How vegetated buffers protect water quality, and a whole lot more

By Judy Preston

What is a Riparian a Buffer?

You don't need to live on a large river to have a buffer make a difference. The lion's share of water from any watershed is delivered from the higher elevations where small streams predominate. 80% of the stream networks that make up the nation's watersheds are considered "headwaters" – small order streams that you can leap over, and in any given watershed more than half of the total length of stream channels can be these unassuming first order streams.

A simple explanation of a riparian buffer is the border of moist soils and plants next to a body of water. Of course, they are way more important than what this may suggest, which is why there is so much interest in them. Riparian buffers serve many functions, but the one that keeps them front and center in the regulatory, scientific, environmental and economic worlds is the ability of these transitional zones between land and water to protect water quality. And in the Anthropocene, it's important to note that clean, potable water is as essential as it is limited.

Only 2.5% of Earth's water is freshwater – the amount needed for life to survive. Of that, only a little more than 1.2% is surface water (most is locked up in ice).

Why Healthy Buffers are Important

In addition to clean water, natural riparian buffers provide essential habitat for a broad variety of wildlife; they protect (store and recharge) groundwater; help temper the impacts of flooding and erosion by reducing water runoff energy; sequester carbon; enhance corridors for plant and animal migration; provide shade to maintain air and water temperature; screen undesirable views and noise, and can increase property value.

The influence on water quality of riparian corridors is proportionately much greater than the relatively small area on the landscape that they occupy.

But it's the ability to protect water resources through biological, chemical and physical processes that give these vegetated buffers their superpowers. The most effective riparian buffer must mitigate three different types of pollutants: those that stick to grains of sediment carried in surface runoff, pollutants dissolved in surface runoff, and dissolved pollutants in groundwater.

Nitrogen removal in the riparian zone is unequivocally recognized as one of the most cost-effective means to control excess nitrogen losses from intensely developed watersheds.

By filtering, transforming, storing and/or neutralizing pollutants from surrounding land uses, riparian buffers provide a margin of safety for public health. And, the influence on water quality of riparian corridors is proportionately much greater than the relatively small area on the landscape that they occupy. Any public official will readily note: it's a lot easier to protect existing clean water than it is to "fix" it once it's contaminated. Once a riparian buffer is lost, engineered solutions can include dams, streambank hardening, dredging, and upland retention and treatment of polluted stormwater.

Clean water relies on the capacity of vegetated buffers to filter and retain contaminants.

Functional riparian buffers are unique and complex; the result of the alchemy of hydrology, soils and vegetation that they are made up of. The greatest improvement to water quality results from the shallow movement of contaminated water through the upper layers of the buffer's soil on its way to the bordering waterbody or stream. This passage enables the many complex root networks and soil organisms to work on contaminants – excess nutrients, pesticides, toxins and metals, breaking them down, locking them up, passing them into the atmosphere – keeping them out of the receiving water. Soil microorganisms can even metabolize organic chemicals such as pesticides as energy sources and in the process, transform them into less toxic compounds.

Riparian buffers can be important areas of groundwater recharge, and existing riparian groundwater plays an important role in diluting concentrated contaminants. The more the soil and its inhabitants can slow polluted water down, the more time there is for processing, resulting in less pollutants reaching the neighboring waterbody.

The Role of Buffer Plants

Buffers and Climate Change
Restoring and preventing the loss of healthy vegetated buffers can be a tool to help offset the anticipated impacts of more frequent and forceful storm events in New England resulting from climate change.

A vegetated buffer area composed of trees, shrubs and undergrowth generates abundant organic matter (leaves, twigs, wood) that becomes the foundation of soil. Between this above-ground contribution and the below-ground network of roots, plants act as linebackers to block polluted sediment from further travel downslope.

The leaf-strewn and uneven surface of the woodland floor is what encourages infiltration, giving the soil organisms an opportunity to work on pollutants. By maintaining high levels of organic carbon in the soil, riparian vegetation fuels denitrification (implemented by soil microorganisms), offering the most permanent removal of nitrogen – the greatest threat to Long Island Sound. Nitrate removal by riparian buffers can remain high even during the winter months.

The connection between a watercourse and its vegetated shoreline is what makes riparian buffers a super-power in environmental protection.

Denitrification is the primary process for permanently removing nitrogen within a buffer. In denitrification, anaerobic bacteria transform nitrate to nitrogen gas (N_2) which is released into the atmosphere.

The shade produced by riparian plants can generate a cooler and moister microclimate for wildlife and keep water temperatures cooler: elevated temperatures can act as a barrier to migratory fish. Overhanging tree roots provide protection from predators for aquatic species, pathways for movement along the shoreline for small mammals, and can slow floodwaters and thus prevent or abate bank erosion.

How Much is Enough?

There are many recommendations about the optimal width for riparian buffers, largely because it depends on what resource is being considered and the many characteristics of each buffer. For water quality, riparian buffers with a minimum of 75 to 100 feet are considered necessary for sensitive receiving wetlands and watercourses, but larger distances may be needed if soils are pervious (sandy, for example), shallow, or if there is a steep slope. A rule of thumb is that the buffer should expand 5 feet for every 1 percent increase in slope.

The zone of influence of riparian disturbance spreads far downstream.

Riparian considerations for animals take into account connectivity; the length of corridors can be essential for successful reproduction and even gene flow, which takes on increasing significance with climate change. Large mammals, especially predators, are thought to need in excess of 500 feet, but even reptiles and amphibians need up to 600 feet when considering the diversity of habitat-type they require.

Intact riparian buffers are what make the Salmon River in Connecticut a pristine waterway and destination site for fly-fishing.

The greatest consensus averages 100 feet.

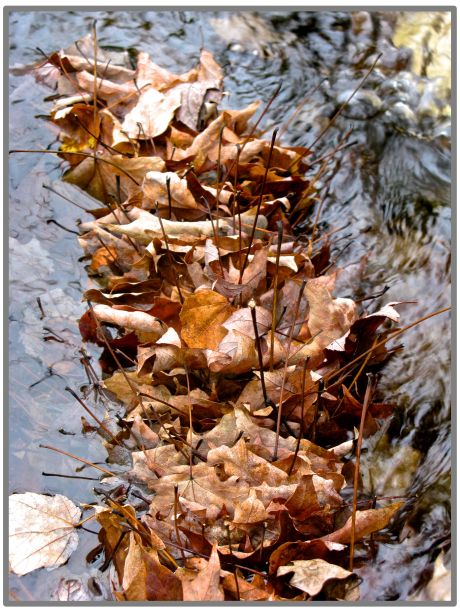
Buffers averaging 100 feet are widely considered to be most beneficial for a variety of species including plants, invertebrates, many mammals, and aquatic species. Forest interior nesting birds (versus edge species) are thought to require at least 200 feet, with some species needing up to a mile. The most commonly prescribed minimum buffer widths for use in water quality and habitat maintenance are approximately 35 to 100 feet. Buffers of less than 35 feet cannot sustain long-term protection of aquatic resources.

The zone of influence of riparian area disturbance spreads far downstream. Even a relatively small gap in a buffer can be a source of contaminants or sediment. Buffer gaps weaken the ability of wildlife to move safely along a shoreline, using that continuity as part of their home range or migration pathway, and the same is true for plant seed dispersal. Gaps also increase the probability of tree blowdowns. Connectivity is key to resilience and recovery from development; recolonization of impoverished sites by aquatic invertebrates occurs by drift from healthy stream reaches upstream.

The Three-Zone Buffer Concept

The total recommended width for all three zones is at least 100 feet. Riparian buffers that are at least 100 feet wide provide the minimum protection for water quality and stream protection.			
	Location and Recommended Width	**Zone Functions**	**Recommended Plantings**
Zone 1	Area closest to the stream or water body Width should be at least **15 feet**	Provides streambank stabilization and leaf litter inputs to the stream. Leaf litter is eaten by macroinvertebrates in the stream, which are in turn eaten by fish. When trees grow in Zone 1, they shade the stream, which cools the water and provides better conditions for brook trout or other cold water-dependent fish species.	Plant with native species of water-tolerant trees and large shrubs with little or no harvesting.
Zone 2	Area upland from Zone 1 Width **20 to 60 feet**	Allows water runoff to be absorbed and held in the soil. Nutrients and other pollutants are also filtered by the soil.	Plant with native faster growing, smaller, shade-tolerant tree or shrub species; faster growing plants are able to uptake and store nutrients in their woody biomass.
Zone 3	Area farthest from the stream and next to land use areas such as houses, crops or pastureland Width **15 to 60 feet**	The plants in this zone slow fast-moving water runoff and filter sediment.	Plant with native grasses, wildflowers, or other herbaceous plants.
Wider buffers provide an even higher level of stream protection and provide better wildlife habitat. Diversity of plants in each zone is key. Zones with a variety of plant species are more resilient to severe weather (drought or extreme storms), disturbance by deer or rodents, and invasive species or pests.			
Adapted from New York Department of Environmental Conservation, Riparian Buffers Three-Zone Concept: https://dec.ny.gov/environmental-protection/water/water-quality/nps-program/riparian-buffers			

Essential for Wildlife



Most aquatic organisms, both invertebrates and fish, are directly or indirectly dependent on inputs of terrestrial detritus – leaves, twigs, and organic debris – to the stream for their food.

Although the two worlds that a riparian buffer share – land and water, would seem to be very different, they interact with one another in many ways. Perhaps the least well recognized contribution of riparian vegetation to the aquatic environment is its most abundant resource: leaves, twigs and woody debris. Microorganisms and insects consume this carbon-rich accumulation that in turn fuels diverse relationships from source to sea in the watershed. Leaves in the fall, bud scales in the spring, and in summer, *frass* – the powdery excrement of innumerable insects that slowly break down the forest's woody debris – will all become part of the food web that drives the aquatic ecosystem.

The painted turtle is among the many animals that benefit from intact riparian buffers.

Cloudy stormwater that has picked up contaminated sediment from a lawn, road or construction site poses several risks for aquatic organisms. Clay particles in particular can carry the nutrients, petroleum products, metals, pesticides and other compounds that contribute to water pollution.

Aquatic wildlife includes not just the more familiar fish, waterfowl, beavers and otters, but a myriad of less visible species such as mayflies, stoneflies and caddisflies (that are essential to a trout's diet, among other fish) and freshwater mussels (that otters love to eat).

Many aquatic insects are filter feeders that live on the stream bottom, where they seek out the oxygen-rich crevices between stones, twigs and leaf litter. Contaminated, silty stormwater can smother that habitat-and abrade and clog fish gills.

Warm, nutrient-laden water stimulates excess aquatic algae growth, capable of smothering key food sources and in worse case scenarios, dramatically altering shallow aquatic habitat – among the most biologically rich areas in our water bodies.

As our understanding of riparian ecosystems increases, riparian buffers are expected to fulfill a greater diversity of objectives beyond protecting fish habitat – the initial goal in the 1970's – to maintaining water quality, moderating stream flow, sequestering carbon, retaining old-growth forest, providing wildlife habitat, and preserving biological diversity.

Buffers can provide valuable resources for pollinating insects including shade, nesting sites, water, nectar and pollen, and protection from pesticides. Buffers can reduce wind and aid in foraging and pollination efficiency.

This naturally occurring summer buffer of aster (white), joe pye weed (pink) and sneezeweed (yellow) grew along the banks of the Salmon River in East Haddam, Connecticut; it provides an idea of how to design a colorful and well-adapted buffer of native plants.

Nearly 70% of vertebrate species in an area will use riparian corridors in some significant way during their lifetime. Turtles and snakes living in riparian areas will move to uplands to nest, overwinter or forage, while frogs and salamanders that live in the uplands will return to aquatic areas to breed and lay their eggs. During migration, migratory birds are 10 to 14 times more abundant in riparian habitats than surrounding upland habitats, where they take advantage of early leaf-out, and the presence of nutritious caterpillars.

Wildlife are an integral part of a healthy riparian area. By foraging, hunting, burrowing, wallowing, or damming, animals significantly affect nutrient cycling, water flow, chemistry, sediment dynamics and the form of the adjoining watercourse.

From an economic and human quality of life perspective, riparian buffers can provide an effective screen, modifying excess illumination and noise. A well-managed wooded buffer can also enhance not only the view to the water, but the equally important view from the water into the surrounding landscape.

A well-managed wooded buffer includes a diversity of plants – trees, shrubs and understory. This buffer has provided good plant density while enabling a view both to and from the water.

Design Considerations: What a Healthy Buffer Looks Like

Because riparian buffers can, will, and need to be employed in the effort to protect clean water and provide important wildlife habitat, among other things, their makeup is an essential consideration.

The best planting template comes from natural, healthy vegetated buffers (meaning that they are undisturbed and largely free of non-native invasive plant and insect species that can compromise the integrity of any natural system). These 'model' buffers will inform your choice of plants and suggest how they can be planted relative to one another.

Key Elements of a Wooded Riparian Buffer

How to assess, amend or create a healthy riparian buffer

- **Plant Native Perennial Plants – those native to the state and appropriate to your site conditions and therefore better adapted to survive and support local wildlife**

  Native plants are essential to sustain diverse wildlife populations, and the location (such as the compass direction – hot late afternoon sun, or predominantly north exposure) and soil (sandy or with a log of clay) will help dictate the best plants to use. Proximity to moving water also needs consideration because of saturated soils and potential for strong currents and flooding.

This 50' buffer was designed and constructed by the Fairfield, CT garden club to protect a tributary flowing directly to Long Island Sound.

- **Plant a Diversity of Plants**

  A greater the mix of plants – different species of trees, shrubs and perennial ground covers – will maximize buffer effectiveness. The greater the variety of plants, the greater habitat for wildlife species and capacity of multiple below-

ground root structures to build soils that can remediate pollutants. A diversity of plant species will also help to minimize pest and disease problems and provide greater resistance to flood waters.

- **Create Layers of Plants**
  To the extent that canopy trees, mid-story trees, shrubs, herbaceous perennial flowering plants (forbs) and ground cover can be maintained or added to your buffer, its capacity to remove pollutants, provide abundant habitat, and create effective screening will be enhanced. The deep roots of woody plants – trees and shrubs, in particular – are important to buffer effectiveness. Migratory and resident birds occupy and use particular zones of stratified woodlands, making these areas inviting habitat for them. A diverse buffer doesn't negate a view. In fact, a managed canopy promotes good air circulation, enhances understory growth, and can lessen damage from high winds. Periodic thinning may be necessary to maintain a desirable mix of woody species. A professional forester should be consulted**.**

Along the steep banks of the Connecticut River these homes have retained the natural character of the wooded hillside, including a diverse assemblage of plants that include mature trees. This is an excellent example of preserving the view both to, and from the nationally acclaimed waters of the estuary.

- **All Ages Represented**
  Differing ages of plants (particularly woody species such as trees and shrubs) will ensure continuity over time as old vegetation dies (and becomes habitat and, eventually, soil) and young plants have the space to mature into gaps left by dead or downed trees. Younger plants are especially good at excess nutrient removal.

- **Leave Organic Matter on the Ground**
  (*and to the extent possible, standing dead wood*)
  The "litter" from your plants – leaves, twigs and downed branches and trunks, provides the carbon and nutrients necessary for a healthy soil – and that's where much of the work of cleaning water happens. Those leaves and sticks also create the "roughness" at ground level that will slow and redirect polluted stormwater into the soil. Soil is your buffer's superpower and it is fed by what the above ground greenery generates and eventually adds to the woodland floor. Leaf litter is also essential habitat for many of the insects that recycle organic matter, fuel the soil (and aquatic) realms, and feed many of the wildlife species that make riparian areas their home.

> *"Ground layer litter, in the form of leaves, twigs, bits of bark and dead wood, seeds and seed pods and capsules, plays a critical role in conserving moisture, replenishing nutrients, and creating niches—microhabitats—needed by various species of animals and plants especially in their earliest stages of regeneration."* — R. Darke & D.



Native woodland shrubs well adapted to a buffer (from left): Summersweet (Clethra alnifolia), Pinxterbloom azalea (Rhododendron periclymenoides), and Buttonbush (Cephalanthus occidentalis).

Other Important Buffer Considerations

- Locate the buffer as close as possible to a known source of pollution; adjoining land uses need to be considered when designing the buffer width.
- Remove anything that impedes the flow of water into the buffer, such as a berm or raised garden bed.

- Steeper slopes require a wider buffer: stormwater will naturally concentrate creating larger and faster channels going downslope, adding sediment through erosion. A slope will need more area to allow the vegetation to do its work.

- To control erosion on steep areas, use check dams to slow water movement and increase retention time for the soil to work on pollutants.

- Create your buffer along the land's contour to slow the flow of stormwater perpendicular to the slope, allowing it to infiltrate.

- Minimize soil disturbance that can result in the recruitment and spread of invasive, non-native plant species. Ensure any soil amendments are from a reputable source.

- Finer-textured and organic-rich soils typically have slower infiltration rates than sandy soils; consider amending your soil to enhance the capacity to handle stormwater.

- Soils in inundation zones (where flooding takes place) need to be moderately permeable to encourage infiltration and will benefit from coarse, woody debris left on the ground to diffuse strong currents.

This buffer on the Connecticut River provides multiple benefits: dense, diverse native perennial vegetation that screens without obstructing the view, and a dock placed at an oblique angle to the slope.

- Avoid soil compaction from traffic in the buffer in order to preserve infiltration capacity and ensure that soil microorganisms continue to thrive. Elevate walkways where possible.

- When creating access to water through a riparian buffer, where possible design the access in a low-angle zigzag that is parallel to the slope to avoid creating an erosion issue.

- Wherever possible connect buffers where gaps exist along a waterway or waterbody.

- At the water's edge provide (or don't remove) downed or drifted woody debris that provides aquatic habitat structure.

Useful Plant Characteristics for Buffers

Consider using plants that:

- Provide deep roots for soil cohesion to reduce slope failure and intercept subsurface waterflow (e.g. shrubby St. John's wort (*Hypericum prolificum*), 'Gro-low' sumac (*Rhus aromatica)*, 'Sixteen Candles' summersweet (*Clethra alnifolia* 'Sixteen Candles'), prairie dropseed grass (*Sporobolus heterolepsis*), common ninebark shrub (*Physocarpus opulifolius*).
- Have high, stiff stems and debris density that can tolerate sediment buildup (e.g. arrowwood viburnum (*Viburnum dentatum*), highbush cranberry (*Viburnum opulus*).
- Can readily re-sprout from roots or from broken branches; ability to rebound from flooding disturbance (e.g. pussy willow (*Salix discolor*), sweet pepperbush (*Clethra alnifolia*).

'Gro-low' sumac (Rhus aromatica) at the Connecticut College Arboretum

- Are tolerant of high nutrient levels if the site is expected to receive polluted stormwater (e.g. Indian Grass *(Sorghastrum nutans*), Switch panicgrass (*Panicum virgatum*).
- Will adapt to the changing climate, such as species tolerant of warmer weather (e.g. Virginia sweetspire (*Itea virginica*), Witch alder *(Fothergilla gardenia*).
- That will offer year-round vegetation (evergreen) for screening and noise control (e.g. Eastern red cedar (*Juniperus virginiana*), American holly (*Ilex opaca*).

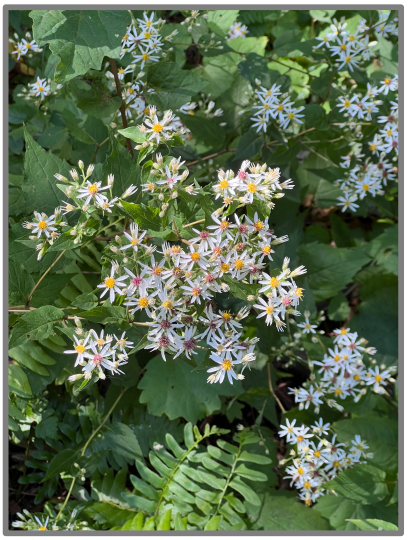
Switchgrass (Panicum virgatum)

Other Buffers Types

Not all buffers are, or need to be forested, although higher rates of denitrification have been observed in forested buffers, and the woody stems and debris from trees and shrubs will offer

greater flood resistance. A buffer of grasses and forbs (a plant that doesn't develop a woody stem, so it dies back to the ground in the fall) can still provide significant benefits for protecting water quality. Many grasses have extensive and deep root systems that make them effective at remediating stormwater pollutants and securing and enhancing the soil.

Grass buffers can also provide substantial habitat for wildlife, particularly when a diversity of plant species, including forbs, is used. Native warm season grasses, such as Little bluestem (*Schizachyrium scoparium*), Indiangrass (*Sorghastrum nutans*), and Switchgrass (*Panicum virgatum*), grow in dense bunches with tall, rigid stems that provide year-round shelter and food, providing habitat for birds and small mammals.



White wood aster (Eurybia divaricate) is an attractive native flowering plant that is shade and drought tolerant, making it particularly suitable for the upper wooded margins of a riparian buffer.

Inter-planting grasses with forbs will provide nectar, seeds and fruits for local wildlife, including pollinators, in addition to the appeal of flowering plants, especially if you diversify your plant selection to provide blooms throughout the growing season. There are many possibilities for plants to use with grasses, such as coneflowers (*Echinacea spp.)*, bee balm (*Monarda spp.),* black-eyed Susan (*Rudbeckia hirta)* and asters (*Symphyotrichum spp.)*.

The same principles for wooded buffers apply to non-wooded buffers: plant native, maximize plant diversity, create layers (heights and a variety of growth habits) and leave organic matter in place to build soil and secure habitat for insects and invertebrates.

Riparian vegetation functions and their ecological role*

Biophysical function of riparian vegetation	Ecological significance for the watercourse
Forest litter supply	Provides food for aquatic invertebrates, influences trophic chain, organic matter storage and release
Coarse woody debris supply	Influences channel structure, flow characteristics, provides refugia for fish, substrates for invertebrates
Shading	Maintains temperatures required by cool-water species of invertebrates, amphibians and fish. Influences light levels and thus aquatic primary productivity and trophic chain
Root strength	Stabilizes river banks
Ground cover	Reduces surface water flow, erosion and sediment input to the watercourse, promotes water infiltration
Uptake of nutrients	Controls nutrients (e.g. fertilizers) input to water and reduces risks of eutrophication
Uptake or soil adsorption of contaminants	Reduces nonpoint source pollution (e.g. pesticides) and maintains water quality

* (from Wenger, 1999; NRC, 2002; Naiman et al., 2005)

Selected Resources

- ***Landscaping at the Water's Edge: manual for landowners and landscapers,*** University of New Hampshire Extension: https://extension.unh.edu/resource/landscaping-waters-edge-book
- ***The Case for Riparian Corridor Protections***, WestCOG: https://westcog.org/2021/08/zoning-strategy-riparian-corridor-protections/
- ***Conservation Buffers: Design Guidelines for Buffers, Corridors, and Greenways,*** USDA: https://www.fs.usda.gov/nac/buffers/index.html
- ***A Guide to Healthy Lakes Using Lakeshore Landscaping,*** The Federation of Vermont Lakes and Ponds: https://dec.vermont.gov/sites/dec/files/wsm/lakes/Lakewise/docs/lp_VTlakescape.pdf
- ***Native Plants for Riparian Corridors in Connecticut,*** CT Sea Grant: https://seagrant.uconn.edu/?p=10305

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