Understanding the Science Behind Riparian Forest Buffers:

Benefits to Communities and Landowners

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The riparian area is that area of land located immediately adjacent to streams, lakes, or other surface waters. Some would describe it as the floodplain. The boundary of the riparian area and the adjoining uplands is gradual and not always well defined. However, riparian areas differ from the uplands because of their high levels of soil moisture, frequent flooding, and unique assemblage of plant and animal communities. Through the interaction of their soils, hydrology, and biotic communities, riparian forests maintain many important physical, biological, and ecological functions and important social benefits.

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Benefits to Communities and Landowners

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Introduction

Riparian forests are found adjacent to streams, lakes, and other surface waters. They are characterized by variable soils and hydrology, frequent flooding, and highly productive plant and animal communities. Through the interaction of their soils, hydrology, and biotic communities, riparian forests maintain many important ecological functions, which in turn, provide important benefits to humans.

Aesthetic and Cultural Benefits

For much of human history, stream valleys have been the focus of exploration and settlement and the place of economic and social activity (Figure 1) (Emerson 1996). Early transportation networks were based almost entirely on river systems. As a result, riparian areas are rich in historic, archeological, and other cultural features.

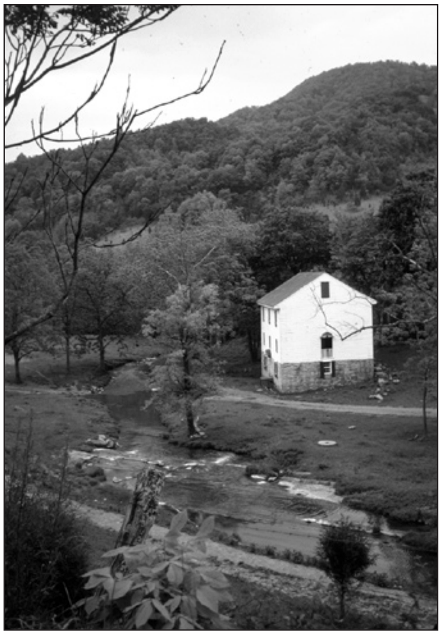

Fig. 1 For much of human history, riparian areas have been the focus of economic and social activity.

Riparian areas also have rich aesthetic appeal. Litton (1977) suggests that water in the landscape tends to draw people because of its "visibility, movement, reflections, and color, its consequent contrasts to adjacent earth surfaces." He concludes that the aesthetic appeal of a stream is a function of its topography, relief, form, vegetation types and arrangement, water variability and pattern, and human use and impacts. Streams that are more sinuous are often more interesting because a hidden view contributes to a sense of "mystery" to the experience. Other features, such as the presence of rapids or a large scenic vista will also increase the appeal of the stream (Leopold 1969, Kuska 1977, Brown and Daniel 1991). However, the presence of litter, man-made features (utilities, roads, dams, etc.), and evidence of poor water quality (discoloration, turbidity, odor, algae) can distract from the aesthetic appeal (Leopold 1969, Hoover and others 1985). Streamside vegetation adds to an area's beauty (Higgins 1996). Although different people have different scenic preferences, most enjoy viewing old, tall, large-diameter trees. A variety of textures and colors are also desirable. Many of the participants in Maryland's Buffer Incentive Program considered aesthetic factors critical or somewhat important in their decision to install riparian forest buffers (Hagan 1996). Some enjoyed the privacy provided, while others just "liked trees." One landowner noted that the buffer provided a "great source of satisfaction and beauty" (Figure 2).

Fig. 2 Riparian areas are aesthetically pleasing.

Recreational Benefits

In recent decades, interest in and the use of riparian areas for recreational enjoyment have increased (Pigrim 1983, Pawelko and others 1995). Not only have stream corridors attracted more users, there is a greater diversity of recreational activities occurring within these environments. Traditional activities, such as trapping, hunting, and fishing are enjoyed by many, while others enjoy rafting, motorboating, hiking, biking, photography, and observing nature (Figure 3).

Fig. 3 Riparian areas are used for many types of recreation.

The importance of streams and riparian areas in providing recreational opportunities is reflected in a survey of visitors to the Delaware River Valley (Pawelko and others 1995). Recreationists were drawn to the area for its clean water, exceptional fisheries, wildlife, and historic and cultural resources. Many visitors, even first time users, shared a concern for and attachment to the river valley. Their comments reflected feelings of possessiveness (for example, "my river"), gravitation to water ("I never get tired of seeing it"), protectiveness ("I would like to see the river remain unpolluted"), or cultural identification with the area ("It's being able to know firsthand what it was like for the pioneers"). Some had developed a tradition of visiting the area with family or friends ("My family comes here every year"). Others came to participate in specific activities ("I'm a kayaker"). Almost unanimously, their comments reflected the sense that the river provided them an important source of mental and physical refreshment.

Residents of Alabama reported that they visited river environments primarily to drive for pleasure along the stream or to picnic or fish (Clonts and Malone 1990). Other reasons for visiting were to observe or photograph nature, swim, hike, camp, canoe, hunt, boat, or raft. These individuals indicated they were willing to pay nearly $57 per year per household to protect the state's rivers in their natural condition. Although economists warn that these types of surveys can often overstate the amount individuals would actually pay, this study suggests that Alabama's citizens recognize stream environments as important natural areas. The most important reasons reported for preserving the rivers were to protect fish and wildlife habitat, water quality, air quality, and scenery. They also wished to protect rivers for future generations, just for the satisfaction of knowing rivers exist and are protected, and to preserve the option to use the rivers in the future.

Riparian areas in urban centers can be especially important places where residents can escape from the activity in the city and engage in recreational activities. A 1995 survey of Marylanders found that nearly 77 percent felt that it was important to them to have natural areas close to where they live and work. Almost half said they would be inclined to move if existing open space in their community were lost (Palone and Todd 1997).

Economic Benefits of Wildland Recreation

Recreational use of riparian areas can be a potential source of income for landowners and communities. A 1996 survey of Virginians found that 44 percent of the population participates in some form of wildlife-related recreation, such as hunting, fishing, or wildlife-watching (U.S. Fish & Wildlife/Bureau of the Census 1996). Recreational fishing contributed almost $821 million to the state's economy; while hunters contributed another $519 million (see Table 1). In addition, Virginians spent almost $698 million observing, feeding, and photographing wildlife. In Maryland, it is estimated that waterfowl hunting alone generates almost 160 jobs and $3.5 million to local economies each year (Lynch 1997). Access to private property for waterfowl hunting generally runs about $3 to $5 per acre for an annual lease, or as much as $80 per person for a single day (Palone and Todd 1997).

Table 1. Percent of Residents Participating in Wildlife-Associated Recreation and Revenues Generated

	Virginia	Mid-Atlantic Region	Nationwide
Fishing	13% $821 million	12%	13% $37.8 billion
Hunting	3% $519 million	5%	7% $20.6 billion
Wildlife-watching	37% $698 million	27%	31% $29.2 billion

From: U.S. Fish & Wildlife and U.S. Bureau of the Census. 1996 National Survey of Fishing, Hunting, and Wildlife-Associated Recreation.

Recreational boating, canoeing, and floating are other popular stream activities (Figure 4). A 1990 study of whitewater boaters on the Upper Youghiogheny River in western Maryland found that they contributed nearly $1.2 million dollars to local economies and another $1 million to neighboring states (Gitelson and Graefe 1990). This included dollars paid to local rafting companies, lodging, food and beverages, entertainment, souvenirs, boating equipment, and auto-related items.

Fig. 4 Recreational boating is a popular stream activity.

Pollution of streams by sediment, nutrients, and other contaminants has a variety of impacts on recreation, including destruction of fish habitat, siltation and eutrophication of waterways, and closing of swimming areas (Ribaudo 1986). The 1994 EPA National Water Quality Inventory Report to Congress identified 374 sites in 22 states where recreation was restricted due to poor water quality, with bacterial contamination cited as the most common cause of these restrictions (U.S. E.P.A. 1995).

Impact of Recreation on Riparian Areas

The construction of riparian forest buffers along streams and lakes can increase the aesthetic beauty of the area, improve water quality for swimming and boating, and enhance the area's fisheries and recreational opportunities.

However, without proper management, recreational activities can destroy the aesthetic and ecological benefits provided by riparian buffers (Figure 5). Heavily used areas may experience soil compaction, reduction in soil organic matter and soil moisture, increasing rates of erosion, injury and mortality to riparian vegetation, disturbance to riparian animals, alteration of stream habitats, and water quality problems (including increases in fecal coliform bacteria and other contaminants such as motor oil, cleaning detergent, and garbage) (Wall and Wright 1977, Clark and others 1985b, Pigram 1983, Harris and others 1990).

Fig. 5 Recreation must be properly managed in order to preserve the aesthetic and ecological benefits riparian areas provide.

Along the Grand Canyon, problems caused by river recreationists include fire, littering, trampling of vegetation, and human waste disposal (Aitchison and others 1977). In addition, nuisance insects, and introduction of certain lizards, exotic birds, and mammals into remote areas has occurred. Researchers in California found that placing campgrounds in riparian areas reduced vegetation density, deadwood, and soil litter depth and resulted in changes in the avian community (Blakesley and Reese 1988).

As more recreationists are drawn to an area, there is also the chance that conflicts will develop among users (Pigram 1983). For example, there may be incompatibility between new visitors and traditional uses of the site or between different types of recreational activities (for example, water skiing and fishing). Conflicts can also develop between recreational uses and other uses of the stream, for example, industrial sites and power generation. Sometimes, conflicts can arise between river users and property owners whose land is adjacent to streams.

Homeowners are often attracted to riparian areas for the recreational and aesthetic benefits found there. A view of the water is often quite important to them. However, this desire for a water view can hinder efforts to install riparian forest buffers in developed areas. As one landowner observed "Why have waterfront property if you can't have the view?" (Hagan 1996). Along shorelines with high land values and tax liabilities, giving land over to environmental uses may be difficult to accomplish. A study in New England estimated the per acre cost of development rights were as much as 53 percent higher on parcels that had a panoramic view of the water than on parcels which had no water view (Wichelns and Kline 1993).

Community Benefits

Riparian areas can provide benefits to communities in addition to recreational and aesthetic value. Although riparian forest buffers cannot begin to mitigate all of the impacts of polluted waters, they can play an important role in reducing the amount of sediment, nutrients, and other contaminants that reach streams and lakes. As a result, communities may benefit from reduced costs for water treatment, water storage, and dredging (Holmes 1988, Ribaudo 1986). In addition, riparian buffers can reduce flood damage to communities and croplands and the need for maintenance to drainage ditches and irrigation canals (Clark 1985, Park and Dyer 1986). Buffers can also benefit groundwater supplies, as well as commercial fisheries and agriculture.

Water Treatment and Storage Costs

Communities across the nation spend millions of dollars each year to treat contaminated waters (Clark and others 1985a). As nutrients, sediments, and other contaminants move off the land and into streams, the costs of treating municipal water supplies increase. Sediment basins must be built, filters cleaned more frequently, and chemical coagulants and disinfectants must be added to the water. Turbid water may also have serious taste and odor problems. In 1991, the costs of treating contaminated water were estimated to be $10 to $15 per month for a family of three (Welsch 1991). Communities such as Washington, D.C., spend as much as $3 to $5 per pound to remove nitrogen from wastewaters (Palone and Todd 1997). In the right location, forested buffers can remove as much as 21 pounds of nitrogen per acre per year, along with about 4 pounds of phosphorus per acre per year from upland runoff (Figure 6).

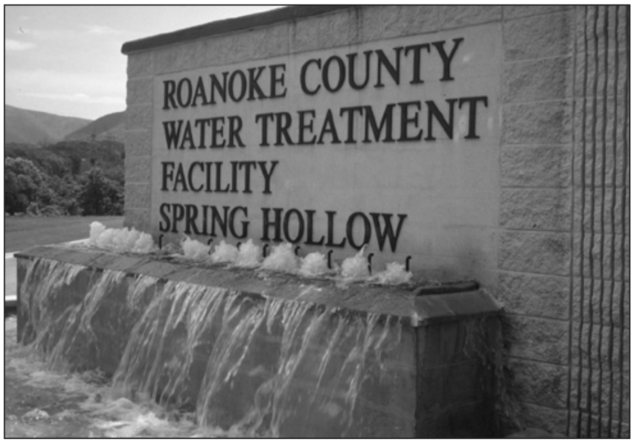

Fig. 6 Clean water means reduced costs for water treatment.

Many studies show the public has an interest in maintaining clean water supplies and is willing to pay for programs that will improve water quality. For example:

- A nationwide survey conducted during the early 1990s found that individuals were willing to pay on average $275 to $366 per household per year to improve water quality to a “swimmable” level (Carson and Mitchell 1993).

- Residents of Georgia expressed a willingness to pay $5.49 to $7.38 per month to improve the quality of drinking water in their state, even though most rated their water quality currently as very safe, safe, or fair (Jordan and Elnagheeb 1993).

- Another survey of Georgia residents found they were willing to pay $641 per household annually for a program that would protect groundwater supplies (Sun and others 1992).

- Citizens of Dover, N.H., were willing to pay $40 per household annually for a groundwater protection plan (Schultz and Lindsay 1990).

- A survey of citizens from Indiana, Nebraska, Pennsylvania, and Washington indicated a willingness to pay nearly $55 per month to remove all nitrates from their water supplies (Crutchfield and others 1997).

Contaminants can also cause problems for industrial users. Contaminated water can increase industrial expenses as it causes steam electric power plants to operate less efficiently, clogs cooling equipment, corrodes pipes, and increases the rate at which pumps and other equipment wear out. Ribaudo (1986) estimated that suspended sediment and algae cost steam electric power plants and other water cooling facilities $24 million annually (1983 dollars) in maintenance costs.

The sedimentation of streams and lakes increases the rate at which lakes and reservoirs are filled, costing communities millions of dollars to create new facilities and to maintain existing ones. In 1985, Clark and others estimated that 1.4 to 1.5 million acre-feet of reservoir and lake capacity are permanently filled each year with sediment. In addition, nearly a million acre feet of additional storage capacity, at a cost of $300 to $700 per acre-foot, must be built to capture and store sediment (Clark and others 1985a). Nationwide, sedimentation of water storage facilities costs communities nearly $1.1 billion annually (1983 dollars) (Ribaudo 1986).

Navigation

The sedimentation of harbors and navigational waterways reduces their capacity to handle commercial ships and often leads to dredging to keep the channels open (Figure 7). For example, each year Baltimore Harbor alone spends almost $10 to $11.5 million to dredge sediments (Palone and Todd 1997). Besides the expense, dredging can create water quality problems by creating turbidity and stirring up heavy metals and other contaminants from the bottom. There is also the problem of where to deposit the dredged material. Dirty waters have been linked to shipping accidents and shipping delays and can cause damage to ship engines and propellers.

Fig. 7 Commercial shipping benefits from clean waterways.

Flooding

Damage caused by floods costs communities millions of dollars each year (Figure 8). The Roanoke Valley of Virginia has had nearly $200 million in flood damage to more than 12,000 homes and 1,000 businesses since 1975 (USA Today, March 24, 1998). Recently, a regional flood control plan identified 130 projects, expected to cost $61 million, that are needed to reduce flood damage. In addition, $60 million will be required to floodproof or relocate structures out of flood-prone areas. In 1986, annual flood damage in the U.S. was estimated at $887 million per year (1983 dollars) (Ribaudo 1986). Nearly half of all flood damage is to agriculture, when crops and livestock are destroyed and soil is washed away (Guldin 1989).

Fig. 8 Damage caused by floods cost communities millions of dollars each year. Nearly half of all flood damages is to agriculture (Photo by Ken Hammond, courtesy USDA).

Riparian forest buffers play an important role in flood control, as they provide a natural basin where floodwaters may spread out horizontally (Lowrance and others 1985). As flood waters move into the riparian area, vegetation slows the water's movement, reducing the its erosive potential and capturing materials carried by the floodwaters (Gregory and others 1991). The porous forest floor acts as a "sponge," quickly absorbing and storing floodwaters, then releasing them slowly back into the stream and groundwater. Restoring forests along headwater streams means more storm flow is captured and retained higher in the watershed.

Riparian forest buffers also reduce flood damage as they capture sediments. The sedimentation of streams contributes to flood damage by filling in streambeds and increasing the frequency and depth of flooding and by increasing the volume of flood waters, as well as by causing additional damage itself.

Severe floods in Virginia in 1994-95 resulted in more than $10 million in damage. In areas where forested buffers existed, damage to river banks and adjacent farmlands was reduced (Palone and Todd 1997).

Groundwater

Safe, dependable supplies of groundwater are important to people as well as stream systems. In the U.S., groundwater is used for public and domestic water supplies, irrigation, livestock watering, mining, commercial uses, and thermoelectrical cooling systems (U.S. E.P.A. 1995). Nearly 34 percent of Virginia's citizens depend on groundwater for drinking water, including 70 percent of those who have private wells (Va. D.E.Q./D.C.R. 1998).

There is a close association between surface and groundwaters. Groundwater is replenished or "recharged" by percolation of precipitation through the soil and by seepage from stream channels (Guldin 1989). Water also moves from groundwater into the stream. Therefore, polluted surface waters can contaminate groundwater, and vice versa. In some streams, as much as 40 percent of the annual flow and nearly all the flow during dry periods is provided by groundwater. This continuous flow of water is critical to maintaining adequate stream water levels and temperatures to support aquatic life. Removing vegetation from riparian lands can result in loss of groundwater recharge and increase the frequency, duration, and severity of low flow conditions in streams.

Commercial Fisheries

In 1991, over 9 billion pounds of fish and shellfish with a value of over $3 billion were harvested by commercial fishermen (U.S. E.P.A. 1995). It is estimated that nearly three-quarters of commercially valuable fish and shellfish depend directly or indirectly on coastal estuaries and river basins for spawning grounds or nurseries (Figure 9). When sediment and other pollutants accumulate in these waters, they can destroy habitat for the organisms that live and spawn there. Ribaudo (1986) estimated that damage to marine fisheries due to man-made

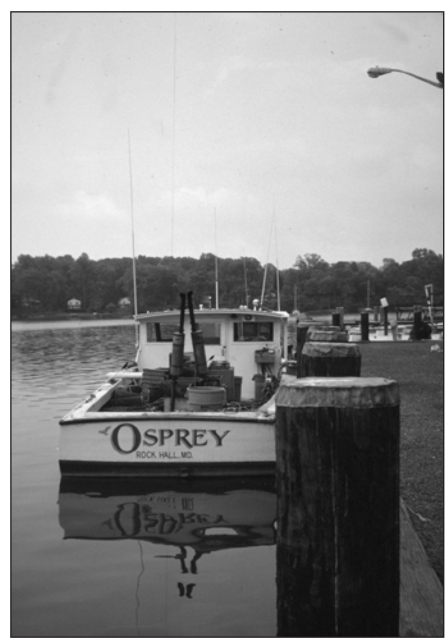

Fig. 9 Nearly three-quarters of commercially valuable fish and shellfish depend on coastal estuaries and river basins for spawning grounds or nurseries.

pollutants was over $1 billion, and damage to commercial freshwater fisheries were another $150 million per year.

Additional Benefits

Besides protecting streams and water supplies, riparian forest buffers provide additional benefits to communities. Trees help clean the air as they trap and filter air pollutants during the process of evapotranspiration. For example, in 1991, the city of Chicago estimated that trees removed 17 tons of carbon monoxide, 98 tons of nitrogen dioxide, and 210 tons of ozone from the atmosphere (Palone and Todd 1997). Urban trees also reduce heating and cooling costs for communities by buffering winds, providing shade, and cooling the air. Studies on the home heating benefits of shelterbelts in Canada suggest that tree plantings can result in as much as a 15 percent to 30 percent savings in home heating costs, depending on weather conditions and house construction (Kort 1995). The value of cooling costs ranged from $15 to $20 per year in Minneapolis to $85 to $170 in Phoenix.

Benefits to Landowners

Agriculture

Agricultural damages due to water pollution includes contamination of water for livestock, irrigation, and personal use, as well as increased flooding and the silting of bottomlands, drainage ditches, and sediment ponds.

Livestock operations, in particular, benefit from safe sources of drinking water for their animals. For example, high levels of sulfates in drinking water can contribute to decreased egg production in chickens (Veenhuizen and Shurson 1992). Many species of animals are susceptible to nitrate poisoning, especially cattle (Johnson and others 1994). Excessive consumption of nitrates has been associated with abortions and other reproductive problems, because it reduces the transfer of oxygen to the fetus. Nitrate poisoning can also cause anorexia, lowered blood pressure, and reduced lactation. Livestock may also be affected by a variety of pathogenic organisms transmitted from manure-contaminated waters (Overcash and others 1983, Palmateer 1992). These include organisms that cause scours, mastitis, salmonellosis, leptospirosis, brucellosis, listeriosis, tetnas, staphloccus, tuberculosis, bronchitis, and other diseases.

Excluding livestock from the stream and providing riparian buffers can improve water quality for downstream users and provide benefits to the herd. A survey of farmers who participated in Pennsylvania's stream fencing program reported that the health of their herds improved when the livestock were no longer allowed in the stream (Kasi and Botter 1994). The animals were also less prone to injury, as they were no longer climbing up and down streambanks.

Forested buffers may also provide a farm windbreak. The shelter of trees can reduce loss of soil from wind erosion and reduce heating and cooling costs for farm buildings and homes (Kort 1995). Shade and winter cover help livestock maintain milk production and weight gain during extreme weather (Dronen 1988).

Income Opportunities

Riparian areas can provide economic benefits to landowners while they provide ecological benefits to communities. Riparian areas can yield many valuable goods, such as floral and wood products, foods, aromatics, pharmaceuticals, and weaving and dying materials. Landowners may also develop recreational enterprises in these areas.

Wood products.

Forested buffers may be used to produce fuelwood, sawtimber, and other wood products (Figure 10) (Walbridge and Struthers 1993, Schultz and others 1994). With their high soil moisture and nutrient availability, these areas are often highly productive sites for growing trees. Riparian areas can also produce valuable hardwood sawlogs, as well as fuelwood for grain driers, space heaters, and small electric generators.

Fig. 10 Forested buffers may be used to produce fuelwood, sawtimber, and other wood products. (Photo courtesy Karen Laco-Breen, Maryland Cooperative Extension)

Researchers in Iowa have suggested an innovative design for producing fuelwood in riparian areas based on the three-zone buffer system proposed by Welsch (Schultz and others 1994). They suggest using specially selected fast-growing tree species (hybrid poplar, green ash, silver maple, black walnut, ninebark, red osier dogwood) as short-rotation woody crop systems to produce biomass for energy in five to eight years and timber products in 15 to 20 years (except black walnut, which is grown on a 45- to 55-year rotation). These particular species were selected because they grow rapidly, reproduce vegetatively by stump or root sprouts, and develop the large root systems required for rapid nutrient uptake and soil stabilization. These trees are combined with native shrubs and grasses to enhance wildlife habitat.

Also in Iowa, Louis Licht (1992) has proposed planting an "ecolotree buffer" of closely spaced (l foot apart in rows 40 feet apart) hybrid poplars for fuelwood production. Hybrid poplars were suggested because they grow very fast in densely planted buffers (producing over 20,000 pounds of wood per acre per year); they coppice easily (producing 2 to 16 new shoots from a harvested stump); they produce roots that grow deep within riparian soils; they are easily cloned from stem cuttings; and they are phreatophytic, capable of surviving root and stem submergence. Preliminary results from Licht's research indicate that the trees grow to almost 18 feet high in two and a half years, while they reduce nitrate-nitrogen concentrations in shallow groundwater by nearly 90 percent.

Other crops.

Riparian areas can be used to produce a variety of crops such as aromatics, botanicals, pharmaceuticals, cooking wood (apple, cherry, and alder), weaving and dying materials, decorative cones, mushrooms, nuts, fruits, honey, and maple syrup (Figure 11). Cut flowers, including cut ornamental grasses, cut grains, cut wildflowers and weeds, and shrubs which produce berries, have unusual or colored bark, or have flowering stems for forcing can be grown in some areas (Kelly 1991).

Fig. 11 Riparian areas can produce crops such as botanicals, ornamentals, nuts, and fruits. (Photo courtesy Karen Laco-Breen, Maryland Cooperative Extension)

One large Virginia grower produces a wide assortment of woody stems and flowers for sale to the Washington, D.C., area (Jenkins 1991). These include cut woody stems for forcing (pussy willow, flowering quince, forsythia, plum, cherry, peach, and crabapple), woody ornamentals for flower production (Bradford pear, Japanese cherry, redbud, spirea, dogwood, mock orange, viburnum, hydrangea, lilac, and weigela), berries (pyracantha, nandina, bittersweet, and deciduous holly), plants with interesting twigs (euonymous and red twig dogwood), and evergreen foliage (privet, holly, pine, spruce, boxwood, and magnolia).

Commercial markets also exist for baby's breath, cattails, mosses, galax, grapevines, witch hazel, corkscrew willow, fantail willow, and birch. In the upper Midwest, sapling-size birch, ironwood, and alder trees are harvested for ornamental purposes (Eisel 1988). Grasses (including love grass, plume grass, Indian grass, fountain grass, reed grass, grama grass, and switch grass) and weeds (such as Queen Anne's lace, wormwood, teasel, goldenrod, wild yarrow, and milkweed) have commercial potential as well (Meyer 1988, Weiler 1988).

Researchers in Indiana have suggested a plan for farm windbreaks that may be applicable to the riparian buffer and would provide income for the farm owner (Miller and others 1994). They suggest a strip of trees and shrubs (in the riparian area, this would be adjacent to the stream) bordered by a strip of perennial livestock forage to be cropped for hay. They suggest shrubs that may be sold as floral crops or landscape stock (corkscrew willow, pussy willow, yellow twig dogwood, red osier dogwood, forsythia, redbud, sea buckthorn, and witch hazel), shrubs for fruit production (hazelnut, elderberry, Nanking cherry), grapes (for fruit and wreaths), trees for fruit production (persimmon, Chinese chestnut, apples, and pears), Christmas trees, hardwoods for fenceposts and firewood, balled and burlap landscape stock, and trees for timber production (green ash, black walnut, and northern red oak). They found that branches from the shrubs could be harvested within two years of planting and resprouted to grow a new crop quickly. Gross returns in excess of $33,580 per acre were anticipated from the sale of pussy willow branches. However, the researchers point out that the timing of planting and removal must be staggered to assure that an effective buffer remains in place.

Kort (1995) has suggested the use of income producing trees and shrubs for shelterbelt plantings in the Great Plains States and the Canadian Prairie Provinces. He suggests the use of boxelder for syrup and saskatoon berry for fruit. Choke cherries, highbush cranberry, buffaloberry, and sea-buckthorn were also being investigated as species with commercial potential. He estimates that 55-year-old shelterbelts in southern Manitoba should yield 3,211 board feet of green ash per half mile and 4,953 board feet of American elm per half mile, for a combined value of $3,464 of hardwood per half mile.

There are two obvious concerns about developing alternative income crops in riparian areas. The first, from the grower's perspective, is finding a way to reasonably incorporate them into ongoing farm operations, and marketing the products once they are harvested. Markets for these types of products are highly variable, and landowners may have work to establish markets with local retailers, such as grocery stores, florist shops, and craft stores to have local buyers. Facilities and costs for harvesting, packaging, storage, handling, and shipping must be considered. From the environmental perspective, there may be concerns about the loss of native plant diversity and the impacts of harvest activities on the functioning of the buffer.

Recreation

Landowners may derive income from leasing hunting and fishing rights to their property, or from developing other recreational opportunities such as wildlife observation/photography areas or swimming/boating areas (Figure 12). On the Eastern Shore of Maryland, hunters and professional guides paid an average of $10,000 per farm in 1988 to lease lands with access to waterfowl (Lynch 1997). Many farmers work as part-time hunting guides during the winter season, reporting incomes between $7,000 to $30,000 for their services. Hunters also purchased food, lodging, equipment, clothing, and other items. Some farms earn additional income by offering shoot and release of pen-raised birds, sporting clays, services to clean game, and similar enterprises.

Fig. 12 Landowners may lease fishing rights to their property

Summary and Recommendations

Riparian forest buffers can provide many benefits to individuals and communities. Communities may benefit from improved water quality, reduced sedimentation, and less flood damage. Riparian areas can offer important recreational opportunities and may provide income to agricultural landowners.

The design of riparian forest buffers to provide these benefits depends on many factors, including the specific objective and the area's hydrology, soils, and upstream land use. Some general guidelines on riparian forest restoration are presented below. More detailed information on restoring riparian forest buffers may be found in the Virginia Cooperative Extension publication Riparian Forest Buffers: Planning, Establishment, and Maintenance.

Water quality

The ability of the buffer to filter chemical contaminants is highly variable; however, forest buffers 35 to 125 feet wide are generally recommended to remove nutrients and other chemical contaminants, depending on pollutant loading and site conditions (Palone and Todd 1977). Buffers 50 to 100 feet wide are usually recommended to trap sediments, with the buffer expanding where there are steep slopes or where sediment loading is high (Palone and Todd 1977).

Flood damage

Buffers designed to moderate flood damages should take into account the floodplain width and upstream land use. A small band of trees may be all that is necessary along small streams; however, wide buffers extending throughout the floodplain are recommended along large streams and rivers (Dosskey et al. 1997).

Bank stabilization

Many streams in agricultural and urban areas have unstable banks, a result of high stream velocities and prior flooding events. Where erosion is moderate, forest buffers of 25 to 55 feet wide are recommended to stabilize and maintain streambanks (O'Laughlin and Belt 1995, Palone and Todd 1997). However, the buffer should be wide enough to accommodate natural shifts in the stream channel that will occur as the stream stabilizes. If erosion is excessive, efforts should first be made to correct or moderate the problem. This may include leveling back the streambank, installing structures such as riprap, gabions, sandbags, or live fascines, and most importantly, taking corrective measures upstream to reduce the intensity of flood waters.

Recreation and aesthetic amenities

In recreational areas, buffers should be large enough to accommodate the desired activity. Measures should be taken to protect the area from overuse. This may include the construction of parking areas outside the buffer, providing toilets, and properly constructed trails and boat ramps. The choice of aesthetically pleasing trees, for example, those with showy flowers, fruit, color, or texture may be a consideration in recreational areas and for landowners who are concerned with aesthetic amenities.

Forest products

Landowners who wish to harvest a marketable product from the buffer must consider the appropriate species for planting, spacing, and cultural practices required. The area in production must be large enough for the operation to be economically viable.

List of Common and Scientific Names

Alder	*Alnus spp.*
American elm	*Ulmus americana*
American holly	*Ilex opaca*
Apple	*Malus spp.*
Baby's breath	*Gypsophila spp.*
Birch	*Betula spp.*
Bittersweet	*Celastrus spp.*
Black walnut	*Juglans nigra*
Boxelder	*Acer negundo*
Boxwood	*Buxus spp.*
Bradford pear	*Pyrus calleryana* 'Bradford'
Buffaloberry	*Shepherdia argentea*
Cattail	*Typha spp.*
Cherry	*Prunus spp.*
Chinese chestnut	*Castenea mollissima*
Chokecherry	*Prunus virginiana*
Corkscrew willow	*Salix matsudana* 'Tortuosa'
Crab apple	*Malus spp.*
Deciduous holly	*Ilex spp.*
Dogwood	*Cornus spp.*
Elderberry	*Sambucus canadensis*
Euonymus (winged)	*Euonymus altata*
Fantail willow	*Salix sachalinensis* 'Sekko'
Flowering dogwood	*Cornus florida*
Flowering quince	*Chaenomeles speciosa*
Forsythia	*Forsythia spp.*
Fountain grass	*Pennisetum alopecuroides*
Galax	*Galax spp.*
Goldenrod	*Solidago spp.*
Grama grass	*Bouteloua spp.*
Grape	*Vitus spp.*
Green ash	*Fraxinus pennsylvanica*
Hazelnut	*Corylus americana*
Highbush cranberry	*Viburnum trilobum*
Holly	*Ilex spp.*
Hybrid poplar	*Populus spp.*
Hydrangea	*Hydrangea spp.*
Indiangrass	*Sorghastrum nutans*
Ironwood	*Carpinus caroliniana*
Japanese cherry	*Prunus yoshino, Prunus shrotea*
Lilac	*Syringa spp.*
Lovegrass	*Eragrostis spp.*
Magnolia	*Magnolia spp.*
Milkweed	*Asclepias spp.*
Mock orange	*Philadelphus coronarius*
Nandina	*Nandina domestica*
Nanking cherry	*Prunus tomentosa*
Nannyberry viburnum	*Viburnum lentago*
Ninebark	*Physocarpus opulifolius*
Northern red oak	*Quercus rubra*
Peach	*Prunus persica*
Pear	*Pyrus spp.*
Persimmon	*Diospyros virginiana*
Plum	*Prunus domestica*
Plume grass	*Erianthus ravennae*
Privet	*Ligustrum spp.*
Pussywillow	*Salix spp.*
Pyracantha	*Pyracantha spp.*
Queen Anne's Lace	*Daucus carota*
Red osier dogwood	*Cornus stolonifera, Cornus sericia*
Red twig dogwood	*Cornus stolonifera, Cornus sericia, Cornus alba 'sibirica'*
Redbud	*Cercis canadensis*
Reed grass	*Calamagrostis spp.*
Saskatoon berry	*Amelanchier alnifolia*
Sea-buckthorn	*Hippophae rhamnoides*
Silver maple	*Acer saccharinum*
Spirea	*Spiraea spp.*
Spruce	*Picea spp.*
Switchgrass	*Panicum virgatum*
Teasel	*Dipsacus sylvestris*
Viburnum	*Viburnum spp.*
Weigela	*Weigela florida*
Wild Yarrow	*Achillea millefolium*
Witch hazel	*Hamamelis virginiana*
Wormwood	*Artemisia caudata*
Yellow-twig dogwood	*Cornus sericea* 'Flaviramea'

Bibliography

Aitchison, S.W., S.W. Carothers, and R.R. Johnson. 1977. Some ecological considerations associated with river recreation management. Pages 222-225. In: *River Recreation Management and Research*. Proceedings of a Symposium. Jan. 24-27, 1977 Minneapolis, Minn. US Department of Agriculture Forest Service Publication GTR-NC-28. St. Paul, Minn. 455 pages.

Blakesley, J.A. and K.P. Reese. 1988. Avian use of campground and noncampground sites in riparian zones. *Journal of Wildlife Management* 52:399-402.

Brown, T.C. and T.C. Daniel. 1991. Landscape aesthetics of riparian environments: relationship of flow quantity to scenic quality along a wild and scenic river. *Water Resources Research* 27:1787-1795.

Carson, R.T. and R.C. Mitchell. 1993. The value of clean water: the public's willingness to pay for boatable, fishable, and swimmable water quality. *Water Resources Research* 29:2445-2454.

Clark, E.H. II. 1985. The off-site costs of soil erosion. *Journal of Soil & Water Conservation* 40:19-22.

Clark, E.H., II, J.A. Haverkamp, and W. Chapman. 1985. Eroding soils: the off-farm impacts. The Conservation Foundation, Washington, D.C. 252 pages.

Clark, R.N., D.R. Gibbons, and G.B. Pauley. 1985b. Influence of forest and rangeland management on anadromous fish habitat in Western North America: Influences of recreation. U.S. Department of Agriculture Forest Service Publication GTR-PNW-178.

Clonts, H.A. and J.W. Malone. 1990. Preservation attitudes and consumer surplus in free-flowing rivers. Pages 301-315. In: Vining, J. (editor) *Social Science and Natural Resource Recreation Management*. Westview Press. Boulder, Colo. 330 pages.

Crutchfield, S.R., J.C. Cooper, and D.R. Hellerstein. 1997. Benefits of safer drinking water: the value of nitrate reduction. U.S. Department of Agriculture Economic Research Service Publication AER-752. Washington, D.C. 15 pages.

Dronen, S.L. 1988. Layout and design criteria for livestock windbreaks. *Agriculture, Ecosystems, and Environment* 22/23:231-240.

Eisel, M.C. 1988. Deciduous woody plants for the florist trade. Pages 57-64. In: *Commercial Field Production of Cut and Dried Flowers*. Proceedings of a symposium December 6-8, 1988. University of Minnesota Center for Alternative Crops and Products and The American Society of Horticultural Science. 207 pages.

Emerson, P.M. 1996. Cultural values in riparian areas. Pages 36-39 In: Laursen, S.B. (editor) *At the Water's Edge: The Science of Riparian Forestry*. Proceedings of a conference held June 19-20, 1995, Duluth Minn. University of Minnesota Publication BU-6637-S. 160 pages.

Gitelson, R.J. and A. Graefe. 1990. Economic impacts associated with whitewater boating on the Upper Youghiogheny River. Pages 65-69. In: Proceedings of the 1990 Northeastern Recreation Research Symposium Feb. 25-28, 1990. Saratoga Springs, N.Y. U.S. Department of Agriculture Forest Service Publication GTR-NE-145. 207 pages.

Gregory, S.V., F.J. Swanson, W.A. McKee, and K.W. Cummins. 1991. An ecosystem perspective of riparian zones. *Bioscience* 41:540-551.

Guldin, R.W. 1989. An analysis of the water situation in the United States: 1989-2040. U.S. Department of Agriculture Forest Service Publication GTR-RM-177. 178 pages.

Hagan, P.T. 1996. Evaluating determinants of participation in voluntary riparian buffer programs: a case study of Maryland's Buffer Incentive Program. University of Maryland Master's Thesis. Marine, Estuarine, and Environmental Sciences Program. 169 pages.

Harris, C.C., W.J. McLaughlin, and D.K. Rawhouser. 1990. Comprehensive evaluation of information/education programs to reduce recreational impacts on the Lower Salmon River. *Journal of Environmental Management* 31:19-28.

Higgins, D.A. 1996. Forest management in riparian areas. Pages 118-122. In: Laursen, S.B. (editor) *At the Water's Edge: The Science of Riparian Forestry.* Proceedings of a conference June 19-20, 1995. Duluth, Minn. University of Minnesota Pub. BU-6637-S. St. Paul, Minn. 160 pages.

Holmes, T.P. 1988. The offsite impact of soil erosion on the water treatment industry. *Land Economics* 64:356-367.

Hoover, S.L., D.A. King, and W.J. Matter. 1985. A wilderness riparian environment: visitor satisfaction, perceptions, reality, and management. Pages 223-226. In: Johnson, R.R., C.D. Ziebell, D.R. Patton, P.F. Folliott, and R.H. Hamre. (editors) *Riparian Ecosystems and their Management: Reconciling Conflicting Uses*. Proceedings of the first North American riparian conference. April 16-18, 1985. Tuscon, Ariz. U.S. Department of Agriculture Forest Service Publication GTR-RM-120. 445 pages.

Jenkins, D.F. 1991. Woody plants as cut flowers. Pages 68-74. In: *From a grower's perspective: the business of growing specialty cut flowers. Proceedings of the 4th National Conference on Specialty Cut Flowers.* November 1-4, 1991. Cleveland, Ohio. Association of Specialty Cut Flower Growers, Inc. 144 pages.

Johnson, J.L., D. Grotelueschen, and M. Knott. 1994. Evaluation of bovine perinatal nitrate accumulation in western Nebraska. *Veterinary and Human Toxicology* 36:467-471.

Jordan, J.L. and A.H. Elnagheeb. 1993. Willingness to pay for improvements in drinking water quality. *Water Resources Research* 29:237-245.

Kasi, V. and B. Botter. 1994. Streambank fencing for the remediation of agricultural nonpoint source pollution. Pages 301-305. In: *Riparian Ecosystems in the Humid U.S.: Functions, Values, and Management*. Proceedings of a conference March 15-18, 1993. Atlanta Ga. National Association of Conservation Districts. 445 pages.

Kelly, J.W. 1991. Field production of cut flowers. *HortScience* 26:1136-1138.

Kort, J. 1995. Economics of Agroforestry. Pages 227-230. In: W.J. Rietveld (editor) *Agroforestry and Sustainable Systems*. Proceedings of a Symposium. U.S. Department of Agriculture Forest Service Publication GTR-RM-261. 276 pages.

Kuska, J.J. 1977. Biological approach to river planning and management. Pages 296-304. In: *River Recreation Management and Research*. Proceedings of a symposium. U.S. Department of Agriculture Forest Service Publication GTR-NC-28. St. Paul, Minn. 455 pages.

Leopold, L.B. 1969. Landscape esthetics: How to quantify the scenics of a river valley. *Natural History* 78 (8):36-45.

Licht, L.A. 1992. Salicaceae family trees in sustainable agroecosystems. *Forest Chronicles* 68:214-217.

Litton, R.B. 1977. River landscape quality and its assessment. Pages 46-54. In: *River recreation management and research*. Proceedings of a symposium. U.S. Department of Agriculture Forest Service Publication GTR-NC-28. St. Paul, Minn. 455 pages.

Lowrance, R., R. Leonard, and J. Sheridan. 1985. Managing riparian ecosystems to control nonpoint pollution. *Journal of Soil & Water Conservation* 40:87-91.

Lynch, L. 1997. Closed geese season brings economic chill to eastern shore's winter. *Economics Viewpoints* 2(1):9-11. University of Maryland Cooperative Extension Service, College Park, Md.

Meyer, M.H. 1988. Everlasting ornamental grasses. Pages 69-73. In: *Commercial Field Production of Cut and Dried Flowers*. Proceedings of a symposium December 6-8, 1988. University of Minnesota Center for Alternative Crops and Products and The American Society of Horticultural Science. 207 pages.

Miller, B.K., B.C. Moser, K.D. Johnson, and R.K. Swihart. 1994. Designs for windbreaks and vegetative filterstrips that increase wildlife habitat and provide income. Pages 567-574. In: Campbell, K.L., W.D. Graham, and A.B. Bottcher (editors) *Environmentally Sound Agriculture*. Proceedings of the Second Conference April 20-22, 1994, Orlando, Fla. American Society of Agricultural Engineers. St. Joseph, Mich. 578 pages.

Overcash, M.R., F.J. Humenik, J.R. Miner. 1983. Livestock waste management: Volume I. CRC Press, Inc. Boca Raton, Fla.

Palmateer, G.A. 1992. Transport of biological pollutants from agricultural sources through aquatic sediment systems in Ontario. Pages 59-77. In: Miller, M.H., J.E. Fitzgibbon, G.C. Fox, R.W. Gillham, and H.R. Whiteley (editors) Agriculture and Water Quality. Proceedings of an Interdisciplinary Symposium. April 23-24, 1991. Centre for Soil and Water Conservation, Guelph, Ontario, Canada. 213 pages.

Palone, R.S. and A.H. Todd (editors) 1997. Chesapeake Bay riparian handbook: a guide for establishing and maintaining riparian forest buffers. U.S. Department of Agriculture Forest Service, Northeastern Area State and Private Forestry. Publication NA-TP-02-97. Radnor, Penn.

Park, W.M and E.B. Dyer. 1986. Off-site damages from soil erosion in West Tennessee. Pages 113-123. In: Waddell, T.E. (editor). *The off-site costs of soil erosion*. Proceedings of a symposium held May 1985. Conservation Foundation, Washington, D.C. 284 pages.

Pawelko, K.A., E.B. Drogin, A.R. Graefe, and D.P. Huden. 1995. Examining the nature of river recreation visitors and their recreational experiences on the Delaware River. Pages 43-49. In: Dawson, C.P. (editor) *Proceedings of the 1995 Northeastern Recreation Research Symposium*. U.S. Department of Agriculture Forest Service Publication GTR-NE-218. 286 pages.

Pigram, J. 1983. Outdoor Recreation and Resource Management. St. Martin's Press, N.Y. 262 pages.

Ribaudo, M.O. 1986. Regional estimates of off-site damages from soil erosion. Pages 29-46. In: Waddell, T.E. (editor). *The Off-Site Costs of Soil Erosion*. Proceedings of a symposium held May 1985. Conservation Foundation, Washington, D.C. 284 pages.

Schultz, R.C., J.P. Colletti, W.W. Simpkins, C.W. Mize, and M.L. Thompson. 1994. Developing a multi-species riparian buffer strip agroforestry system. Pages 203-211. In: *Riparian Ecosystems in the Humid U.S. Functions, Values, and Management*. Proceedings of a conference March 15-18, 1993. Atlanta, Ga. National Association of Conservation Districts. 445 pages.

Schultz, S.D. and B.E. Lindsay. 1990. The willingness to pay for groundwater protection. *Water Resources Research* 26:1869-1875.

Sun, H., J.C. Bergstrom, and J.R. Dorfman. 1992. Estimating the benefits of groundwater contamination control. *Southern Journal of Agricultural Economics* 19:63-71.

U.S. Environmental Protection Agency. 1995. National water quality inventory: 1994 report to Congress. U.S. Environmental Protection Agency Office of Water. EPA841-R-95-005. Washington, D.C.

U.S. Fish and Wildlife Service and U.S. Bureau of the Census. 1996. National survey of fishing, hunting, and wildlife-associated recreation. U.S. Fish and Wildlife Service FHW/96 NAT. 115 pages.

USA Today. March 24, 1998. Across the USA: news from every state – Virginia. USA Today. Section A Page 10.

Veenhuizen, M.F. and G.C. Shurson. 1992. Effects of sulfate in drinking water for livestock. *Journal of the American Veterinary Medical Association* 201:487-492.

Virginia Departments of Environmental Quality and Conservation and Recreation. 1998. Virginia Water Quality Assessment 1998. 305(b) Report to the Environmental Protection Agency Administrator and Congress. Virginia Departments of Environmental Quality and Conservation and Recreation. Richmond, Va.

Walbridge, M.R. and J.P. Struthers. 1993. Phosphorus retention in non-tidal palustrine forested wetlands of the mid-Atlantic region. *Wetlands* 13(2):84-94.

Wall, G. and C. Wright. 1977. The environmental impact of outdoor recreation. University of Waterloo Department of Geography Publication 11. Waterloo, Ontario, Canada. 69 pages.

Weiler, C.J. 1988. Wildflowers and weeds: a floral designer's view. Pages 153-158. In: *Commercial Field Production of Cut and Dried Flowers*. Proceedings of a symposium December 6-8, 1988. University of Minnesota Center for Alternative Crops and Products and The American Society of Horticultural Science. 207 pages.

Welsch, D.J. 1991. Riparian forest buffers – function and design for protection and enhancement of water resources. Publication NA-PR-07-91 U.S. Department of Agriculture Forest Service Northeastern Area State & Private Forestry. Radnor, Penn. 20 pages.

Wichelns, D. and J.D. Kline. 1993. The impact of parcel characteristics on the cost of development rights to farmland. *Agricultural Resources & Economics* Review 93:150-158.

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