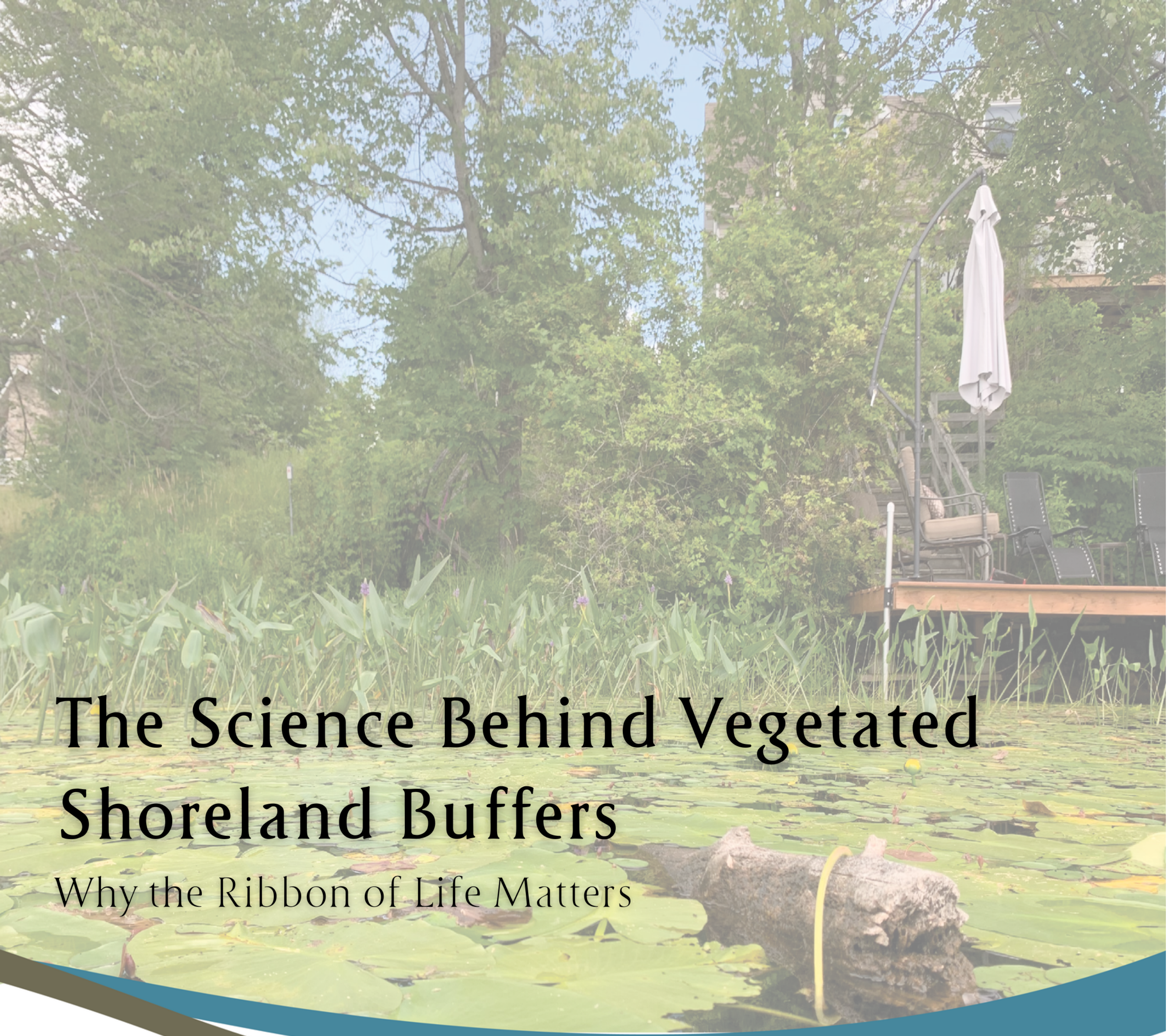

The Science Behind Vegetated Shoreland Buffers

Why the Ribbon of Life Matters

PLANNING FOR OUR SHORELANDS

Watersheds CANADA

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This document was produced and reviewed by the Planning For Our Shorelands program steering committee:

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The Planning For Our Shorelands program presents webinars and best practices resources to address common and very complex problems facing waterfront communities today by promoting an ecosystem-based approach in land use decision-making. By restoring shoreland vegetation, creating opportunities for environmental net gains, and promoting sustainable development practices, Planning for our Shorelands highlights natural climate solutions as holistic and resilient solutions to these common waterfront challenges. This program is led by Watersheds Canada, a national charitable organization (863555223RR0001): https://watersheds.ca/

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I. Introduction

Vegetated shoreland buffers, also known as the 'Ribbon of Life', are essential to the health and sustainability of Canada's freshwater.

According to numerous scientific studies, vegetated shoreland buffers:
- Naturally protect the water quality of lakes, rivers, and streams by intercepting harmful pollutants.
- Mitigate erosion.
- Provide food and shelter for wildlife, including many at-risk species.
- Contribute to the beauty and economic value of waterfront properties.
- Protect freshwater ecosystems from the impacts of climate change.

The restoration and maintenance of vegetated shoreland buffers is widely promoted by scientists as an effective best-management practice for freshwater health.

Unfortunately, the removal of native vegetation from shorelands has become a harmful and growing trend across Canada and is a major factor in the decline of water quality and wildlife communities (Hadley et al., 2013).

Supporting healthy freshwater ecosystems will depend on policy makers and property owners making sustainable land-use decisions informed by scientific evidence.

Using highly-cited and peer-reviewed scientific studies, this document outlines the benefits of vegetated shoreland buffers, and discusses why local decision makers, landowners, developers, and landscape professionals should maintain or restore native vegetation to achieve holistic protection for waterfront properties and ecosystems.

II. The Shoreland: An Integrated Ecosystem-based Management Approach

When making land-use decisions, it is important to use an ecosystem-based approach that recognizes the waterfront as a holistic, interconnected system rather than focusing on impacts or functions in just one area (Slocombe, 1993; Osborne & Kovacic, 1993). For this reason, we recommend the term shoreland be used within the context of waterfront management, as this term encompasses the full ecosystem that makes up a waterfront property, including the following four major ecological zones (Figure 1):

The Upland Zone encompasses the elevated, well-drained area outside the flood zone of a watercourse. Mature uplands maintain a forest-like community of native trees and shrubs that provide habitat for mammals, birds, and amphibians (Bub et al., 2010; Bateman & Merritt, 2020). Upland forests also produce important organic materials such as leaf litter and coarse woody debris (Stevens, 1997; Vanderbosch & Galatowitsch, 2010). Since most land-based pollutants originate in this zone, vegetation and organic material in the upland act as a first line of defence for freshwater health.

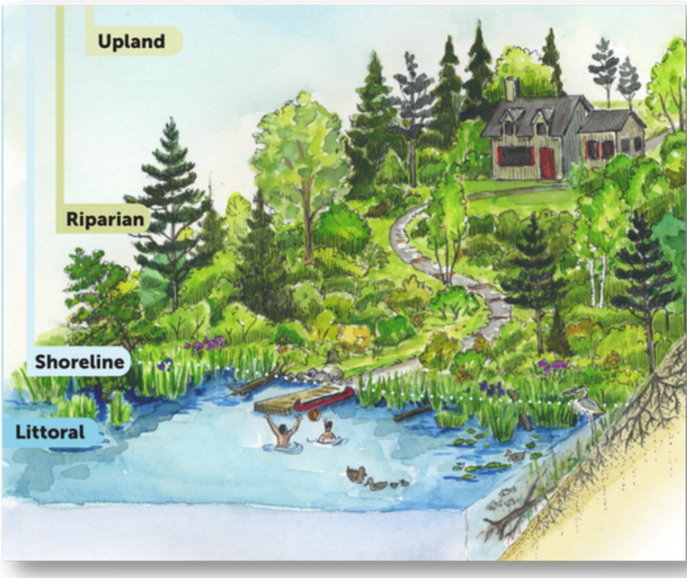

Figure 1. A healthy Shoreland Ecosystem including four major Ecological Zones: a) Upland, b) Riparian, c) Shoreline, and d) Littoral. Adapted from: Resilient Shorelands, Watersheds Canada. Retrieved from: https://watersheds.ca/planning-for-our-shorelands/

The Riparian Zone is the transitional area that extends inland from the shoreline for at least 15 metres. Composed of moisture-tolerant vegetation, plant and wildlife diversity in the riparian zone is generally higher than upland zones (Naiman & Dechamps, 1997). Scientists suggest that up to 70% of terrestrial wildlife globally will rely on riparian habitat at some point in their life cycle (Riis et al., 2020; Naiman et al., 1993).

The riparian zone also plays a fundamental role in preventing pollution from entering freshwater through the interception of runoff and associated pollutants from upland areas (Kieta et al., 2018; Lee et al., 2003). Since developed uplands are a source of many pollutants and runoff, and are routinely cleared of vegetation and organic debris to build dwellings and other structures, a vegetated riparian zone can often be the most important line of defence against pollution within a shoreland area (Riis et al., 2020).

The Shoreline is the physical edge where land and water meet. The mix of herbaceous plants, shrubs, and trees on the shore form an intricate web of roots and organic debris that mitigate erosion from wind, rain, boat wakes, and ice.

The Littoral Zone covers the area of aquatic habitat extending from the high water mark to the point where light does not reach the bottom of the water (Muskoka Watershed Council, 2011). Composed of emergent and submergent aquatic plants, the littoral zone provides habitat for fish (Jennings et al., 1999), macroinvertebrates (i.e., molluscs, insect larvae, etc.) (Brauns et al., 2007), and waterfowl (Sibilia et al., 2022). Up to 90% of aquatic lake species utilize the littoral zone during their lifecycle (Vandeboncoeur et al., 2011). The littoral zone also plays an under-appreciated role in protecting water quality. Studies have shown that wetland and littoral vegetation serve as a sink for nitrogen (Mickle, 1993) and are active in cycling other nutrients and pollutants within nearshore aquatic ecosystems (Pieczynska, 1993; Li et al., 2018).

From the Scientists:

"Buffer strips are strips of vegetated land composed in many cases of natural ecotonal and upland plant communities which separate development from environmentally sensitive areas and lessen [the] adverse impacts of human disturbance." (Norman 1996, p. 263).

Removal of shoreland vegetation is sometimes called a "death by one thousand cuts", in which the impacts of unsustainable land-use and development across many shoreland lots results in a cumulative, ecosystem-wide decline in habitat and water quality (Radomski & Goeman, 2001).

The negative impacts in one shoreland zone are often felt in others. According to Dr. Steven Carothers (1977): "[...] when a riparian habitat is removed or severely manipulated, not only are the riparian species of the area adversely influenced, but wildlife productivity in the adjacent habitat is also depressed." (p. 3).

EVERY zone that makes up a shoreland, from the upland zone down to the littoral zone, plays an important role in maintaining sustainable ecosystem functions. When conserved or restored TOGETHER, the four shoreland zones work in tandem to create climate resilient shorelands, provide critical habitat for wildlife, and protect water quality from land-based pollutants.

III. Water Quality, Eutrophication, and the Importance of Vegetated Shoreland Buffers

Vegetated shoreland buffers protect the health of freshwater by slowing runoff and trapping pollutants. Runoff, whether from rainfall, stormwater, or ice melt, carries dissolved and sediment-bound pollutants, including:

1. Nutrients (e.g., phosphorus and nitrogen) from septic systems or residential fertilizers.
2. Sediments, oils, and chemicals from machinery or waterfront construction sites.
3. Pesticides used in lawn or garden care.
4. Road salts.
5. Fecal coliform bacteria from septic systems or animal waste.

Of these pollutants, nutrients and sediments are of particular concern due to their contribution to eutrophication: the introduction of excess nutrients into a waterbody (especially from human-made sources), causing increased rates of algae growth. The acceleration of human-made eutrophication is one of the greatest threats to freshwater globally (Chislock et al., 2013). In addition to reducing water clarity and limiting the survival of freshwater plants, molluscs, and fish, some algae blooms that result from eutrophication are a health concern to humans and pets due to the toxins they produce, leading to serious concerns over water quality across the world (Chislock et al., 2013; Puschner, 2018).

> Quick math!
>
> For every additional foot of water clarity, homebuyers in Central Ontario's Cottage Country are willing to pay an estimated 2% more for waterfront homes (Clapper & Caudill, 2014). The median price of waterfront homes in Cottage Country as of July 2022 was $1,050,000. That's $21,000 for each additional foot of clear water!

Since 2013, water quality has been ranked the most valued lake-related characteristic for over 85% of shoreland property owners surveyed through the Love Your Lake program (Watersheds Canada, 2021). However, only 22% of properties surveyed met minimum standards for addressing the health of their lake, which includes maintaining a naturally vegetated buffer. These statistics demonstrate a prominent disconnect between values and actions among shoreland property owners. Fortunately, science supporting the maintenance or restoration of vegetated shoreland buffers is extensive, and can provide the basis for engaging property owners about the importance of shoreland naturalization and the consequences of unsustainable land-use practices.

The Dangers of Blue-Green Algae

Blue-green algae, or cyanobacteria, is the most well-known and harmful consequence of eutrophication. Notable impacts include (but are not limited to):

1. Reduced ability for molluscs and fish to feed and/or avoid predation due to reduced water clarity and changes in water chemistry (Chislock et al., 2013).
2. When algae blooms die, their decomposition uses high levels of dissolved oxygen in the water, which is critical to oxygen sensitive species such as Lake Trout and can lead to significant loss of fish populations (Nelligan et al., 2016).
3. Some types of blue-green algae produce toxins that are a risk to the health of humans, pets, and wildlife (Hilborn & Beasley, 2015).

Canada's provinces and territories each maintain their own algae bloom monitoring programs, and some, such as Ontario, have kept consistent records. Since the mid-1990s, the number and longevity of blue-green algae blooms in Ontario has risen significantly (see Figure 2), promoted by higher water temperatures and above-normal nutrient inputs from human-made sources (Winter et al., 2011; Pick, 2016; Smith et al., 2021).

Elsewhere, the trend is similar to that of Ontario. The number of blue-green algae blooms in Quebec reported during a six year period between 2004 and 2010 increased from 24 to 150 (Pick, 2016). Western Canada has not been immune to eutrophication either, with scientists reporting that several lakes have recently experienced significantly greater rates of nutrient-loading from human-made sources, resulting in widespread concerns over the development of toxic algae blooms (Schindler et al., 2008). Blue-green algae thrive under high-nutrient conditions (e.g., phosphorus) and higher water temperatures. These conditions have detrimental impacts on native aquatic species. With increased rates of eutrophication and higher than average temperatures due to climate change, the negative effects of blue-green algae are projected to increase in magnitude, length, and geographic scope in the coming years.

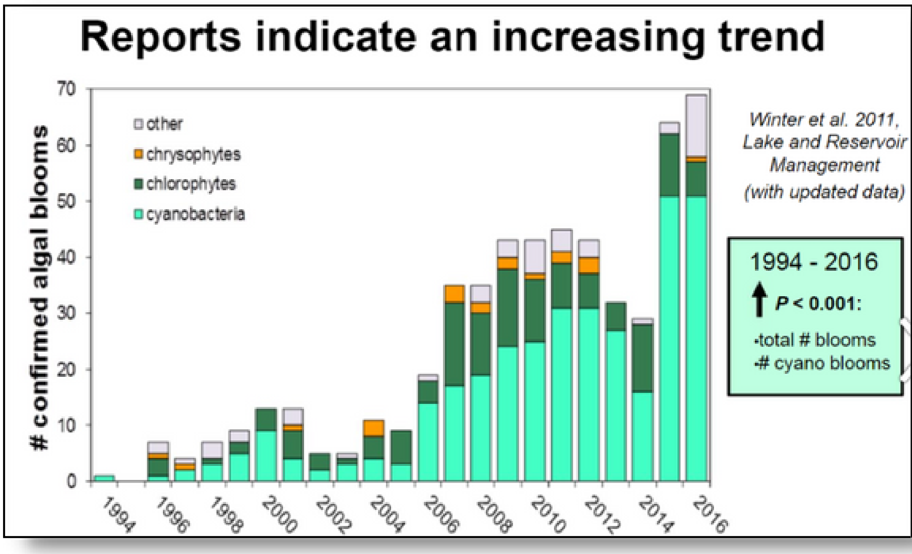

Figure 2. Reported Algal Blooms in Ontario Lakes 1994-2016. Adapted from: Muskoka Stewardship Conference presentation (Published on May 24, 2017). Claire Holeton, Ontario Ministry of the Environment and Climate Change. Retrieved from: https://issuu.com/72926/docs/2017msc-bloomtrends-choleton.

Why Planting Shoreland Vegetation Matters to Water Quality

Vegetated Buffers have proven highly effective in protecting watercourses from the negative influence of pollution carried by runoff, including nutrients that contribute to eutrophication (Kieta et al., 2018).

The interception of runoff and associated pollutants by vegetated buffers is the result of two main processes: a) decreased rates of runoff flow, and b) an increase in soil infiltration. When slowed, runoff is much more likely to enter the soil, a process known as soil infiltration. Once infiltration occurs, pollutants and sediments are deposited into the soil instead of entering the water (Kieta et al., 2018).

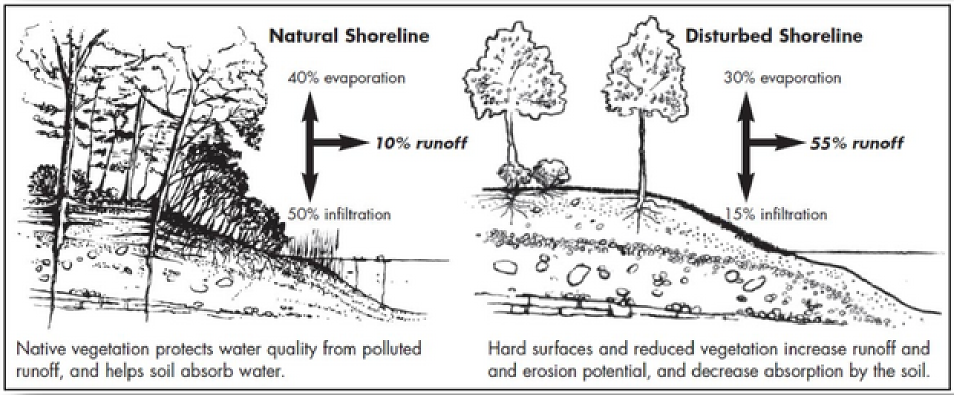

Figure 3. Natural shorelands promote soil infiltration and subsequent reduction in runoff. Adapted from: Benefits of a Natural Shoreline. Rideau Valley Conservation Authority. Retrieved from: https://www.rvca.ca/stewardship-grants/shoreline-naturalization/benefits-of-a-natural-shoreline.

When runoff flows through a vegetated buffer, its speed is physically reduced by plants and organic materials like leaf litter and coarse woody debris. The more diverse, dense, and expansive the buffer, the more effective it is at slowing runoff. This effect is illustrated in Figure 3, which shows the significant increase in soil infiltration and subsequent reduction in runoff that a natural shoreland area promotes compared to a mowed lawn to the water's edge.

In addition to slowing runoff flow, the native plant community that comprises a vegetated buffer promotes soil infiltration directly by enhancing the porosity of the soil with its root systems. Indirectly, native vegetation provides habitat for soil-burrowing organisms (e.g., insects and worms) that create micro-pores in the soil, allowing for deeper and faster absorption of water and associated pollutants (Betard, 2020). With climate change threatening more extreme rainfall events in parts of Canada, the promotion of soil health leading to stable rates of infiltration has never been more necessary.

How Wide is Wide Enough?

A common question among property owners and decision makers is this: what size of buffer is necessary to protect water quality? Some regions provide recommendations for minimum vegetated buffer widths in municipal planning documents, but these recommendations can range between 10 metres and 30 metres. Is there a truly optimal buffer size for the retention of pollutants from runoff?

Buffers in the range of 20 - 30 metres have exhibited rates of nutrient and pollution abatement between 80% and 90% (Zhang et al. 2010; Henshaw & Ursic, 2012). However, variation in the effectiveness of different buffer widths across available scientific studies is quite high (Henshaw & Ursic, 2012). More simply, some studies show high rates of pollution abatement with small buffers while others show a relationship between higher rates and larger buffers.

Many shoreland properties with non-conforming or "grandfathered" buildings do not allow for vegetated buffers within the 20- or 30-metre range since the non-conforming structure is typically within 30 metres of the water.

Quick Science!

I) Nutrient moderation (e.g., total phosphorus and nitrogen) by vegetated buffers is influenced by a) soil infiltration, and b) flow rates of runoff. By increasing soil porosity and physically reducing the speed of surface runoff, vegetated buffers promote infiltration of nutrients and sediment-carrying runoff into the soil before they can enter lakes, rivers, or other watercourses (Kieta et al., 2018).

II) Insects and burying organisms have a significant impact on the hydrology of soils. By increasing soil porosity and promoting infiltration, insects can reduce surface runoff rates more than 25%, but vegetation is needed to provide habitat for insects (Bailey et al., 2015; Betard, 2020).

III) Scientists from the University of California found that a 30m vegetated buffer removed 85% of pesticides, sediment, nitrogen, and phosphorus from runoff (Zhang et al., 2010).

IV) Two field studies found that, under certain conditions, vegetated buffers less than 20m can remove >92% of Total Nitrogen, >91% of Total Phosphorus, and >90% of the Total Sediment (Lee et al., 2004; Mankin et al., 2007).

V) There is significant variation across different studies regarding the relationship between buffer size and retention rates (See points III and IV). Buffer effectiveness is impacted by: a) buffer width, b) surface slope, c) the type of plants comprising the buffer, and d) soil composition (Tsai et al., 2022). In general, steeper slopes and shallower soils require larger buffers.

Considering the complexities of shoreland issues, a golden rule should always be followed: a vegetated buffer should be as wide and biologically diverse as the property or circumstances will allow.

In some cases, simulated or experimental buffers of 10 metres or less have exhibited modest and sometimes even high rates of nutrient and pollution prevention (Prosser et al., 2020). Not being able to meet a recommended width should NEVER preclude waterfront property owners from maintaining or planting a vegetated shoreline buffer.

While size sometimes dominates discussions about vegetated shoreline buffers, other factors that determine capacity to moderate runoff and associated pollution should also be considered, including:

1. Plant community and composition (e.g., plant type, density, and maturity).
2. Slope (e.g., higher slopes increase runoff flow, necessitating a wider buffer).
3. Soil type (clay soils may require larger buffers due to lower soil infiltration rates compared to loam or sand soils).

Shoreland properties are as diverse as the waters they surround, and each situation deserves careful and balanced consideration before a buffer is planted or expanded.

30-metres: Fact of Fiction?

According to the Ministry of the Environment, Conservation and Parks Lakeshore Assessment Handbook 2020 (as cited in White, 2020):

“While small buffers (2 to 15 metres) can remove some sediment and phosphorus, scientific studies overwhelmingly support buffer widths of 30+ metres to provide effective mitigation and protect aquatic resources”.

On the other hand...

“Site specific characteristics alter a buffer’s ability to control nonpoint source pollution, requiring variable buffer widths [...] Additionally, core habitats for semi-aquatic wildlife often extend beyond 30m from aquatic habitats [...]” (Goates, 2006, p. 1).

The Golden Rule: ANY BUFFER IS BETTER THAN NO BUFFER AT ALL!

IV. Erosion and Shoreline Stabilization

Erosion is the process by which soil is detached and moved, whether by waves, rain, snow melt, or floods (Dabney, 2008). When this occurs on the shores of freshwater, sediments (and sediment-bound pollutants) enter the adjacent waterway, contributing to a reduction in water quality and clarity, as well as a general loss of waterfront property due to bank destabilization and erosion (Hewlett et al., 2015). Erosion is a natural process, but in human-made or altered landscapes, it can be accelerated to a rate that causes loss of land, and rapid nutrient and sediment loading into adjacent waterways.

How Erosion Works and How Vegetated Buffers Can Help

Runoff is a major contributor to eroded shorelands that lack native vegetation. The maintenance of mowed lawns and other landscaping activities directly adjacent to a waterbody produce large areas of exposed soil that promote runoff. According to France et al., (2018), erosion rate is proportional to runoff speed. In situations where runoff moves faster, such as on non-vegetated shorelands, the potential for erosion is significantly higher.

As noted in section IV. of this document, vegetated buffers reduce runoff speed and promote soil infiltration, thus mitigating potential for exposed soils to be carried into a waterbody. In addition to moderating erosion caused by surface runoff, vegetated buffers also control erosion below the surface!

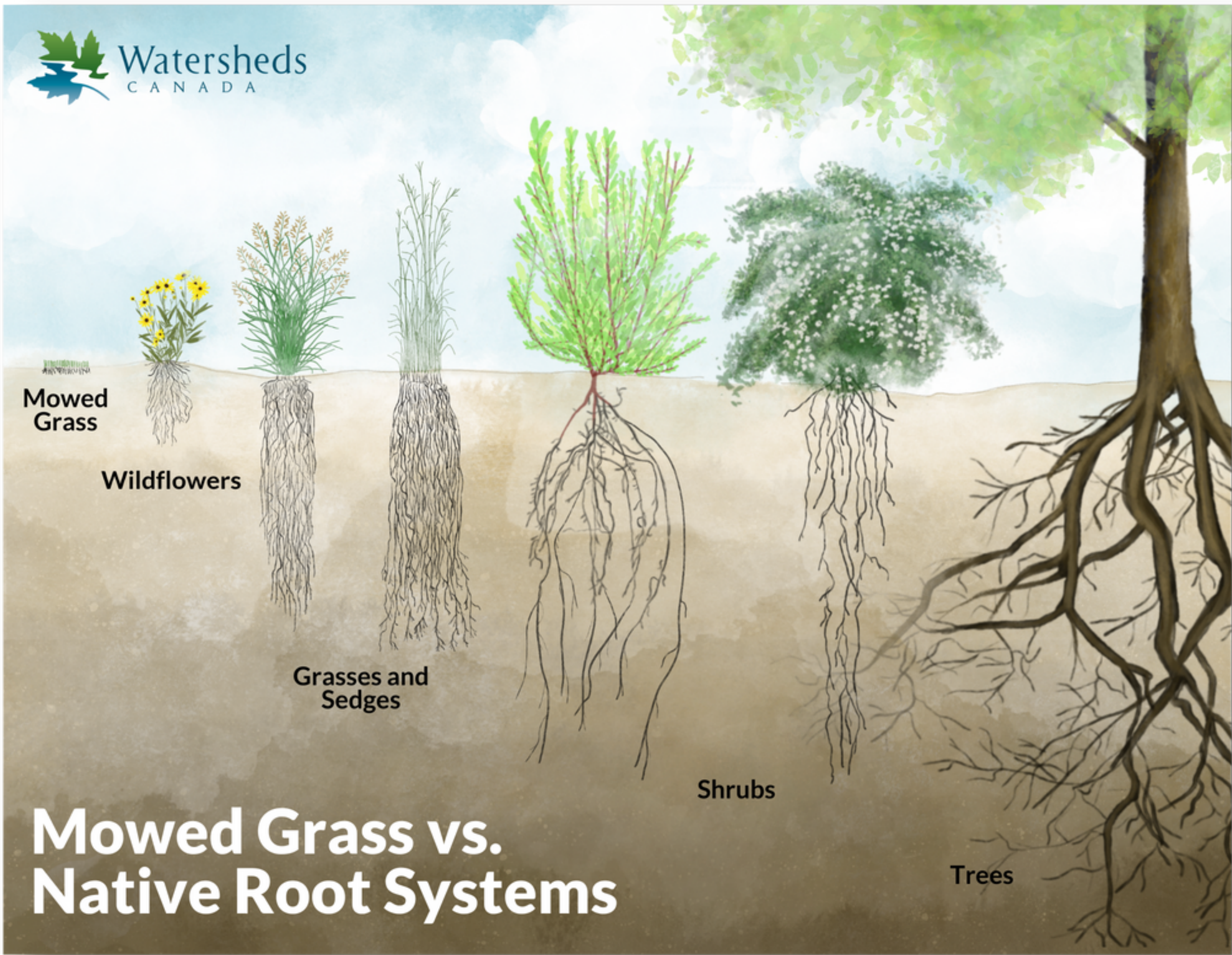

Figure 4. Root Systems of Shoreland Trees and Shrubs Compared to Mowed and Manicured Lawn Grass. Nicole Dubé. 2022. Watersheds Canada.

The root systems of native trees, shrubs, wildflowers, grasses, and sedges reduce the erodibility of soil beneath the ground through the aggregation of soil particles and their attachment to organic materials produced by the plants and nearby fungi (Mitchell & Hirschi, 2012). In areas with low to moderate wave action, vegetated buffers will reduce the risk of bank destabilization and erosion over time.

On properties where mowed lawns extend to the water's edge, the root system below the soil is extremely limited, contributing to destabilization of soil and higher rates of runoff that make it to the water. This changes when native trees and shrubs are introduced or maintained as their root systems are significantly deeper and denser than mowed and manicured lawns (see Figure 4).

Natural vs. Human-Made Solutions

Shoreline erosion is a significant issue for shoreland property owners.

Techniques that address the problem of shoreland erosion are quite diverse but all share the similar goals of improving soil and bank stability, reducing impacts of wave action, and mitigating flooding and/or flood risk. Techniques that address erosion can be categorized as either:

1. Soft Shoreline Engineering (SSE) techniques
2. Hard Shoreline Engineering (HSE) techniques

Quick Science!

I) Nutrients and other pollutants bind to sediments in the soil and are carried by runoff towards a body of water (Goharrokhi et al., 2021). Sediment entry into lakes or rivers from shoreline erosion affects not only water clarity, but can also contribute to pollution and eutrophication. In some situations, shoreline erosion can contribute up to 10% of a waterbody's total nutrient load (Hewlett et al., 2014).

II) The way in which shoreline erosion is mitigated or controlled has significant impacts on aquatic ecosystems. In a 2020 study of Big Rideau Lake in Ontario, Dr. Auston Chhor et al. (2020) discovered changes in aquatic species communities and a significant decrease in woody debris and macrophyte (aquatic plant) richness on shorelines armoured with riprap or retaining walls.

In their 2010 article, John Hartig and his colleagues define SSE as:
"...the use of ecological principles and practices to reduce erosion and achieve the stabilization and safety of shorelines, while enhancing wetland habitat, improving aesthetics, and even saving money." (p. 3116).

In contrast to hard engineering solutions, such as stone-wall armouring and rip-rap (i.e., human-made rock walls), soft engineering involves the planting and/or placement of organic materials (including mulch) to stabilize soil and mitigate runoff-induced erosion. Unlike most hard engineering techniques, soft engineering avoids the ecological risks of hard engineering, including:

1. Degradation or removal of aquatic habitat and a reduction in littoral habitat complexity (Brauns et al., 2007; Ostendorp et al., 2020).
2. Damaged or destroyed communities of littoral macrophytes (aquatic vegetation) (Chhor et al., 2020).
3. Possible reductions in invertebrate diversity and changes in fish community composition (Brauns et al., 2007; Chhor et al., 2020).

In addition to its provision of important ecological benefits, soft, or natural, solutions to erosion are comparatively cost effective in the long-term when compared to hard engineering approaches such as bulkheads and rip rap (Rella & Miller, 2012; Narayan et al., 2016).

Combining Hard and Soft Shoreline Solutions

Solutions to erosion can be complex and are not always easy to solve with a single solution. While use of natural, soft engineering techniques are advisable for protecting water quality and wildlife habitat, there are situations where hard engineering techniques are necessary to mitigate intense wave action or flooding. In these situations, it is important that landowners consult the appropriate experts in engineering to ensure that the design is appropriate for specific site conditions.

According to a report produced by Dr. Briana Shea and her colleagues at the University of Wisconsin:

"In high wave energy environments, hard armoring like seawalls, breakwaters or revetments may be necessary to reduce erosion and flooding. However, there are several ways to enhance hardened coastal infrastructures to add some ecological benefits and/or lessen their impact on the environment" (Shea et al., 2021, p. 26).

> A Real World Example!
>
> On average, a shoreland naturalization project facilitated through the Natural Edge Program (including all costs associated with iOS App development, staffing, purchasing of native plants and materials, and associated labour) costs $2,000. Stone rip rap can cost up to $100 per linear foot, meaning a 100 foot shoreland needing reinforcement can cost up to $30,000!

Offshore breakwaters or armour made of stone can be augmented with littoral vegetation and organic materials to support wildlife. Furthermore, the spaces between rip-rap and revetment stones can be planted with vegetation, creating what is known as a Joint-Planted Revetment (Shea et al., 2021). However, it should be noted that for most small inland lakes, native vegetation can provide a sufficient means of erosion control on shorelines without the need for hard engineering practices.

Nature-based techniques that combine hard and soft approaches to prevent erosion have quickly gained recognition and support by land managers (Miller et al., 2015). This includes the maintenance or restoration of shorelands and the augmentation of hard engineered structures with native vegetation or other organic materials (Shea et al., 2021). Despite being developed for use in coastal settings, the application of approaches that combine hard and soft engineering solutions are also highly effective for situations on inland lakes (Northwest Regional Planning, 2004), rivers (Hartig, Kerr, & Breederland, 2003), and streams (Kail et al., 2007).

V. Shoreland Wildlife: Buffers as Habitat

The zones that comprise a shoreland ecosystem provide some of the most critical habitats for wildlife globally (Grazianno et al., 2022; Vandeboncoeur et al., 2011). Native shoreland vegetation provides breeding (Knopf et al., 1988) and developmental (Bryan and Scarnecchia, 1992) habitat for native wildlife species, some of which are threatened or endangered under federal or provincial legislation in Canada. Considering the importance of habitats close to freshwater, vegetated shoreland buffers need to be maintained with the needs of local wildlife in mind.

Buffers as Habitat

Larger buffers are often needed to support wildlife habitat. Some scientists have suggested that vegetated corridors of up to 100m are necessary to support certain species of reptiles, birds, and aquatic invertebrates (Larsen-Gray & Loehle, 2021).

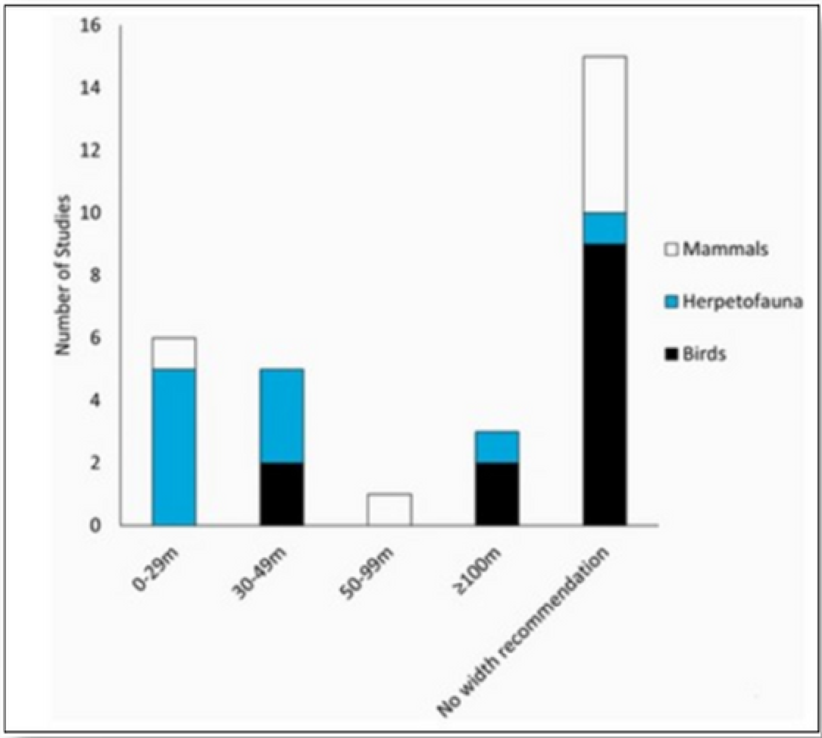

Figure 5. Buffer width recommendation for wildlife conservation strategies. Adapted From: "Relationship Between Riparian Buffers and Terrestrial Wildlife in the Eastern United States". A. Larsen-Gray, & C. Loehle (2021). Journal of Forestry 120(3): 336 - 357. https://doi.org/10.1093/jofore/fvab067.

Vegetated buffer widths exceeding 30 metres are typically difficult to achieve on most private or commercial properties. This should not, however, deter landowners and decision makers from restoring or promoting buffers to the fullest extent possible to re-establish or maintain habitat. For several species that rely on shoreland habitat, it is often less about the size and more about the type and diversity of native plants that determine its effectiveness. Figure 5 is taken from a literature review of thirty studies analyzing vegetated buffers along freshwater streams. A large proportion of these reviewed papers provided no specific width recommendation to achieve specific wildlife-related goals, and instead recommended that managers focus on the “structural components” of the buffer that align with the needs of certain species (Larsen-Gray & Loehle, 2021, p. 338).

When designing shoreland restoration plans, wildlife habitat functions can easily be incorporated to increase the quality and quantity of habitat. Indeed, the proper management of a vegetated buffer, regardless of size, can offer critical habitat to a variety of species. For example, overhanging shoreline vegetation and aquatic plants provide shade and habitat for developing fish and other aquatic species (Johnson & Jones, 2000; Tabor et al., 2010). In the planning and management of vegetated buffers, the needs of local species MUST be considered alongside considerations of size.

Quick Science!

I) Riparian vegetation is thought to support more nesting and migratory birds "than any other vegetation type" in continental North America (Sanders & Edge, 1998, p. 461).

II) Certain species, such as bats, some amphibians, and even some small mammals can thrive in narrower buffer zones, assuming adequate plant structure and composition (Larsen-Gray & Loehle, 2022).

III) Semi-aquatic species, such as salamanders, frogs, and toads, rely upon sound riparian and terrestrial habitats close to aquatic breeding areas for overwintering and foraging for food (Semlitsch & Bodie, 2003).

IV) Many species actively seek naturalized shorelands as their preferred habitat relative to developed shorelines, including Northern Map Turtles (Graptemys geographica), juvenile Yellow Perch (Perca flavescens), Bluegill (Lepomis macrochirus), and Green Frogs (Lithobates clamitans) (Carriere, 2007; Bryan & Scarnecchia, 1992; Woodford & Meyer, 2003).

V) In stream habitats, riparian vegetation is critical for the maintenance of temperature regimes that support cold-adapted species such as Brook Trout (Salvelinus fontinalis) and Brown Trout (Salmo trutta) (Broadmeadow et al., 2022; Henshaw & Ursic, 2012). Removal of riparian vegetation can lead to the extirpation of these species.

Within a planning and management context, Craig Johnson and Susan Buffler (2008) provide a list of 'Primary Site Attributes" (in addition to size) that should be considered in the planning, planting, and maintenance of vegetated buffers for the purpose of supporting wildlife:

1. Plant Community Vigour: Having many species of plants that are installed appropriately (e.g., flood-tolerant plants nearest to the littoral zone) and which mimic the composition of a natural shoreline plot. Following this rule will “support a greater diversity of wildlife than sites without these characteristics" (p. 36).

2. Level of Human Induced Disturbance or Fragmentation: Development and buildings are not mutually exclusive to a wildlife-friendly shoreland, but every measure should be taken to offset changes in habitat structure. "In general, landscapes with high levels of human induced disturbance [...] are reduced in habitat value for most native wildlife species" (p. 36).
3. Relative Abundance of Invasive Plants: Non-native plants can out-compete native species, and are not as beneficial to native wildlife species as either food or habitat. "High populations of invasive plants (greater than 25 percent surface coverage of the buffer unit) are indicative of ecosystem dysfunction" (p. 36).

A Real World Example!

Creating a successful shoreland buffer requires careful planning and consideration of native plants. Check out Watersheds Canada's Shoreline Naturalization Planting Plan Template for help with planting your shoreland, as well as the Native Plant Database provided through the Natural Edge Program.

VI. Climate Change and Water Quality

Climate change is affecting the biological and physical nature of Canada's freshwater. Water temperatures are rising steadily, reducing the duration of ice cover on lakes during winter (Sharma et al., 2019). Some lakes are experiencing stratification periods much longer than those recorded historically, resulting in reduced levels of dissolved oxygen, habitat degradation for important fish species, and a general reduction in water quality (Woolway et al., 2022).

Warmer temperatures are also a major contributor of algae growth in lakes and rivers. Higher temperatures are projected to promote blue-green algae outbreaks in lakes of differing characteristics, including those whose physical and biological characteristics make them less susceptible to algae growth naturally occurring. In regions that experience more extreme rainfall events, nutrient-loading will become a more severe issue. As climate change increases the likelihood and longevity of harmful blue-green algae blooms in lakes across Canada, there is an even greater need for shoreland naturalization on ALL lakes to prevent loading of bloom-causing nutrients into freshwater systems.

> A Real World Example!
>
> In 2017 an extreme rainfall event caused a 27-fold increase in phosphorus loading in Conestogo Lake, Ontario, facilitating a premature blue-green algae bloom in spring (Larsen et al., 2020).

Climate Resilience and Adaptation

Shoreland naturalization offers an opportunity for shoreland property owners to strengthen their resilience to extreme weather events which grow in intensity and regularity due to climate change. Scientists concur that the most important and effective ways to improve climate-resilience for shorelands are nature-based solutions (Seddon et al., 2020). This includes the planting and maintenance of vegetated shoreland buffers.

According to a 2022 report:

"Living or vegetated shorelines (sometimes called nature-based shorelines) have many advantages from an adaptation standpoint. [Shoreline] vegetation can reduce wave energy, [...] erosion, and flood hazards that may increase as a result of climate change while providing co-benefits such as runoff filtration, aesthetic value, and habitat value for species that may be vulnerable to climate pressures" (Schmitt et al., 2022, p.22).

Quick Science!

I) Increased average temperatures in Canada due to climate change will result in shorter (or limited) ice cover periods for Canada's freshwaters. Earlier ice melt and higher temperatures will allow for earlier algae blooms and potentially longer periods of blue-green algae growth (Sharma et al., 2019).

II) Globally, the surface temperature of lakes which freeze over in winter are estimated to increase by 0.72°C per decade, leading to significantly shorter periods of ice cover (O'Reilly et al., 2015).

III) Riparian zones will be essential areas of refugia and habitat for aquatic wildlife since they have "higher water content than surrounding upland areas [and] absorb heat and buffer organisms from extreme temperatures." (Seavy et al., 2009, p. 332).

IV) Riparian vegetation helps maintain balanced temperatures in many streams and small riverine systems. According to a 2017 study conducted by Casey Justice and others from the Columbia River Inter-Tribal Fish Commission: "restoration of riparian vegetation and channel width could offset [the impacts of climate change], reducing peak summer water temperatures by about 3.5°C in the Upper Grande Ronde and 1.8 °C in Catherine Creek", protecting important cold-water fish species (p. 212).

While the impacts of climate change on freshwater ecosystems are difficult to generalize, most freshwater systems will experience negative impacts through rising water temperatures (Larsen et al., 2020; Woolway et al., 2022), increased flooding (Eyquem, 2021), and shifts in wildlife assemblages (Harrison et al., 2018; Tickner et al., 2020).

Natural shorelands that include native vegetation and associated organic structures (e.g., coir or natural logs, stones, and debris) are quickly gaining recognition as ecologically and economically sound solutions to the negative impacts of climate change (Shea et al., 2021). Living and natural shorelines enhance climate-resilience:

1. Through carbon sequestration via the planting of native vegetation (Davis et al., 2015).
2. Through suppression of erosion and the stabilization of shorelines (Mitchell & Hirschi, 2012). A higher incidence of severe flooding events will increase the likelihood of shoreline erosion over time, necessitating more effective means of shoreline stabilization.
3. Through the provision of wildlife habitat not provided through hard-engineering (Seavy et al., 2009). When kept natural and well-vegetated, shoreland zones, most notably the riparian zone, host miniature climates that are resilient to humidity and heat due to their higher water contents, making them ideal areas of refuge for birds, amphibians, and reptiles.

From the Scientists:

"Riparian ecosystems are naturally resilient, provide linear habitat connectivity, link aquatic and terrestrial ecosystems, and create thermal refugia for wildlife: all characteristics that can contribute to ecological adaptation to climate change" (Seavy et al., 2009, p. 330).

"Functional riparian systems have tremendous potential to reduce the adverse effects of climate change by enhancing ecosystem resilience. To benefit from this capacity, we urgently need riparian restoration and the science that guides it" (Seavy et al., 2009, p. 335).

VII. Conclusion

Whether by protecting water quality, mitigating erosion, providing habitat, or increasing resilience to climate change, vegetated shoreland buffers provide critical ecosystem services for freshwater communities across Canada. Each time native vegetation is removed from the shore of a lake, river, or stream, the quality and enjoyment of the environment is diminished.

Through education and engagement with freshwater stakeholders (property owners, lake associations, etc.), local decision makers must balance social, economic, and environmental needs. Fortunately, the maintenance or restoration of natural shorelands do not impact recreational enjoyment and property rights. As discussed in this document, any buffer is better than no buffer at all. With careful and informed land use management, even a modest vegetated shoreland buffer can achieve significant increases in water quality and provide habitat for native species.

There is a wealth of peer-reviewed literature on the biological needs of healthy freshwater ecosystems, as well as the impacts of human development on these systems. Through such a vast amount of information, there is clear consensus on a single fact: shorelands that, to the fullest extent, mimic nature provide the greatest benefits to freshwater environments and their inhabitants. As time passes, this consensus grows stronger. It is up to decision makers and landowners to use this information to protect vegetated shoreland buffers and the Ribbon of Life.

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