Shoreline Vegetative Buffers

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Picture an idyllic lake setting. The sun is glimmering on clear, clean water; children are wading and swimming along the shore; a fisherman is casting for the elusive bass. Chances are this view also includes lushly vegetated shorelines blending into the surrounding landscape.

The interrelationship between a lake and its shoreline is important. The shoreline zone is the last line of defense against the forces that may otherwise destroy a healthy lake. A naturally-vegetated shoreline filters runoff generated by surrounding land uses, removing harmful chemicals and nutrients. At the same time, shoreline vegetation protects the lake edges from the onslaught of erosion caused by waves and ice. The shoreline zone also provides critical habitat for aquatic insects, microorganisms, fish, and other animals, thereby helping to maintain a balance in sensitive aquatic ecosystems.

Unfortunately, as lake landscapes are developed, natural shorelines often are damaged or destroyed. Beneficial natural vegetation is cut, mowed, or replaced. This often leads to eroded shorelines, degraded water quality and aquatic habitat, impaired aesthetics, and a reduction in property values.

Why is it Important to Maintain Shoreline Vegetation?

The transition from the natural high water line to the upland vegetation has been referred to as the 'Ribbon of Life' and is essential to the survival of the lake. Bilby (1988), in discussing the major interactions between aquatic and terrestrial ecosystems, says that upland and aquatic systems are intricately interconnected physically, chemically and biologically. Trees and plants regulate the outflow of lakes, prevent soil erosion and protect the lake from siltation and over fertilization.

The naturally vegetated shoreland supports a wide variety of plant and animal life including plants of all kinds, soil organisms, insects, reptiles and mammals. This is a balance between the lake and the land. Much of the land energy for the food chain of the lake is derived from the terrestrial plant and animals of the shore. The shoreline produces the ultimate "Edge" effect upon which 70% of land-based animals and 90% of the aquatic plants and animals rely (Kipp and Callaway, 2003).

What are Shoreline Buffers?

Shoreline buffers refer to forested or vegetated strips of land that border creeks, rivers and lakes. These buffers can help filter sediment and other pollutants (such as fertilizers and pesticides) from runoff that flows from the land into waterways, thus protecting these waters from various nearby land uses.

A buffer is different than a building setback from a waterbody, as defined through a zoning by-law. A buffer is a naturally vegetated or revegetated strip of land adjacent to a waterbody. A building setback does not include a specific requirement in a zoning bylaw to maintain vegetation.

Why Should we Protect Buffers?

Development around lakes has resulted in the removal of trees, shrubs and other protective vegetation and an increase in the amount of impervious area in the lakeside landscape. Native vegetation, with its deep root systems and natural duff layer, act like a sponge to hold storm water runoff and associated nutrients. Impervious surfaces result in more storm water running directly into the lake. Stormwater runoff picks up non point source (NPS) pollutants like soil sediment, nutrients and chemicals that can be detrimental to lake water quality. NPS pollution that enters lakes affects the nutrient balance of the water and creates a bottom habitat ideal for aquatic to root. It can cover fish eggs and habitat as well. Maintenance and restoration of shoreline vegetation and revegetation allows native landscape plants to fill in the shoreland zone and will increase biodiversity, wildlife habitat and protect property values.

Shoreline buffers perform a broad range of functions with significant economic, ecological and social value to people. Most researchers generally acknowledge the following functions of shoreline buffers. The specific list has been modified from North Carolina Department of Environment and Natural Resources Bulletin entitled *Riparian Buffers for the Catawba Mainstem and Lakes.*

1. Filters runoff – rain that runs off the land can be slowed and infiltrated in the buffer, which helps settle out sediment, nutrients and other pollutants before they reach waterbodies.
2. Protects bank from erosion – Tree roots hold the bank soils together and stems protect banks by deflecting the cutting action of currents, waves, boat wakes, and stormwater.
3. Absorbs Nutrients – Nutrients from fertilizers and animal waste that originates on land are taken up by tree roots. Phosphorus and nitrogen are stored in leaves, limbs and roots instead of reaching the stream. Phosphorus is the main nutrient of concern in the lakes of Muskoka. There are three mechanisms of phosphorus removal in shoreline buffers:
    a. Deposition of phosphorus with sediment
    b. Adsorption of dissolved phosphorus on to sediment particles
    c. Uptake of phosphorus by vegetation
4. Performs effective flood control and stormwater management – slowing the velocity of runoff, the shoreline buffer allows the water to slow and recharge the groundwater supply. Groundwater enters the stream at a much slower rate and over a longer period of time than water that has traveled as surface water. This helps control flooding and maintains stream flow during the driest times of the year.
5. Provides canopy and shade – shading by lake vegetation can moderate water temperature along the shoreline providing relief for aquatic life in the hot summer months.
6. Provides food and habitat for wildlife – leaves and woody debris fall into a lake or river where they provide food and habitat for small bottom-dwelling creatures that are critical to the aquatic food chain. The shoreline buffer itself also offers habitat for many animals, including songbirds, foxes, loons, turtles and amphibians. This habitat provides linkages between natural areas and acts as a migration corridor for a wide variety of plants and animals.
7. Protects property values – using buffers to set-back development and land uses from the shoreline is a cost effective way to protect many of the natural features and water quality that are an essential component in establishing the market value of a lakefront property.

    A new study of lakes in north-central Minnesota shows that clear water can boost the value of lakeshore property (Krysel et al 2003). The study notes that mowing to the waters edge with sloping land, removing emergent vegetation, rip-rapping heavily, loading the riparian zone with docks and lifts after removing indigenous vegetation makes the property environmentally vulnerable.
8. Provides aesthetic value – Lakeside property owners often have varying opinions about what constitutes “appropriate” shoreline landscaping. However, most will agree that “natural “ is better than “artificial”. Even a narrow buffer can enhance the view from across the lake.

How does development affect the shoreline?

The effects of land uses on the shoreline and the sensitive ribbon of life can be multiple and varied, depending on the type of land use, degree of disturbance and succession after disturbance. Most studies have looked at dramatic changes in land use such as logging, agriculture and road construction, however, while land use may vary, the resulting environmental alterations generally affect the near shore area in similar ways. Increases in sediment from loss of vegetation, for example, will be the same whether the loss of vegetation resulted from logging, road construction or cottage landscaping (Johnson and Ryba 1992).

How wide should a buffer be?

What minimum buffer width is needed to protect the shoreline environment? The answer to this frequently asked question depends on many factors. Among the factors to consider are lake sensitivity, type of land use, groundwater and flood hydrology, the desired function, the structural characteristics of the shoreline vegetation, including the type of vegetation communities and soils, and the gradient controlled by physiographic factors such as slope.

There is no simple answer to the question about minimum buffer width. Many variables need to be considered. Based on the review of various studies identified below, there appears to be a broad consensus that 30-metres achieves a broad range of desired outcomes.

The discussion on buffer width is divided into two primary variables being buffer function and physiographic factors.

a. Function

Widths for vegetative buffers recommended by various investigators varies widely depending on the specific resource or function to be maintained. The buffer width recommended by 17 separate investigators to maintain six major functions ranged from 3 to 200 metres (Table 1). Some variation is due to the lack of consistent focus for research efforts. While extensive data are available, for example, on the ability of vegetated buffers to reduce the quantity of fecal coliform bacteria in surface runoff, individual researchers typically emphasize different aspects of the issue and, therefore, the results are not always comparable. Castelle et al (1991) reviewed seven studies that analyzed the effectiveness of buffer strips for nutrient removal, including bacteria, and indicates that the studies generally agree that a 30-metre buffer reduced nutrient levels in the water to “far below drinking water standards”.

The effectiveness of vegetative buffers in maintaining water quality, including sediment removal, fecal coliform reduction, nutrient reduction, and stormwater runoff management generally increases with increasing buffer width. Most investigators recommend buffers widths of 30 to 122 metres.

The widest range in recommended widths was for buffers to filter suspended sediments. This is largely due to one reference (Wilson 1967) that reports separate buffers widths for filtering sediment particles of different sizes. These include sand (3m), silt (15 m), and clay (122 m). Four of the remaining authors suggest buffers of 30-38 metres; one recommends 88 metres.

As discussed below (Table 1), recommended buffer widths to maintain wildlife habitat range from 30 metres to protect salmonid habitat, (Hickman and Raleigh 1982, Raleigh et al 1986) 67 – 93 metres for small mammals (Jones et al 1988), 75 – 200 metres for some birds during breeding season, and up to 100 metres for large mammals (Jones et al 1988, Allen 1983). This broad range is the result of the wide variation in the requirements of different wildlife species. For terrestrial species, for example, the recommended buffer is for direct maintenance of essential habitat. For fish, the buffer is to protect elements of the nearshore that contribute directly to required habitat.

Benthic communities were investigated by Erman et al. (1977), Roby et al. (1977), and Newbold et al. (1980). They concluded that logged streams with buffer strips of at least 30 metres supported benthic communities indistinguishable from unlogged streams. Benthic communities in streams with no buffers, or with buffers less than 30 metres, were significantly different from unlogged streams. These three authorities agree that 30 metres was the width necessary to protect benthic communities.

Table 1:
Various functions of vegetative buffers and recommended widths to maintain those functions

Function	Recommended Buffer Width	Reference
Bank Stability	Minimum 20-30 metres	Corbett and Lynch 1985
Maintenance of Benthic Communities	30 metres	Erman et al. 1977 Roby et al. 1977 Newbold et al. 1980
Reduce Fecal Coliforms	30 metres 23 – 92 metres	Grismer 1981 Johnson et al. 1992
Nutrient Reduction	10 – 36 metre	Young et al. Lynch et al. Jones et al. Jacob and Gilliam 1985 Petersen et al. 1992 Castelle et al. 1991
Sediment Removal	30 metres 3 m (sand), 15 m (silt) 122m (clay) 75% removal in 30 –38 metre 50% deposition w/in 88 metre	Erman et al. 1977 Wilson et al. 1967 Karr and Scholosser 1977 Gilliam 1988
Wildlife Habitat	30 metres (various fish) 75-200 metres (birds, large mammals, small mammals) 30 – 100 metres (beaver)	Hickman and Raleigh 1982 Raleigh et al 1986 Jones et al 1988 Allen 1983

b. Physiographic Factors

In general, buffer width needs to increase as slope increases and as the infiltration rate and soil porosity decrease.

Soil characteristics determine in large part whether or not overland flow occurs, how fast water and contaminants move to the stream, and other factors relevant to the effectiveness of shoreline buffers. Denitrification rates are strongly influenced by soil moisture and soil pH (Groffman et al 1991 a,b) In general, as soils become finer (clay) a wider buffer is required to remove sediment and nutrients (Wilson et al. 1967). Determining soil characteristics on a Muskoka-wide basis is unrealistic given the scale and detail of existing data. Determination on a site-specific basis may be required to address soil properties.

The slope of the bank may be the most important variable in determining effectiveness of the buffer in trapping sediment and retaining nutrients. The steeper the slope, the higher the velocity of overland flow and the less time it takes nutrients and other contaminants to pass through the buffer, whether attached to sediments or moving in subsurface flow.

Although Niewand et al (1990) make a case for a width that varies exponentially with slope, research by Trimble and Sartz (1957) and Swift (1986) found a linear relationship in their field studies. Trimble and Sartz suggested that width should increase by either two or four feet for each percent increase in slope; Swift suggested that width should increase by either 0.40 or 1.39 feet for each percent increase in slope. Since Swift ignored soil type and in particular, small silt and clay particles, his variables may be low. Therefore, it is commonly believed that Trimble and Sartz's recommendation of increasing the buffer by 2 feet per 1% increase in slope is more appropriate.

Many researchers have noted that very steep slopes cannot effectively remove contaminants, though there is debate over what constitutes a steep slope. Among the recommendations are:

- 40% slope (Cohen et al 1987)
- 25% slope (Schueler 1995a)
- 15% slope (Nieswand et al 1990)
- 10% slope (Herson-Jones at al 1995)

Soil surveys typically do not recommend agriculture on slopes over 10% because of the erosion hazard. There appear to be very few other studies that evaluate buffer effectiveness at greater than moderate slopes. Any cutoff will be somewhat arbitrary, but Wenger 1999 suggests that 25% appears to be reasonable. Therefore, Wenger suggests that the buffer width should increase from the base width by two feet for each percent up to 25%. Slopes steeper than this are not credited toward the buffer width.

c. Ontario Experience

Where the proposed land use adjacent to a waterbody is residential, the Ministry of Natural Resources recommends a minimum 15-metre buffer for water quality protection around lakes and streams supporting warm water species of aquatic life and a 30-metre buffer where the waterbody supports coldwater species (OMNR, 1994). Where the proposed adjacent land use is forestry, the Ministry has established 120-metre area of concern with a minimum 30-metre no cut zone and a 90-metre modified cut zone depending on slope (Operational Prescriptions for Areas of Concern, Forest Management Plan 1999-2003).

What should a buffer look like?

A shoreline vegetative buffer should generally be a broad corridor of undisturbed vegetation adjacent to a lake, river, stream or other surface water. In a lake-based recreational environment such as Muskoka, it is unrealistic to believe that no clearing or vegetation removal will occur in this area. It is, therefore, important to develop a buffer model that substantially maintains the function of the buffer while recognizing the need for water access and views.

A three-zone shoreline buffer has been proposed by jurisdictions such as in the Chesapeake Bay watershed. This approach provides a framework through which water quality, habitat and other objectives can be accomplished.

Zone 1: this zone begins at the lake edge and is the area that provides streambank stabilization and habitat for both aquatic and terrestrial organisms. Primary function of this zone includes provision of shade and input to the lake or river of detritus and large woody debris from mature forest vegetation.

Vegetation in this zone also helps reduce flood effects, stabilizes the bank, and removes some sediments and nutrients. Vegetation should be composed of native trees and shrubs of a density that permits understory growth. This zone should be a ‘no touch’ zone, however, limited shoreline access may be provided. Access paths should be constructed to minimize erosion, soil compaction and disturbance to habitat. The width of this zone should be at least 10 metres (Fischer and Fischenich 2000).

Zone 2: This zone extends inland from Zone 1 for a minimum of 3 metres up to several hundred metres, depending on the objective, lake type, soil type, slope or topography, and land use. The objective of this zone is to provide a managed forest area with vegetation composition and character similar to natural forests in the area. Limited and well-constructed paths that do not significantly increase overland flow to the lake may be permitted in some situations. (Fischer and Fischenich 2000).

The primary function of Zone 2 is to remove sediment, nutrients and other pollutants from surface and groundwater. This zone, in combination with Zone 1, also provides most of the enhanced habitat benefits, and allows for recreation and aesthetic benefits.

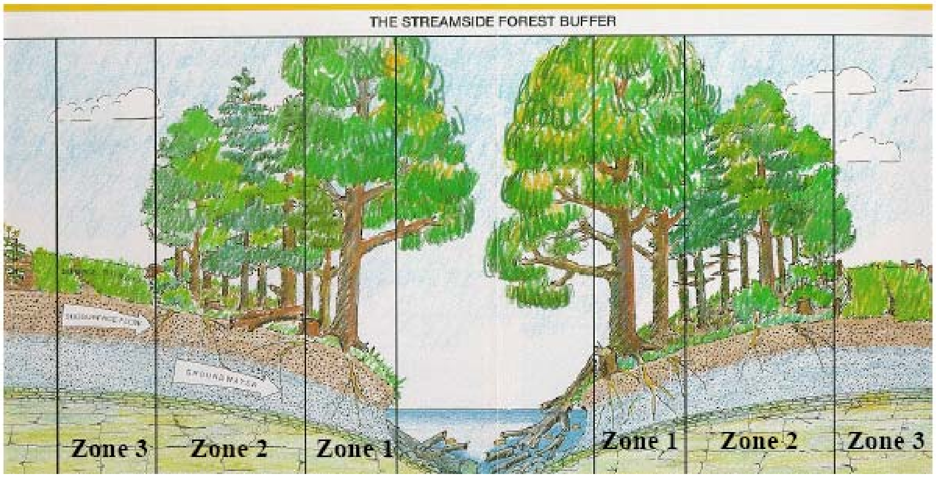

Figure 1: Depiction of a three-zone buffer approach developed for the Chesapeake Bay Watershed. This approach may be applicable to most forested riparian buffer strips in North America (From Welsch 1991)

Zone 3: This zone typically contains grass or herbaceous filter strips and provides the greatest water quality benefits by slowing runoff, infiltrating water, and filtering sediment and its associated chemicals. The minimum recommended width of Zone 3 is 5 metres. The primary concern in this zone is initial protection of the lake from overland flow of non-point source pollutants such as herbicides and pesticides applied to lawns and timber stands. Properly designed grassy and herbaceous buffer strips may also provide quality habitat for several upland wildlife species. (Fischer and Fischenich 2000)

Summary

In summary, the most comprehensive reference on buffer strip effectiveness is that produced by Knutson and Naef (1997) for the Washington State Department of Fish and Wildlife. The evidence presented by those authors suggest that a minimum 30 m buffer strip provides many beneficial uses including:

i) Maintenance of 50 to 100% shading of the stream is assured at 30 m;
ii) Maintenance of large woody debris requires 30 m to 50 m;
iii) 90% sediment removal at a 2% grade requires 30 m or more;
iv) Removal of nutrients and coliform bacteria requires 4 m to 36 m (30 m is sited most often);
v) Bank erosion control requires a minimum of 30 m;
vi) Aquatic invertebrates, salmonid fish and reptiles and amphibians all require a 30 m buffer strip.

ADDITIONAL RESOURCES

1. Vegetative Filter Strips for Improved Water Quality Iowa State University, April 2000

   http://www.extension.iastate.edu/Publications/PM1507.pdf

2. Buffer Strips For Riparian Zones ISU Forestry Extension, 253 Bessey Hall Ames, Iowa 50011-1021 October 2001.

   http://www.forestry.iastate.edu/ext/buffstrips.html

3. Buffer Strip Design Establishment and Maintenance Iowa State University, April 1997

   http://www.exnet.iastate.edu/Publications/PM1626B.pdf

4. Maintenance of Riparian Buffers Iowa State University, March 2002

   http://www.extension.iastate.edu/Publications/PM1626C.pdf

5. Tried Buffers Yet? Story Soil & Water Conservation District Iowa State University, Summer 2002

   http://www.story-swcd.org/TriedBuffers.pdf

6. Shoreline Buffer Strips. October 1996. Illinois Environmental Protection Agency and the Northeastern Illinois Planning Commission

   http://www.epa.state.il.us/water/conservation-2000/lake-notes/shoreline-buffer-strips/shoreline-buffer-strips.pdf

7. Ecological Restoration: A Tool to Manage Stream Quality: Executive Summer. EPA, August 2003

   http://www.epa.gov/owowwtr1/NPS/Ecology/exsum.html

8. Key Buffer Choices for Watershed Managers. EPA September 2002.

   http://www.epa.gov/owow/watershed/wacademy/acad2000/protection/index7.html

   http://www.epa.gov/owow/watershed/wacademy/acad2000/protection/index8.html

9. Model Ordinance to Protect Local Resources. EPA, October 2002

   http://www.epa.gov/owow/nps/ordinance/buffers.htm

10. Buffer Strip Benefits. Illinois EPA, 2003

    http://www.epa.state.il.us/water/conservation-2000/lake-notes/shoreline-buffer-strips/buffer-strip-benefits.html

11. The Buffer Concept, Illinois EPA, 2003

    http://www.epa.state.il.us/water/conservation-2000/lake-notes/shoreline-buffer-strips/buffer-concept.html

12. How to Create and Effective Buffer Strip. Illinois EPA, 2003

    http://www.epa.state.il.us/water/conservation-2000/lake-notes/shoreline-buffer-strips/create-buffer-strips.html

13. THE BUFFER HANDBOOK "A Guide to Creating Vegetated Buffers for Lakefront Properties" U.S. Environmental Protection Agency, Boston Regional Office and Maine Department of Environmental Protection 1998

    http://www.state.me.us/dep/blwq/docwatershed/bufa.htm

14. What is a Shoreline Buffer. Korth September 1999.

    http://www.co.lincoln.wi.us/html/what_is_a_shoreland_buffer.htm

15. Vegetative Buffer Zones in Shoreline Landscape Design, Maintenance and Management to Protect Water Quality, Sustainable Urban Landscape Information Series 1998-2003 Regents of the University of Minnesota.

    http://www.sustland.umn.edu/related/water2.html

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