DELAWARE RIVERKEEPER®

Riparian Buffers

Riparian buffers are naturally vegetated areas adjacent to waterways, including streams, ponds, estuaries and wetlands. This natural vegetation protects the land adjoining a waterway by preserving the floodplain, keeping native soils intact, and maintaining the streamside land and streambanks. Vegetative buffers help encourage infiltration of rainfall and runoff, and provide absorption for high stream flows – this sponge like action and infiltration provided by the buffer helps reduce flooding and drought. The vegetative community provides habitat for many species of plants and animals, many of them dependent on riparian habitat features for survival and many of them threatened or endangered species. The buffer area provides a living cushion between upland land use and water, protecting water quality, the hydrologic regime of the waterway and stream structure. The naturally vegetated buffer filters out pollutants, captures sediment, regulates stream water temperature and processes many contaminants through vegetative uptake. In this way, buffers efficiently provide water quality benefits and environmental enhancement for waterways and wetlands. Riparian buffers should be kept intact or restored wherever possible.

Buffers Work Hard

Buffers protect floodplains and reduce flooding

The floodplain is the area adjacent to a waterway where floodwaters periodically flow in storms. When the floodplain is naturally vegetated it can function as the sponge nature intends. Vegetative buffers allow water to be taken up by buffer vegetation and encourage infiltration through the soil to groundwater. Vegetative buffers absorb storm flows, holding and gently releasing floodwater over time, which helps to regulate the flow of the stream and reduces downstream flooding during a storm.[1] The floodplain's access to water, nutrients, and the dynamic forces of nature allow it to support productive and beautiful landscapes and combine to make the riparian area some of our most fertile soils.[2] And the beauty of healthy, vegetated floodplains is economically valuable – attracting and supporting water-based recreation and ecotourism, and increasing the market value of nearby properties.[3]

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Buffers protect streambanks and waterway morphology (stream structure)

Streams are formed over time by the forces of nature. A stream's physical structure shifts naturally over time but often is forced to change more dramatically, unnaturally and even dangerously by human intrusion such as increased stormwater runoff, dams, rip rap, levees, floodplain disturbance and hydrologic alterations. A vegetated buffer along a waterway protects and supports the banks and other critical parts of a stream's make-up, allowing it to resist erosive forces and remain stable. Riparian buffers are the glue that holds together nature's design. The vegetation's roots hold the riparian lands in place, maintaining the hydraulic roughness of the bank, slowing flow velocities in the stream near the bank.[4] Also, the absorption ability of a vegetated buffer, especially when it contains a mix of woody shrubs and trees, slows down the water in high stream flows and soaks up water, reducing in-stream channel velocity and volume during storm events[5], and thereby reducing the damage to the stream of poorly controlled stormwater flows. Root systems of woody shrubs and trees do a better job of anchoring soils -- a job turf grass cannot do effectively.[6]

Buffers protect life in and associated with the stream

Riparian buffers and streamside forests are complex ecosystems vital to the protection of our streams and stream life.[7] Forested riparian buffers provide a balanced, integrated, adaptive community of riparian and aquatic organisms that have the capacity for stability and self-repair.[8] They do this in many ways:

- Riparian buffers provide food, cover and habitat for wildlife and aquatic organisms.[9] They also support diverse and productive plant communities.[10] Many species of flora and fauna found there can survive nowhere else, using the riparian area as both temporary and permanent habitat.[11] Many birds are particularly dependent on the unique resources of the riparian area.
- Buffers also regulate stream temperature through shading, important for healthy habitat. Denuded waterways typically suffer from increased instream water temperatures. Studies have concluded that removal of streamside vegetation can result in a temperature increase of 6 to 9 degrees Centigrade[12] and a Pennsylvania study found increases from 4 to 9 degrees Fahrenheit which is the equivalent of moving the stream over 400 miles south.[13] Also, riparian vegetation moderates stream temperature reducing the daily and seasonal fluctuations in stream temperature.[14] The heating up of a stream reduces the oxygen carrying capacity of the waterway,[15] harming stream life that is temperature-sensitive. Also, as water temperature increases above 60 degrees F, phosphorus (a nutrient) attached to sediment, is more readily released from its sediment hosts and dispersed into the stream as a pollutant.[16] Increased water temperatures also produce heavy growth of filamentous algae (from increases of 9 degrees F), encourage the growth of parasitic bacteria, and can adversely affect benthic organisms. [17]
- Vegetated streambanks, low lying branches, root systems, submerged logs and other detritus provide critical wildlife habitat, benefiting terrestrial, aquatic and reptile/herptile species. [18] The rich habitat adds to the organic food base and increases biological diversity and productivity of stream communities. In small upland streams as much as 75% of the organic food base may be supplied by dissolved organic compounds or detritus such as fruit, limbs, leaves, and insects that fall from the forest canopy. [19] Benthic organisms feed on the detritus, forming the basis of the food chain.[20] The woody debris added by riparian buffers also enrich stream and streamside habitat.[21]
- The stream's physical composition is protected by buffer vegetation, supporting the habitat that is needed by the life in and associated with the stream.
- Forested corridors connect isolated blocks of habitat allowing wildlife to migrate from one community to another.[22]

Buffers protect the stream from negative impacts of overland flow

It is critical that riparian buffers not be intruded upon by concentrated flow from upland use, as is recommended by the Natural Resources Conservation Service in Conservation Service Practice Standard Code 390, "Riparian Herbaceous Cover".[23] Vegetated buffers intercept the diffuse flow of runoff from adjacent land, slowing the velocity and reducing the volume of the flow. They also turn would-be pollutants into a resource for the plants and trees in the buffer, protecting the waterway's water quality.

This is done in many ways:

- Sediment and particulates are trapped by the structure of the forest floor and other naturally vegetated communities. Riparian buffer vegetation and organic litter slow the flow of runoff, allowing a greater opportunity for sediment and particulates to settle out before entering a stream or other waterway.
- Plants, via their root systems, take up pollutants, especially nitrogen and phosphorus that are essential for plant growth.[24] About 80% of phosphorus in runoff is removed by forested buffers; about 80% of nitrogen is transformed to gases by the anaerobic conditions in leaf litter and surface soil layers, removing it from runoff; pesticides are formed into gases by the anaerobic conditions in leaf litter and surface soil layers or are taken up as nutrients by plants and trees, removing them from runoff; pesticides are also transformed and biodegraded.[25]

Buffers have multiple benefits, provide added value

Riparian corridors provide shelter for insects that are beneficial in the control of agricultural pests [26] and provide a natural integrated pest management system for the local environment. Riparian buffers enhance property market values. For example, "Pennypack Park in Philadelphia is credited with a 38% increase in the value of a nearby property."[27] Buffers enhance human health through protecting and improving drinking water quality, saving money and resources on water treatment as well. They also add to our quality of life through aesthetic amenity and the peace of mind that a person has knowing of and experiencing the healthy stream and riparian ecosystem that the buffer provides. There may be no precise way to monetarily measure the value of quietly sitting under a tree or fishing in a creek, but these benefits are very real nonetheless.

Buffer Widths

In general, riparian buffers should be as wide as possible. The recommended buffer width will vary depending on the goals being strived for and surrounding land use. For example, a wider buffer may be required for areas where there is a higher intensity of land use such as residential areas, as compared to areas with a low-intensity land-use[28] such as open space. Also, chemically treated land such as typical golf courses, silviculture, and agriculture that do not employ organic management practices may require wider buffers to protect water quality. Buffer width needs will also vary with the characteristics of the stream being protected -- for example streams used by salmonids for spawning may require a larger buffer than a stream used only as a salmonid migration corridor. [29]

The width of a riparian area varies with the functions the buffer serves and there is a large volume of scientific research that studies how to define an effective width. It is reasonable to base decisions concerning buffer width on environmental and wildlife needs.

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Buffer widths serve a variety of functions, "including streambank stabilization; erosion control; providing organic matter critical for aquatic organisms; serving as nutrient sinks for the surrounding watershed; water temperature control through shading; reducing flood peaks; and serving as key recharge points for renewing groundwater supplies", according to the *Army Corps of Engineers*.[30] The Corps recommends a minimum riparian buffer width of 300 ft. for avian populations and points out that the wider the buffer, the more protective of ecological functions, which they consider to be a mandated goal of the Clean Water Act.[31]

A White Paper submitted to the *Washington Dept. of Fish and Wildlife* reports that literature on forest stream buffers suggest that 300 to 600 ft. buffers are needed for bird populations to limit the effects of nest predation from invading birds.[32] Scientists have recommended 600-foot buffers in order to accommodate important bird species such as herons and bald eagles.[33] And certain birds and amphibians are documented to need 600' or more as shown below:[34]

For songbirds:	660' (Scheuler)
For breeding birds:	660' (Stauffer and Best 1980)
For travel corridors;	660' (Forman 1983)
(For all wildlife except black bears)	
For bald eagle, heron:	600' (Roderick and Miller 1991)
For cavity nesting ducks:	600' (Roderick and Miller 1991)
For wood duck:	600' (Grice and Rogers 1965)
For blue-winged teal:	840' (Duebbertand Lokemeon 1976)
or red shouldered hawk:	330' (AppD-4, State of Vermont 2001)
For wood turtle:	330' (AppD-4, State of Vermont 2001)
(distance from nest to water)	
For wood turtle:	100' to 1 mile (AppD-4, State of Vermont 2001)
(feeding habitat distance from water)	
or spotted turtle:	100' to ½ mile (AppD-4, State of Vermont 2001)
(feeding habitat distance from water)	

The *State of Vermont* reports on various buffer widths and their functions in its buffer guidance document.[35] They cite the following literature and widths of 300' or greater needed to protect numerous wildlife species:

For general protection:	50'-300' (Roman and Good 1985)
For nutrient removal:	150'-300'(Clark 1997)
For waterfowl nesting:	300' (Foster et al 1984)
For beaver, mink:	300'-330' (Roderick and Miller 1991)
For dabbling ducks:	300'-330' (Roderick and Miller 1991)
For furbearers:	330' (Dibello 1991)
For beaver feeding:	330' (Hall 1970)
For mink den sites:	330' (Mequist 1981, Linn and Birks 1981)
For mink habitat:	600' (Mequist 1981, Linn and Birks 1981)
For sm. Mammals:	330' (Golet et al 1993)
For reptiles, amphib.:	330' (Golet et al 1993)
For pileated woodpker:	450' (Roderick and Miller 1991)
For breeding birds:	575' (Hooper, unpub. Mauscr.)

A study of riparian areas and bird use in central *Pennsylvania* resulted in a recommendation of a 410-foot buffer of natural vegetation in order to support the full compliment of birds in the area. [36] While smaller widths will provide habitat for some of the birds present, studies focused on Delaware and Maryland found that riparian forests which are less ten 328 feet wide are dominated by short distance migrants but forest buffers wider than 328 feet have more neotropical migrant species, and the numbers of bird species present continued to increase in forests wider than 656 feet. [37]

Widths for Protecting Aquatic Life

The Corps states, "that establishing or maintaining existing vegetated buffers to open waters is critical to overall protection of the nation's aquatic ecosystems".[38] Therefore, there is a federal mandate for the protection of aquatic ecosystems in order to protect water resources and open waters.

The *Washington Dept. of Fish and Wildlife White Paper*, citing the US Fish and Wildlife Service, recommends a 150 ft. buffer beyond the 100 yr. floodplain on both sides of the stream (which, depending on the location of the regulated floodplain can be wider than 300 ft.) to accommodate the channel migration zone for bull trout in Washington's streams. The buffer is required in order to include tall trees, filter sediments, provide microclimate and shallow groundwater thermal buffering to protect aquatic habitats, and to allow for stream meandering.[39] It has been found that meander bends are five times less likely to be significantly eroded from a major flood than nonvegetated bends.[40]

Widths Needed to Protect Water Quality and Waterway Health

Riparian areas are critical for the protection of the ecological resources that are dependent on them and for maintaining high quality streams. The riparian area adjacent to a stream directly impacts the stream's water quality. In order to protect and improve stream water quality, a buffer needs to be of sufficient width.

The Wisconsin shoreline-zoning program (*Wisconsin Administrative Code* Ch NR115) uses a 1000' buffer from any lake and 300' from a stream or its floodplain. Nationally, public lands, in general, are required to have a 25' to 500' riparian management zone where forests are kept intact. The Maryland Chesapeake Bay Critical Area Program employs a buffer of 1000' from the mean high waterline of tidal waters or the landward edge of tidal wetlands or tributaries.[41]

The *State of Vermont* report calls for widths ranging up to 375 feet for water quality protection; specifically the report cites:[42]

For water quality:	25'-300' (Palmstrom, 1991)
	45'-300' (Nieswand et al 1990)
	50'-330' (Trimble 1957)
	75'-375' (75'-375') [specifically for sediment]

In recommending buffers on lands where the pesticide terbufos is used (an organophosphate), the *Environmental Protection Agency* lists riparian buffer widths to mitigate risk factors for drinking water and ecological impacts: a 500 ft. vegetative buffer between treated area and surface water on neighboring lands and between a standpipe drain outlet and surface water on neighboring land; a 300 foot setback between the treated area and entry points to surface water bodies on highly erodible soils; and the restriction of loading, rinsing, and washing equipment within 300 ft. from surface water bodies or within 50 ft. from wells unless conducted on an impervious surface.[43]

"The integrity of the stream depends on an intact buffer."[44]

Recommended buffer widths for water quality enhancement varies depending on what water quality parameter is considered and site-specific conditions such as geology, slope, and vegetation present. For instance, one study has determined that 300 to 400 foot buffers are needed to remove clay particles. [45] One study in *North Carolina* found that a buffer width of up to 300 feet could be required to remove nitrates from field drainage, depending on conditions. [46] Further, it has been observed that there is no guarantee that a certain width buffer will provide total pollutant removal. For example, while a shorter buffer width may remove the bulk of the sediment carried in overland flow, a much wider buffer might be needed to increase the contact and settling time necessary to remove the smaller sediments which will not/and cannot be removed without that larger width and settling/contact time.[47]

The Riparian Buffer as a Stormwater Best Management Practice

With the advent of the Federal Clean Water Act's NPDES 2 and the development of more effective stormwater management regulations in the Delaware Watershed states, best management practices (BMPs) are being prescribed to prevent the damage to our streams and watersheds caused by stormwater runoff that results when land is disturbed. Employed as a BMP, riparian buffers can be installed and/or preserved on a site to manage and prevent stormwater, allowing the would-be stormwater runoff to be the resource nature intends. Careful attention to design and maintenance is required to successfully employ this BMP.

Overall consideration

Native plants, specific to the locale, should always be used in vegetated buffers. Native plants are best adapted to our area, rainfall patterns, and soil conditions. They have evolved and developed relationships with wildlife and other plant species. As a result, native plants provide optimal performance and will require little care or maintenance. Exotic species should be avoided as they are often invasive, supplanting native vegetation, and are subject to pests and disease.

Also very important to the effective functioning of a riparian buffer is the quality and mix of vegetation. Characteristics such as species diversity, vegetation type, physical condition and maturity all affect the ability of the buffer to do its job. Forested buffers, for instance, can perform better in certain situations than other BMPs. The forested buffer which includes a mix of plants, shrubs, and trees can work on steep slopes, where other vegetation, especially grass, and other BMPs may be difficult to install and maintain.

Land development, agricultural, and open space projects should all endeavor to preserve and protect all existing riparian buffers and integrate riparian buffers of sufficient width and quality into the entire site plan, and re-vegetate riparian buffers where they have been disturbed and/or removed.

Design considerations

A constructed riparian buffer must be designed to fit with the stream and the physical characteristics of the watershed. The use of GIS data, natural resource inventory data, stream classification information, and on-site analysis of the specific conditions and needs of the stream and buffer area will inform the designer about the site's ecology and will make for a successful riparian buffer. Questions need to be addressed such as: are there any threatened and endangered species to be considered; what natives grow here now; what are the water quality needs of the stream; what is the condition of the riparian areas upstream and downstream of the site? There is no one size-fits-all riparian buffer design that will be successful -- the design elements being dictated by the specific environmental features of the site, the stream and its watershed.

However, there are some general guidelines that apply, which include

- Buffers should be made as wide as possible to accommodate site-specific needs of the stream, the stream corridor, the riparian lands and uplands (the watershed).
- The riparian buffer closest to the stream should be planted with species that:[48]
    - Tolerate saturated or partly saturated soils;
    - Can be inundated for short periods after storms;
    - Withstand occasional drought during dry weather;
    - Stabilize the streambank from erosion;
    - Provide shade and cooling to adjacent waterways;
    - Enhance pollution uptake;
    - Are very low maintenance since access can be difficult;
    - Provide food and cover for wildlife;
    - Provide habitat inhospitable to resident waterfowl;
    - Are native species;
    - Are propagated from seed rather than cloned, to allow for maximum reproductive virility.
- The floodplain area upland from the riparian buffer should be planted with species that:[49]
    - Tolerate occasional short-term inundation during storms;
    - Tolerate moist soils and drought conditions;
    - Stabilize the floodplain;

- Are low maintenance;
- Provide food and cover for wildlife;
- Provide structure for under-plantings;
- Provide shade and cooling.

Maintenance

While a riparian buffer is being established, it is important to inspect it regularly. Weeding is critical to keep out invasive species. Watering, especially in the first two years, and replacement of vegetation may be necessary. In addition to careful observations during the first year or so, inspections should also be done after large storms and heavy runoff to remove unnatural debris, to check for damage to vegetation, and to inspect for erosion and for channelized flows through the buffer. Once the buffer is established routine maintenance is minimal. This includes litter removal, spot vegetation repair, removal of sediment buildup (over 6") and periodic fertilization (only natural fertilizers should be used). Annual inspections should be done to look for encroachment by vehicles or foot traffic, gully erosion or any evidence of concentrated flows through the area, especially if surrounding conditions have changed.[50] Inspections and maintenance may also be required to monitor for, and if necessary to address, invasion by non-native species.

For more information on buffer monitoring and maintenance:
Adopt-A-Buffer Toolkit: Monitoring and Maintaining Restoration Projects, Delaware Riverkeeper Network, Sept. 2003. (Adobe PDF File)

A Mature Riparian Buffer

Darby Creek Pennsylvania before planting of riparian buffer

Darby Creek one year after riparian restoration planting

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[1]J. Toby Tourbier, "Open Space Through Stormwater Management, Helping to Structure Growth on the Urban Fringe".

[2] David Welsch, Forest Resources Management, USDA Forest Service, “Riparian Forest Buffers: Function and Design for Protection and Enhancement of Water Resources”, NA-PR-07-91

[3] For example, "Pennypack Park in Philadelphia is credited with a 38% increase in the value of a nearby property." Center for Watershed Protection, *Better Site Design: A Handbook for Changing Development Rules in Your Community*, August, 1998, p. 134

[4] Water, Science, and Technology Board, Board of Environmental Studies and Technology, “Riparian Areas: Functions and Strategies for Management”, 2002, citing Swanson, et al.

[5] J. Toby Tourbier, "Open Space Through Stormwater Management, Helping to Structure Growth on the Urban Fringe"

[6] DNREC and Brandywine Conservancy, *Conservation Design for Stormwater Management: A Design Approach to Reduce Stormwater Impacts from Land Development and Achieve Multiple Objectives Related to Land Use*, September, 1997

[7] David Welsch, Forest Resources Management, USDA Forest Service, "Riparian Forest Buffers: Function and Design for Protection and Enhancement of Water Resources", NA-PR-07-91

[8] David Welsch, Forest Resources Management, USDA Forest Service, "Riparian Forest Buffers: Function and Design for Protection and Enhancement of Water Resources", NA-PR-07-91

[9] David Welsch, Forest Resources Management, USDA Forest Service, "Riparian Forest Buffers: Function and Design for Protection and Enhancement of Water Resources", NA-PR-07-91

[10] Julia Klapproth & James E. Johnson, "Understanding the Science Behind Riparian Forest Buffers: Effects on Plant and Animal Communities" Virginia Cooperative Extension, Virginia State University, Publication No 420-152, October 2000.

[11] Julia Klapproth & James E. Johnson, "Understanding the Science Behind Riparian Forest Buffers: Effects on Plant and Animal Communities" Virginia Cooperative Extension, Virginia State University, Publication No 420-152, October 2000.

[12] Jennifer Leavitt, "The Functions of Riparian Buffers in Urban Watersheds", page 4, Master of Science Degree Report, University of Washington, 1998 citing Karr and Schlosser, 1977.

[13] Julia Klapproth & James E. Johnson, "Understanding the Science Behind Riparian Forest Buffers: Effects on Plant and Animal Communities" Virginia Cooperative Extension, Virginia State University, Publication No 420-152, October 2000.

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[15] J. Toby Tourbier, "Open SpaceThrough Stormwater Management, Helping to Structure Growth on the Urban Fringe"

[16] DNREC and Brandywine Conservancy, *Conservation Design for Stormwater Management: A Design Approach to Reduce Stormwater Impacts from Land Development and Achieve Multiple Objectives Related to Land Use*, September, 1997

[17] Julia Klapproth & James E. Johnson, "Understanding the Science Behind Riparian Forest Buffers: Effects on Plant and Animal Communities" Virginia Cooperative Extension, Virginia State University, Publication No 420-152, October 2000.

[18] DNREC and Brandywine Conservancy, *Conservation Design for Stormwater Management: A Design Approach to Reduce Stormwater Impacts from Land Development and Achieve Multiple Objectives Related to Land Use*, September, 1997

[19] David Welsch, Forest Resources Management, USDA Forest Service, "Riparian Forest Buffers: Function and Design for Protection and Enhancement of Water Resources", NA-PR-07-91

[20] David Welsch, Forest Resources Management, USDA Forest Service, “Riparian Forest Buffers: Function and Design for Protection and Enhancement of Water Resources”, NA-PR-07-91; Pennsylvania Handbook of Best Management Practices for Developing Areas, Prepared by CH2MHILL, Spring 1998

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[22] DNREC and Brandywine Conservancy, *Conservation Design for Stormwater Management: A Design Approach to Reduce Stormwater Impacts from Land Development and Achieve Multiple Objectives Related to Land Use*, September, 1997

[23] ftp://ftp-fc.sc.egov.usda.gov/NHQ/practice-standards/standards/390.pdf

[24] DNREC and Brandywine Conservancy, *Conservation Design for Stormwater Management: A Design Approach to Reduce Stormwater Impacts from Land Development and Achieve Multiple Objectives Related to Land Use*, September, 1997, p. 1-25

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[30] Army Corps of Engineers WRAP, “Technical and Scientific Considerations for Upland and Riparian Buffers Strips in the Section 404 Permit Process”, ERDC-WRAP-01-6, May 2002, citing DeBano and Schmidt 1990; O’Laughlin and Belt 1995”.

[31] Army Corps of Engineers WRAP, “Technical and Scientific Considerations for Upland and Riparian Buffers Strips in the Section 404 Permit Process”, ERDC-WRAP-01-6, May 2002.

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[34]State of Vermont, Department of Environmental Conservation, Dept. of Fish and Wildlife, “Riparian Buffer Procedure”, App.D-4, Draft 2001.

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[46] Julia C. Klapproth & James E Johnson, “Understanding the Science Behind Riparian Forest Buffers: Effects on Water Quality”, Virginia Cooperative Extension, Virginia Tech & Virginia University, Publication Number 420-151, October 2000.

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