Enhancing Water Resources in Tompkins County:

Benefits of Riparian Areas and Stream Buffers

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Tompkins County
Planning Department

Introduction

Riparian areas, the areas immediately adjacent to flowing waters such as streams, lakes, shorelines, and wetlands, provide a transition between aquatic and terrestrial ecosystems (Environmental Law Institute 2003). Though riparian areas and stream buffers generally comprise a small proportion of the landscape, they provide a disproportionably high amount of habitat and ecosystem benefits, including protecting water quality, stabilizing streams, minimizing flood damages, and enhancing ecological diversity. "If properly designed and maintained, riparian buffers can provide a variety of benefits, from water quality protection to ecosystem maintenance to recreation and education to flood damage prevention." (Davis and Hitchings, 2000)

To minimize adverse human impacts on water quality, biodiversity, and stream stability, communities are increasingly developing protective buffers around riparian areas and along streams, lakes, and rivers. Developing riparian buffers helps protect riparian and streamside areas and ensures they can continue to provide ecosystem benefits. Protecting and restoring streamside areas also enables streams "to recover dynamic equilibrium and function at a self-sustaining level." (Federal Interagency Stream Restoration Working Group, 1998).

As municipalities in Tompkins County take steps to protect and restore streams and riparian areas, understanding the benefits of riparian buffers and the buffer width needed to sustain those benefits will empower communities to make the best choices. The findings presented in this document are intended to educate community leaders on the benefits of riparian and stream buffers, and provide a scientific foundation for implementing riparian and stream buffers in Tompkins County. Although the term "riparian buffer" includes a variety of buffer types, this document emphasizes the benefits of *forested* riparian buffers, which are considered by many researchers to be the most effective. In addition, this document focuses on the benefits of buffering streamside areas, though buffering other riparian areas yields similar benefits.

Benefits of Stream Buffers

Forested stream buffers provide a variety of benefits:

- **Habitat and Biodiversity.** Stream buffers enhance habitat and biodiversity by providing terrestrial wildlife habitat and travel corridors, and food and habitat in aquatic ecosystems;
- **Stream Stability.** Buffers attenuate flooding, stabilize stream banks and prevent erosion of streambanks and streambeds;
- **Water Quality.** Buffers protect water quality by removing pollutants and moderating temperatures; and
- **Financial Savings.** Buffers prevent property damage, reduce public investment and enhance property values.

Paxton Creek Watershed and Education Association

Exemplary stream buffer. *Forested stream buffers provide the greatest benefit when compared to other types of stream buffers.*

Habitat and Biodiversity

Buffers enhance habitat and biodiversity by providing terrestrial wildlife habitat and travel corridors, food for aquatic food webs, and structural complexity for aquatic habitat.

Enhance Wildlife Diversity

- ***Habitat.*** Located at the interface of land and water, riparian and streamside areas provide permanent habitat for a diversity of organisms that require both aquatic and terrestrial habitats, including many species of fish and other in-stream organisms, amphibians, and terrestrial plants and animals.

- ***Wildlife corridors.*** Stream buffers can provide "'corridors' which link [larger tracts of protected open space and] facilitate movement of wildlife between habitat 'islands' in otherwise developed areas." (USACE, 1991) These corridors provide vital connective areas and prevent fragmentation and isolation of populations.

Restore Aquatic Ecosystem

- ***Aquatic food.*** Stream buffers help support healthy aquatic ecosystems "by supplying plant detritus as food sources, the principal energy source for aquatic webs in small streams." (USACE, 1991)

- ***Shading.*** Shading caused by overhanging vegetation and tree canopies helps keep streams and rivers cool during summer months. This is especially important for cold-water aquatic organisms. It is important to note temperature within a stream "is dependent not only on conditions such as canopy cover or imperious surfaces in the local area, but in the upstream river system as well." (Mannik, 2004)

- ***Stream complexity.*** Stream buffers allow for stream channel complexity. "The presence of woody vegetation (living, decaying or dead, standing or fallen) is also important in the creation of large woody debris, which maintain a diversity of habitat niches" for fish and other aquatic organisms. "Logs falling into streams increase the complexity of the channel, block and slow stream flow, capture and retain organic material, and create protective habitat for fish." (USACE, 1991)

- ***Silting prevention.*** Stream buffers help prevent silting of streams by filtering sediment-laden runoff and preventing stream bank erosion. Clean surfaces of submerged gravel are critical for spawning of many species.

Natural Stream Dynamics

Forested streamside buffers enable streams to recover their natural complexity and processes of dynamic equilibrium and fluctuation, critical characteristics of riparian ecology. (Federal Interagency Stream Restoration Working Group, 1998) "Natural features such as sandbars, undercut banks, oxbows and floodplain pools resulting from a stream's or river's interaction with adjacent lands are created, undergo change through time, and eventually disappear, while the overall pattern (e.g., meandering, braiding) remains constant, at least on some larger spatial scale and longer time scale. This form of dynamic equilibrium is a singular property of rivers and accounts for much of the high biological diversity and productivity of riverine systems." (Cohen, 1997)

US Fish & Wildlife Service

Buffers are stream right-of-ways. *Most stream channels shift or widen over time. By allowing for lateral movement, buffers protect both streams and nearby properties.*

"As long as the [stream] is allowed to freely interact with adjacent vegetated riparian areas, a diversity of habitats in various stages of ecological succession will be maintained." (Cohen, 1997) "Altering or changing natural conditions to which species are adapted often harms native wildlife communities by destroying key conditions that make a given site suitable habitat. An obvious example is the removal of snags (dead trees) that are essential nesting structures, food sources, and perches for many birds, mammals, reptiles, and amphibians." (Brown and Schaefer. et al.. 1987)

Stream Stability

Forested stream buffers can help stabilize streams by providing flood protection, stabilizing streambeds and streambanks, and maintaining streamflow.

Provide Flood Protection

Forested stream buffers protect against flooding by intercepting rainfall, slowing melt-water and overland flow, promoting infiltration into soil, and providing a protective zone for built structures. Vegetation roughness enables stream buffers to "store water and reduce peak runoff during storm events" (USACE, 1991). Streamside vegetation also provides steadier rainwater infiltration, which "stabilizes runoff flows as water is stored in the soil profile, moves into groundwater supplies, or is taken up by plants and used in photosynthesis and envapotranspiration" (Mannik, 2004). Finally, stream buffers provide a zone that can accommodate floodwaters so that they do not interfere with or impact built structures.

Stabilize Streambanks and Streambeds

Forested stream buffers help stabilize streambanks and streambeds. "The roots of plants, especially trees, provide increased erosion resistance as fine roots bind with the soil. Root structures also help armor the [stream] bank or lakeshore from erosion" (Mannik, 2004). Stream buffers also reduce stream channel erosion by reducing "runoff and streambed scour caused by excessive flows" (USACE, 1991). By naturally stabilizing streams, stream buffers lower the need for public investment in waterway restorations and floodwater management.

Southeast Michigan Resource Conservation & Development Council

Severe erosion on property lacking a streamside buffer. *Observe the soil loss is more aggressive away from the bush's unseen, stabilizing root system.*

Maintain Streamflow

Stream buffers also reduce the effects of drought, by "storing water and maintaining groundwater levels and maintain stream base flow during low flow periods" (USACE, 1991).

Forested Stream Buffers Grow Stronger with Time

"Vegetative buffers are the only streamside stabilization technique that actually grows *stronger* over time. As plants mature and become more numerous and diverse, they actually do a better job of holding soil in place and filtering and slowing runoff. All [artificial] structural erosion control methods weaken over time." (Cornell Cooperative Extension)

Before Stream Buffer

University of Missouri Center for Agroforestry

After Stream Buffer

These pictures were taken upon the reestablishment of a forested stream buffer. Four years after reestablishment, the buffer continues to strengthen and grow.

Water Quality

Stream buffers and other riparian areas can help improve water quality by capturing and filtering out sediments, nutrients, and other pollutants, and by moderating stream temperatures.

Prevent Sedimentation

"Riparian areas [reduce] stream sediment in the following ways: vegetation in riparian areas reduces soil erosion and filters sediment [from runoff]; roots of riparian vegetation bind streambanks and reduce erosion; pools created by [fallen trees] can trap substantial amounts of sediment, at least temporarily; and riparian areas reduce sediment transport by moderating stream flows and [streambed] scour during flood events" (USACE, 1991).

USDA Soil and Conservation Service

Nutrient and sediment laden stream. *Cattle-trodden and grazed streambanks offer little protection from runoff and associated pollutants.*

Remove Nutrients

Riparian and streamside buffers lower pollutant concentrations in runoff by slowing runoff velocities, and trapping and removing nutrients and contaminants (Mannik, 2004). "[Riparian buffer soil and vegetation] reduce nutrient inputs into streams by: 1) filtering sediment-bound nutrients (ex. phosphorous) from runoff, 2) removing nutrients (ex. nitrogen) from groundwater via uptake in vegetation and by denitrification, and 3) pushing back development which could increase nutrient loading (i.e. septic systems [and pesticide use])" (USACE, 1991).

US Forest Service

Clean forestland stream. *Forested watersheds are the generally accepted benchmark for achieving high quality water resources.*

Moderate Temperatures

"Riparian vegetation is one of the most important factors for [moderating] water temperatures in small streams" (USACE, 1991). "Shade provided by riparian vegetation helps keep the water temperature cooler in the summer and warmer in the winter" (Davis and Hitchings, 2000). Riparian forest buffers also store and gradually release water through subsurface flow, which maintains stream flow and lowers water temperatures. By also removing contaminants, riparian stream buffers further facilitate clearer and cooler stream water. Colder stream water holds more dissolved oxygen, critical for many aquatic species (USACE, 1991).

Protecting Sensitive Headwaters

Riparian stream buffers in headwaters have proportionally greater impact on watershed health than buffers in downstream waters. Clean and healthy headwater streams are critical for protecting the water quality, stream stability, and wildlife habitat of an entire watershed. The downstream effects of even small disturbances in small upstream brooks and creeks may be compounded as waters join to feed into larger and larger streams.

Research shows headwaters have proportionally greater impact on:

Water Quality. "Small tributaries or other sensitive areas will benefit more from a buffer than will a large river. A relatively small change on a headwater or low order stream may greatly impact local water quality, while a similar change on a large river will not have an easily discerned impact" (McGlynn). "Even the best [riparian buffers] along larger rivers and streams cannot significantly improve water that has been degraded by improper buffer practices higher in the watershed" (Fischer & Fischenich, 2000).

Stream Stability. The success of downstream riparian buffers "depends heavily on the hydrology in the upstream watershed. If the upper watershed becomes developed without adequate stormwater controls, the amount and rate of runoff flowing into area streams during storm events can increase dramatically. These increased flows can destabilize the streambanks and cause them to erode, even if the banks are well-vegetated" (Davis and Hitchings, 2000).

Wildlife Habitat. Upstream buffers also have proportionally larger impact on aquatic wildlife habitat. "Regional land use is [likely] the primary determinant of stream conditions, able to overwhelm the ability of local [buffer] vegetation to support high-quality habitat and biotic communities. Degradation of in-stream habitat likely results from altered flow regime, increased sediment inputs and decreased organic inputs over considerable distances upstream of a site" (Roth et al., 1996).


David Funk

Quality water sources, evidenced by a natural, healthy headwater stream.

Financial Savings

Streams buffers minimize property damage, reduce municipal investment, increase property values, and reduce maintenance costs.

Minimize Property Damage

"Buffers mitigate property destruction [by keeping development] away from floodwaters" (Hernandez et al). Floodplains are often attractive places to build because of their scenic beauty and their proximity to water. However, locating homes, businesses, and other structures in these places often puts people in harm's way of flooding, standing water, and bank erosion. Setting back development enables floodwaters to spill out across undeveloped floodplains, not into people's living rooms. If the stream buffer includes the 100-year floodplain, stream buffers may also eliminate the need for expensive flood controls.

Reduce Municipal Investment

Stream buffers financially benefit municipalities in ways that, in the long term, can greatly exceed investment in stream buffer restoration. In areas lacking stream buffers, and where streams consequently deteriorate, municipalities must repair the damage to eroded streams, respond to results of downstream flooding, treat contaminated drinking water, dredge silted streams, and artificially and expensively reproduce ecosystem services that stream buffers provide naturally. By naturally stabilizing streams, controlling erosion, and reducing flooding, buffers lower the need for significant public investment in waterway restorations and stormwater management. Buffers can also reduce the number of flood-related complaints received by local officials, and provide space and access for future stream restoration, bank stabilization, and reforestation (Hernandez et al).

Fairfax County, Virginia

***Planting trees to restore a riparian forest buffer.** Buffer restoration is a great opportunity for environmental education and citizen involvement.*

City of Winston-Salem

***Restored urban stream buffer.** This urban creek's banks were restored and designated "no mow" areas.*

Increase Property Values

Residences near stream buffers often have higher property values. A national study found that land next to protected floodplains had an average increase in value of $10,427. Another study found that homes located next to restored streams have a three to 13 percent higher property value than similar homes located on unrestored streams (Hernandez et al). In addition, numerous studies show that greenways, such as stream buffers, can improve quality of life for communities, increase property values, and in turn increase local tax revenues (McMahon, 1994).

Reducing Maintenance Costs

Forested stream buffers reduce reoccurring maintenance costs of spraying, mowing, and watering cultivated grass lawns. "Corporate landowners can save between $270 to $640 per acre in annual mowing and maintenance costs when open lands are managed as a natural buffer area rather than turf" (Hernandez et al).

Considerations for Stream Buffer Implementation

Site Conditions

Several factors influence buffer effectiveness for water quality protection: soil type and erodibility; topography, slope and unevenness; vegetation type and amount; buffer width; local and regional hydrology, groundwater, and streamflow; seasonal variation; and species spatial requirements, availability of upland habitat, and proximate noise and light. Among these, buffer width and vegetation are most easily influenced.

Buffer effectiveness is also strongly influenced by watershed land use. "Some land uses outside the buffer will have a greater impact on surface runoff than others. For example, a high percentage of impervious area, such as pavement or roofing, will result in a larger volume and higher velocity of surface runoff. Agricultural runoff may include nutrients or pesticides, whereas runoff from residential or urban land uses may result in the manufacturing, use, or storage of potential contaminants. Land use in the entire watershed of the wetland or surface water will affect the volume and pollutant load of surface runoff, as well as subsurface flow" (Chase, 1997).

Understanding Local Water Resources

The quality of water is influenced both by human activities and by characteristics of the natural environment. Important natural characteristics that influence water quality in Tompkins County include steepness of slope and soil type.

To better understand how these natural characteristics impact local water quality, the Tompkins County Planning Department initiated a study to identify land areas that contribute disproportionate amount of runoff to local streams based on slopes and soil types. These "hydrologically sensitive" areas can potentially contribute higher levels of runoff and pollution to streams, depending on the land management practices that affect them.

For more information about this research and for locations of these areas, please contact the Tompkins County Planning Department.

Recommendations for Buffer Width

In this document, recommended stream buffer widths are measured starting from the top of the bank (or level of bankfull discharge) extending away from the water body. Thus, a 165-foot buffer on a stream that is 30 feet wide would result in a total buffer width of at least 360 feet.

Scientific recommendations for appropriate buffers widths vary considerably. "As with other conservation thresholds, the scientific literature does not support an ideal buffer width applicable in all circumstances. The necessary buffer size varies considerably based on the specific management goal. In general, recommended buffer sizes are significantly greater if the intent is to protect ecological functions, such as providing wildlife habitat and supporting species diversity, as opposed to water quality functions" (Environmental Law Institute, 2003).

According to the Environmental Law Institute, "based on the majority of scientific findings, land use practitioners should plan for buffers that are a minimum of 25 meters (approximately 80 feet) in width to provide nutrient and pollutant removal; a minimum of 30 meters (approximately 100 feet) to provide temperature and microclimate regulation and sediment removal; a minimum of 50 meters (approximately 165 feet) to provide detrital input [for aquatic ecosystems] and bank stabilization; and over 100 meters (approximately 325 fee) to provide for wildlife habitat [and movement corridors]." (Environmental Law Institute, 2003)

At a minimum, a stream buffer should encompass "the stream channel and the portion of the terrestrial landscape from the high water mark towards the uplands where vegetation may be influenced by elevated water tables or flooding, and by the ability of soils to hold water" (Naiman et al. 1993).

Stream Buffer Width Recommendations (Adapted from Environmental Law Institute, 2003; Fischer and Fischenich, 2000)

Benefit	Minimum Width	Description
Water Quality Protection	100 feet	Buffers, especially dense grassy or herbaceous buffers on gradual slopes, intercept overland runoff, trap sediments, remove pollutants, promote ground water recharge, and moderate temperature changes. For low to moderate slopes, most filtering occurs within the first 30 feet, but greater widths are necessary for steeper slopes, buffers comprised of mainly shrubs and trees, where soils have low permeability, or where non-point source pollution loads are particularly high.
Streambank Stabilization	165 feet	Riparian vegetation moderates soil moisture conditions in stream banks, and roots provide tensile strength to the soil matrix, enhancing bank stability. Widths for erosion control will vary based on site conditions. Wider buffers will help ensure that built structures are protected from the natural meandering of stream channels.
Aquatic Habitat	100 feet	Buffers provide food, shelter, and migration corridors for reptiles and amphibians and help ensure adequate protection of macro-invertebrates.
Detrital Input	165 feet	Detrital input (e.g., leaves and twigs) provide the principal energy source for aquatic food webs in small streams.
Flood Protection	65 to 500 feet	Riparian buffers promote floodwater storage due to backwater effects, they intercept overland flow and increase travel time, resulting in reduced flood peaks. Areas needed for flood attenuation are highly variable based on the physical characteristics and level of development within a watershed. Riparian buffers also set back development from flood hazard areas.
Wildlife Habitat	330 feet	Buffers, particularly diverse stands of shrubs and trees, provide food and shelter for a wide variety of mammals.

Uniform vs. Variable Width

To determine stream buffer widths for regulation, two approaches are commonly used: uniform buffer widths versus variable buffer widths.

Uniform Width. Uniform- or fixed-width buffers are commonly adopted because they are "easier to enforce, require less specialized knowledge, time, and resources to administer, and allow for greater regulatory predictability. Uniform widths are often based on a single resource protection goal, usually related to water quality" (Environmental Law Institute, 2003). However, depending on the area that is regulated, use of a uniform buffer width may not provide adequate protection for the issue of concern. For example, a 30-meter (100-foot) buffer designed to help filter pollutants may not be adequate to provide streambank and streambed stabilization.

Variable Width. In contrast, variable-width buffers can accommodate multiple management goals, account for the benefit(s) provided at a particular location, and integrate considerations of adjacent land use and site and stream conditions. Buffer width may be adjusted depending on the importance of the aquatic resources, hydrological sensitivity, surrounding land use, and vegetation, topography, soils, or hydrology. "For example, a larger width may be required for buffers surrounding hydrologically sensitive wetlands or streams, [ecologically sensitive areas], disturbed land, steep slopes, highly erodible soils, or sparse vegetation" (Environmental Law Institute, 2003).

Conclusion

The scientific findings presented above describe how forested stream buffers and riparian areas play important roles in protecting water quality, stabilizing water channels, enhancing ecological diversity, and providing financial benefits. As municipalities in Tompkins County take steps to protect and restore streams and riparian areas, understanding the functions and optimum widths of buffers will empower communities to make the best choices. This document is intended to educate community leaders on buffers and provide a scientific grounding for their application in Tompkins County.

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