be avoided.
2. Existing federal, state and local stream protection programs are not well coordinated. Some zoning and other means of land use guidance have the effect of preventing RFB implementation or even eliminating existing RFBs.
3. Landowners' key concerns are what size stream must be buffered and how much land will be required for the RFB (definition of "stream" and RFB size requirements).
4. Typically, RFBs receive no credit as Best Management Practices (BMPs), and often their presence restricts the implementation of other BMPs.
5. Costs and potential time delays are key concerns of developers. Developers must weigh an individual site's increased value due to RFB implementation against the loss of revenue when development density must decrease to accommodate those RFBs.
6. It has been questioned whether a working definition of "stream" should be based on science or observation, and there is no commonly accepted set of criteria used across programs to identify or classify streams in the field.
7. It is not clear what criteria should be used to prioritize stream systems or watersheds for RFB implementation.
8. There are varying opinions about what uses are appropriate within RFBs and what level of management is appropriate or needed for RFBs to remain healthy, viable and functioning.
9. There are distinctions between RFB policy recommendations that would be effective and appropriate in an already developed area versus the greater range of opportunities in developing areas. These distinctions need to be identified and the recommendations need to reflect them. What threshold determines that an area qualifies as urban (instead of developing) land?

DEFINITION OF A STREAM

The Policy Team recommends that any program or locality implementing RFBs adopt a clear definition of "stream," thus establishing the bodies of water RFBs are intended to protect. The definition should reflect local conditions and values, be consistent with existing program guidance, and include a description of stream flow characteristics (perennial, intermittent), channel morphology, floodplain area included, and a reference point for delineation (topographical or drainage area mapping system). It should be based on sound science, but it should also be tempered by public acceptability. Furthermore, the definition should allow refinement of delineation through field verification.

It is generally accepted among scientists that the smallest streams (first and second order, or headwater streams) are considered the most important for maintaining good water quality downstream. These low-order drainage areas comprise the largest land area and greatest challenge. Some members of the Policy Team expressed the opinion that a definition should establish a threshold or cutoff point for stream drainage areas in general, and the cutoff should be quantitative for headwater streams. Others believed the definition should be simple and not based on size or extensive mapping, realizing that any definition that is too technical will not work for the average landowner. While Policy Team members agreed that first and second order streams are extremely important, they also agreed that streams in urban areas and larger downstream segments should not be ignored.

Ideally, all programs would use the same definition. However, the Policy Team recognizes that a unified definition is probably not practical, given the number of jurisdictions and agencies that regulate or otherwise address streams with programs having widely varying objectives and already differing definitions. RFB Panel members have agreed that, ideally, the definition of "stream" should be consistent across land uses. The Policy Team also agreed that it is not the Panel's charge to develop a new stream definition for broad use among federal, state and local agencies.

PRINCIPLES

The conservation, restoration and management of RFBs in developed and developing areas present a challenge for any community. To ensure that RFBs are being effectively promoted and managed in the developed and developing landscape, the following principles should be considered in developing the Panel's recommendations:

1. Recognize that first and second order streams are the most important locations for RFBs, but don't ignore urbanized streams and rivers and the wider downstream reaches;
2. Public lands should incorporate RFBs in ways that set an example for private landowners;
3. Promote RFB guidelines that are clear, but allow flexibility for on-site interpretation;
4. Provide guidance documents and training/education programs for various groups among the public to improve knowledge and understanding of RFBs and their importance;
5. Promote better communication between developers, design consultants, resource managers, and local government officials;
6. Encourage conservation and restoration of RFBs by providing appropriate tax and other incentives, such as density compensations, buffer width averaging, and stormwater management (SWM) pollution removal credit;
7. Recommend flexible policies and implementation options to avoid a prescriptive "one size fits

all" type of program; allow each jurisdiction to develop its own approach tailored to be compatible with existing programs;

8. RFB implementation should be targeted to small watersheds by some system of priorities;
9. Embrace the three-zone buffer planning model(U.S. Forest Service) as appropriate for achieving a sustainable forest environment along the stream corridor and protecting stream corridor integrity, at the same time recognizing that such buffers are not always feasible;
10. In order to create a low-maintenance, sustainable system, promote the use of native species, appropriate species diversity, and natural succession while discouraging the use of exotic species and maintaining against the invasion of invasive, nuisance species.

IMPLEMENTATION RECOMMENDATIONS

The key to the success of this policy will be how it is implemented and maintained at the local level. There are practical differences in how an RFB policy can be implemented in existing developed areas versus newly developing areas, For example, the following criteria, entitled *Nuts and Bolts of a Developed Stream Buffer,* were developed by the Center for Watershed Protection:

A RFB should be a minimum total width of 100 feet, including the floodplain.

- ✦ There should be zone-specific goals and restrictions for the outer, middle and streamside zones.
- ✦ A vegetative target should be established based on the pre-development plan community.
- ✦ The middle zone could be expandable to include wetlands, slopes and larger streams.
- ✦ Use clear and measurable criteria to delineate the origin and boundaries of the RFB.
- ✦ The number and conditions for allowing buffer crossings should be limited.
- ✦ The use of RFBs for stormwater runoff treatment should be carefully prescribed.
- ✦ RFB boundaries should be visible and obvious before, during, and after construction.

Other implementation recommendations from this Policy Team are categorized as follows:

GOALS AND OBJECTIVES

- ✦ Conserve and manage RFBs where they already exist.
- ✦ Restore RFBs, as much as is feasible, where they do not exist,
- ✦ Provide flexibility and incentives, rather than more regulations, to landowners and jurisdictions to encourage and promote more RFBs.

EXISTING PROGRAM COORDINATION

- ✦ Encourage the integration of RFB guidelines with those of other land use and resource protection programs.
- ✦ Jurisdictions should prepare or support the preparation of a listing and description of existing federal, state and local regulations and programs that may be used or required as related to RFB implementation; this directory should include such information as cost-share rates, process information, and a contact name, address and telephone number,
- ✦ Support existing state and local laws, regulations and programs that protect RFBs.
- ✦ Examine existing programs and regulations for potential coordination and integration, reassess their criteria and requirements to eliminate unintended conflict with one another.

PUBLIC EDUCATION AND TECHNICAL GUIDANCE

General

- Promote RFB education and monitoring programs that protect buffer integrity.
- State and federal natural resource agencies should consider stimulating the creation of statewide or regional citizen-based organizations to provide information, training and direct assistance to their communities regarding RFBs.
- Promote the establishment of RFB vegetation according to a hierarchy of vegetation types, recognizing that trees provide more diverse functions and benefits than shrubs, and shrubs more than herbaceous plants such as grass.
- Natural resource agencies and organizations should develop and distribute fact sheets, videos, posters, etc., to assist in education/outreach efforts.
- Appropriate staff of natural resource agencies should be cross-trained to be prepared to advise property owners and work together to provide assistance.

Developed Lands

- Educate citizens regarding the benefits of RFBs, and encourage their participation in stream restoration and clean-up events, watershed organizations, etc.
- Promote citizen participation in RFB conservation and maintenance and in stream monitoring and clean-up efforts (e.g., walk-your-watershed, adopt-a-stream, and citizen monitoring programs).
- Work with organizations and associations in each jurisdiction to develop linear recreational sites as living laboratories and urban RFB demonstration sites.

Developing Lands

- Promote RFB guidelines that are clear, but allow for site-specific consideration for application.
- Reference existing program directory - mentioned above under "Existing Program Coordination."
- Encourage developers, planners, design consultants, and local governments to communicate more effectively with one another during the development process to arrive at plans that achieve the developers' goals while conserving RFBs.

INCENTIVES

General

- Allow flexibility for expansion, contraction and averaging with respect to buffer width criteria to account for steepness of slope, drainage patterns, floodplains, shoreline erosion and accretion trends, limited lot size, etc.
- Provide for flexible uses within RFBs, including freedom to harvest timber for firewood or even commercial sales, consistent with state forestry agency criteria ensuring a sustainable forest environment (e.g., Virginia allows the removal of 50 percent of the basal area within a "streamside management zone").
- Promote tax credits, exemptions, preferential assessments, and other tax incentives to encourage landowners to conserve existing buffers or create them where they do not exist.
- Promote a unified and streamlined development plan and permit review process.
- Promote tax credits, exemptions, preferential assessments, and other tax incentives to

encourage landowners to conserve existing buffers or create them where they do not exist.

- ✦ Encourage property owners to establish RFB conservation easements.
- ✦ Establish watershed-wide or state-specific banks to ensure that appropriate and inexpensive riparian tree seedlings are readily available at a reasonable cost to landowners, and provide opportunities for private support of such banks.

Developed Lands

- ✦ Target limited RFB restoration funds to priority watersheds, to be chosen by each jurisdiction.
- ✦ Establish small grant programs that will provide seed money to local watershed groups and community organizations to develop and implement RFB restoration activities.

Developing Lands

- ✦ Promote RFBs as low-maintenance stormwater management BMPs or as a part of a BMP system that incorporates stormwater management ponds and wetlands within the buffer to allow treatment of runoff from the greatest possible area and to make construction easier and less expensive; allow the pollution removal effectiveness of buffers to be credited in stormwater management plans and calculations.
- ✦ Provide for development density compensation where buffers are required or proposed, so that a developer can establish the same number of lots on the parcel outside the RFB that he or she would be allowed to establish on the entire parcel if there were no RFBs.
- ✦ Consider the institution of Transfer-of-Development-Rights (TDR) and Purchase-of Development-Rights (PDR) programs

LAND USE PLANING

- ✦ States, planning districts and local jurisdictions need to work together to identify stream networks and watershed boundaries and inventory where RFBs exist and where they do not.
- ✦ Local governments should evaluate local stream systems, determine relative levels of stress on them, identify existing and preferred uses, and determine appropriate levels of protection that might be provided by RFBs.
- ✦ Local comprehensive planning activities should be linked with regional or watershed-wide SWM planning to assist in understanding the potential effects on the stream system and other natural resource of various build-out scenarios, and to help with planning to mitigate the negative effects; RFBs may be among the various mitigation practices.
- ✦ Promote guidance to localities that incorporates RFB retention (conservation) and design among development planning considerations.
- ✦ Incorporate RFBs into the design of stormwater management (SWM practices such as ponds and wetlands).
- ✦ Reforest previously disturbed areas that are utilized and, perhaps, abandoned (e.g., vacant lots, brown fields, etc.).
- ✦ Restore RFBs along open streams on public lands, such as parks, and other open lands with the participation of willing landowners, linking RFBs to public recreational uses wherever feasible.
- ✦ Promote a unified and streamlined development plan and permit review process.

FEDERAL LANDS FORUM

Federal Lands are diverse:

✦Public recreationals lands ✦ Restricted-use lands ✦ historical sites ✦National Monuments ✦Floodways ✦ Open space

Federal Agency missions are diverse:

✦ Manage public forests and parks ✦Military defense and training ✦ Research and refuge lands ✦ Tecnical landowner assistance programs ✦ Grant providers

The following proposed actions were discussed and endorsed by federal agencies.

Public Land Management

1. Federal land managers will review current practices and policies related to stream corridor and riparian buffer management and develop specific plans and goals for riparian forest buffer protection and restoration on those lands.

2. Federal land managers will ensure, that all land uses, including agricutlural, silvicultural or commercial leases on public lands will implement practices which promote, protect and where feasible restore riparian forest buffers and stream corridors.

3. Develop plans for federal land management which reduce unnecessary mowing, manage leases, prevent wildlife damage, encroachment and disturbance of riparian buffers in order to enhance forest growth.

4. Provide opportunities on federal lands for the establishment of demonstration and research sites for riparian forest buffer establishment, function, maintenance and management.

Assistance, Education, and Research

5. By 1997, complete an assessment of federal cost-share and incentive program accomplishments, barriers, and recommendations for targeting, modification and use in promoting riparian forest buffer establishment and stream corridor management.

6. By 1998, Federal agencies which provide landowner assistance within the Chesapeake Bay watershed will develop a strategy for enhanced outreach and implementation of riparian forest buffers on private and public lands.

7. Federal Agencies will provide technical assistance and training in cooperation with the states to increase stream restoration activities and riparian forest buffer establishment of private lands.

8. Establish and implement an education and training program for federal land managers on watershed assessment, stream corridor management, and riparian forest buffer protection and establishment.

POTENTIAL ACTIONS

The following menu of actions includes all items that were suggested during Panel meetings and land use Policy Team discussions. They are presented as recorded without significant editing or assessment of feasibility.

AGRICULTURAL LANDS ACTIONS

Increase Awareness and Recognition of Stream Corridor Management

✦ Utilize "Master Farmer" peer programs to educate landowners and create demonstration farms to illustrate proper stream corridor management.

✦ Utilize non-profit groups to assist in door-to-door contacts and bring landowners together in individual watershed meetings or efforts.

✦ Establish forested stream corridor management demonstration sites at research sites conducting agriculture "Field Day" programs and incorporate them into education programs.

✦ Establish a farmer recognition program to reward and recognize farmers practicing proper stream corridor management.

Education/Training for Resource Professionals and Farm Assistance Personnel

✦ Provide training to agency staffs and field resource professionals so that they can explain stream corridor management needs and the benefits of riparian forest buffers.

✦ Develop educational materials and tools such as videos, posters, fact sheets, displays, and brochures to assist in education efforts.

✦ Establish several riparian forest buffer/stream corridor demonstration streams in each of the major tributary watersheds in each jurisdiction.

Enhance Existing Programs

✦ Designate interagency state "Riparian Teams" charged with coordinating and monitoring the implementation of statewide stream corridor enhancement.

✦ Increase the level of field personnel commitments of federal and state conservation agencies based on watershed-based planning for stream corridor management.

✦ Increase the capacity of public and private partners to facilitate restoration efforts by establishing a small grants program for outreach and education to farmers and coordination of restoration projects.

✦ Increase priority placed on stream corridor management in existing conservation programs.

✦ Establish a specific stream corridor management component in Farm Conservation Plans.

✦ Ensure that existing agricultural cost-share programs support a wide range of stream corridor management practices including planting trees and shrubs, greater use of temporary/portable fencing for pasture livestock management, and development of off-stream water development.

✦ Ensure that periodic maintenance, weed control, and selective harvest in the forested buffer is allowable where it is does not affect or is beneficial to buffer function, growth and health.

✦ Provide increased resources for development of Soil and Water Quality Conservation Plans on farms in the watershed.

✦ Encourage farmland preservation and other land conservation easements to include conditions for stream corridor management in easements and extra compensation for riparian forest buffer establishment.

✦ Pool multiple agency resources at the state level to establish a stream corridor management incentive program and relax rules on piggy-backing RFB programs.
✦ Establishment of a streamlined permit processes at the state and local level applicable to landowners who implement a complete stream corridor management approach including establishment of riparian forest buffers.

Provide Adequate Incentives
✦ Establish a unique package of programs and incentives for stream corridor management.
✦ Provide preferential property tax treatment for protection or establishment of proper stream corridor management with priority for forested buffers.
✦ Create a flexible tax credit system based on % of forested stream corridor completed and adjust the credit by width.
✦ Develop and establish mechanisms for conversion of CRP or other temporary stream corridor protection to permanent easements through a bonus payment or other means.
✦ Establish variable cost share rates in existing conservation programs that give preferred consideration and added incentive for riparian forest buffers (100% for forest, bonus payments, etc.) or in priority watersheds.
✦ Ensure that riparian forest buffers are given highest priority consideration in CRP offerings.
✦ Allocate a minimum fixed portion of state agricultural cost share programs for stream corridor management activities to increase interest and local delivery.
✦ Establish a watershed-wide or state-specific private seedling bank to ensure that appropriate and inexpensive riparian tree seedlings are readily available to landowners and conservation districts and provide opportunities for private support.
✦ Modify existing cost-share programs to allow use of funds for maintenance of riparian forest buffer plantings for a minimum of 3 years.
✦ Increase cost share support for BMP's and practices that support forested stream corridor establishment such as polywire fencing, off-stream watering, etc.
✦ Initiate a Bay-wide legislative effort to target funds to forested stream corridor management efforts.

Research/Technical Support Needed for Implementation
✦ Develop a simplified computer model useful in the field to generate buffer widths, management info, and determine costs and benefits of stream corridor and forest buffers maintenance or establishment.
✦ Establish a tracking system which utilizes existing federal, state, and local institutions to identify and report stream corridor and forested buffer accomplishments.

FOREST LAND ACTIONS

Education and Voluntary Compliance
✦ Keep current programs voluntary.
✦ Reinforce the message that forested buffers are the best land use for water quality using all technical agencies with State Forestry Agencies and Forest Industry taking the lead.
✦ Utilize the recently enacted Industry Sustainable Forestry Initiative to further develop this issue.
✦ Management within the forested stream corridor is essential to program success.

Enforcement Capacity

✦ Continue in Maryland and Virginia and begin in Pennsylvania a site auditing process to examine and track progress.

✦ Recommend no new regulations by localities or more stringent than the States'.

✦ Do not use forest management ordinances to control growth and development.

Incentives

✦ Develop a tax structure that rewards the landowner for keeping the stream corridor in forest. Suggest a "no tax" zone for the stream corridor. Another suggestion would be to offer "tax credits" for forested stream corridors.

✦ Offer a targeted and liberal cost-share program designed to increase the width and length of forested stream corridors.

✦ Propose a uniform inheritance system that discourages the break-up of property in order to ease financial burden.

URBAN AND DEVELOPING LANDS ACTIONS

Developed Lands Guidance

Increase Awareness and Recognition of Stream Corridor Management

✦ Develop stream corridor management demonstration sites specific to the urban landscape.

✦ Target churches, local governments, neighborhood and civic organizations, schools for stream cleans ups/stream corridor education/forest buffer plantings.

✦ Work with local governments to develop solutions.

Education/Training for Resource Professionals and Property Owners

✦ Provide training to agency staffs and field resource professionals so they are better able to communicate the importance of stream corridors to the public.

✦ Develop fact sheets, videos, posters, etc. to assist in education/outreach efforts.

Financial Incentives

✦ Research grants available from government, state, and non-profit organizations.

✦ Provide incentives to landowners willing to maintain their forest buffer.

✦ Recommend small grant program that will provide seed money to local watershed groups and community organizations to develop and implement restoration activities .

Coordination and Targeting of Existing Departments and Programs

✦ Continue to support existing federal, state and local buffer regulations.

✦ Encourage coordination of federal, state and local programs and policies.

✦ Promote buffer averaging - allows flexibility to identify areas to build out.

Other Ideas

✦ Tax incentives - offered by state or local governments to riparian landowners to protect and enhance stream corridors.

✦ Tax exemptions - offered to landowners who retain stream corridor for established period of time.

✦ Preferential Assessment - land would be assessed at a current open space value and a reduced tax pressure than highest and best use level.

Developing Lands Guidance

Increase Awareness and Recognition of Stream Corridor Management

✦ Develop stream corridor management demonstration sites specific to developing areas.
✦ Provide educational outreach to school groups, civic organizations, local governments.
✦ Coordinate approaches with local governments.

Education/Training for Resource Professional and Property Owners

✦ Provide training to agency staffs and field resource professionals so they are better able communicate the importance of stream corridors.
✦ Develop fact sheets, videos, posters, etc. to assist in education/outreach efforts.

Financial Incentives

✦ Provide preferential property tax treatment for protection or establishment of proper stream corridor management with priority for forested buffers.
✦ TDR programs to focus growth and development in planned areas that provide resource protection.
✦ Create a flexible tax credit system based on % of forested stream corridor completed and adjust the credit by width.
✦ Establish a watershed-wide or state-specific private seedling bank to ensure that appropriate and inexpensive riparian tree seedlings are readily available to landowners and provide opportunities for private support.
✦ Initiate a Bay-wide legislative effort to target funds to forested stream corridor management efforts.
✦ Provide BMP "credits" for buffer flexibility.

Coordination and Targeting of Existing Departments and Programs

✦ Strongly encourage developers, planners, landscape architects, and stormwater managers to communicate more effectively with one another in the development process.
✦ Review existing regulations and polices for effectiveness.
✦ Allow flexible width approaches, such as standard width associated with stream order.

1-3	100'
4-5	150'

✦ Promote stream corridor and RFB considerations in comprehensive planning. Prioritize stream order and habitat (trout streams, oyster beds).

SECTION 7:
STAKEHOLDER COMMENTS

PUBLIC INVOLVEMENT

At the outset, both the RFB Panel and the Alliance for the Chesapeake Bay have been totally committed to an open and public process. The Panel did not meet or deliberate in secret and meeting dates, times and locations were available to anyone who asked. In addition, meeting dates were included with the interim report and were occasionally printed in the Bay Journal. At times towards the end of the process I was instructed by the Panel not to distribute the current draft of the report. However even this was not to be secretive. Instead it was only because the entire Panel had not had the opportunity to agree that the draft accurately reflected comments and meeting discussions.

One early P.R. piece was the white paper that was written by Karl Blankenship and Al Todd. The white paper attempted to get the Lowrance report and other sources into a form that could be digested by the general public. This was, and still is, being distributed widely. Also, Karl repeatedly published articles about RFBs and the Panel's deliberations and reports. The Bay Journal mailing list is 30,000+ and covers the entire Bay watershed and beyond. The Alliance for the Chesapeake Bay received a good number of requests for information from people who had read articles in the Bay Journal.

Later in 1995 a large mailing was sent out which included the interim report and the white paper. A memo was included with this mailing which offered a speaker from the Panel, additional copies of the white paper, the opportunity to get on a mailing list for information about future Panel meetings, and more detailed information about RFBs.

The mailing lists used for this distribution were complied from ACB databases of stakeholder groups and individuals as well as lists and individuals contributed by Panel and Technical Team members. The mailing went to a broad range of people and organizations such as SCDs, Trib Teams, river groups, CBP committees, trade associations (i.e., farm bureau, etc) and more. In addition Bay Journal carried a series of stories about the Panel and its work including contracts for information. The Delmarva Farmer newspaper also carried a story.

In addition to requests received through the response form mentioned above, ACB and Panel members worked to coordinate meetings where representatives of the Panel could present the Panel's work. Over 20 meetings were held where Panel or Technical Team members of staff spoke about the Panel's work. Panel members may have spoken to other meetings, formally or informally, which were not reported. Some organizations which were contacted could not schedule a speaker but printed articles in their newsletter/journal or distributed (and instructions for comment) at their meetings. Audiences for these meetings covered a wide range of interests, from river groups to trade associations to government bodies. General oral comments from these meetings were noted by the speakers. Speakers notes were made available to all speakers.

It should also be noted that written comments were always encouraged because they increased our ability to accurately portray the comments. All written comments (and speakers' notes of oral

comments) were kept by ACB. Each was summarized into a matrix and categorized into general, technical and policy issues. These summaries of comments were repeatedly sent or distributed to the Panel and Technical Team members to be reflected in the drafts of the report. In sum there were over 60 sets of comments from individuals and groups. All written comments are available for anyone to view.

ACB served as the point-of-contact for the Panel and often fielded phone calls and provided information about the Panel and its work. The following pages contain a matrix of written comments received during the Panel Outreach process.

COMMENTORS ON POLICY DRAFT

RFB PANEL AND TECHNICAL TEAM

Bill Bostian, *The Natural Conservancy*
Ian Hardie, *University of Maryland/STAC*
Tom Simpson, *MD Department of Agriculture/University of Maryland*
Jeri Berc, *USDA Natural Resources Conservation Service (MD)*
Royden Powell, *MD Department of Agriculture*
Paul Swartz, *Susquehanna River Basin Commission*
Sandy Sage, *Bigelow Laboratory*
Ann Swanson, *Chesapeake Bay Commission*
David Brubaker, *PennAg Industries*
Sean Davis, *LDR International*
Ron Hedlund, *VA Department of Conservation and Recreation*
Mike Eckert, *MD Farm Bureau*
Bill Adams, *PA Farm Bureau*
Bob Tjaden, *MD Cooperative Extension Service*
Patty Engler, *Natural Resources Sonservation Service (MD)*
John Lipman, *Chesapeake Bay Commission*

PRIVATE

Franklin Hall, *Hallwood Enterprises*
John Blake, *MD Forests Boards and Fredrick County Forest Conservancy*
Wayne Barfield, *Westvaco*

TRIBUTARY STRATEGY TEAMS

Patapsoc/Back River Tributary Team
Upper Potomac Tributary Team
Middle Potomac Tributary Team
Patuxent River Commission
Lower Eastern Shore Tributary Team

FARM BUREAU

VA Farm Bureau Forestry Committee
VA Farm Bureau President
MD Farm Bureau
PA Farm Bureau
PA Farm Bureau NER Advisory Committee

CONSERVATION GROUPS/ADVISORY COMMITTEES

Trout Unlimited, PA
Izaak Walton League, VA
Friends of the North Fork Shenandoah, VA
Coastal and Watershed Resources Advisory Committee

Save Our Streams, MD
MD State Water Quality Advisory Committee

AGENCIES/GOVERNMENT

Judy Okay, *VA Department of Forestry*
Jim Cox, *VA Department of Conservation and Recreation*
Y.D. Hance, *Calvret County Soil Conservation District (MD)*
Board of Supervisors, *Washington County Soil Conservation District (MD)*
Garrett County Soil Conservatin District (MD)
Executive Board, *VA Association of Soil & Water Conservation Districts*
MD Association of Soil Conservation Districts
Soil Conservation Committee, MD Assoc. of Soil Conservation Districts
David Welsch, US Forest Service
Jeffrey Mahood, *USDA Natural Resurces Conservation Service, PA*
Elmer Dengler, *USDA Natural Resources Conservation Service, MD*
Robert Whitescaver, *USDA Natural Reources Conservation Service, VA*
Ken Carter, *USDA Natural Reources Conservation Service, VA*
Bruce Nichols, *USDA Natural Resources Conservation Service*
George Lechilder, *Montrgomery County Soil Conservation District, MD*
Joan Kean, *Somerset County Dept. of Technical & Community Services*
Dept. of Environmental Protection & Resources Mngt, Baltimore County
Ron Tibbott, *PA Fish & Boat Commission*
Robert Heidecker, *USDA Natural Resources Conservation Service, PA*
Wicomico County Soil Cosnervation District (MD)
Cindy Tibbott, *PA Field Office, US Fish & Wildlife Service*
Larry Land, *Director, Policy Development, VA Association of Counties*
Claudia Jones & Greg Schaner, *MD Chesapeake Bay Critical Areas Com.*
Ronald Schabel, *US Department of Agriculture*

INDIVIDUAL CITIZENS

Roger Waldman
Charles Conklin
Bea Dewing
Barbara Taylor-Suit
Ajax Eastman
Steele Philips
Frank Lucas
Guy Steucek, Millersville University
John Clark Barber

CHESAPEAKE BAY PROGRAM ADVISORY COMMITTEES

Local Government Adivsory Committee
Citizen Advisory Committee
Scientific and Technical Advisory Committee

RIPARIAN FOREST BUFFER PANEL
PUBLIC COMMENT MATRIX

COMMENTORS	C	W	O	GENERAL COMMENTS	TECHNICAL COMMENTS	ISSUE COMMENTS
Bill Bostian The Nature Conservancy	R	X		✦ supportive of recommendations ✦ excellent effort	✦ editorial comments ✦ recommends additional goal change ✦ move up some time lines ✦ incorporate Trib Teams as coordinating committees	✦ clarify focus on natural streams and specify focus is not on ditches
Friends of the North Fork Shenandoah	A	X	X	✦ supportive ✦ additional comments will be sent	✦ increase focus on economic uses of RFBs	✦ make delivery of programs and buffer practices simple to gain acceptance ✦ keep flexibility and allow alternatives to RFBs ✦ recognize need to address specific needs of cattle farmers
Franklin Hall Hallwood Enterprises	P	X		✦ look more closely at industry and urban areas, not farmers ✦ not supportive ✦ 90% of goals can be reached along shorelines of the Bay, not in the watershed ✦ not the best technology	✦ none	✦ voluntary approaches are only a precursor to mandatory regulations ✦ regulations place too much burden on private landowners
Westvaco	P	X		✦ very supportive ✦ liked focus on voluntary approach, tax strategies, incentives and streamling programs	✦ desirability of a minimum width vs. site flexibility which considers land use ✦ is a 3-zone concept too complex to implement - may want a simpler approach	✦ none
Patapsco Tributary Strategy Team	T	X	X	✦ need to acknowledge existing laws in MD and reduce overlap or confusion ✦ agriculture is disproportionately targeted ✦ increase recognition of opportunities for federal land RFB restoration	✦ better define intermittent streams ✦ concern about desired width not matching inventory	✦ availability of funding and incentives to implement - will it be available
Patuxent River Commission Tributary Strategy Team	T	X		✦ need to acknowledge existing laws in MD and reduce overlap or confusion ✦ agriculture is disaproportionalely targeted ✦ increase recognition of opportunities for federal land RFB restoration	✦ better define intermittent streams ✦ concern about desired width not matching inventory	✦ availability of funding and incentives to implement - will it be avaible
VA Farm Bureau Forestry Committee	F		X	✦ cautiously optimistic ✦ support voluntary and flexible approach	✦ none	✦ concern that voluntary approach may lead to regulation

R = Riparian Forest Buffer Panel & Technical Team Member
G = Agencies/Government
C = Affiliation of Commentors

P = Private
T = Tributary Strategy Teams
W = provided written comments

F = Farm Bureau
I = Individual Citizens
O = provided oral comments

C = Chesapeake Bay Program Advisory Committees
A = Conservation Groups/Advisory Committees

COMMENTORS	C	W	O	GENERAL COMMENTS	TECHNICAL COMMENTS	ISSUE COMMENTS
VA Farm Bureau President	F	X		✦ not supportive ✦ provide only broad guidance ✦ appreciate involvement in process	✦ RFBs should not be favored above all others ✦ ensure flexibility to allow application to diversity of VA landscapes ✦ need better information to deal with wildlife damage to agricultural lands ✦ goals should not be measured in miles or acres	✦ fear of future regulations ✦ need assurance that additional incentives will be in place
MD Farm Bureau	F	X	X	✦ have concerns about goals and applicability to small streams ✦ change structure of goals and definitions to match NRCS Riparian Buffer Standard	✦ editorial comments ✦ delete intermittent from stream definition ✦ remove 75' desired width and allow flexible width based on site conditions ✦ remove 60% from retention goals ✦ replace guidance with NRCS technical standard references ✦ apply goals to targeted priority watersheds	✦ delete all quantitative goals which specifically focus on forested buffers and replace with goals that reflect a general multiple BMP approach ✦ do not preclude non-forest vegetative buffers where forests are not practical ✦ report should recognize and not infringe upon private property rights ✦ do not increase focus on agricultural incentive programs on RFBs - competition for incentive dollars
PA Farm Bureau NER Advisory Committee	F		X	✦ positive toward approach being taken by Panel ✦ interested in information on buffer functions ✦ don't try to move too fast - new ideas require time to take hold	✦ RFBs need to be presented in the context of farm management ✦ stream maintenance issues including gravel bars - groups needed clarification ✦ groundwater issues - groups need clarification about differences between groundwater and surface water movement	✦ need to explain RFBs in simple terms with an emphasis on benefits to the landowner ✦ concern that "voluntary" programs are the first step toward regulatory programs
Ian Hardie, University of Maryland, STAC, Panel Member	R	X		✦ supportive	✦ restoration of buffers should be prioritized based on cost effectiveness and the potential for water quality and stream benefits ✦ need for detailed analysis to quantify costs and potential benefits	✦ none
Tom Simpson University of MD/Maryland Department of Agriculture	R	X		✦ well written report ✦ too many sub-goals and actions ✦ need to re-emphasize voluntary approach and landowner role	✦ describe additional scientific and technical information needs ✦ clarify application to ditches and on-farm drainage ✦ specific width recommendations are problematic - supports lower minimum but need for more than 75' in other cases ✦ too many sub-objectives confusion in implementation strategy ✦ editorial comments	✦ reassess goals 2 and 3 ✦ relationship of Panel report and recommended action and EC directive or Governor's Executive Orders ✦ need to ensure financial incentives are available
Judy Okay VA Department of Forestry	G	X		✦ supportive	✦ editorial comments	✦ none

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Bob Tjaden MD Cooperative Panel Members	G	X		✦ supportive	✦ editorial comments ✦ need to move away from specific width *recommendations* ✦ do not rely on NRCS technical standard as a recommendation - it is not currently accepted in states and is inadequate for many situations ✦ allow variety of standards to be references ✦ strengthen connection of stormwater with urban aspects of RFB	✦ none
Y. D. Hance Calvert SCD, MD	G	X		✦ none	✦ narrow widths and steep banks create erosion problems ✦ proper maintenance is essential to protect stream buffers	✦ should add section dealing with "management and maintenance of riparian corridor"
Jeffrey Mahood NRCS- PA	G	X		✦ definitions should be changes to make with site specific (suggestions included) ✦ landowner economics is critical	✦ cost-share money should not be siphoned off of existing programs ✦ is proposed policy meant to include RFBs around wetlands? ✦ where temperature is primary goal, RFBs should be especially encouraged	✦ add section on importance of recreational value of buffers, especially in urbanizing areas ✦ RFBs should be a component of a treatment system - they can't replace upland treatment and will be more effective if upland controls are in place
Elmer Dengler NRCS- MD	G	X		✦ none	✦ editorial comments	✦ none
Jeri Berc MD State Conservationist NRCS - Panel Member	G	X		✦ favors "ecosystem flexible" approach based on ecology, economics and site factors ✦ remove 75' width and replace with language allowing for site-specific adjustments	✦ editorial comments ✦ remove 60% from conservation goal ✦ change "native species" reference - don't exclude non-native but encourage natives ✦ suggested re-wording for restoration goal to focus on priority areas	✦ none
Dave Welsch U.S. Forest Service	G	X		✦ supports emphasis on "sound science' ✦ supports 75' minimum width	✦ prohibit grazing in buffer ✦ if NRCS standard is recommended if should say "minimum width of 75'" ✦ recommends using technical specifications from Lowrance study	✦ concern about the ter "stakeholders' since it seems to apply to selected interest groups rather than all citizens ✦ if an interdisciplinary coordinating committee is created, it should be a new committee not NRCS Tech Committee
Robert Whitescaver NRCS - Verona, VA	G	X		✦ "Headwaters Conservation Partnership" says they are excited about draft report - timely, needed, ambitious ✦ RFBs will be main thrust of Shenandoah segment of Potomac Trib Strategy	✦ include wetlands in definition of riparian area ✦ don't limit to native species - first priority but not the only good plant material	✦ will be glad to share information on incentives and the 31 newly planted sites in their district

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Ken Carter VA State Conservationist NRCS	G	X		✦ report seems to be moving in the direction of removing flexibility ✦ 75% goal seems unrealistic	✦ need to document stream miles currently protected, in need of protection, etc. ✦ 3-zone description not adequate for technical purposes ✦ RFBs should be presented as a tool in the toolbox	✦ need more technical information on implementation, flexibility, site specific decisions and how to combine with other management practices
Trout Unlimited, PA	A		X	✦ supportive of need for forest buffers ✦ *sensitive to concerns of landowners in* agricultural areas	✦ none	✦ need an effective tax structure for setting aside buffers ✦ focus on stream corridors and watershed-based planning
Izaak Walton League, VA	A		X	✦ there is a lack of support at the local level for recommendation like these ✦ this audience very supportive but frustrated with perceived lack of local support	✦ use SWCD's as source of information at local level ✦ local engineers and VdoT people need to be educated ✦ flood plain functions and storm/flood events poorly understood	✦ need education for local planners, engineers and supervisors ✦ need incentives for farmers ✦ need to relate buffers to economists, especially in connection to stormwater management
Middle Potomac Tributary Strategy Team Bill Magette	T	X		✦ raised series of questions about the draft - asked Eric Schwaab to respond at their meeting ✦ agree that forest buffers provide ecological benefits	✦ incentives need to be in place at beginning of effort, not in the year 2000 ✦ *forest buffers may not be as beneficial to* farmers as grass because of maintenance issues	✦ report appears to discount value of grass buffers ✦ *want more information and discussion on* economics of forest buffers on agricultural land
Local Government Advisory Committee Tony Redman	T	X		✦ recommendations should be consistent with LGAC'S work on Local Government Partnership directive ✦ written comments will be sent	✦ width standards may undermine local ordinances - either do not set one or set an ambitious one	✦ better define role for local governments by listing specific actions
Upper Potomac Tributary Strategy Team	T		X	✦ not supportive ✦ concerned about first and second order streams	✦ buffer widths are too wide and would eliminate mush farmland in western Maryland ✦ prefer non-forest buffer types for agricultural land ✦ *remove 25' no-cut zone for forested land* - fear of regulation	✦ tax breaks and easement programs are the best way to encourage buffer use ✦ feel that current programs are insufficient

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Royden Powell MD Dept. of Agriculture Panel	T	X			✦ eliminate definition of stream because it conflicts with the ongoing inventory - as a result we won't know the current status of *RFBs as defined by the Panel* ✦ the science shows most nutrient removal is in first 15 m, so 75' width requirement is not essential - use of a site-specific system which as NRCS standards is more acceptable and may result in 75' or more of the width anyway ✦ RFB width is not currently being tracked by agriculture agencies ✦ the amount of farmland required for 75' RFBs is cost-prohibitive ✦ existing cost-share (BIP) programs provide incentives for RFBs with width less than 75'	✦ retain prominently the intent to achieve water quality and stream protection goals in the context of stream corridor management systems ✦ the *recommendations are unacceptable unless* they provide flexible, site-specific, and cost-effective mechanisms to protect streams ✦ whever possible make use of existing mechanisms for implementation ✦ any implementation oversight committee should include private interests
VA Association of Soil & Water Conservation Districts Executive Board	G		X	✦ RFBs not just a panacea - should be considered just one of many BMPs. ✦ not supportive of basin-wide numeric goals- should be set locally or by watershed ✦ lots of issues and concerns raised by group but in a polite and reasonable way	✦ need to be able to manage buffer areas for insects, animal damage, etc. ✦ need to assure that scientific data is Virginia-specific so we will know what to expect from RFBs in VA ✦ shoreline erosion problems sometimes will require removal of trees ✦ need document describing existing buffer programs, funding and baseline data ✦ if buffers are good for the Bay they are good for all waters and should be promoted statewide	✦ if public access is linked to buffers it could be a bid issue for landowners ✦ what is the implication of numeric goals? If they are not reached will regulations follow? ✦ emphasize voluntariness and provide adequate incentives ✦ don't make criteria too flexible so that RFB effectiveness would be compromised ✦ need for considerable public education about RFBs ✦ tax breaks are preferable to cost-share
Paul Swartz Susquehanna River Basin Commission Panel	R	X		✦ supportive of the need for RFBs ✦ does not support making stream corridor management and RFBs two separate issues ✦ promote riparian areas first with a stream corridor management approach in order to achieve all of the objectives in the directive	✦ remove 60% from retention goals ✦ include more detail on 3-zone buffer concept ✦ include a suggested minimum width of 75' if NRCS standard is recommended	✦ none
John Blake VP, MD Forests Association Chair, Frederick County Forest Conservancy Board.	P	X		✦ commends recognition of need for incentives, flexibility, education and forest management	✦ MD Forest Conservation Act should be amended to allo local jurisdictions to include floodplains in net tract area	✦ urban buyers of small plots of forested land are unaware of need to protect streams on their property ✦ education of urban environments needed regarding benefits of forest management

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Sandy Sage Bigelow Laboratory Panel	R	X		✦ report is well written Noticed the scent of the air has changed suggests that "tone" of report be more encouraging and emphasize landowner involvement	✦ more emphasis need on quantitative improvement in specific stream reaches	✦ states need to commit to production of adequate numbers of native trees by state nurseries ✦ need greater effort to educate landowners with first to third order streams on their property of the importance of their participation
Ann Swanson & John Lipman Chesapeake Bay Commission Panel	R	X		✦ too long - needs editing ✦ put detail in supporting document or appendix ✦ change format to respond to '94 directive ✦ focus on key actions and measures of progress	✦ definitions too long - should just focus on riparian forest buffers ✦ include range of widths ✦ minimize number of actions being proposed to 3-4 per section	✦ report should have these sections: 1. accepted definitions, 2. quantifable goals, 3. communications and partnerships, 4. support other stream protection efforts
Lower Eastern Shore Tributary Strategy Team	T			✦ none	✦ 75' width is inadequate - standard should be 100'	✦ none
David Brubaker PennAg Industries	R	X		✦ very supportive of voluntary approach ✦ need for considerable education ✦ use some type of numeric target	✦ none	✦ none
Washington County (MD) SCD Boards of Supervisors Almer Weibley	G	X		✦ editorial comments ✦ identify NRCS standards by name	✦ none	✦ none
Roger Waldman	I	X		✦ need a precise definition of "native vegetation"	✦ none	✦ none
Bruce Nichols District Conservationist NRCS	G	X		✦ define "forest" - shrubs may play an important role and, if allowed, could help sell buffers to ag community ✦ 75' buffer width is good bu not magic number - don't make it a hard rule ✦ if buffers are so important then make conservation goal 100% and make restoration goal 100% on selected watersheds	✦ suggest a formula for buffer width based on slope, soil, etc	✦ economics is the one approach to selling RFBs - program must be economically driven

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CBP Citizens Advisory Committee	C		X	✦ don't go for consensus if it results in a very watered-down report ✦ keep measurable goal, stream corridor approach, definitions, voluntary, site-specific ✦ need PR and education - value of RFB to stream and Bay ✦ integrate with ongoing programs- don't make a new, independent program ✦ don't give a big list of recommendations to PSC/EC	✦ how do you quantify benefits of RFBs as part of natural infrastructure ✦ make goals specific to land use	✦ none
Jim Cox VA DCR	G	X		✦ the coordinating agency should be the lead nonpoint source agency in each state ✦ current buffer widths are unrealistic- if you suggest one at all give a minimum of 15-25 ' ✦ educational materials and programs, should be established but not be limited to forest buffers	✦ if the inventory is completed first and agencies track buffer establishment then *there is no need to do a GIS inventory every* 5 years ✦ do not set any goals for conservation or restoration until the inventory is set ✦ do not limit effort to forest buffers, allow all types of buffers - delete forest where it limits the type of buffer that could be used ✦ do not spend more money on buffer research - use those funds to expand cost-share programs	
Charles Conkline	I	X		✦ specific actions should be identified to address RFBs in agricultural areas ✦ will goals be distributed across the states, local jurisdictions, or watershed? ✦ should state goals be states? ✦ editorial comments		✦ tributary strategy teams could play a management/leadership role - identify a role for the teams ✦ some local jurisdictions (i.e., Baltimore County, MD) do not allow harvest with RFB areas
MD Association of Soil Conservation Districts George Lechlider President	G	X		✦ RFBs have been taken out of context and should be treated as just another alternative ✦ remove "forests" from tile to make clear that all buffers are allowed ✦ must continue to be strictly voluntary	✦ width should be a site-specific criteria ✦ NRCS standards for different buffer types should be used ✦ allow select cutting within buffer - use a written permit	✦ provide compensation to landowners for loss from restricted harvesting in RFB
Garrett Soil Conservation District, MD George Bishoff, Chairman	G	X		✦ report is flawed because it fails to recognize all buffers ✦ cannot emphasize voluntaries enough	✦ buffer width should be site-specific many variables	✦ landowners need written, permanent guaranteed from state and federal government that proper harvesting and management practices will be allowed in new woodlands
Bea Dewing Lower Potomac Tributary Strategy Team	T	X		✦ should ensure public access to buffered shoreline areas so that move people can feel that they are stakeholders		

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CBP Scientific and Technical Advisory Committee Mr. Grant Gross, President	C	X		✦ report is quite sound on its scientific and technical aspects	✦ STAC is prepared to assist with increasing the level of scientific and technical knowledge about buffers	
Richard John stone Forestry Supervisor, Delmarva Power MD Coastal and Watershed Resources Advisory Committee	C	X		✦ overall strategy is sound	✦ low trees and shrubs should be allowed on farm buffers at the edge of the field	✦ tax incentives are good relief for private property owners ✦ require buffers on farm ditches on eastern shore through may not succeed with forested buffers ✦ put emphasis on natural succession rather than planting trees
Steele Philips	I	X		✦ must be voluntary effort with incentives to encourage and promote objectives ✦ change reference to Stream Corridor Management to recognize current BMPs being used with different types of vegetation in buffers	✦ recommendations should be site-specific and seek best site objective ✦ agricultural drainage ditches should not be considered a stream except in the upper areas of rivers where channels have been cleared	✦ promote RFBs where applicable but realize that shoreline trees on large rivers and the Bay can accelerate erosion ✦ do not let RFBs become a threat to dwindling pool of prime agricultural land
Dept. of Technical & Community Services Somerset County, MD Hoan Kean, Director	G	X		✦ avoid "one size fits all" approach ✦ recognize buffers other than forested buffers	✦ in the lower eastern shore, grass and shrub buffers may be as good as or better than forested buffers ✦ reconsider definitions to exclude drainage ditches	✦ include long-term water quality monitoring, not just modeling'✦ develop a re-evaluation element
Montgomery County, MD Soil Conservation District George Lechlider	G	X		✦ keep this a voluntary program	✦ be flexible to include grass buffers ✦ focus on perennial streams and eliminate intermittent form stream definition - not cost-effective to apply program to intermittent streams ✦ clarify how the 75' buffer width relates to 3-zone concept	✦ high maintenance cost (equipment and labor) min establishing buffers could deter implementation - factor this into incentives ✦ what level of tree survival is adequate for a successful program ✦ timelines should be earlier for technical assistance, education/outreach, demonstration sites, adding technical assistance staff and modification of cost-share programs to support stream corridor management
Department of Environmental Protection and Resource Management, Baltimore County, MD George Perdikakis Director	G	X		✦ insufficient emphasis on role of RFBs in maintaining stream stability	✦ does not state at what scale streams and buffers will be mapped and managed ✦ 3-zone model is useful but only valuable if flexible and site-specific ✦ buffer width should be stated as a range rather than a minimum and should state that the key fact is that the buffer protect the resources on site ✦ guidelines and BMPs for forest harvest do exist but data shows that harvest operations do not fully comply	✦ RFBs are the most effective and most cost-effective measure against for protecting this resource, but report sacrifices maximum implementation for compromises in recognition of landowners objectives and economic gain ✦ program should focus on "assisted participation" rather than "voluntary compliance" and include a comprehensive education program

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PA Fish & Boat Commission Ron Tibbott, Hyd. Engineer Technical	G	X			✦ report should not advocate planting trees right at stream edge - this can lead to increased erosion and stream de-stabilization - instead plant trees back form edge and plant shrubs at edge	
Soil Conservation Committee, MD Association of Soil Conservation Districts Louise Lawrence	G	X		✦ coordination and implementation of goals should use existing mechanisms and committees	✦ buffer width should be site-specific for all land uses- NRCS standards accomplished this ✦ current stream definition is too broad - do not include drainage ditches V recognize, promote and credit vegetative buffer types other than forest	✦ buffer zone management should not preclude harvest or noxious weeds or pest control ✦ if fencing is required incentives should be available for maintenance costs as well
Robert Heidecker State Resource Conservationists NRCS - PA	G	X		✦ focus should be on steam corridor restoration rather than simply RFBs ✦ SE PA farmers interested in stream corridor conservation but not RFBs		
Wicomico County, MD Soil Conservation District Robert Davis, Chairman	G	X		✦ report does not acknowledge geographic diversity and whether a RFB is appropriate in a particular region	✦ will strenuously oppose inclusion of drainage ditches in stream definition ✦ width should be site-specific ✦ no scientific evidence that forested buffers provide any more protection than other vegetative buffers'	
PA Field Office, US Fish & Wildlife Service Cindy Tibbott, Acting Supervisor	G	X		✦ program should not be implemented without increased staffing at technical assistance agencies	✦ tree planted at the steam edge can cause more sediment and nutrient problems as well as stream instability ✦ no evidence that trees are more effective than grass or shrubs	✦ program will require enormous education effort ✦ in PA 75' of buffer may be financially impossible
VA Association of Counties Larry Land, Director of Policy Development	G	X		✦ VA Chesapeake Bay Preservation Act already requires local to adopt ordinances seeking to preserve at least 100' of vegetative buffer	✦ need to complete inventory ✦ need to accurately monitor increases or decreased after completion of the inventory	✦ need financial and other incentives to encourage establishment of additional RFBs
MD State Water Quality Advisory Committee	G	X			✦ scientific studies indicate varying opinions on optimal buffer width	✦ in 1992 MD Planning Act requires buffers to be addressed in all comprehensive plans- education program should be used for local governments ✦ setting minimum width may undermine local ordinances

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MD Chesapeake Bay Critical Area Commission Claudia Hones - Science Advisor/Greg Schaner, Natural Resource Planner	G	X		✦ concern that recent version of watered down from May 8 version of report V retain statement in report that, "forests provide the greatest number of environmental benefits..." there is sufficient discussion in text of report to alleviate on-size-fits-all concern ✦ retain monitoring and tracking recommendations	✦ as long as site-specific flexibility is recognized, a fixed and scientifically - derived minimum width is an appropriate goal and creates a quantifiable performance measure ✦ if a 75' standard is uses, specify that it is based on water quality and aquatic habitat goals - more width is required for many terrestrial species	
Ronald Schnabel Research Coil Scientist USDA	G	X		✦ very well thought out ✦ strategy suggests flexibility for forest buffers but not other types ✦ requiring trees over other buffers of engineered solutions may prolong compliance time and benefit realization	✦ whether a forest buffer should be used to the exclusion of other types depends on the restoration or management goal	✦ ensure that cost-share program dollars don't just shift form non-forest programs ✦ list of assistance programs would be useful
Frank Lucas Pequea-Mill Creek Project PA	I	X		✦ great idea in theory but doesn't see it being successful, especially in farm country		
Guy Steucek Dept of Biology Millersville University	I	X			✦ distinguish between forested wetlands and riparian zones more like upland streamside forests - riparian forests not often "wet" ✦ 75' of forest will not buffer 100' of agriculture/suburbia ✦ report omits focus on restoring many small wetlands (<1/2 acre) this would do more for water quality than streamside buffers ✦ be careful to adopt the 3-zone concept much more flexibility in management is needed	
John Clark Barber	I	X		✦ recognize in introduction that most benefits acres downstream to the public and little to the landowner who implements - basis for public assistance	✦ clarify buffer averaging	

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SECTION 8:
LIST OF STATE/FEDERAL PROGRAM CONTACTS

FEDERAL AND STATE INCENTIVE PROGRAM CONTACTS

Buffer Incentive Program
MD DR Forest Service
580 Taylor Avenue, E-1
Annapolis, MD 21401
State Foresters Office
(410) 974-3776

Virginia Agricultural BMP Cost-share Program
Woodland Buffer Filter Area
Loafing Lot Management System
Virginia Department of Forestry
Forest Health Management/Water Quality
PO Box 3758
Charlottesville, VA 22903
(804) 977-6555

Streambank Fencing Program
Pennsylvania Department of the Environment
Bureau of Land & Water Conservation
PO Box 8555
Harrisburg, PA 17105-8555
Mr. Larry Nygren
(717) 787-5259

Environmental Quality Incentives Program (EQIP)
Natural Resource Conservation Service
John Hanson Business Court
339 Busch's Frontage Rd, Ste 301
Annapolis, MD 21401
Attn: Resource Team
(410) 757-0861

Conservation Reserve Program
MD State FSA Office
8335 E Guilford Road
Columbia, MD 21046
Ilka Gray
(410) 381-4550

Wetlands Reserve Program
Natural Resource Conservation Service
John Hanson Business Court
339 Busch's Frontage Rd, Ste 301
Annapolis, MD 21401
Anne Lynn
(410) 757-0861 x319

Woodland Incentive Program
MD DR Forest Service
580 Taylor Avenue, E-1
Annapolis, MD 21401
State Foresters Officer
(410) 974-3776

Forest Stewardship Program
MD DNR Forest Service
580 Taylor Avenue, E-1
Annapolis, MD 21401
State Foresters Office
(410) 974-3776

Virginia Dept of Forestry
PO Box 3758
Charlottesville, VA 22903
State Foresters Office
(804) 997-6555

Pennsylvania Bureau of Forestry
PO Box 8552
Harrisburg, PA 17105
State Foresters Office
(171 787-2703

Forestry Incentive Program
Natural Resource Conservation Service
John Hanson Business Court
339 Busch's Frontage Rd, Ste 301
Annapolis, MD 21401
Anne Lynn
(410) 757-0861 x319

Stewardship Incentive Program
MD DNR Forest Service
580 Taylor Avenue, E-1
Annapolis, MD 21401
State Foresters Office
(410) 974-3776

Pennsylvania Bureau of Forestry
PO Box 8552
Harrisburg, PA 17105
State Foresters Office
(717) 787-2703

Special Rivers Project
MD DNR Forest Service
580 Taylor Avenue, E-1
Annapolis, MD 21401
State Foresters Office
(410) 974-3776

Tree-mendous Maryland
MD DNR Forest Service
580 Taylor Avenue, E-1
Annapolis, MD 21401
State Foresters Office
(410) 974-3776

Forest Conservation and Management Program
MD DNR Forest Service
580 Taylor Avenue, E-1
Annapolis, MD 21401
State Foresters Office
(410) 974-3776

Reforestation/Timber Stand Improvement Tax Deduction (TAXMOD) Program
MD DNR Forest Service
580 Taylor Avenue, E-1
Annapolis, MD 21401
State Foresters Office
(410) 974-3776

Agricultural Use Assessment
Maryland Department of Assessments & Taxation
Real Property Division
300 West Preston Street Rm 511
Baltimore, Maryland 21201
State Supervisor
(410) 767-1199

Use/Value Taxation
Virginia Department of Forestry
Forest Health Management
PO Box 3758
Charlottesville, VA 22903
(804) 977-6555

Farmland and Forest Land Assessment Act ("Clean and Green Act")
Pennsylvania Department of Agriculture
Department of Farmland Preservation
2301 N. Cameron Street
Harrisburg, PA 17110-9990
Mr. Ray Pickering
(717) 787-1079

Reforestation Tax Incentive (Public Law 96-451)
USDA Forest Service
5 Radnor Corporate Ctr Ste 200
Radnor, PA 19085-4585
Lloyd Casey
(610) 975-4135

REGULATORY PROGRAMS

Chesapeake Bay Critical Area Act
Chesapeake Bay Critical Area Commission
45 Calvert Street 2nd Floor
Annapolis, MD 21401
Executive Director's Office
(410) 974-2426

Forest Conservation Act
MD DNR Forest Service
580 Taylor Avenue, E-1
Annapolis, MD 21401
State Foresters Office
(410) 974-3776

Nontidal Wetlands Act
Maryland Department of the Environment
Tawes State Office Building, B-3
580 Taylor Avenue
Annapolis, MD 21401
Denise Clearwater
(410) 974-3265

Economic Growth, Resource, Protection and Planning Act
Maryland Office of Planning
Comprehensive Planning
301 W. Preston Street
Baltimore, MD 21201-2365
Chief Planner
(410) 767-4562

Reforestation Act
MD DNR Forest Service
580 Taylor Avenue, E-1
Annapolis, MD 21401
State Foresters Office
(410) 974-3776

Chesapeake Bay Preservation Act (VA)
Virginia Department of Forestry
Forest Health Management/Water Quality
PO Box 3758
Charlottesville, VA 22903
(804) 977-6555

Dams Safety and Encroachments Act
Pennsylvania Bureau of Dams, Waterways & Wetlands
POBox 8555
Harrisburg, PA 17105-8554
Director
(717)787-6826

Water Quality Law ("Bad Actor" Law) (VA)
Virginia Department of Forestry
Forest Health Management/Water Quality
PO Box 3758
Charlottesville, VA 22903
(804) 977-6555

Special Protection Streams
Pennsylvania Bureau of Water Quality Managment
PO Box 8465
Harrisburg, PA 17105-8465
Chief
(717) 787-9637

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Chesapeake Bay Program

The Chesapeake Bay Program is a unique regional partnership leading and directing restoration of Chesapeake Bay since 1983. The Chesapeake Bay Program partners include the states of Maryland, Pennsylvania, and Virginia; the District of Columbia; the Chesapeake Bay Commission, a tri-state legislative body; the U.S. Environmental Protection Agency (EPA), which represents the federal government; and participating citizen advisory groups.

In the *1987 Chesapeake Bay Agreement*, Chesapeake Bay Program partners set a goal to reduce the nutrients nitrogen and phosphorus entering the Bay by 40% by the year 2000. In the *1992 Amendments to the Chesapeake Bay Agreement*, partners agreed to maintain the 40% goal beyond the year 2000 and to attack nutrients at their source--upstream in the tributaries. The Chesapeake Executive Council, made up of the governors of Maryland, Pennsylvania, and Virginia; the mayor of Washington, D.C.; the EPA administrator; and the chair of the Chesapeake Bay Commission, guided the restoration effort in 1993 with five directives addressing key areas of the restoration, including the tributaries, toxics, underwater bay grasses, fish passages, and agricultural nonpoint source pollution. In 1994, partners outlined initiatives for habitat restoration of aquatic, riparian, and upland environments; nutrient reduction in the Bay's tributaries; and toxics reductions, with an emphasis on pollution prevention.

The 1995 *Local Government Partnership Initiative* engages the watershed's 1650 local governments in the Bay restoration effort. The Chesapeake Executive Council followed this in 1996 by adopting the *Local Government Participation Action Plan* and the *Priorities for Action for Land, Growth and Stewardship in the Chesapeake Bay Region*, which address land use management, growth and development, stream corridor protection, and infrastructure improvements. A 1996 riparian forest buffers initiative furthers the Bay Program's commitment to improving water quality and enhancing habitat with the goal of increasing riparian buffers on 2010 miles of stream and shoreline in the watershed by the year 2010.

Since its inception, the Chesapeake Bay Program's highest priority has been the restoration of the Bay's living resources--its finfish, shellfish, bay grasses, and other aquatic life and wildlife. Improvements include fisheries and habitat restoration, recovery of bay grasses, nutrient reductions, and significant advances in estuarine science.