The Massachusetts Buffer Manual

Using Vegetated Buffers to Protect our Lakes and Rivers

Prepared by
the Berkshire Regional Planning Commission

For
The Massachusetts Department of Environmental Protection

2003

About The Massachusetts Buffer Manual

In 2001 the Berkshire Regional Planning Commission was awarded a Nonpoint Source Pollution grant to conduct a demonstration and outreach project. The goal of this project was to promote the benefits of vegetated buffers. The three main objectives to achieve this goal were to 1) create a buffer guidance document, 2) plant five buffer demonstration sites and 3) talk about vegetated buffers to the public. This document, three of the buffers seen in Chapter 2 and several presentations made to lake groups and conservation commissioners are direct outcomes of this project. Russ Cohen of the Riverways Program was our partner and co-presenter for three of our "on the road" presentations. Many thanks, Russ.

Acknowledgements

To our Partners:

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To our Team:

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- Russ Cohen, Mass. Riverways Program
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Introduction

Massachusetts waterbodies are some of our greatest natural assets. They provide us with swimming, fishing, boating and relaxing. Most everyone dreams of living along the water. But as we live out our dreams and develop our shorelines, we threaten the health of the waterbodies that we have chosen to live on. Our traditional development practices removing natural vegetation, creating impervious surfaces and designing stormdrain systems have made it easy for stormwater runoff to carry pollution into our water bodies. It has also destroyed wildlife habitat, displacing animals that were once plentiful.

The Term "Water Body"

The intent of this manual is to help all waterfront property owners understand the benefits of maintaining or restoring vegetated buffers along our shorelines. This includes land along rivers, streams, lakes and ponds. For simplicity, we will use the generic term "water body" to refer to these four resources. Although this manual is written with freshwater resources in mind, the concepts discussed are also applicable to salt water resources.

Traditional development practices removed shoreline vegetation and displaced wildlife, as in this lakefront property.
Source: BRPC archive, 2002.

The new trends in landscaping are now creating a new, more natural look for waterfront properties. Recognizing that traditional development patterns have negatively affected the health of our waterbodies, landscape professionals are maintaining shoreline vegetation on newly developed lots. They are also adding a new mix of vegetation and color to old lots to create a fresh look. In both cases, these new trends help to protect water quality, provide wildlife a refuge and ultimately maintain or increase property values.

The main body of this manual is intended to help you look at your waterfront property in a new way. First we will explain what a vegetated buffer is and how it benefits the health of your water body. Next we will examine a few examples of buffers at work. Then we will offer creative new ways to help you landscape your shoreline without losing your yard, your view or your access to the water. An extensive list of native plants, which also includes the conditions (soil type, sunlight level, etc.) under which each plant will grow the best, is included in Appendix B.

Appendix A of this manual describes in more detail how pollution enters our water bodies and how vegetated buffers function to intercept that pollution. It also describes how important buffers are to wildlife. We hope it helps you understand your property and its direct connection to the water.

Chapter 1

What is a Vegetated Buffer and How Does it Work?

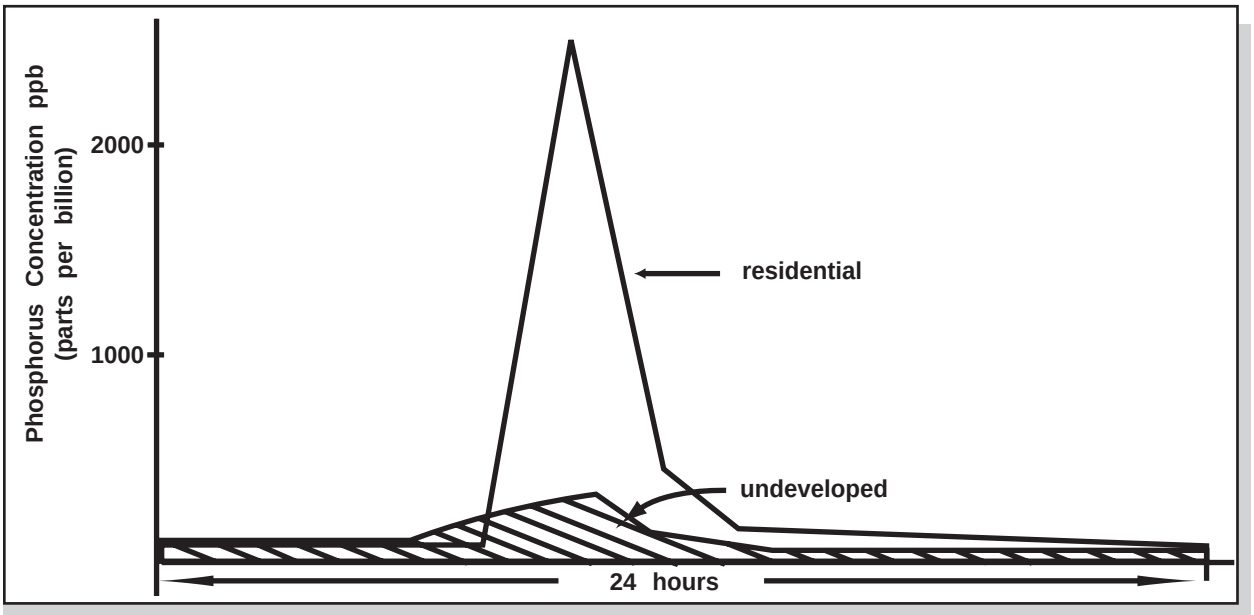
What Is a Vegetated Buffer and How Does It Work?

Simply put, a vegetated buffer is a protective area between a waterbody and human activity, such as development or agriculture. They are "living filters," because they capture many of the pollutants that travel through them. Buffers filter out sediment and debris from surface runoff. Plant root systems and chemical and biological activity in the soil can capture and transform nutrients and other pollutants and transform them into less harmful forms.

New polluting substances follow residential and commercial development. These pollutants include sediment, sand, salt, oil, gas, antifreeze, and other pollutants from the roads and driveways; pesticides and fertilizers from home gardens and lawns; and trash, pet droppings and other debris left by homeowners and visitors. Subsurface and groundwater flow can carry effluent from improperly functioning septic systems; it can also carry soluble nutrients from over-fertilized lawns and gardens.

Phosphorus, a pollutant of particular concern in freshwater, is one of those pollutants that follow residential development. One study in Maine found that even careful development of woodland into two-acre house lots caused a 2- to 10-fold increase in phosphorus concentrations in stormwater runoff (YCSWCD).

Phosphorus Concentration in Stormwater Runoff



This chart compares stormwater runoff from a residential development and runoff from adjacent forest for one storm. The residential development contained seven times as much phosphorus! Chart by Jeff Dennis, Maine Department of Environmental Protection.
Source: YCSWCD.

Buffers Capture Pollution

The mechanisms by which vegetated buffers capture pollution are a combination of physical, biological and chemical processes. The overriding reason that these processes are allowed to work is because vegetated buffers disperse and slow down the flow of surface waters, trap sediment, extend retention times and increase the rate of infiltration. Buffers can:

- Impede velocity: The stems of plants and leaf litter within the buffer physically slow the pace of surface runoff. The slower the movement of water, the less power it has to erode soil and carry sediment.
- Filter pollutants: As the velocity of runoff is slowed, the debris and sediment that is traveling in runoff gets filtered out. It is estimated that 80-90% of phosphorus reaches our freshwaters adhered to sediment, and buffers can capture the vast majority of that sediment.
- Extend retention times: The longer that runoff is in contact with the soil, the more time plants and soil microorganisms have to absorb and transform pollution into less harmful forms.
  - Plant root systems and chemical and biological activity in the soil can capture and transform nutrients and other pollutants into less harmful forms. Trees and shrubs have deep and extensive root systems, allowing them to take in nutrients, such as soluble phosphorus, from subsurface water.
  - Water is cooled to a more natural temperature as it percolates through the soil and makes it way to the receiving waterbody.

The root mass of one typical hardwood is extensive, enabling it to take in nutrients over a vast subsurface area. When multiplied by dozens of other trees and a host of shrubs and herbaceous vegetation, a forested buffer is effective at capturing subsurface nutrients
Source: Welsch, 1991.

Buffers Provide Wildlife Habitat

Our shoreline areas support the greatest diversity of wildlife in New England, as they are a transition zone where the terrestrial and aquatic worlds meet. As waterfront property owners, we are the first line of defense in protecting our shorelines and waterbodies. What we do on our property directly affects the lake or stream we live on, and thus we are caretakers not only of our own yard, but of the lake or stream itself.

- Habitat: Shorelines are transition zones for both terrestrial and aquatic wildlife. It is especially important to have shoreline vegetation for rare species and for those species that need both aquatic and terrestrial habitat to complete their life cycles (turtles, many amphibians, many birds).
- Travel corridors: Wildlife needs travel corridors to move freely from one habitat to another.
- Food source: Buffers provide aquatic ecosystems with the basic organic matter that drives their food webs.
- Cool water temperatures: Vegetation along the shoreline shades and cools the water. In general, cooler water is better able to hold life-giving oxygen. Also, temperature spikes are detrimental to the health and reproductive rates of aquatic creatures.

Red spotted eft
Source: BRPC archive, 2003

Painted turtle
Source: MN DNR, 2002

Many reptile and amphibian species require both water and land to complete their life cycles. Turtles spend much of their lives in water, but need land as a place to lay their eggs. Many salamander and frog species spend most of their lives on land, but need water to lay their eggs.

Home Owner Benefits

Vegetated buffers provide landowners with several additional benefits.

- Flood control: Buffers absorb and help break the force of high velocity floodwaters that overflow their banks. The higher the velocity of the flow, the higher the ability to cause property damage.
- Erosion control: Roots hold bank soil together while trunks and stems protect banks by absorbing the erosive energy of waves, ice and boat wakes. This is especially important on properties located on recreational lakes or rivers where motorized traffic is heavy.
- Privacy: A buffer with a healthy mix of trees provides privacy.
- Property value: Properties with mature trees are valued at up to 20% more on the real estate market (Fitzpatrick, 2002).
- Comfort: Deciduous trees provide shade in the summer and allow solar rays through bare branches in the winter.
- Seasonal delights: Ferns provide fiddleheads in the spring, and fruit-bearing shrubs provide berries for people and wildlife.
- Wildlife attraction: Wildflowers and flowering shrubs provide rich color and fragrances to a landscape, which in turn attracts hummingbirds and butterflies. See the plant list in Appendix B for more specific information.

Goose Barrier

Source: MN DNR, 2002

Last (and often not least), vegetated buffers are goose barriers and will deter Canada geese from coming up onto your lawn to feed, rest and defecate. Geese like to have a wide, unobstructed view and they need to have close and easy access to the water to escape predators, such as coyotes or Fido. This is especially important when they have goslings that cannot yet fly. Although succulent green grasses (such as residential lawns) are a favorite food, geese will not travel through tall grasses or dense vegetation to get to them, because of the barrier created by that vegetation.

Canada geese are creatures of habit, and will often return to the water body at which they were born, to mate and raise goslings. When geese are provided with easy and abundant food, their chance of successfully raising large broods is greatest. Several generations of geese returning and raising young can cause them to become overpopulated. This situation can be detrimental to the flock, to water quality and to recreational values. The simplest way to avoid this situation is to bar them from your lawn and other grassy areas.

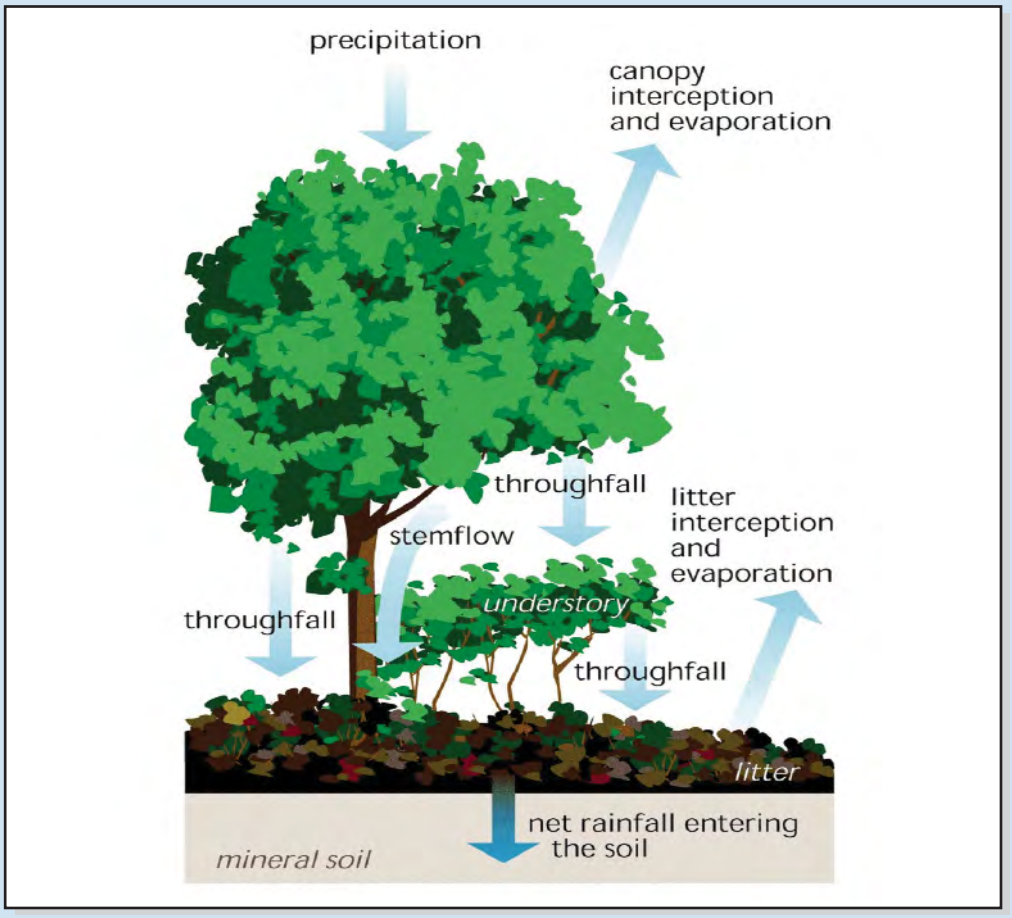
This introduction is a summary of the benefits that vegetated buffers can provide to homeowners, wildlife and water quality. A more detailed explanation of each of these benefits, can be found in Appendix A.

1-4 What are buffers?

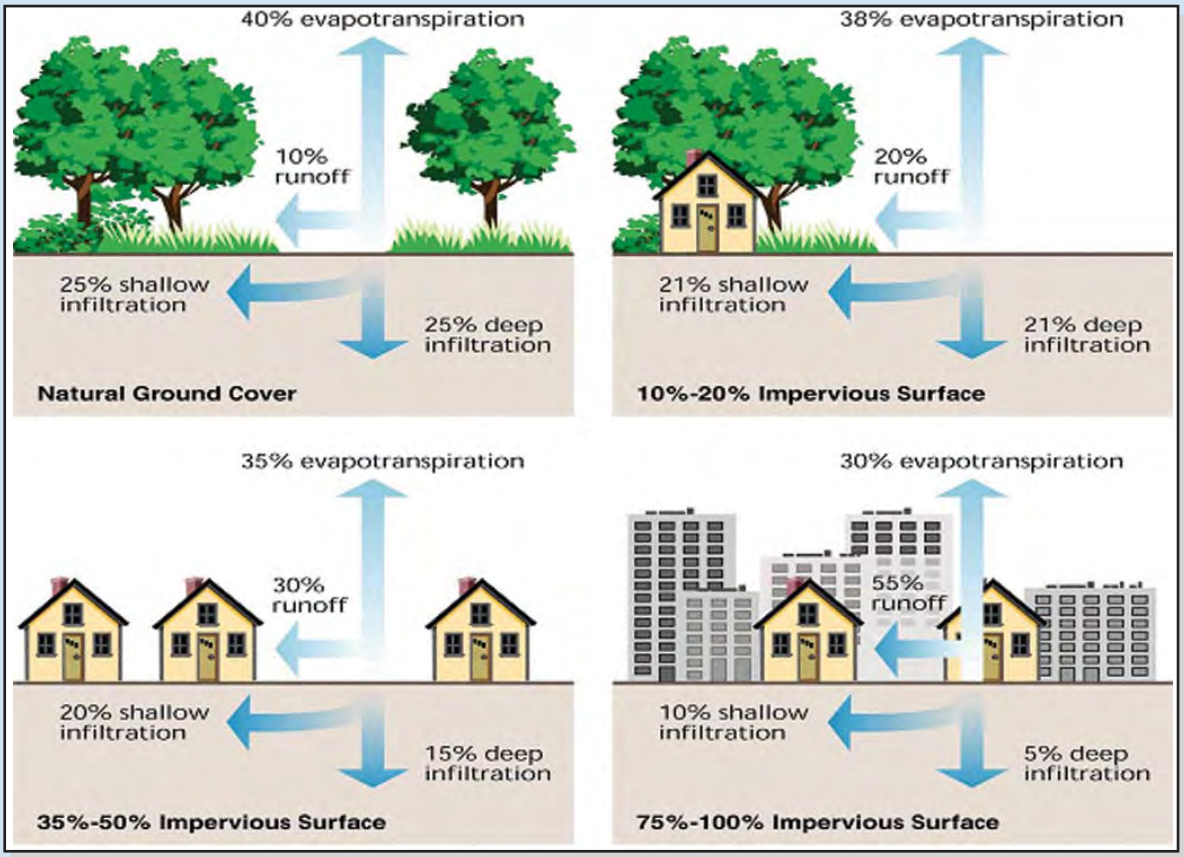
How Development Alters Stormwater Runoff and Affects Water Quality

Stormwater runoff is the single largest contributor to water quality degradation in the state of Massachusetts. The pollutants carried by runoff that cause the most concern in lakes and streams are sediment, nutrients, and pathogens, all three of which can be largely captured in vegetated buffers.

When rain falls to the ground in a rural or forested area, as much as 50% of it slowly percolates into or infiltrates the soil, while another 40% may reenter the atmosphere as evaporation or transpiration. This is because the tree canopy intercepts falling rain, allowing some to return to the atmosphere and allowing some to gently fall to the ground. The woody debris and leaf litter accumulated on the forest floor act like a rough sponge, slowing down, filtering and absorbing most of the limited runoff that accumulates. This gives vegetation, soil and microorganisms time to absorb and filter most pollutants out of the runoff before it gets to the water body.



Vegetation disperses rainfall, allowing it to settle more gently and erode less.
Source: FISRWG, 1998.



Relationship between impervious surface and stormwater runoff. In short, the greater the runoff, the greater its capacity to carry pollution.
Source: FISRWG, 1998.

In contrast, development disturbs the soil and creates impervious surfaces such as building rooftops, roads, and parking areas. These hard surfaces replace the tree canopy and spongy forest floor. In residential areas, the infiltration rate may be reduced to 35%, while stormwater runoff may be increased to 50%. Stormwater runs off impervious surfaces at an accelerated rate, collecting trash, debris, sediment, bacteria, petrochemicals, and other substances as it moves. The particles that are collected scour the ground and create soil erosion. As a result, an increased amount of runoff from developed areas delivers an increased amount of pollution to the nearest water body. This situation becomes even more acute as the shorelines of water bodies become developed and the runoff is quickly and directly delivered into the water without the chance for infiltration.

Shoreline vegetation provides that last chance to capture pollutants traveling in stormwater. Forested areas can capture, absorb and store 15 times more rainfall than grass or turf (Palone & Todd, 1998).

1-6 What are buffers?

Chapter 2

Buffer Examples

Buffer Examples

Vegetated buffers come in all shapes and sizes. In this chapter we will look at five buffers from around Massachusetts. Some of the local buffers were planted with the support of a U.S. Environmental Protection Agency Nonpoint Source Pollution Program grant, awarded and administered by the Massachusetts Department of Environmental Protection (DEP). The focus of this grant program is to mitigate the impacts of pollution by designing and installing mechanisms to capture it. Our mechanism was the planting of vegetated buffers along a small residential property (example 2), at a parking lot expansion project (example 4) and along a public recreational trail (example 5). All three of these examples were designed by landscape architects who donated their time to the various projects.

We will also look at a shorline buffer from Minnesota. This demonstration site was overseen by the Department of Natural Resources. Minnesota, the land of 10,000 lakes, has taken a leading role in studying the effects of development on water quality and has recently banned the use of phosphorus fertilizers in certain parts of the state (visit Chapter 3 for more information).

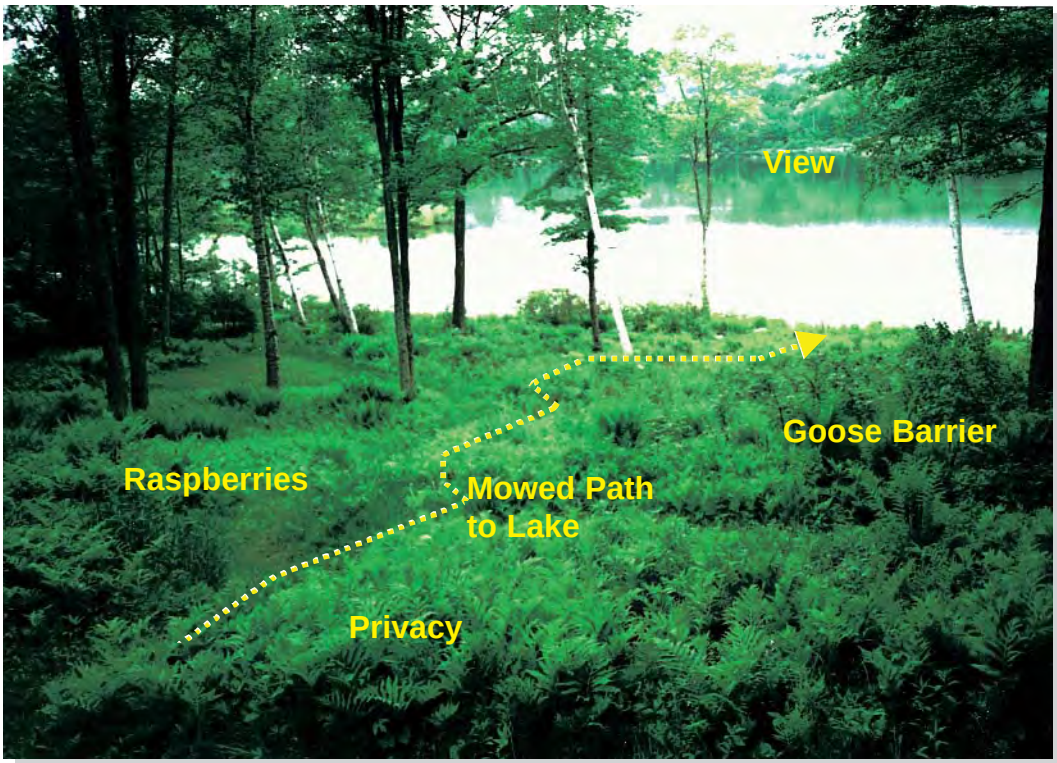
In all the examples shown here, native plants were used exclusively. A native species can be found to meet most landscape desires. Native flowers such as blue flag iris, cardinal flower and great blue lobelia are as brilliant and showy as non-natives. Shrubs such as native azaleas, mountain laurel and sweet pepperbush display colorful flowers, while blueberry bushes provide fruit to humans and wildlife.

1. Residential Waterfront

Specifics of the Site

Our first property is located on a recreational pond. The pond is relatively small and shallow, so even slight pollution concentrations have the potential to alter water quality significantly. The yard provides wildlife with a variety of habitats.

The owners have cultivated a lush mixture of trees, shrubs and ferns along the shoreline. A small mowed lawn for lounging, relaxing and holding family events has been maintained around the house. The open lawn around the house and the canopied buffer along the shore provide a pleasant mix of sun and shade in the summer.



View of the pond from the house
Source: BRPC Archive, 2001

View of the house from the pond
Source: BRPC Archive, 2001

Priorities of the Landowner

- Maintain privacy. The property is partially screened by mature trees and tall ground vegetation.
- Maintain view of the pond. This is accomplished by selectively pruning branches of the trees and restricting the height of herbaceous undergrowth. Unwanted shrubs or saplings are weed-whacked once every one or two years. Note that in pruning for a view, all the lower branches have been removed, diminishing the value of the area for birds and small mammals that need the lower branches for refuge from predators.
- Maintain easy access to the water. This is accomplished by mowing a path through the under-growth which connects the lawn to the water. Note that the path is winding. A straight pathway can become a channel for stormwater, while a winding path slows the flow of water, allowing for more infiltration.

Buffer Design

The owner of the property pruned lower tree limbs to create a view of the prond. The vegetated understory is allowed to grow naturally.

Other Applications for This Design

The abundance of ferns gives this landscape a lush appearance. In general, ferns do better under a canopy that provides shade and help to keep the soil moist. So creating or maintaining tree shade is important. To attain a denser mix of vegetation along the shore, you can simply stop mowing there and see what sprouts. You can help the transition to a more natural setting by planting a few shrubs within the zone to add variety and depth. As stated earlier, you should keep a sharp eye out for invasive species, which might find your "no mow zone" a fine place to colonize.

2. Residential Waterfront

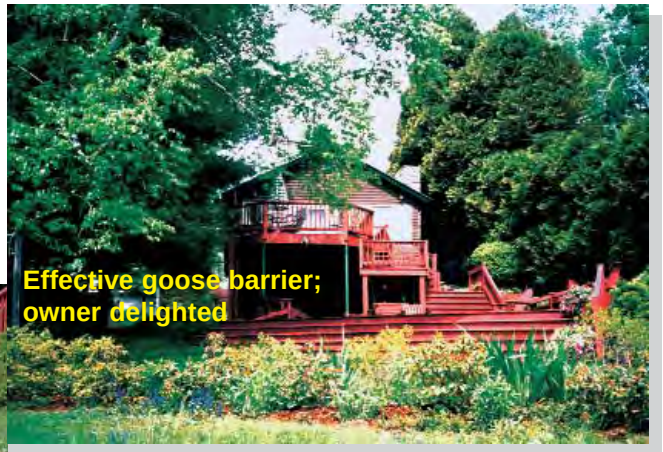
Specifics of the Site

The property is one of many in this neighborhood of one-acre-or-less lots. The house is in line with its neighbors and is set back approximately 30 feet from the water. The house faces the east, so it receives direct morning sun and is shaded in the afternoon. The soil is gravelly, having been altered during development. Ideally the buffer would be planted right along the shoreline, but this shore is being undermined by wave action. Water is washing in between the rocks, washing away soil and leaving large air pockets in the soil. Stabilization of the shoreline is the next improvement project.

Priorities of the Landowner

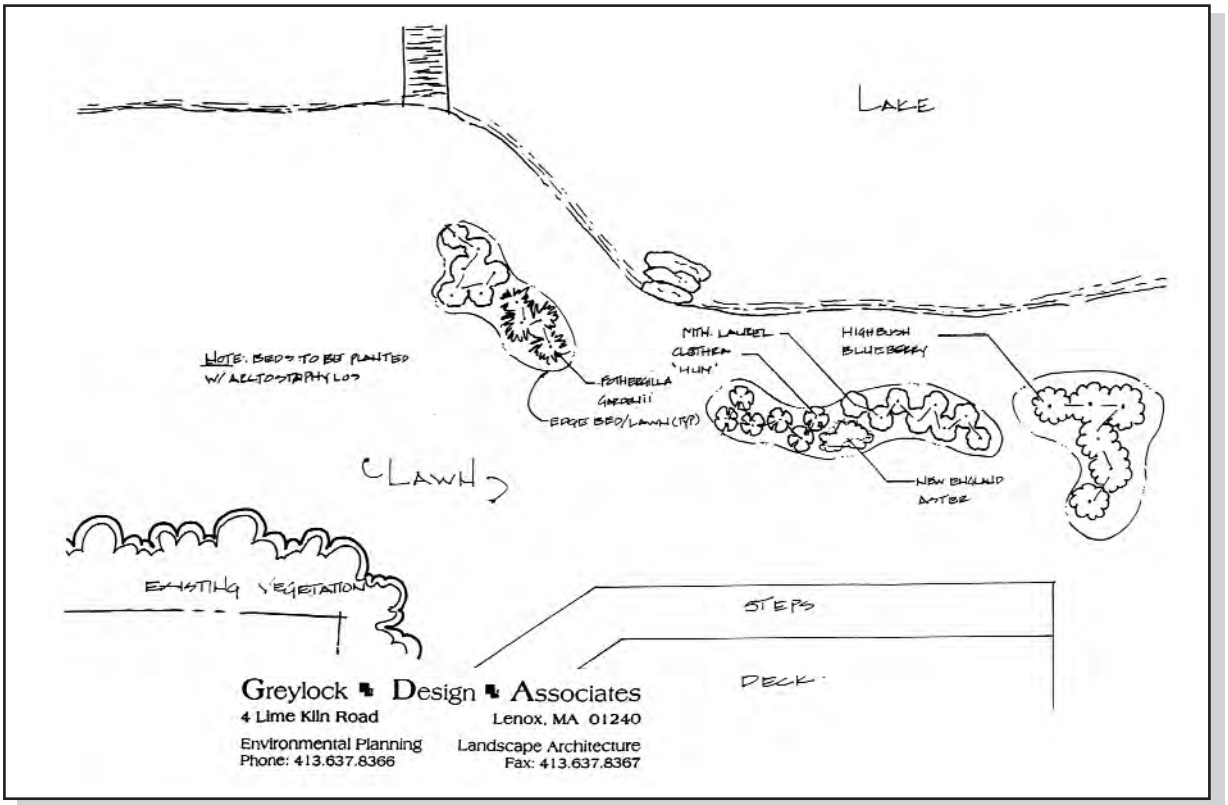
- Maintain aesthetics. As the waterfront yard is a relatively small area, the buffer would be a very prominent landscape feature on the property. The owner prefers a diversity of shrubs that provide color throughout the seasons.
- Maintain an unobstructed view of the lake.
- Deter geese - from the lawn in particular and the waterfront area in general. Increasing numbers of geese are invading the lawn, making it unpleasant and possibly unhealthy for grandchildren to play and swim in the area.
- Feature low-maintenance plants.
- Maintain approximately 20 feet of lawn between the house and the buffer for family events.

A small buffer on a small lot. This buffer is approximately 60 feet long and 6-8 feet wide. The buffer has stopped Canada geese from visiting the lawn - much to the owner's delight! ▶
Source: BRPC archive, 2002.



◀ *This buffer provides year-round color: Spring welcomes green foliage and an array of pink flowers; summer is predominantly green, with dashes of purple from the irises, asters and blueberries; autumn color is predominantly yellow.*
Source: BRPC archive, 2002.

Buffer Design



Source: Greylock Design Assoc., 2002

Robert Akroyd of Greylock Design Associates of Lenox designed the buffer according to the needs of the landowner. He chose to plant the buffer with a mix of shrubs, perennial wildflowers and ground cover. Shrubbery allows a continual view of the lake, and the plants provide an array of color throughout the year. In addition to the plants shown on the planting plan, bearberry, an evergreen ground cover, was planted between the shrubs and several blue flag were planted facing the house. The iris temporarily fill in open spaces between young shrubs.

Due to proximity to the water's edge, fertilizers were not used to boost plant growth. Compost was added during planting to improve the soil's texture and moisture-holding capacity. The nutrients within the compost are released slowly, giving plants a chance to absorb them.

Other Applications for This Design:

Small house lots are the perfect place for landscaped buffers of this sort. The fruit and flowers of the buffer attract birds and butterflies, the foliage provides shade and refuge for small animals, and the shrubs add depth and complexity to the root system. Small sections of buffers can also be planted in public recreation areas to filter runoff and capture subsurface pollutants.

3. Residential Waterfront

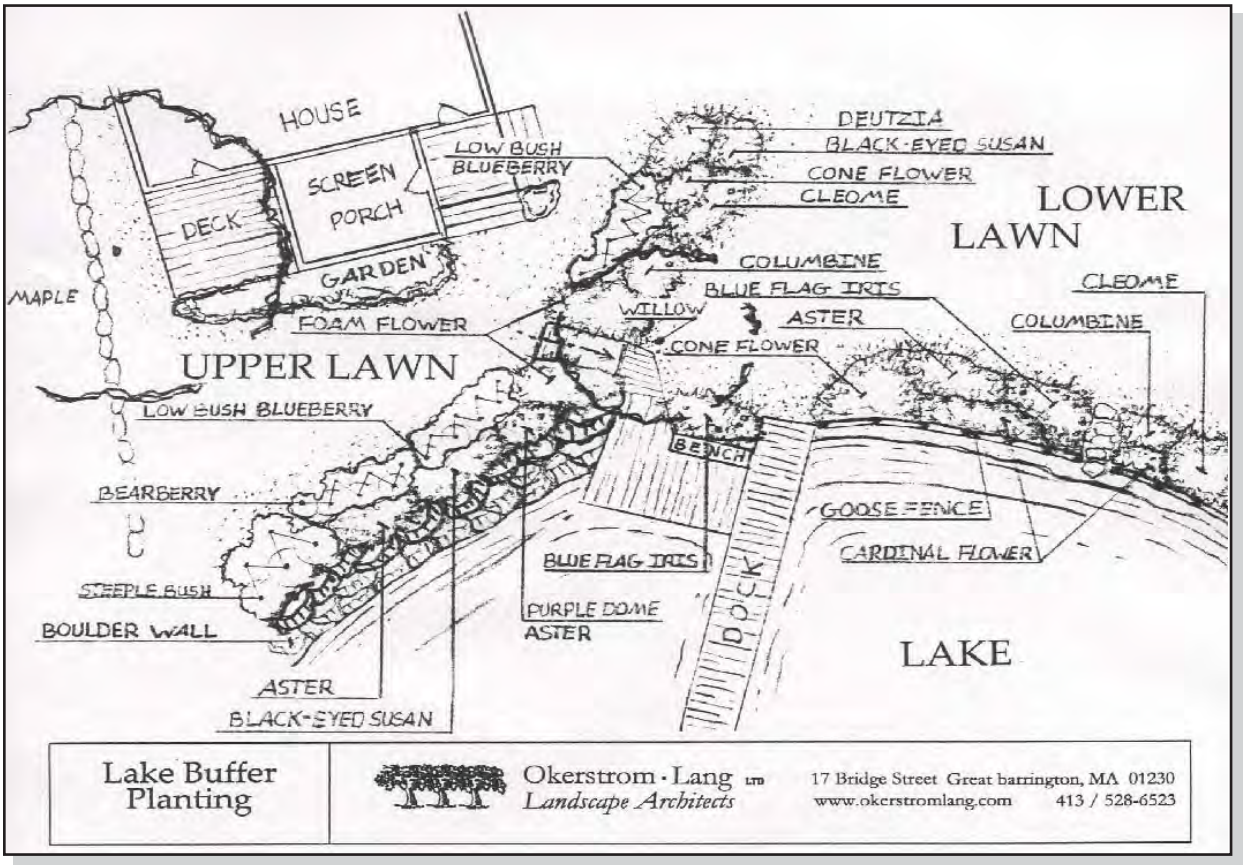
Specifics of the Site

This property is one of many large-lot properties along a recreational pond. The house is set back on a hill overlooking the water. The house faces west and receives full sun all day. A large lawn is located to the south where the owners have access to the dock and water. The wave action from motorboats on the lake undermines the shoreline soils.

Priorities of the Landowner

- Maintain direct access to the water for swimming and canoeing.
- Maintain views of the water.
- Provide color throughout the growing season.
- Feature low-maintenance plants.
- Maintain lawn for family gatherings.
- Deter geese from entering the property. Every year the numbers of geese on the property are increasing. The geese can be offensive and make using the lawn and swimming in the water undesirable.

Buffer Design



Source: Okerstrom Lang, Ltd., 2003

2-6 Buffer examples

Okerstrom Lang, Landscape Architects of Great Barrington, designed the buffer to meet the needs of property owners. The designers chose low growing, native perennials along the shoreline that would provide a variety of color. Since it will be several years before the buffer completely fills in, a small picket fence with a gate was installed to deter the geese. The gate allows access to the water for swimming and canoeing, and the six-inch clearing below the fence allows small animals, such as turtles and amphibians, to crawl beneath it.

Gardens were also planted on top of an existing stone wall and on the other side of the stairs leading down to the dock. This created a separation of space with an upper lawn and a lower lawn. The plants were chosen to be low growing so that a clear view of the water will be maintained. This buffer is a mixture of low-growing shrubs (low-bush blueberry), ground cover (bearberry) and native perennial wildflowers. The owners are considering allowing the lower lawn to grow into a field, where they would maintain a mowed path to the pond. This will provide cover for nesting turtles, birds and other wildlife.

◀ *View of the pond from the house. Source: Okerstrom Lang, Ltd., 2003.*

View of the house from the pond. Source: Okerstrom Lang, Ltd., 2003. ▶

Other Applications for This Design

Large expansive lawns are a thing of the past. This design illustrates how large open areas can be broken up into smaller segments and revegetated in new ways. Revegetating shoreline areas are most important. Allowing overly large lawns to revert to field or a more natural mix of field, shrubs and trees will restore habitat that was once lost to the bulldozer.

4. Wetland Garden at The Berkshire Botanical Garden

Specifics of the Site

The Berkshire Botanical Garden (BBG) is a nonprofit arboretum, with a need to expand its parking lot. Pretreatment of stormwater runoff was required prior to its discharge into the local storm drain system. Planting a buffer to mitigate runoff was the first option, but topography and the layout of the property precluded this option. Instead, it was decided that a wetland garden, planted with a mix of wetland and upland plants, would be created in a prominent location on the grounds to serve both as a functioning pretreatment structure and as an educational tool about nonpoint pollution. The garden, which can be visited at the BBG, is located at the intersection of Routes 102 and 183 in Stockbridge.

Priorities of the Landowner

- Capture sediment from the parking lot and capture nutrients in stormwater runoff.
- Capture at least 80% of total suspended solids, as required by the Massachusetts Stormwater Management Policy, before discharging runoff into the storm drain system.

Construction of a retention basin, which is being converted into a wetland garden. It captures sediment and other pollutants.
Source: BRPC archive, 2001.

Buffer Design

Okerstrom-Lang Ltd., a landscape architecture firm in Great Barrington, designed the wetland garden basin in coordination with BBG horiculturist Dorthe Hviid. The garden is located behind the Visitor Center and is very visible from the main road, so it had to be designed to be attractive as well as functional. Turf lawn was dug out, and the hollow of the basin was bermed to contain exceptional flows. The garden is approximately 20 feet by 20 feet. Plants selected for around the berm are a mix of upland shrubs and ground cover. Plants selected for the inside of the garden are a mix of wetland shrubs and herbaceous plants.

Most storm drain systems discharge untreated runoff directly into the nearest water body in older lakeside neighborhoods. Detention basins can be retrofitted into existing stormdrain systems to capture pollutants.
Source: BRPC archive, 2002.

Other Applications for This Design:

The wetland garden is a modified detention basin. These basins trap sediment and filter pollution. They can work in conjunction with the planting of buffers to treat polluted runoff in older lakeside developments. Stormwater runoff was typically collected in storm drain systems and discharged into the lake untreated. Chances are, the same old system is still in place, with polluted runoff being discharged directly into the lake. While buffers can filter runoff from shorelines, detention basins can be installed at the end of the storm drain system to treat road runoff.

5. Recreational Trail Improvement

Specifics of the Site

Recreational trails along water bodies can be a source of pollution if they are not properly designed or if they are allowed to erode. The Great Barrington Housatonic RiverWalk is a pedestrian greenway. The project is an effort to reclaim the beauty of a "working river" abused by years of industrial waste and neglect. The denuded riverbank has been revegetated, and the trail has been designed to protect water quality by minimizing erosion and capturing and filtering stormwater runoff.

Priorities of the Landowner

- Revegetate the bank with fast-growing plants to stabilize the bank, minimize soil erosion and give a native plant community a chance to establish.
- Create an attractive buffer along the edge of the parking lot, to filter and cool parking lot runoff.

The Riverwalk trail, looking north. The river is below to our right and the parking lot is to our left.
Source: BRPC archive, 2002.

Buffer Design

Openspace Management of Great Barrington provided the landscape design for the buffer and trail system, and Marconica, Inc., along with a corps of volunteers, planted the vegetation on the riverbank and along the parking lot buffer.

The Housatonic River lies immediately east of the trail. The slopes of the riverbank are very steep, so it was important to maintain infiltration of stormwater and keep trail runoff from creating erosive channels. To accomplish this the trail was constructed with "porous" pavement that allows water to percolate through. Grasses were planted along the edge of the trail, to filter sediment and help to evenly spread runoff flow, thereby minimizing channel creation. To further filter runoff and stabilize the bank, a mix of tree saplings, shrubs and herbaceous vegetation was planted between the trail and the river. The split-rail fence is not only a safety feature, it keeps people from going down the embankment and trampling the much-needed vegetation.

A commercial parking lot lies immediately west of the trail. A 6-foot wide buffer consisting of grass, young trees and native perennial wildflowers was planted between the parking lot and the trail. The grass will filter sediment and allow infiltration of runoff. Parking lot stormwater will be returned to the river through subsurface flow, and will be in a cleaner and cooler condition. Once again, a fence will help keep people off the buffer and prevent trampling of vegetation.

Standing along the water's edge you can see the steep slope of the riverbank. It is why minimizing runoff is so important. A combination of herbaceous cover, shrubs and trees is the best mixture for long-term bank stabilization. ▶
Source: BRPC archive, 2002.

◀ *Note the increase in vertical layering of vegetation with perennial wildflowers and young trees. Once established, the vegetation will provide valuable shading to cool stormwater.*
Source: BRPC archive, 2002.

Other Applications for This Design

Plant buffers between water bodies and parking lots, eroded trails and bare-ground sections of public recreation areas. Fences and dense shrubs can be strategically placed to keep people out of sensitive environments.

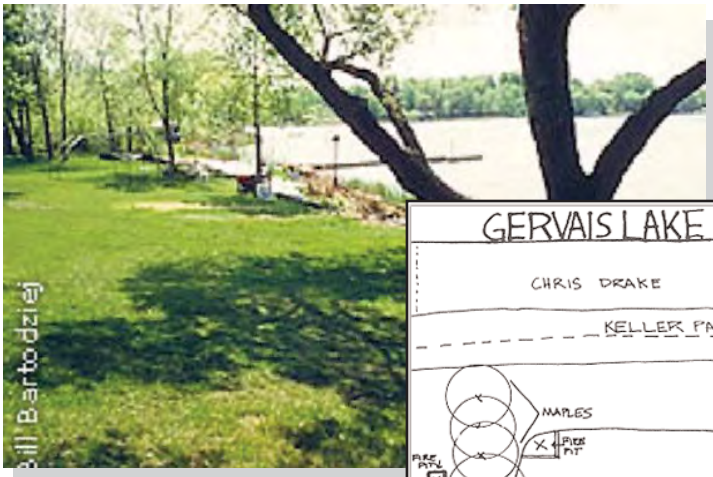
6. Restoring the Lakefront in Minnesota

Specifics of the Site

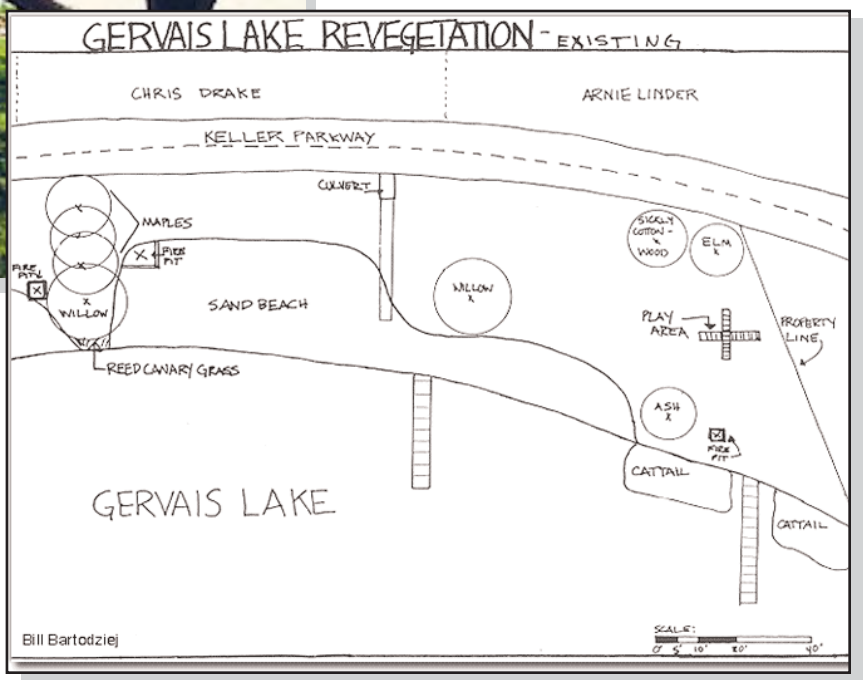
Most of the native vegetation along a portion of the shoreline along Lake Gervais had long been removed and replaced with grass. The site, used jointly by the two landowners for recreation and picnicking, looked "very nice and clean and neat." Their properties were bisected by a local road, with the houses located upland of the road. A sandy beach ran along the length of the property. The owners were becoming tired of the fertilize-it-and-mow-it routine, but were concerned that invasive species would colonize the site if they created a "no mow zone." Reed canary grass, an invasive species, was already present. So, they partnered with the local watershed district to create a Shoreline Restoration Demonstration project and return the site to a more lush and natural condition.

Priorities of the Landowners

- Create a more natural look and feel, one that will filter runoff from the road and from areas of activity.
- Maintain some grassy areas for personal use.
- Minimize erosion.
- Discourage invasive species colonization.



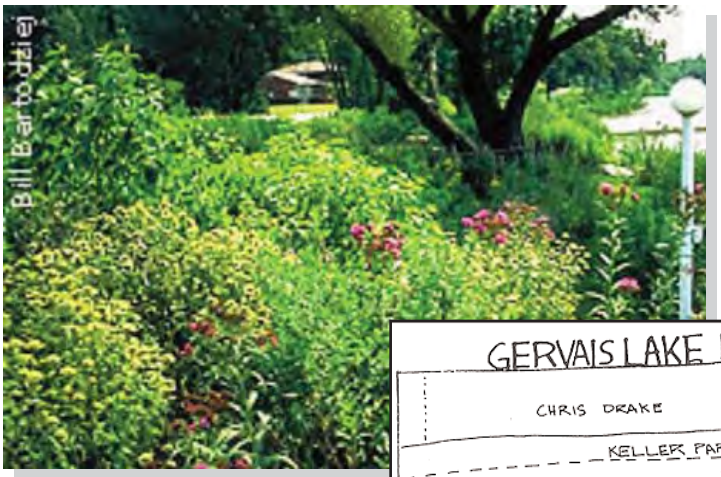
◀ *Pre-restoration condition. This willow tree was one of only a few trees left on the site. Grass was the dominant vegetation.*
Source: MN DNR, 2002.



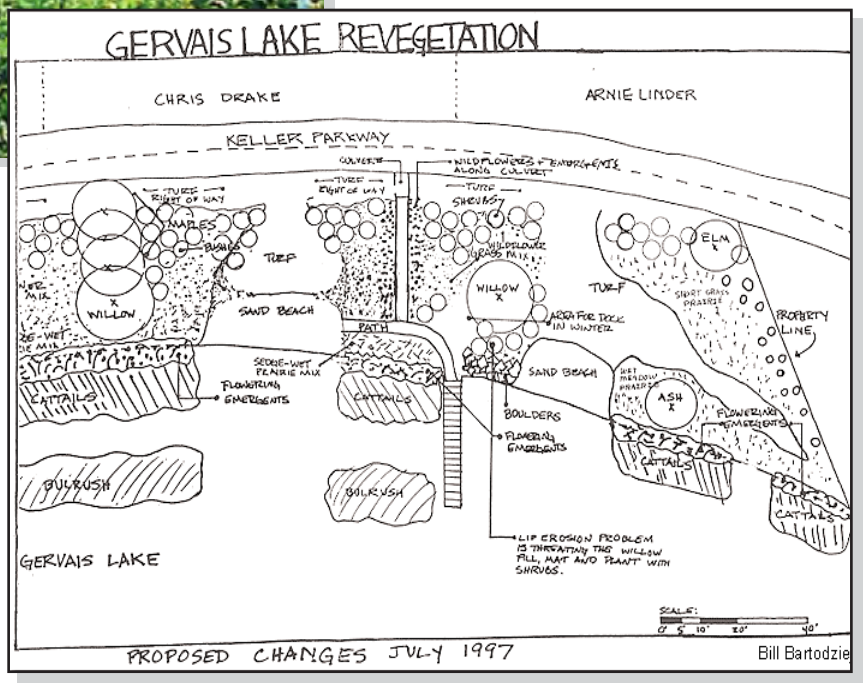
This is a map of Pre-restoration condition of the site.▶
Source: MN DNR, 2002.

Buffer Design

Bulrush and cattails were planted in the shallow water along eroded banks to absorb the force of waves and wakes. The beach and lawn areas were reduced and replaced with a mix of native grasses and shrubs. The wildflowers provided color and attracted scores of butterflies and hummingbirds. Although at first their neighbors were skeptical of the new landscape, it is now very well accepted. In fact, most of the questions the owners receive from visitors are related to how it can be replicated on their own properties. It has become a focal point of the neighborhood, where people come to walk and enjoy the flowers.



◀ *The shoreline is now lush with wildflowers that filter runoff and attract butterflies and other wildlife.*
Source: MN DNR, 2002.



The design for the new landscape. Note the reduction in turf and beach and the addition of shrubs, wildflowers. Note also additional plantings of cattails and bulrushes. ▶
Source: MN DNR, 2002.

Other Applications for this Design

Revegetating eroded recreational shoreline areas would be a perfect application for this design. Creating a walkway through the vegetation would give people an opportunity to saunter through and enjoy the flowers without "bushwhacking" into the buffer. This design would also be perfect for those who would like to increase their chances of viewing butterflies and birds.

Chapter 3

Designing and Planting Your Buffer

Designing and Planting Your Buffer

People live along the waterfront for a variety of reasons: a view of the water, access to outdoor recreation, privacy, or the soothing sounds of a babbling brook or waves lapping against the shore. Whatever the reason, a vegetated buffer can be designed to meet the needs of the landowners and improve the use and look of the property.

In general, a mix of mature trees, shrubs and low-growing plants (grasses, wildflowers, ferns or ground cover) is the best composition to protect water quality and provide wildlife habitat. Vertical layers of vegetation above the ground mean that a maze of roots exists below the ground. The more complex and deep the root systems, the greater their capacity to capture dissolved nutrients and other pollutants as they travel in subsurface flow. A more detailed discussion of how vegetated buffers capture and filter pollutants can be found in Appendix A.

Maintain a Lawn Area

You can still maintain the lawn around your house for picnicking, lounging and family events. Maintain grass height at a lush 2-3 inches; this will encourage a deeper and denser root growth and help the grass resist drought and weeds.

Maintain Your View

Low-growing vegetation such as shrubs, grasses, wildflowers, ferns and ground cover add root depth without adding height. A few trees can be situated to frame the view of the water from vantage points on the property. Careful pruning will maintain these views as the trees mature.

Maintain Your Lake Access

A mowed pathway through the buffer can provide access to the water. A pathway that is curved or meandering, especially on steep slopes, will help prevent the trail from becoming eroded and becoming direct channel for stormwater runoff.

Add Privacy

Pines and spruces provide year-round screens for privacy. Deciduous trees provide nice seasonal changes: leaves provide shade in the summer, foliage provides color in the autumn, and bare branches allow solar rays to light and warm the house in the winter. A dense thicket of shrubs, especially a prickly species like raspberry bushes, will discourage trespassers.

Provide Wildlife Habitat

A complex mix of vegetation, coupled with the nearby presence of water, attracts a greater number and diversity of wildlife. Vegetated buffers can help to reconnect isolated populations of wild creatures that we have separated by creating open, developed areas. Maintaining healthy wildlife populations and gene pools is becoming more of a challenge as we continue to pave over or fragment wild places. Buffers provide the cover wildlife needs to travel between the remaining wild areas.

To attract wildlife, resist that tendency to tidy up a natural buffer. Wildlife habitat is more than trees and shrubs; it is dead snags (perches for hawks and owls, cavities for nesting), downed

logs (hollows for cover and dens, cover for burrowing animals), brush (cover and food) and leaf litter. Cavities within standing snags provide nesting places for bird species such as wood ducks, mergansers, owls, woodpeckers, nuthatches, and bluebirds, as well as homes for many mammal species such as fishers, porcupines, raccoons, squirrels and bats. Logs provide den sites for foxes, bears and several other mammals. Raspberry bushes provide you and your wild friends with a summer treat.

Stabilize the Bank

A mix of trees and shrubs planted along the edge of the bank will best anchor soils. A plant list compiled by the Connecticut River Joint Commissions (Appendix B) provides an assortment of native trees and rates their ability to stabilize eroding banks. Willows, for example, are excellent for stabilizing shorelines, and they can grow from cuttings taken from nearby trees. Do not, however, plant them near septic systems or sewer lines; their roots seek out water and will invade these areas, clogging leach fields and strangling pipes. If conditions allow, plant wetland vegetation such as cattails and sedges in the shallows of the water; these plants will deflect and absorb the shock of flows and wakes before they hit the bank.

Deter Nuisance Geese and Deer

In some locations within Massachusetts, Canada geese and white-tailed deer are considered pests. Planting buffers along the shoreline helps to restore the landscape back to a more natural condition and will deter Canada geese from visiting your lawn. Geese love succulent green grass, but will not travel through tall grasses or dense vegetation to get to it. This is especially true when parents have goslings that cannot yet fly. Geese are most comfortable in open areas that provide unobstructed views around them and easy access to the water, which is their safe haven from predators. Planting a mix of shrubs and trees, or even allowing grasses and ferns to grow tall, will act as a barrier between the water and your lawn. Removing waterfront lawn means removing a ready source of food, which ultimately helps to maintain goose populations at more natural levels.

In some areas within the state, white-tailed deer have become accustomed to living alongside humans and have come to find that ornamental shrubs and trees can be quite delectable. If this is the case in your area, landscape the property and design the buffer to include native plants that deer find less appealing. A list of "deer-resistant" native plants can be found in Appendix D. If the deer are persistent, try spraying plants with deer repellant, which can be found at many nurseries and garden centers.

Maintain Cooler Water Temperatures

Streamside shade

Trees will help shade the stream channel and maintain lower water temperatures. At a minimum, trees planted on the south and west banks shade the water from the warmest rays of the sun. The height of the trees should be equal to or exceed the stream width to provide almost full shading. To quickly establish a forest buffer in an open area, plant fast-growing "pioneer species" such as

poplars and gray birch along the bank. Planting a shrub layer along with the trees will provide some additional shading and support a larger mix of wildlife. Pioneer species often do not have the thick foliage that produces the truly cool shading offered by slower-growing species such as maples, oaks, pines and spruce. Therefore, planting a mix of such trees among and behind the shoreline pioneer trees will provide denser shade in the long term.

Lakeside shade

Planting native trees along the shoreline of a lake will help to maintain cooler temperatures along the water's edge through shading. Shallow waters along the shoreline are easily heated by the summer sun. Because the shallow waters are the most productive for wildlife, it is important to maintain cooler temperatures here. For a more detailed discussion of water temperature and wildlife, visit Appendix A.

Infiltration

In addition to providing shade, vegetated buffers enable infiltration. Water is cooled as it comes in contact with and moves through the soil. Enabling infiltration is especially important for runoff originating from unnaturally warm areas, such as roads, parking lots, roofs and patios. Although not as warm as that from hard surfaces, runoff from open lawns is also unnaturally warm and should be allowed to flow through a shaded buffer before reaching the water body.

What Can I Do If My Yard Is Small?

The shorelines of many lakes and ponds are heavily developed; residential lot sizes are often less than one acre, and houses are often located less than 100 feet from the water. So the ideal buffer of 100 feet in width is out of the question in these cases. If your property fits into this category, you might think that you do not have enough room for a worthwhile buffer.

Think again. Even a small buffer is better than no buffer at all. Even returning a 20 to 30 foot-wide strip of shoreline to a more natural state can filter some pollutants and provide a travel corridor or habitat for wildlife. Maintaining a turf lawn around your house is acceptable because grass encourages stormwater to flow in a sheet, which then allows your buffer to work better. See Example 2 in Chapter 2 to view a small buffer on a small house lot.

Where a continuous buffer along the shore is not possible, consider planting segments of a buffer. Plant vegetation on openly bare areas on the property. Observe runoff patterns on your property during a heavy rainstorm and note the problem areas. Strategically plant your buffer segments in the path of runoff, where it can do the most good. To determine the location where a buffer will do the most good, conduct a Rainy Day Survey, described at the end of this chapter.

7 Steps to Designing and Planting Your Buffer

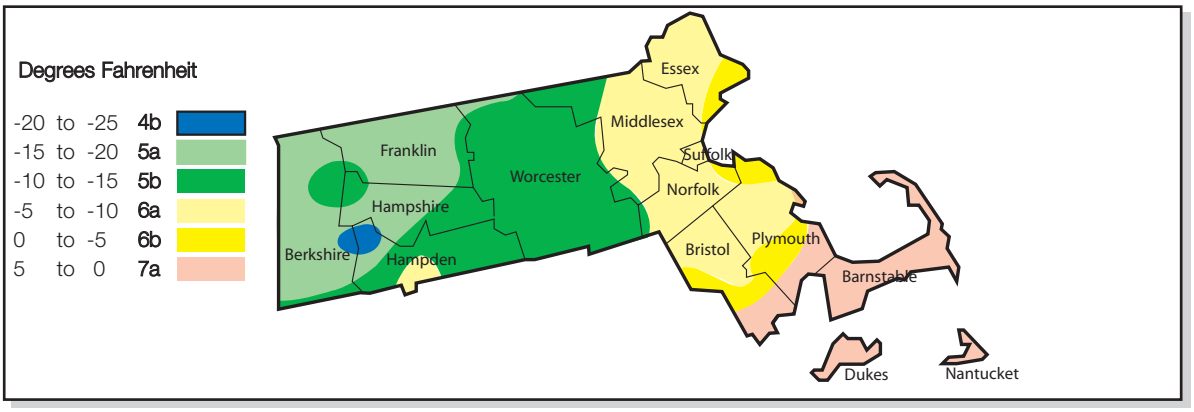
1. Envision New Landscaping Ideas

The first step in designing a buffer is to list the goals you have for your property. Draw a Site Map of your property in its current condition, noting the location of structures, driveways, walkways, beaches and other areas of activity, and trees and other vegetation. Then conduct a Rainy Day Survey, described at the end of this chapter, to identify runoff problem areas that a buffer may be able to correct. Use a second colored pencil to note problem areas on your map. Finally, sketch new ideas and goals onto your map, using a third colored pencil, to note the location and size of your buffer. Visit our sample Site Map in Chapter 5 for helpful ideas.

2. Evaluate Your Environment

You should then analyze your property's environment. Key factors that should be considered are soil type (deep, rich soil or shallow, poor soil; wet or dry soil; alkaline or acidic soil), sunlight level (full sun, partial sun, total shade) and hardiness zone. Also consider harsh winter winds that blow across your lake or pond. These winds can dry out the leaves or needles of evergreens (mountain laurel, pines, spruce) harming or even killing them. If possible, look at and identify the native plants that flourish in undeveloped areas around your property. These will be helpful indicators of what type of soil you are working with and what types of plants will succeed.

If you have questions regarding the condition of your soil, consider having it analyzed at your local Cooperative Extension Service. The cost of soil testing is minor in comparison to the overall costs of plants, soil amendments (if needed), and your labor. Home soil-test kits can also be used to determine soil conditions, although the results are not as reliable as those provided by the Cooperative Extension Service.



Hardiness zones in Massachusetts range from 4b to 7a. Please note that these are general and do not take into consideration site specifications such as soil type and daily sunlight levels. Southern exposures and sheltered areas may warm a site so that it is really a zone higher than the map indicates; likewise, northern exposures may make a site a zone lower.
Source: adapted from USDA.

Determine your general hardiness zone by referring to the map on page 3-4. The lower the number, the colder the conditions. Appendix B is an extensive list of native plants and includes the hardiness zones where the plants can be expected to succeed.

3. Layout Your Design

Delineate your buffer so you have a clear picture of its dimensions. If you have a planting plan, lay out your buffer according to its specifications. If you do not have a planting plan, this is your opportunity to determine how many plants are needed and where they should go. Delineate pathways or other areas that you want to remain open within your buffer, such as a picnic or sitting area. The edges can be marked with spray paint, flags, or stakes and twine.

4. Visit Your Conservation Commission

Once you have assessed your environmental conditions and have designed your buffer, you should approach your local Conservation Commission for guidance on how to comply with the Wetlands Protection Act (WPA). The Conservation Commission reviews projects in close proximity to water bodies to make sure that they comply with the WPA. Commission members can be a great source of information when you are designing your vegetative buffer. As well as helping you understand the wetland review and permit process, the Commission can also provide you with information on the various exemptions that, if your project qualifies, will allow you to perform the work without first receiving a permit from the Commission.

Most small-scale buffer plantings on residential property will require the filing of a Request for Determination of Applicability form (visit http://www.state.ma.us/dep/appkits/wpaform2.doc). This form helps you explain your project to the Conservation Commission. The planting of additional vegetation along water bodies is an environmental benefit, and in most cases the Commission will allow the work to continue as planned. To ensure that the work will not cause undue harm during planting, the Commission may set conditions on the project, such as requiring erosion controls, limiting the use of heavy machinery in the work area, and ordering the use of native plants only. For more information on the how the WPA may affect your planting work, see Chapter 4.

5. Select Your Plants

A mix of vegetation heights will generally provide the best mitigation for nonpoint source pollution. A mix of grasses, shrubs and trees will impede surface runoff. The deeper and more complex the root system, the better the chances of capturing soluble nutrients and other pollutants in subsurface flow.

If possible, buy plants that have been propagated from native seed and grown in your general vicinity. These plants are already acclimated to your weather conditions. Plants that were started as close as 100 miles south of you may struggle to survive the colder nights and harsher winters in which you are placing them. Likewise, plants used to cooler and moister conditions north of you may struggle under a more intense summer sun.

Buying plants in containers is generally suggested for the general public, due to their wide availability and ease of handling. However, these plants have been grown in an artificial environment and will require more careful planting and watering than other forms of plants. Take care to cut and tease their roots out of the potted soil, to encourage their root systems to expand into their new soil conditions.

Bare-root plants can also be purchased, though these are generally larger in scale and not as readily available in nurseries. Bare-root plants are dug out of their site without soil packed around their roots like container plants. In most cases they can establish themselves quicker because they have larger root systems and because they have been grown in "real" soil, not an artificial soil mix like container plants. Care should be taken to prevent their roots from drying out during the transport and holding of these plants prior to planting.

Larger, field-grown, balled-and-burlaped landscape sized plants can also be used if the budget allows. These plants will provide an immediate benefit to the environment and the aesthetic feel of the property. However, their size and weight make them more difficult to transport and handle.

When selecting plants, tell your nursery owner that you will accept only native, non-invasive species. Many nurseries sell fast-growing and easily maintained invasive species such as Norway maple, burning bush and Japanese barberry. Be alert, and outright ask if the plants you are purchasing are native to your area.

Care should be taken when transporting and holding all plants. If the plants are to be transported for a long distance in the back of a pickup truck, cover them with a tarp to prevent them from drying out. Keep root systems moist during storage and prior to planting. Avoid prolonged storage or holding times in direct sunlight, as plants can become dehydrated easily.

6. Prepare Your Site

Erosion and siltation barriers such as silt fencing and straw bales should always be placed between your work site and the water's edge. This is to prevent sediment-laden runoff from your work area reaching the water in the event that a heavy rain event occurs in the midst of planting. Choose straw bales over hay bales, as there is less of a chance that they will transport weed seed to your site. On sites where new construction has taken place, the soil will probably be loose and exposed. In these cases, simply plant vegetation in the ground. If you want grass around your plantings, seed and cover with straw. If you want a landscaped look, cover the area around your plantings with 2-4 inches of bark mulch. The mulch will prevent erosion of exposed soils, conserve moisture, and help prevent weeds from establishing and competing with your new plants. Use hardwood bark mulch over wood chips, as they are less prone to being washed away in runoff. Avoid using mulch of any kind right along the water's edge, because any mulch can be washed away under heavy rains. Note that it is not necessary, and in fact would be detrimental, to put plastic under mulch as conventional landscapers sometimes advocate. In establishing a buffer, you want to encourage infiltration.

Straw bales protect the water from sediment during a buffer planting.
Source: BRPC archive, 2001.

When the waterfront has lawn or other vegetation and a landscaped look is desired, you will need to remove the existing vegetation to make way for your planting. If you have a relatively small site, this can be done by hand with a grub hoe, manual sod cutter, spading fork or shovel. Either compost the cut sod or use it to patch eroded areas elsewhere on the property.

For larger areas, a machine-powered sod cutter can be a labor-saving tool. These can be rented from garden shops and hardware stores. Care should be taken to save as much of the existing soil as possible. For a very large site, a Bobcat or backhoe can be brought in to remove sod and/or existing vegetation. The use of large, heavy machinery directly along the waterfront area is generally discouraged due to the sensitive nature of the soils and the chance for erosion. Also, heavy equipment can compact the soil, decreasing its capacity for infiltration.

It is not necessary to remove the existing turf in all instances. Many waterfront property owners prefer maintaining an underlying layer of grass while adding a mix of native ferns, wildflowers, shrubs and or shade trees. In these cases, only the turf where new plants will be located will need to be removed.

Once competing sod or undesirable brush has been removed, the area should be lightly tilled or spaded to loosen soil for planting. In most cases, soil amendments such as compost, peat or fertilizers will not be necessary if buffer plants have been properly selected to match the soil and sunlight conditions. However, in some cases, when the original soil has been disturbed or removed and fill has been brought in, it may be necessary to add some compost or organic fertilizer to help the plants get started.

Compost is relatively low in nutrients compared to commercial fertilizers. However, it is beneficial in that it improves the overall condition of the soil. It keeps the soil loose, allowing plant roots to expand outward and extract nutrients from their surroundings. The looser soil also allows for a better exchange of air, greater infiltration of water and an improved habitat for earthworms and soil microbes. In addition, the lower nutrient content of compost decreases the chances that it will leach soluble nutrients into subsurface waters (and ultimately the water body).

7. Planting Your Buffer

Planting can occur at most times of the year. The main factor to be considered is water and its availability for the newly planted vegetation. All new plantings will require some artificial watering during their first growing season, and the time and amount of water is determined by the season you plant. Planting when vegetation is dormant (in the fall or in the very early spring when the environment is cool and moist) requires far less watering than planting during the midst of the warm growing season. In addition, planting in the fall or early spring, when growing processes are shut down, will give the plants time to acclimate to their new surroundings.

Lay out the plants to make sure that you have enough and that they are properly spaced.
Source: BRPC archive, 2001.

Each plant should be planted at the proper soil height, which is the height it was growing in its container or in the field. In general, dig out a hole twice the size of the container or the root system. Place the plant in the hole and fill it back in with soil. If the plants are from containers, save the soil you loosen from the roots and mix it with soil dug out of the ground. This gives the plants a combination of the soil they grew up in and the soil they must become accustomed to. Mulch over the exposed soils around the base of the new plants. Do not place removed turf over the disturbed soil (directly over the roots) for a year or two, as the grass will compete with the new plants for water and nutrients. Thoroughly water the site after planting.

Before you start digging, lay out your plants to make sure you have right number and the right spacing to create the look you desire. Leave enough space between shrubs and trees for them to grow without crowding each other. Although the actual space between shrubs will vary, generally plant them as least 3 feet apart. The space between them can be planted with ferns, flowers or groundcover during the early years. Blue flag iris is an easily grown perennial flower whose leaves grow in a tall and fan shape. These irises can fill in empty spots between newly planted shrubs in the short term. If the buffer is intended to have a landscaped look, you can maintain a permanently mulched planting bed. If the buffer is intended to have an underlying layer of grass, the mulch can be replaced with native grasses once the plants have established themselves, usually within two to three years.

*Blue Flag Iris (*Iris Versicolor*)*
Please Note Yellow Irises (Iris Pseudacorus) are an Invasive Species
Source: BRPC archive, 2003.

Your vegetated buffer should require little maintenance if the plants were carefully selected to meet the soil and sunlight conditions of the site. Watering the first season is the key to success! Also, remove undesirable plants in the buffer, as they will compete with your plants. Once buffer vegetation has become established, after a year or two, consider removing the mulch and allowing grasses and forbs to fill in around your plants. Continue to remove undesirable plants, especially invasive non-native plants. Careful pruning of shrubs and tree branches will help you maintain a view of your lake, pond or river.

Overfertilization is a common problem, and the excess can run off directly into your water body or leach into groundwater. If fertilizers are necessary, avoid their use near the water and use slow-release fertilizers. Also, select the proper season to apply fertilizers, because incorrect timing may render the fertilizer useless or stress vegetation. Do not apply pesticides or fertilizers before or during rain due, to the strong likelihood of runoff.

Consider Outside Help

Designing and planting a vegetated buffer can be a lot of hard work. If you feel that you do not have the knowledge to design your buffer, or that the labor involved is beyond your capacity, consider hiring a local landscape professional. If the cost of a professional is beyond your means, consider contacting local conservation organizations. Once they learn that you are willing to plant a buffer to improve the environment, they may be able to provide low-cost or free technical assistance and labor for a "planting party." The local student conservation organization may be looking for a hands-on project such as your buffer.

Work With Your Neighbors

If your property is in a traditionally landscaped neighborhood along a densely developed shoreline, you should consider discussing your buffer project with your neighbors. Although maintaining shoreline vegetation on a newly developed property is now quite common (and often required), removing turf and planting native vegetation on an existing lot may cause alarm among traditionally minded thinkers. Here are some tips to maintain a healthy and friendly relationship with your neighbors:

- Talk to your neighbors, because what you do will affect them and their shoreline. Explain your goals in planting this buffer.
- Recognize their right to disapprove of your new landscaping ideas, just as you expect them to recognize your right to create a non-traditional yard.

- Talk to the local lake or home owners association, explaining the reasons that you've decided to plant additional vegetation along your shoreline.
- Start small: plant your vegetated buffer in phases to minimize the rate of change. This will not only ease the transition for your neighbors; it will allow you to learn as you go, possibly saving you time, money, and an aching back.
- Consider creating a border around your buffer to give it a more professionally landscaped look. This could be a fence (one that allows wildlife movement), a hedgerow or a border of trees.
- Share your buffer with local conservation groups. Professional experts working with these groups can lend you their support. They may be able to provide you with tips on maintaining the long-term health of your buffer.
- Dare your neighbors to be different! Challenge them to resist keeping that "clean-shaven" lawn right down to the water's edge. If they do not or cannot plant a landscaped buffer, they can simply create a "no mow" zone. This will allow a more diverse mix of vegetation to grow there.

Hopefully, education and time will convince your neighbors and your local landowners association that your vegetated buffer is the landscaping trend of the future.

It will take several buffers, extending along several properties, to truly benefit the water body. Developing such a system of buffers could be done in coordination with neighborhood associations, lake associations and with the municipality in which the water body is located. In areas that are already densely developed, it is important to work with neighboring property owners to develop a shoreline buffer that extends along several lots. A united group of several neighbors may be able to save money by bundling several small buffers into one landscaping contract and purchasing materials in bulk. In areas where a continuous buffer is not feasible, concentrate on planting sections where they will do the most good: in the path of runoff.

After you have become an expert on stormwater runoff from conducting a Rainy Day Survey on your property (see pages 3-17 and 3-18), organize a neighborhood survey. Evaluate runoff from public areas along the shore of your water body. Look for areas in parks and at boat launches and canoe put-ins where stormwater runoff and erosion might be affecting water quality. Look for stormwater discharge pipes that are depositing sand and other pollutants into the water. If you find them, advocate for the creation of a buffer or some other technique to minimize or eliminate the pollution.

Once we acknowledge that we all are part of the problem, we can work together to become part of the solution. Vegetated buffers can be a part of that solution. If there is an open, eroding area along the shoreline, plant a vegetated buffer. If there is a parking lot from which sediment and other pollutants can run directly into the water, plant a buffer. If there is a spot on your property where stormwater runs into the water, plant a buffer. Restoring vegetation along the shoreline will incrementally begin to undo the damage we have wrought with impervious surface areas, lawns and storm drain systems. It might even provide cover for a wild creature in need.

Waterfront Neighbors Work Together for Water Quality - A Case Study

Waterfront property owners on West Boggs Lake in southern Indiana are jointly enrolled in a unique program to mitigate problems related to nonpoint source pollution. The 622-acre recreational lake suffered from the types of degradation that many lakes in Massachusetts suffer from: high turbidity, persistent algae blooms, extremely high nutrient loads, and high bacteria counts. Under the Buffer Management Program, established in 1994, the Parks and Recreation Department purchased a 100-foot-wide buffer zone around the lake from the private lakefront owners. Private property owners who abut the buffer must apply for permits and pay fees for day-to-day uses that negatively impact the lake's water quality. For instance, they must apply for special permits to mow, fertilize, or remove trees in the buffer, or to erect a boating dock. Applying pesticides is strictly regulated. Violations of permit conditions can result in the ultimate loss of use of any buffer zone land. The buffer lands in question would be allowed to revert back to a natural state to act as a filter strip for irresponsible land uses. User fees remain within the Buffer Management Program. Although private lakefront owners initially resisted the purchase of land and the development and implementation of buffer zone regulations, most have since changed their opinion, because personal property values along the lake have risen dramatically (Axsom, 1999).

These native shrubs have been planted along the shore of public lake to act as a buffer between a hiking trail and the water to filter runoff.
Source: BRPC archive, 2002

The regulations on West Boggs Lake may seem stringent, but lake associations, lake districts and municipalities can develop protective measures to mitigate pollution and encourage vegetated buffers. This can routinely be done in development or redevelopment projects situated along waterfront properties.

More Helpful Hints

A Few Words About Fertilizers

Plants need a number of nutrients to flourish. The nutrients that they require in relatively large amounts are nitrogen, phosphorus, and potassium. Nitrogen is associated with lush vegetative growth, phosphorus is needed for flowering and fruiting, and potassium is necessary for structure and durability. Although these nutrients are valuable in soil, they end up feeding algae and noxious weeds if they end up in water bodies. Phosphorus is the nutrient of most concern in freshwater systems, while nitrogen is the nutrient of most concern in salt-water systems. So the goal is to maintain nutrients in the soil and keep them out of your lake or pond.

This is the label of a popular lawn fertilizer called Milorganite. The formulation for this fertilizer is 6% nitrogen, 2% phosphorus, 0% potassium. Photo: BRPC archive, 2003.

In general, most Massachusetts soils already have enough phosphorus to feed plants, so adding fertilizer may overdo it. The typical fertilizer formulation is a set of three numbers, with each number representing the percentage of the three in main nutrients in fertilizer. The first number represents nitrogen (N), the second phosphorus (P), and the third potassium (K). So, a common fertilizer of 6-2-0 would be 6% N, 2% P, and 0% K.

Source: National Association of Conservation Districts, Wildlife Habitat Council

Phosphorus-free fertilizers are best for areas near freshwater bodies and you should try not to go over 3% P (nitrogen-free fertilizers are best for saltwater bodies). In fact lawns, which are the most heavily fertilized areas, need higher amounts of nitrogen than phosphorus, so a 6-2-0 formula will benefit lawns while minimizing the chance that phosphorus will leach into your lake. Better yet, just leave grass clippings on the lawn after mowing - they are largely nitrogen and leaving them is a cheap fertilizer.

If you feel that your soil is not fertile enough, here are some tips to determine what, if any, nutrients are lacking, and on using fertilizers if necessary.

- Conduct a soil test to see if indeed your soil is lacking the proper nutrients. Soil test kits can be purchased at garden centers. These tests are not as reliable as those that can be done by the Cooperative Extension Service, but they should give you a general idea of what your nutrient levels are.
- Follow the soil test kit directions closely! Human error is the main cause of faulty soil readings.

- Make sure your shovel and other tools are clean for each test. Residuals from past projects that involved compost or fertilizers will skew the test results.
- Dig into the soil at least 6 inches to get beyond the root system of existing plants.

If you determine that you need to add nutrients to your soil, here are some tips:

- Consider using compost instead of fertilizer. Compost nutrient levels are generally lower than those in fertilizers, but compost releases those nutrients more slowly, giving plants more of a chance to absorb all or most of it. This in turn makes it less likely that nutrients will leach into the water body.
- If fertilizer application is necessary, do so under dry conditions. Fertilizer nutrients travel easily in runoff.
- Most fertilizers have more nutrients than you will need. So, apply conservatively; this will save your lake and your wallet.
- At most, apply no more than one pound of fertilizer per 1,000 square feet of lawn.
- Avoid applying fertilizer near the water's edge, where it can easily be washed into your stream or lake.
- Also avoid applying fertilizer near sidewalks, driveways and roads, where runoff can easily carry it through the storm drain system and into your water body.

Maine and Minnesota Work to Limit Phosphorus Fertilizer Use

In 1999 the state of Maine began promoting the use of phosphorus-free fertilizers to protect and improve the health of its recreational lakes, many of which have become degraded due to algae blooms, noxious weeds and lower oxygen levels. Impressively, the lawn care and fertilizer industry joined in the effort, and sales of phosphorus-free products skyrocketed. Approximately 3,200 pounds of P-free fertilizers was sold in 1998. Sales jumped to 56,445 pounds in 1999 and reached 134,590 pounds in 2001. Phosphorus-free fertilizers are available in Massachusetts - you just have to ask for them.

It is estimated that 80% of the lawns in Minnesota are already saturated with phosphorus (Barten). To protect water quality, the state passed a law in 2002 that bans the use of phosphorus on most lawns in seven counties around the St. Paul area. Fertilizers are allowed to be used only in establishing new lawns or where soil tests have indicated a need. Where fertilizers are allowed to be used, the phosphorus content is limited to a maximum of 3% of content. Some communities outside the St. Paul area, convinced that phosphorous was a problem for local lakes, developed local bans of their own. The city of Plymouth established a ban on phosphorus in 1996, after which the water clarity in its recreational lake improved dramatically. A 2001 comparative analysis was conducted on runoff from Plymouth and runoff from a neighboring city, one with similar watershed characteristics and which had not banned phosphorous fertilizers. The results showed that Plymouth's phosphorus content had been reduced by 23%.

Choose Native Plants

Choose native plants for buffer areas. They provide local wildlife with familiar food sources and habitats. Avoid invasive plants, which can become pests. Because of their propensity for reproduction, invasive plants can overrun native vegetation and result in a decrease in native plant diversity. Consequently, biodiversity (variability in animal life) is compromised by invasive plants. Globally, 42% of all threatened or endangered species are at risk of extinction due to the spread of invasive plant species (TNC, 2002).

Typical native upland trees, shrubs and wildflowers serve as a variety of food sources for game species. Hardwoods such as oaks, hickory, beech and hop hornbeam produce mast (nuts and acorns) that grouse, turkey, wood ducks, deer and black bear depend on for survival. Ferns, skunk cabbage and other early-emerging herbaceous vegetation provide much-needed nutrition after a long and hard winter. Native berry-producing shrubs such as blueberry, raspberry, dogwoods, shadbush and viburnum produce berries eaten by bear, fox, and coyote, as well as by many smaller mammals and birds. Berries are an important source of energy for migrating songbirds during late summer and autumn. An extensive list of native plants and their value for wildlife can be found in Appendix B.

Negative Impacts of Invasive Plants on Wildlife

Many invasive shrub species produce berries that are unhealthy for local birds and other animals. Invasive species such as Japanese barberry, oriental bittersweet, buckthorn and burning bush produce large berry supplies. Because many of these plants produce berries late in the season, they would seem like a good food source for wild animals facing a long, cold winter. Not so. Many animals are not able to digest non-native fruits and so are not able to receive nutrition from them. In fact, the fruit from some non-native plants, such as buckthorn, actually acts as a diuretic in certain songbirds, robbing them of much-needed nutrition.

To Learn more about invasive plant species, visit The Nature Conservancy's website: *www.lastgreatplaces.org/berkshire/issuues/art6406.htm*

Once established, invasive plants are stubborn. Landowners may be forced to use herbicides in order to control them. Because there is a chance that herbicides could find their way into a nearby water body, especially if used in close proximity to the shore, it is best to avoid their use whenever possible.

Despite the threat they pose to our natural environment, many non-native plants are still being sold at nurseries across Massachusetts. Most people, including some nursery workers and owners, would be surprised to learn that many popular trees (Norway maple, black locust), shrubs (burning bush, Japanese barberry, many honeysuckles) and other plants (yellow iris, oriental bittersweet, goutweed) are actually invasive. Therefore, it is important to visit the nursery armed with information. If you have several nurseries from which to choose, try to support those that offer and promote the use of native plants.

Finally, in choosing the types of species for planting, let Mother Nature be your guide. Look at the assemblage of grasses, ferns, flowers, shrubs and trees along a natural stretch of the shoreline that has the same characteristics as your unbuffered area. If these plants flourish in neighboring areas, chances are good that they'll flourish on your property, too. An extensive list of native trees, shrubs and ground covers can be found in Appendix B.

*Northern arrowwood (*Viburnum recognitum*) can be used as a stand alone shrub or can be used to create a hedge. Showy white flowers bloom in June and dark black berries ripen in late summer.* ▶
Source: BRPC archive, 2003

*Thorny blackberry bushes (*Rubus Allegheniensis*) can be used to create a barrier to trespassers. They have white flowers in late spring and black raspberries in summer.* ▶
Source: BRPC archive, 2003.

Conduct a Rainy Day Survey to Identify Runoff Problems on Your Property

You can identify runoff-problem areas on your property by conducting a Rainy Day Survey. Simply observe your land during a heavy rainstorm and note the problem areas. Use the checklist below to help you detect problem areas. The map you create will provide a bird's-eye view of your existing property and will provide a place to sketch new landscaping ideas. Visit our Site Maps in Chapter 5 for ideas.

1. Create a Map of Your Property

- Outline the footprint of large structures (house, patio/deck, garage, storage sheds, gazebo, dog-house), vehicle areas (driveway, parking spots), activity areas (beach, dock, canoe launch, playground, pool, horseshoe pit, gardens) and other areas of importance (paths, walkways).
- Use an assessor's map if possible, because it may already show the location and size of buildings.
- Outline large trees and other areas of vegetation.

2. Get Your Rain Gear Out

With map in hand, conduct your survey once the ground is soaked and water has saturated the soil and leaf litter. It is then that runoff is more easily observed. We suggest that you start at the water's edge and work your way inland. Where does stormwater flow? Does it all flow towards the lake? Does some of it flow elsewhere, like into the town storm drain system? Mark the pathways of runoff to their final destination. Use this checklist to help you survey your land and map your problem areas.

In the water along shore

Mark these on your map:

- ☐ Sandy or muddy deposits in the water. The sand or mud has been transported by runoff, so mark the pathway it followed to get there.
- ☐ Eroding bank
- ☐ Discharge pipes. Identify the origin of the discharge and mark the pathway it followed, if possible. Note color of discharge from pipe (if any).

On land

Mark these on your map:

- ☐ Sandy or muddy deposits. Mark the pathway the sand or mud followed to get there.
- ☐ Bare unvegetated patches
- ☐ Ditches or gullies
- ☐ Pathways, boat launches, driveways
- ☐ Drain spout for roof runoff. How far does the runoff travel? Is it channelized? If so, mark its path.
- ☐ Discharge pipes. Identify the origin of the discharge and mark the path way if followed, if possible. Note color of discharge from pipe (if any).
- ☐ Areas of gas, oil, or other vehicle leaks
- ☐ Areas waterfowl frequent
- ☐ Arrows to show direction of runoff

3. Evaluate Your Problem Areas and Consider New Ideas

Using your map, look at your problem areas and consider ways to fix them.

- Plant a vegetated buffer along your shoreline (of course!) to filter and disperse runoff.
- Revegetate bare and eroded areas.
- Create berms or plant vegetated buffers around hard surfaces.
- Replace concrete or blacktop surfaces with "porous pavement," such as bricks or stones that allow some infiltration through the cracks.
- Install a dry well or rain barrel to capture roof runoff.
- Replace dirt pathways with grassed ways.
- Eliminate direct discharges and redirect runoff through vegetated areas.
- Relocate sediment-generating areas such as pathways, driveways and gardens as far away from the water's edge as possible.
- Relocate pollution-generating areas such as fertilizing, car washing, pet walking (and pooping) as far away from the water's edge as possible.
- Replace a portion of your beach area with vegetation.

4. Prioritize Your Problems for Corrective Action.

Problems that directly affect water quality, such as those located along the shoreline or where muddy or cloudy runoff is reaching the water body, should be ranked highest on your list. This includes runoff traveling in ditches, gullies and storm drain systems.

Chapter 4

Buffer Plantings and the Massachusetts Wetlands Protection Act

Buffer Plantings and the Massachusetts Wetlands Protection Act Regulations

The term "vegetative buffer," as used thus far in this manual, is somewhat different from the meaning of the term "buffer zone" under the Massachusetts Wetlands Protection Act (WPA) regulations. A vegetative buffer, as used is this manual, is a planted area along a water body that functions to filter runoff, capture pollutants before they reach nearby waterbodies, and provide wildlife habitat. It does not have any regulatory connotations.

A "buffer zone" in Massachusetts, however, does have regulatory implications. A buffer zone is an area 100 feet wide along the bank of a lake, pond or wetland. Development and other human activities that negatively impact the water resource or wetland are restricted within this area. Activities that are allowed within this area are regulated by the local Conservation Commission and the Department of Environmental Protection (DEP). Understanding the WPA and following its regulations are important, so it is recommended that you visit your local Commission to discuss your buffer plans before you begin planting. They will advise you as to whether you need to file any forms or apply for any local or state permits. In addition, some communities have adopted local bylaws that may be more restrictive than the state regulations. Your local Commission will explain these to you when it explains the state regulations to you. In general, restoring vegetation along the shoreline is beneficial for the environment and follows the intent of the WPA.

Local Conservation Commission Responsibilities

In general, planting of vegetative buffers is considered a valuable project that helps the Commission in its efforts to protect water and wetland resource areas. There are five inland (freshwater) resource areas that fall under the jurisdiction of the Conservation Commission and the WPA:

1) banks of lakes, ponds, streams and rivers
2) wetlands (swamps, bogs, marshes) that border on a water or wetland resource
3) land under any water body
4) land subject to flooding (100-year floodplain)
5) 200-foot riverfront area along perennial streams and rivers

It is the responsibility of each local Conservation Commission to review projects within these specific wetland resource areas and enforce the protective WPA regulations. The Commission is composed of a board of up to seven volunteers with a variety of backgrounds, knowledge and experience, such as farmers, businesspeople, home owners, professors, environmental consultants, and engineers. Although their primary role is enforcing the wetland regulations, they can be a great resource for information when you are designing your vegetative buffer, as well as help you understand the wetland review and permit process. The Commission can also provide you with information on the various exemptions that, if your project qualifies, will allow you to perform the work without first receiving a permit from them.

A copy of both the Massachusetts WPA and its regulations can be found at the DEP website http://www.state.ma.us/dep/brp/ww/regs.htm. They can also be obtained from your local Conservation Commission or be viewed at your local library.

The local Commission's role is to protect the eight public interests that are listed in the WPA regulations, as they relate to jurisdictional wetland resource areas. The eight interests protect the quality of life for all of the residents in the Commonwealth.

The Eight Interests

Protection of public and private water supply

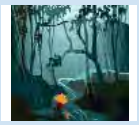
Prevention of pollution

Protection of groundwater supply

Protection of land containing shellfish

Flood control

Protection of fisheries



Prevention of storm damage

Protection of wildlife habitat

Local Bylaws

Another reason for meeting with your local Conservation Commission is that there may be local wetland bylaws that you need to be aware of. Knowing what these might be will help you better design your buffer and meet these requirements. Some types of work that may qualify for an exemption under the state regulations may not be exempt under a local bylaw. This is because local bylaws are more restrictive than the state law. For example, many towns have adopted bylaws that extend the width of the buffer zone past 100 feet, add a 100-foot-or-greater buffer zone to other environmentally sensitive areas not covered under the WPA regulations, give added protection to vernal pools, or extend the Commission's jurisdiction in other ways.

4-2 Buffer plantings

Exempt Minor Activities

Planting vegetated buffers along water bodies is generally an "exempt minor activity" under the WPA regulations. The DEP has put together a fact sheet titled "Exempt Minor Activities in Riverfront Areas and Buffer Zones" that outlines certain types of minor projects that do not require a filing with the Conservation Commission when they are located in the buffer zone and/or the Riverfront Area (see Appendix E). Please note that the same minor activities proposed in other wetland resource areas, including the land under water or stream or riverbanks, are not exempt. It is important to keep in mind that some types of work which may qualify for an exemption under the state regulations may not be exempt under a local bylaw.

What Procedures Should I Go Through?

1. Request a pre-permitting meeting with the Conservation Commission.

Some Commissions (not all) will review informally your proposed project at one of their regular meetings prior to submission of an application, to give you suggestions and discuss areas of concern. Call ahead to find out if this is possible. The purpose of the pre-permitting meeting is only informational. Bring with you any information that you may have about the site and the work you wish to do. On an assessor's map or plot plan, sketch a planting plan that shows the area and extent of the planting, and the plant species that you have selected. Also bring any photographs of the area you may have.

2. Check with your local Commission about any local bylaws and application fees

Calling ahead to find out this information can ensure that your application is not held up due to submittal of insufficient fees or lacking a legal ad fee. Knowing what local bylaws your town has adopted will help you better design the project and meet these requirements. Some types of work that may qualify for an exemption under the state regulations may not be exempt under a local bylaw. This is because local bylaws are generally more restrictive than the state law.

3. File a Request for Determination Application

The Conservation Commission may require that you file a Request for Determination application, which includes a clear and detailed plan of work. This process was designed so that you can formally and fairly easily ask the Commission to determine whether or not the WPA regulations apply to your buffer planting. Following this process will protect you if you are unsure of whether or not your site or work is under the jurisdiction of the Commission. It may give you peace of mind to have the decision made by the Commission and have the piece of paper in hand. If you are confident that your site is out of the Commission's jurisdiction - that your work is not in a buffer zone or wetland resource area, or that your work qualifies for one of the exemptions - you may proceed with work at your own risk. However, be aware that should you be mistaken, the Conservation Commission can order you to stop work and restore the site to pre-construction conditions at your own expense.

Generally, planting vegetated buffers receives a "Negative Determination." Although this sounds ominous, it is a good thing; it means that your work will not negatively impact the water resource or the buffer zone and you can proceed with planting. The Commission may impose "conditions" on your project, such as erosion control measures (e.g. installing hay bales and silt fencing between the work and the waterbody, covering exposed soils to prevent sedimentation). You must comply with these conditions.

4. Read the instructions

The Request for Determination (WPA Form 1) and Notice of Intent (WPA Form 3) forms come with very detailed instructions. The instructions and the application forms are available from the DEP website http://www.state.ma.us/dep/appkits/forms.htm or from your local Conservation Commission office. Be sure to include all information that is required in the instructions, including a detailed description of the site and proposed work, a plan showing existing and proposed conditions, and adequate information for the Commission to locate the site.

5. Attend the Conservation Commission meeting and any site meetings

The Commission may request an on-site meeting to answer questions they may have. Questions and modifications that may be required can often be addressed at the site. Your presence will help facilitate and speed up the process. Bring copies of all your information and any alternatives that you may have considered to discuss with the Commission.

6. Consider hiring a consultant

If your buffer planting project is unusually large, you might consider hiring a consultant experienced in wetland permitting. Hiring a landscape architect or wetland consultant from the start may save time and money in the long run. Knowing where the buffer zone and wetland resource areas are located is essential to a well-designed project and often avoids delays in the application process due to project changes forced by inaccurate delineations. A consultant may also help you determine if the proposed work is exempt or suggest modifications that would help the work qualify for an exemption. Keep in mind that the delineation of any resource areas is not final until it is approved by the Conservation Commission.

Tips for Meeting the Minor Activities Exemptions

Keep in mind that seemingly simple modifications to your buffer may possibly make a non-exempt project into an exempt one. For example, changing your proposed planting plan to include only native species, or agreeing to cover exposed soils during planting of the buffer may produce this result. These modifications may include the following:

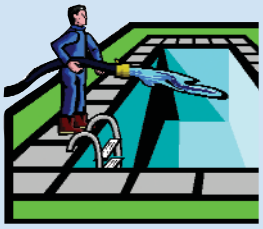
1) Unpaved pedestrian walkways for private use. Note that this does not include paved walkways, bike paths, or other public use paths.

2) Fencing that does not create a barrier to wildlife movement. You may wish to review with the Conservation Commission the type and extent of fencing that you are proposing, in order to make sure that the Commission does not determine that it will create a barrier to wildlife movement. Some things to consider are the length and height of the fencing, current wildlife corridor usage, fence material, and spacing that will allow wildlife to safely pass through, over and under it.

3) Vista pruning (the selective thinning of tree branches or understory shrubs to create a "window" to improve visibility), as long as it occurs more than 50 feet from the mean annual high water line within a riverfront area or from a bordering vegetated wetland, whichever is farther. This activity does not include the cutting of trees that reduces the leaf canopy to less than 90% of the existing crown cover, or the mowing or removal of understory brush.

You will need to know where the mean annual high-water line and boundary of the bordering vegetated wetland are to ensure that you meet the requirements for this exemption. If there is any question as to their location, you should consider filing a Request for Determination application with the Conservation Commission.

4) Plantings of native trees, shrubs, or ground cover, but not turf lawns. Note that this exemption does not include planting of non-native exotic species or lawn grasses.



5) Conversion of patios, pools, sheds, or other impervious surfaces to lawn or natural vegetation. This type of work is generally viewed as an improvement to the area that will help protect the wetland resource area. Note: Maintenance of existing landscaping, including lawn mowing and pruning, is exempt from review regardless of location in the buffer zone or any wetland resource area.

Chapter 5

Unfold Your Imagination and Redesign Your Property

Our Imaginary Waterfront Property

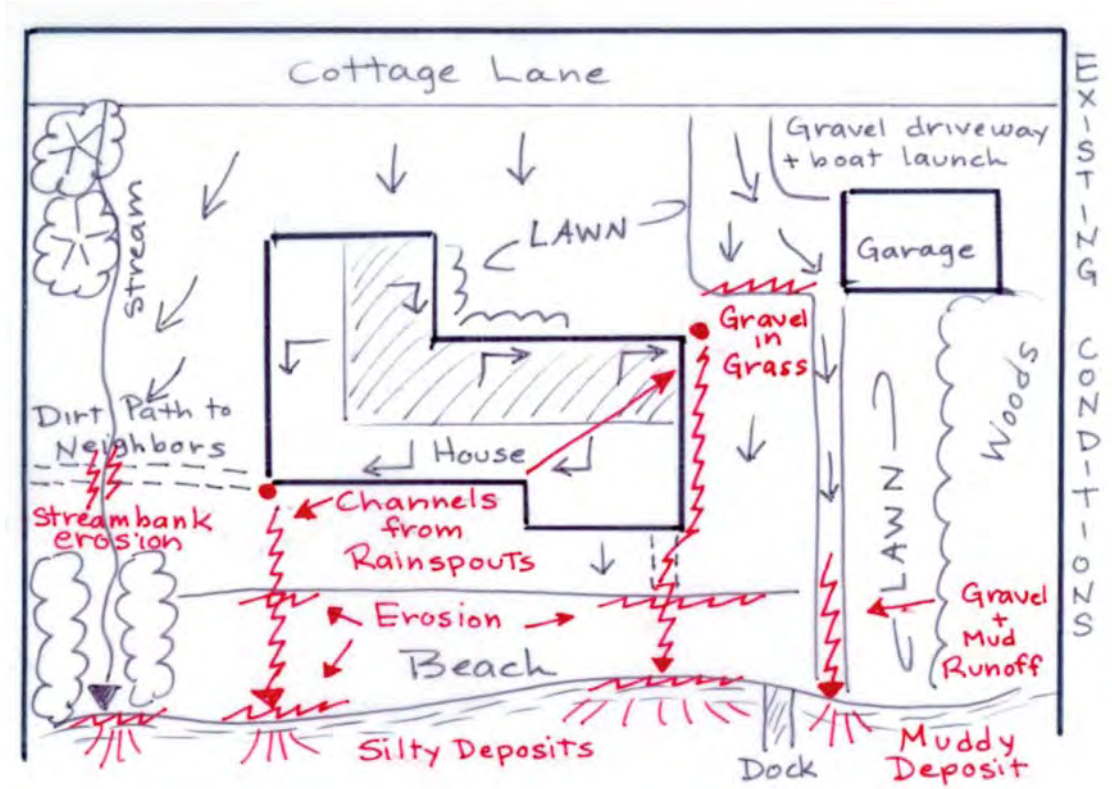
Wondering how to get started on designing your vegetated buffer? We've created a sample of what a typical Site Map, produced during a Rainy Day Survey, might look like. It shows the current condition of a waterfront property, including problematic erosion and runoff.

We have also created a sample Site Map of future ideas and goals for the property. As we discussed earlier, sediment is a major transporter of nutrients, bacteria and other pollutants, so these are the areas on which the owners should focus their attention. We hope you find these samples helpful as you design your own buffer project.

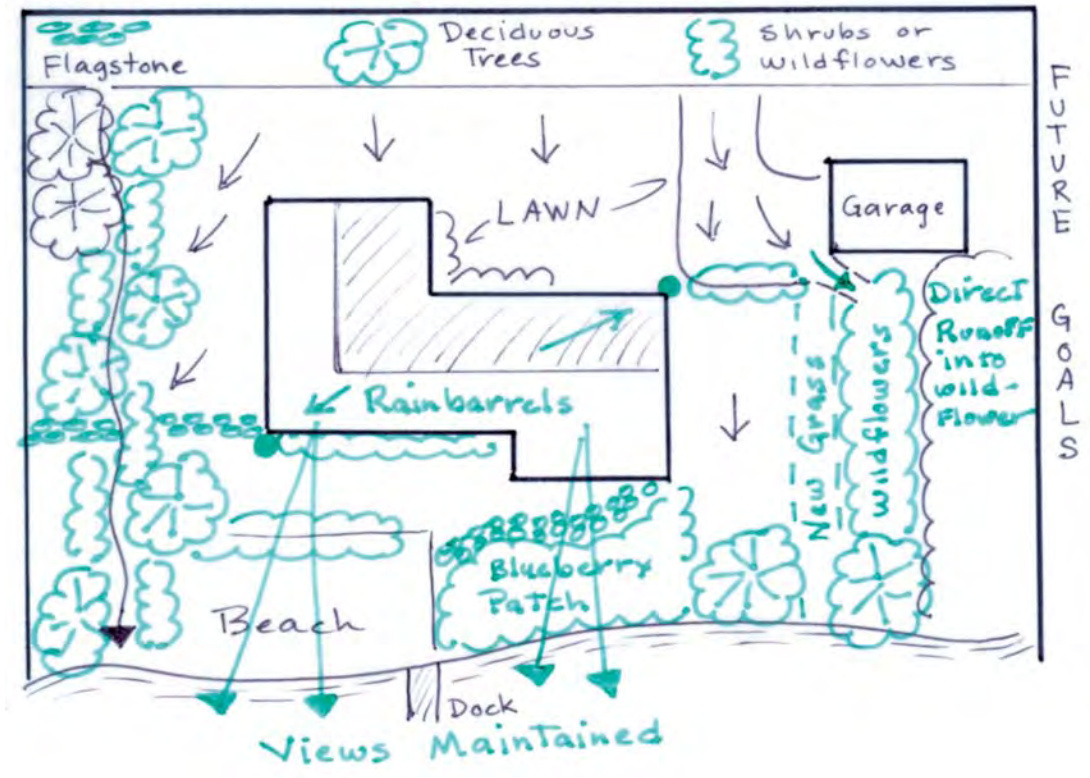
Existing Conditions

The property consists of a modest house on a small building lot. Most of the natural tree cover has been removed. A grass lawn surrounds the house and a sandy beach runs along the full length of the water-front. The owners conducted a Rainy Day Survey and found these problem areas:

- Informal dirt pathways have been created from heavy use. These include one from the house to the beach and one from the house to the neighbors' property.
- The streambank is eroded where people travel between the two properties.
- The stream has no shading or cover for wildlife.
- Channels have formed in the lawn and on the beach from roof runoff being discharged through the drain spouts. As a result, the soil along the edge of the beach is eroding and the beach sand is being washed into the lake at an accelerated rate.
- The gravel driveway and boat launch often wash out during heavy storms. Gravel from the driveway washes into the grass, sending dirt and stones flying during mowing. Gravel and mud have formed a delta in the lake, making boat launching difficult and unpleasant.



Artist renderings supplied by Okerstrom Lang, Ltd., 2003



New Ideas and Future Goals

- Lay flagstone along the informal dirt pathway between the house and the neighbors' property. Plant grass seed in the spaces between the stones. The grass will hold soil particles and allow rain to percolate into the ground.
- Plant vegetation along the streambank. A mix of trees and shrubs will shade the water and provide cover for wildlife. Deciduous trees provide cooling shade in the summer while allowing warm solar rays onto the house in the winter. The shrubs we chose are Northern Arrowwood, which will form a nice dense hedge with white flowers blooming in mid-summer. The cattails at the water's edge will filter sediment, break the force of waves and wakes, and provide food and cover for wildlife.
- Place rainbarrels to capture roof runoff and provide water for the newly planted vegetation.
- Plant a hedge of shrubs along the boundary between the lawn and the beach. The shrubs provide a landscaped look while helping to bind the soil. The view of the lake from the house is maintained by the low-growing shrubs.
- Replace the informal dirt path from the deck with a curved path of flagstones and grass. The curved design reduces the chance that runoff will form another channel.
- Create a small berm along the lower edge of the driveway and plant shrubs along it. The berm keeps gravel from washing onto the grass and the shrubs will filter overflow during heavy storms. Shrubs will also add a landscaped look to the area.
- Channel driveway runoff through a grassy swale into an area dense with wildflowers. The vegetation will filter runoff and attract songbirds and butterflies. The flowers will add color and depth to the dark green back-ground of mature trees.
- Replace the gravel boat launch with a grassed area. The launch is only used a few times per year, so gravel really isn't necessary.
- Reduce the size of the beach, replacing a portion of it with low-bush blueberries. The bushes will filter runoff from the path and provide fresh fruit, while still maintaining a view of the water from the house.
- Plant trees along each side of the property. The trees will frame the view of the lake from the house; likewise they will frame the house when being viewed from the lake.
- Overall, the appearance of the property is richer, as the vegetation adds a variety of depth and color. In addition, the value of the property is greater, as landscaped properties with mature trees are worth up to 20% more on the real estate market (Fitzpatrick, 2002).

I've planted my buffer - What else can I do?

Now that you understand the role that vegetated buffers play in protecting water quality and providing habitat, we hope that you will share your knowledge with your neighbors, homeowners association, local officials and anyone else who manages land along your stream, river, lake or pond. Here are additional tips to reduce runoff from your property, so that even a relatively narrow buffer will do some good.

- Conduct a Rainy Day Survey of your property. This will help you to determine runoff problems and prioritize improvements. If you are limited as to where you can put a buffer and how wide a buffer you can design, place the buffer in the direct path of stormwater runoff.
- Minimize impervious surfaces wherever practical. Consider replacing blacktop or concrete driveways and walkways with stone or "porous pavement" alternatives that allow some infiltration. Build a wood deck with open slats instead of a concrete pad for your patio.
- Allow the grass to grow to a lush height of 3-4 inches. This will encourage a deeper and thicker root mass that will better resist drought and weeds. It will also improve the capacity of the grass to filter sediment and promote sheet flow.
- Do not allow mowed grass to enter the water. Grass is easily broken down and the nutrients from it can cause algae blooms and accelerated weed growth. This leads to lower oxygen levels for aquatic animals and can cause noxious odors.
- Minimize exposed soils, especially along the water's edge. Revegetate eroded areas like dirt paths, bare slopes and exposed tree roots. Consider replacing dirt paths and driveways with grassed ways. If slopes are severe and stormwater tends to create channels, try constructing wood or stone steps.
- Eliminate direct discharges from your property into the water body. Install a dry well to capture rooftop runoff. Or capture roof runoff in a barrel or cistern and use it to water your lawn and buffer and for washing your car. Redirect gutter drains, driveway ditches, and other channels or pipes through grassed swales or thick vegetation so water can be filtered, or redirect them into low-lying areas so the water can collect and percolate into the soil.
- Do not wash pet waste or direct nutrient-laden water (car wash detergent, fertilizers) into the storm drain system. Chances are, the system collects runoff from your neighborhood and discharges it untreated into your lake somewhere down the line.
- If you must water your lawn or buffer, use slow-watering techniques such as trickle irrigation or soaker hoses. Such devices reduce runoff and are 20% more effective than sprinklers.
- Create berms or plant vegetated buffers around impervious surfaces to hold back runoff and capture pollutants. These berms and buffers can be disguised as flower beds or shrub hedges.
- Minimize your phosphorus use by purchasing fertilizers and detergents that have no or little (less than 1%) phosphorous content. Phosphate content in various dishwashing detergents sold in the state ranges from 0% to 8.7% by weight. Gel detergents tend to have less phosphorous than powder detergents (MA DEP, 2001a).
- Maximize the amount of natural vegetation on the property, especially along the water's edge, to buffer the lake from runoff from human activity. A mix of grasses, leaf litter, shrubs, and trees will impede sediment transfer and capture pollutants (such as nutrients) in runoff.
- Maintain mature trees if possible. Careful pruning of tree branches will frame your view of the lake while maintaining the protection that tree foliage provides.
- Resist the urge to tidy up your buffer. Woody debris and leaf litter enable infiltration, and the cavities of dead trees and fallen logs provide cover for wildlife.

5-3 Unfold Your Imagination

Appendix

A

How Vegetated Buffers Improve Water Quality and Benefit Wildlife

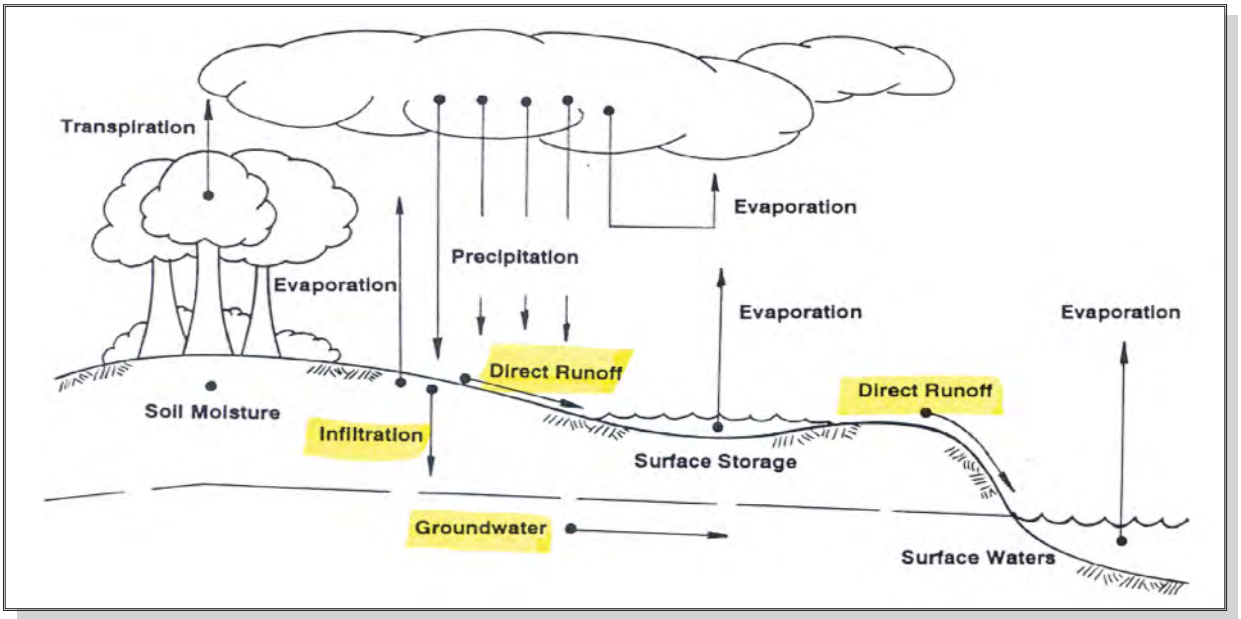
How Vegetated Buffers Improve Water Quality and Benefit Wildlife

Welcome to a more detailed discussion of how pollution impacts water quality and wildlife, and how the use of vegetated buffers can mitigate those impacts. In this section we will discuss different types of pollution, such as sediment deposition, nutrient enrichment and thermal increases. We will describe how these types of pollution lead to algae blooms, explosive weed growth and lower dissolved-oxygen levels. We will also describe how the life cycles of wildlife are affected.

Surface runoff, which usually occurs as stormwater runoff, contributes over 80% of the sediment and nutrients to Massachusetts water bodies. Vegetated buffers can capture much of these before they wash or seep into our rivers, lakes and ponds. Several detailed studies have been conducted in the Chesapeake Bay watershed. One study found that forests can capture, absorb, and store amounts of rainfall 40 times greater than disturbed soils (tilled soils or construction sites) and 15 times more than grass, turf or pasture (Palone & Todd, 1998). Studies have also been conducted in the states of Maine, Minnesota and Wisconsin, and elsewhere across the country by the U.S. Forest Service and by the U.S. Department of Agriculture. We will refer to some of these as we move forward.

To understand how surface and subsurface water moves, it is important to understand the hydrologic cycle. The figure below represents the earth's surface and atmosphere and depicts how precipitation is cycled through the earth's system. Direct surface runoff, infiltration, subsurface flow and groundwater flow are the pathways that we will be discussing in this section. Water that enters a surface water body through precipitation, runoff or subsurface flow recharges the water supply. Stormwater runoff is the flow of rainwater, snow and ice melt across the land's surface. During the first few minutes of a rainstorm the first flush, which is the

The Hydrologic cycle



Adapted from Terrene Institute, 1996.

first half inch to 1 inch of rain, washes the landscape and carries a high concentration of pollutants. These pollutants include debris, sediment, nutrients, bacteria, petrochemicals, metals and salts. If we are to minimize the amount of pollution washing into our water bodies in runoff, it is critical that we somehow treat that first flush of a rainstorm.

Subsurface or groundwater flow is the movement of water as it percolates through the soil and moves underground toward the water body. Water that reaches the water body through subsurface flow is valuable in many ways. First, it is generally of higher quality than surface runoff, especially in developed areas. This is because the physical, biological and chemical processes in the soil help to render pollutants into less harmful forms prior to recharging the receiving water body. Second, subsurface water seeps into streams and lakes at a slower and steadier pace, which helps to maintain healthy water levels in times of dry weather or droughts. Third, subsurface water temperatures remain cool and constant. The soil through which it travels helps to cool down runoff that has been heated on roads, parking lots, driveways and lawns.

Vegetation Creates a Physical Barrier to Stormwater Movement

Vegetation within the buffer physically intercepts the movement of water on several levels. First, it absorbs the impact of rainfall, breaking the force that falling raindrops have before hitting the ground, dispersing the water over a wider area. Like a watering can with a sprinkler head, the softer and wider flow caused by foliage is less prone to dislodging soil particles and creating ruts. This is especially true in buffers that consist of different layers of foliage, as in forested buffers or those with thick shrubs and grasses.

The impact of falling rain can dislodge soil particles, making the soil vulnerable to erosion.
Source: FISRWG, 1998.

Second, the forest floor acts like a rough sponge, slowing down, filtering and absorbing most of the rainfall and runoff of the first flush. Vegetation and leaf litter impede the flow of stormwater runoff and encourage infiltration. Stormwater runoff tends to concentrate and create channels. Water flowing through channels generally travels faster and has a greater capacity to carry sediment, which then has a greater capacity to scour and erode the soil and pick up more sediment. It is in this way that channels perpetuate themselves and continue to grow. The standing stems, trunks and leaves of vegetation, as well as fallen logs, branches and leaf litter, physically block the path of stormwater runoff. Lessening the velocity of stormwater runoff causes it to drop its sediment load.

Buffers Capture Sediment and Nutrients Above the Ground

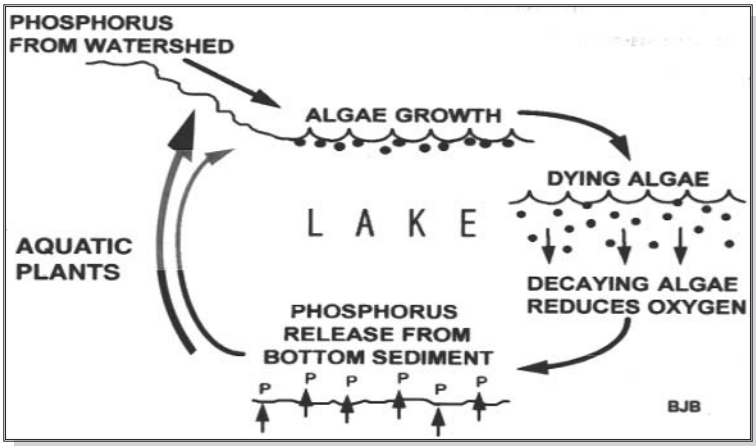
High concentrations of nutrients can be found in stormwater runoff adhered to sediment particles and dissolved in the water. Vegetated buffers have been shown to effectively remove 50-100% of sediment from stormwater (CRJC, 2000). They capture sediment on which pollutants such as phosphorus, petrochemicals, pathogens and some heavy metals are known to adhere. This is the reason that the Massachusetts Stormwater Management Policy requires developers to remove at least 80% of total suspended solids from post-developed stormwater runoff.

Sand and gravel washed from a dirt road after a severe rainstorm is captured by a forested buffer. The nearby lake is in the background.
Source: BRPC archive, 2000.

Phosphorus is the nutrient of main concern for most freshwater ecosystems in Massachusetts (nitrogen is the nutrient of concern for most brackish or saltwater ecosystems). All lakes, pristine and developed, can accept a certain amount of phosphorus without experiencing a significant change in water quality. However, excessive amounts of phosphorus from our activities can over-fertilize algae and noxious aquatic weeds, creating algae blooms and weed-choked shorelines. Once in a water body, phosphorus will continue to be recycled through the system. Refer to the figure on page A-4 for a simplified illustration of the phosphorus cycle.

It is estimated that 80%-90% of phosphorus reaches water bodies adhered to soil particles, and retaining sediment within the buffer effectively lowers the phosphorus load of stormwater runoff. Removal rates are dependent on site conditions (precipitation rates, slope, soil, vegetation types) and the width of the buffer.

An Overview of The Phosphorus Cycle



Source: MA DEP, 2001b.

Researchers in Wisconsin conducted a study to identify the main sources of phosphorus in urban stormwater runoff. Phosphorus data was collected from lawns, streets, roofs, driveways and parking lots to determine the loads from each. They found that lawns and streets were the largest sources of total and dissolved phosphorus (Waschbusch et al, 1999). The source of phosphorus in lawn runoff is from fertilizers and cut grass, while the source of phosphorus from streets is lawn runoff, lawn clippings and leaves. The phosphorus was adhered to sediment and plant debris.

Most soils in Massachusetts contain sufficient phosphorus to support vegetation, so there is no need to apply it through commercial fertilizers. The overapplication of phosphorus is the reason that some states are beginning to encourage or require the use of low- or no-phosphorus fertilizers in sensitive watersheds. Minnesota has enacted a new law that restricts the use of phosphorus-containing fertilizers on established lawns, unless a soil test proves that phosphorus is truly needed.

The state of Maine is sponsoring a program to strictly reduce the use of phosphorus-containing fertilizers. Many in the commercial sector had already been using phosphorus-free fertilizers, and they are now readily available at dozens of hardware and lawn care retail stores, including the large retailers like Agway, Home Depot and True Value. The program has been a success, as phosphorus-free fertilizer sales jumped from early amounts of approximately 3,000 pounds per year to over 56,000 pounds per year by 2001 (ME DEP, 2003). Many retailers offer phosphorus-free fertilizers in Massachusetts as well - you just have to ask for them.

Buffers Capture Nutrients Underground

Ground level vegetation and leaf litter act as a blanket, holding in soil moisture that facilitates microbial action, chemical breakdown and retention of pollutants. As stormwater percolates through the soil, plant root systems and microorganisms have a chance to take in nutrients and use them in their life processes. Soil is composed of inorganic mineral particles of differing sizes (sand, silt, clay), organic matter in various stages of decomposition, numerous species of living organisms (worms, insects, microbes), water, various gases, and a variety of water-soluble ions.

Leaf litter helps to physically impede the movement of runoff. It also provides an ideal blanket to protect soil microorganisms, which can transform pollutants into less harmful forms.
Source: Welsch, 1991.

The roots of grass and other ground-level plants are concentrated at or near the surface and they can absorb the nutrients settling out from sediment deposition. The roots of shrubs and trees grow both laterally and vertically, adding to the complexity and depth of the total root zone. These roots can absorb dissolved nutrients that percolate deep into the soil and travel in subsurface flow. The main sources of dissolved nutrients in developed areas are fertilizers from lawns and gardens, leachate from improperly functioning septic systems and detergents from car washing and domestic use.

Root systems continually push through the soil and create pockets for life-giving air and water; they provide a surface and food source for insects and microbes; and they provide a microhabitat in which gases, water and ion exchanges can occur. It is the minute organisms within soil that immobilize, break down, absorb, and render less harmful many of the pollutants within stormwater, including toxins.

Stormwater percolates downward through the soil, joining subsurface flow. This water will flow through the moist environment of the rooting zone of the vegetated buffer, which maintains a low oxidation/reduction potential. This condition allows for a freer exchange of ions and is conducive to chemical reactions within the soil that retain nitrogen, phosphorus and other pollutants. Studies conducted on nitrogen retention in Maryland and North Carolina have shown that

vegetated buffers are removing 89% and 85% of the nitrogen inputs for those sites, respectively (Palone, et al, 1998). Although the exact processes by which this is occurring is unknown, suspected mechanisms include denitrification (by chemical and biological means), assimilation and retention (by vegetation), and transformation to more basic compounds. Field studies of nitrate balance within a buffer show that it is effectively removes nitrogen at all times of the year, even in temperate climates, and from subsurface waters at depths of several meters (Correll, 1996).

Researchers with the U.S. Department of Agriculture studying the nitrogen removal rates of river buffers have found that vegetation within the buffer can take in and store large amounts of the nutrient from subsurface flows. However, the amount of the nutrient that they are able to take in is directly related to the amount of moisture within the soil (Gold, 2002). As areas become more developed and the impervious cover increases, surface flow is channeled through storm drain systems, bypassing vegetated buffers and entering the nearest waterbody untreated. Maintaining buffers, directing stormwater through them as sheet flow, and increasing infiltration will ensure that the soil at the root zone will have the constant moisture content necessary for plants to take in much of the nutrients created by human activity.

Generally speaking, waterfront areas are better at retaining pollutants than are upland areas. This is due to the fact that uplands are often more sloped than waterfront areas, thus the retention time is shorter. The shorter the retention time, the less opportunity there is for infiltration and uptake of pollutants. In addition, moist soils have a higher rate of pollution retention than dry soils, due to microbial action and ion exchange. It is therefore critical that vegetation be maximized along the waterfront.

General summary of buffer composition and water-quality benefits when applied in an agricul-

BUFFER SIZE AND VEGETATIVE MIX	BENEFITS*	COMMENTS
• Woody veg. along bank • Dense stiff grasses 35'-50'	• Traps 75% sediment from runoff • Traps 25% of nitrates & phosphorus from surface runoff	• Allows most nutrients to pass into water body
• Woody veg. along bank • Shrubs 37'-75' • Dense stiff grasses 25'	• Traps 75% of sediment from runoff • Shrubs trap more nitrates & phosphorus than grass alone	• Additional root complexity and depth improves soil porosity and promotes more infiltration
• Woody veg. along bank • Trees & shrubs 50'-75' • Dense stiff grasses 25'	• Traps 95% sediment • Traps 75-80% nitrogen • Traps 80% phosphorus	• Maximum canopy breaks force of storms • Root complexity and depth provides maximum porosity and infiltration • Root complexity and depth provide maximum nutrient "sink" through plant uptake and storage

Adapted from CRJC, 2000, "Buffers for Agriculture," Fact Sheet #5.
Source: http://www.crjc.org/buffers/Buffers%20for%20Agriculture.pdf
** Note: General removal rates are from agricultural lands, where surface runoff and subsurface flow often contain high nutrient concentrations.*

Buffers Capture Sediment and Nutrients From Agricultural Activities

Maintaining vegetation as a living buffer between intensive land uses, such as agricultural and logging operations, has been well documented by both the U.S. Department of Agriculture and the U.S. Forest Service. Buffers are not only effective; they are simple to oversee and extremely cost-effective.

If vegetated buffers can capture pollutants from such a land-intensive use as tilled fields, they can certainly help capture pollutants from residential development. The table on the previous page describes the benefits of planting vegetated buffers between natural water bodies and agricultural operations. All buffers include forest vegetation immediately along the shoreline, which benefits the water body by anchoring the bank, shading the water, dropping coarse woody debris for the food web and taking up and storing a maximum amount of nutrients. A mix of trees and shrubs within this buffer will provide vertical layering of foliage to attract a wider variety of birds. A buffer of grasses landward of the trees and shrubs will trap sediment, disperse stormwater into sheet flow and take in some surface nutrients. The ability of a grass strip to disperse runoff into sheet flow is the buffer's great asset, facilitating infiltration and all its benefits.

Buffers Protect Aquatic Ecosystems

Runoff flowing over roads, paved drainage ditches, parking lots and driveways is heated as much as 2-10 degrees Fahrenheit as it travels (FISRWG, 1998). This can also happen to water that runs across open grass lawns. In some instances, runoff can transform a naturally cold-water stream to a warm-water stream, seriously stressing or killing sensitive microorganisms, insects and fish species.

Temperature changes within a water body alter chemical composition within the system, which ultimately alters the biological composition. Warmer temperatures can cause nutrients that are sediment-bound at lower temperatures to break free, resulting in a substantial increase in the concentration of nutrients available for algae and aquatic plants. For example, slight increases in water temperature can produce substantial increases in the amount of phosphorus released into the water column (Palone & Todd, 1998).

The increase in temperature allows the algae population to grow exponentially and consume large amounts of oxygen. Warmer waters also aid plant growth, and when the plants die back, an inordinate amount of oxygen is consumed by organisms that feed on the dead material. In lakes and shallow rivers that are infested with noxious invasive plant species such as curly leaf pondweed or Eurasian water-milfoil, the oxygen levels drop precipitously at certain times of the year as the plants flourish and die back in great numbers. In addition to all this, warm waters are not able to chemically hold as much oxygen as cooler waters. The metabolic rate of fishes like trout is raised when temperatures are raised, which is unfortunately right at the very time that less oxygen is available for them. It is during such times that fish kills occur.

Temperature governs many biochemical and physiological processes in freshwater fishes, amphibians, reptiles and insects because their body temperature is essentially that of the surrounding water.

An overview of habitat conditions needed for sustainable fish populations

Fish Species	Max. Weekly Avg. Temp. for Growth (Juveniles)*	Max. Temp. for Survival of Short Exposure (Juveniles)*	Max. Weekly Avg. Temp, for Spawning*[a]	Max. Temp. for Successful Incubation and Hatching*[b]	General DO Requirements**	General Turbidity Tolerance**
Atlantic Salmon	68°F	73°F	41°F	52°F	NA	Low
Brook Trout	66°F	75°F	48°F	55°F	>5.0 ppm	Low
Common Carp	NA	NA	70°F	91°F	>0.5 ppm	High
Channel Catfish	90°F	95°F	81°F	84°F	>4.0 ppm	High
Largemouth Bass	90°F	93°F	70°F	81°F	>5.0 ppm	Low-moderate
Rainbow Trout	66°F	75°F	48°F	55°F	>5.0 ppm	Low
Smallmouth Bass	84°F	NA	63°F	73°F	>5.0 ppm	Low-moderate

** Adapted from FISRWG, 1998.*

a. Optimum or mean of the range of spawning temperature for the species

b. Upper temperature for spawning

*** Adapted from Palone + Todd, 1998*

Temperature therefore plays a central role in the life cycles of several aquatic organisms, regulating behavior, growth, and mating and spawning habits. The hatching rate of some fish and other aquatic organisms is also dependent on temperature. For more information on how temperature affects the life cycles of fish, refer to the table above.

Because temperature and oxygen play such subtle but critical roles in the life cycles of aquatic organisms, they are a major determinant in their distribution within a watershed. Fish such as trout and bass are at the top of the freshwater food web, and their distribution and abundance are often seen as water-quality indicators for aquatic ecosystems. Freshwater fish species have different levels of tolerance when it comes to temperature, dissolved oxygen and turbidity. Trout and salmon are the most sensitive, able to tolerate only a slight change in temperature. Bass are slightly more tolerant, while catfish and carp can tolerate the highest change in temperature. In general, brook and rainbow trout are among the most sensitive of the freshwater species in Massachusetts, needing cool, clear and well-aerated waters to live and breed successfully.

Shallow waters, often located along the shoreline of a lake or pond, are more vulnerable to the warm summer sun than are deeper waters. On land, shoreline vegetation can help to shade the water. Below the surface, soil cools runoff to a more natural temperature. Shallow waters of lakes and ponds are breeding grounds for aquatic insects and the many animals that feed on them, including fish, frogs, and turtles. Therefore, maintaining cooler temperatures along the shoreline is critical to sustaining a healthy aquatic ecosystem.

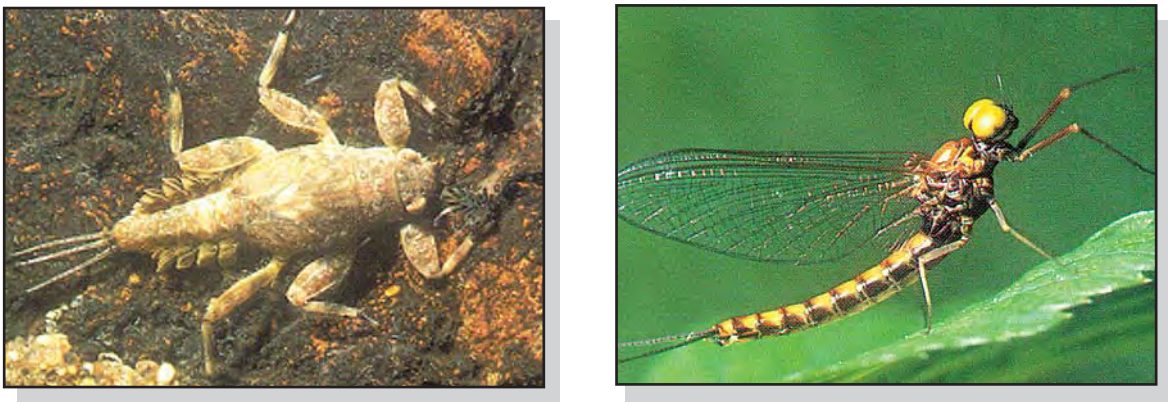
Aquatic ecosystems also rely on shoreline vegetation to provide the basic organic matter that drives their food webs. Vegetation along banks and overhanging streams drops leaf litter, branches and insects into the water. This natural organic matter provides food and cover to aquatic microbes and macroinvertebrates (insects, worms, tiny crustaceans) that are the base of the aquatic food web. This organic matter is coarse and relatively difficult to break down and decomposition and uptake of nutrients by creatures at the bottom of the food web occurs slowly and in balance with the ecosystem.

The logs, branches and snags that fall into a water body provide more than energy for the food web. They provide fish and other aquatic creatures with shade and cover from predators. They also break the flow of streams and rivers, creating eddies and pools. Fish and other aquatic creatures must constantly be on the move and run water through their gills to take in oxygen. By breaking and diverting the current, trunks and branches provide creatures a place to swim less vigorously and rest.

Buffers Provide Wildlife Habitat

Waterfront areas are used by wildlife more than any other type of habitat. They are important areas of transition between the terrestrial and aquatic worlds, and are critical for those animals that need both worlds to complete their life cycles. Most turtles, frogs and salamanders are such creatures, as are some waterfowl. Wildlife habitat consists of areas for cover, food and breeding.

Many species of insects breed and live much of their lives underwater, providing a rich energy source near the bottom of the aquatic food web. In the water, fish, salamanders, frogs and turtles rely on these creatures. Above the water, these and other insects provide a valuable protein source for songbirds and waterfowl during the breeding and nesting seasons. Young birds of many species eat insects during their early stage of growth, turning to a mix of insects and vegetation as they mature.



Mayfly nymphs (left) grow underwater, but the adults (right) leave the water to breed. They are an important food source for trout and other fish, as well as swallows and other birds.
Source: Welsch, 1991.

Many rare and endangered species rely on the aquatic-terrestrial transition zone to complete their life histories. Maintaining or restoring vegetated buffers in the areas where rare species are known or strongly suspected of living helps to sustain viable populations across the state. The Natural Heritage and Endangered Species Program (NHESP), which is administered by the Massachusetts Division of Fisheries and Wildlife, collects and maintains information on over 400 rare and endangered species around the Commonwealth. The goal of the NHESP is to protect biological diversity in the state through biological research and the inventorying of species, data management, environmental impact review, restoration and management of rare species and their habitats, land acquisition, and education.

NHESP has created the Massachusetts Natural Heritage Atlas, which attempts to map rare species habitats across the state. Copies of the atlas are available at local Conservation Commission municipal offices. Maintaining or restoring natural vegetated buffers in the areas highlighted in the atlas would greatly benefit and support healthy populations of the rare species that live within these areas.

Wood, spotted and Blanding's turtles are three rare species that require both aquatic and terrestrial habitats to survive and breed successfully. These turtles need aquatic habitats for mating, resting, foraging and hibernating, but also spend much of the time traveling through upland habitats to find food and nesting sites (Chase et al, 1997). Populations of these three species have declined dramatically over the past few decades, due to collections for the pet trade, pollution and disturbance of habitat. Turtles living in fragmented habitats also become victims of increased vehicle traffic and predation. Predation often increases in developing areas, due to domestic pets and common wildlife such as raccoons, skunks, coyotes and crows.

Aquatic habitat for wood turtles typically is streams, small ponds or swamps that offer them a permanently wet or damp place to overwinter. Nests are located in upland sites not far from the mother's home stream or pond. Hatchlings and young turtles tend to stay close to their home stream, but adults often travel a mile or more from home.

Spotted turtles and Blanding's turtles prefer densely vegetated, slow-moving streams or ponds, where they spend much of their lives. Nests of both are located in uplands. Spotted turtles can only eat when submerged, so they tend to stay near their home, but they are known to frequent nearby vernal pools and wetlands as far as one-third of a mile away for food. There are only a handful of known breeding populations of Blanding's turtles, so little is known about their life cycle or population trends.

Shoreline areas with a complex vegetative mix provide birds with areas to rest and feed, as well places to nest. Osprey, kingfishers, flycatchers and other birds use tree branches and snags as feeding perches. Wood ducks prefer shoreline trees for nesting. Rivers often serve as routes for migrating songbirds, waterfowl and raptors.

Wildlife also use vegetated buffers as travel corridors because of the cover they provide. Sprawling development continues to consume and fragment wildlife habitat and isolate animal populations. Vegetated buffers provide cover for animals as they travel through developed areas to reach new habitat. Black bears, raccoons, beavers and otters are known to prefer traveling along shoreline buffers. Maintaining or improving vegetated buffers along water bodies is now encouraged or required for most types of development, and buffers will play an increasing role in maintaining healthy wildlife populations and allowing these animals to move freely.

Buffers Help to Dissipate Floodwaters

The impervious surfaces created with development alter the hydrology of a watershed. Surface runoff creates higher and faster peak floodwaters. Buffers absorb and help break the force of high-velocity floodwaters that overflow their banks. The higher the velocity of the flow, the higher the ability to cause property damage. Therefore, maintaining woody stems and trunks can aid in protecting landscapes and structures. By comparison, grass covered areas, when submerged underwater, do not impede flow at all (Palone & Todd, 1998).

Buffers Help to Stabilize Banks

Vegetated buffers help to stabilize the banks of streams, rivers, lakes and ponds. Roots hold bank soil together, while trunks and stems protect banks by absorbing the erosive energy of water flow, waves, ice and boat wakes. Although not often thought of, the constant cutting action of boat wakes should not be underestimated, especially for properties located on the shores of recreational lakes or rivers where motorized traffic is heavy. Boat wakes eat away at the shoreline, causing a reduction in lot size and a lowering of property value.

Buffer Width

Ideally, buffers should be designed with one or more purposes in mind, such as capturing pollution, shading streams, providing wildlife habitat or offering privacy to waterfront property owners. In general, the wider the buffer and the more complex the vegetation within it, the more effective it is in meeting those purposes. However, the capacity of a vegetated buffer to meet its intended purposes depends on several site-specific factors. To capture pollution, those factors include land use, soil type, slope, buffer width and vegetative mix within the buffer. To provide wildlife habitat, those factors include the buffer width, vegetative mix within the buffer and wildlife value of the water body along which the buffer is located. To provide privacy, those factors include location, vegetative mix and density.

No one buffer width can satisfy all needs. For example, a narrow buffer of trees, 15-20 feet in width, can adequately shade a small stream, and it may be wide enough to act as a travel corridor for small animals. But such a simple and narrow buffer is probably not wide enough or complex enough to adequately capture pollutants from intensive land uses or to provide habitat for most animal species. This is because a narrow line of trees may be only one mature tree in width. Adding a mix of shrubs and herbaceous vegetation will greatly increase its ability to capture pollution and provide habitat.

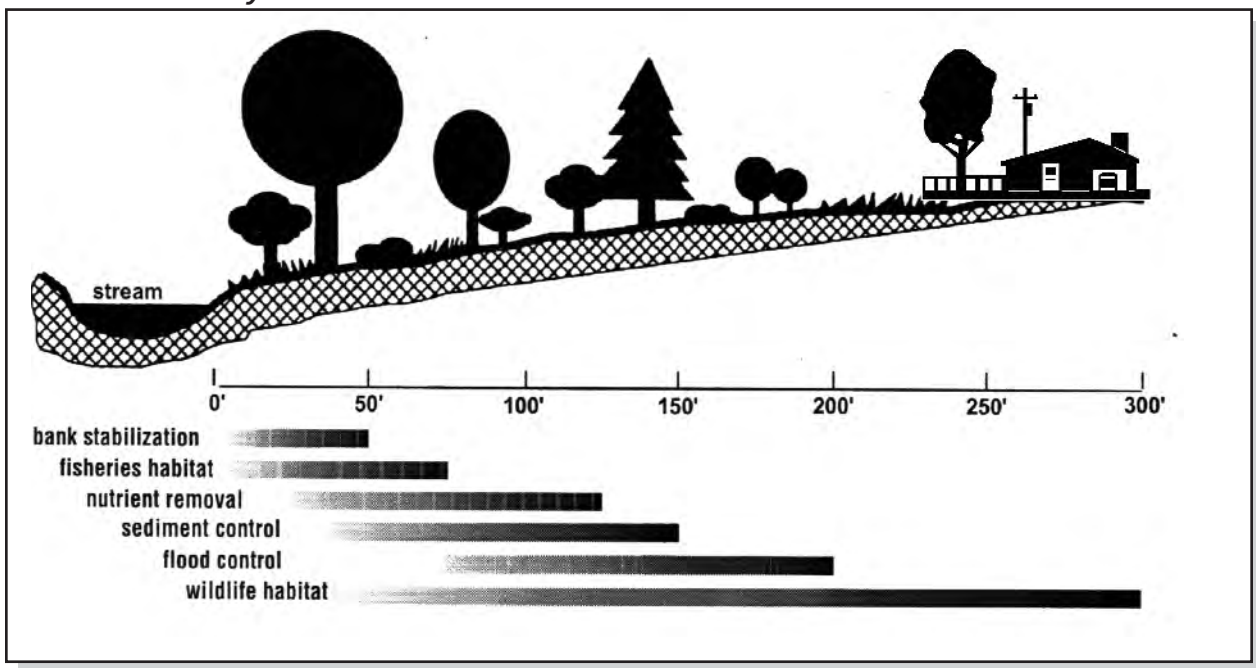
That said, there does seem to be some consensus that a 100-foot width for buffers is an acceptable standard to adopt. However, land uses that generate high pollutant loads adhered to sediment, such as from intense development, tilled agricultural fields or concentrated livestock operations, will require a fairly wide buffer (at least 100-150 feet) of mixed forest, shrubs and grass. Low-density residential development, such as modest cottages on lots no smaller than one acre and with limited impervious area, may only require 35-50 feet of buffer (Palone & Todd, 1998). Buffer width should be increased for areas where stormwater runoff is unnaturally high due to human activity (land uses are intense, impervious surface cover is high, soils are heavily compacted), or where slopes are steep (greater than 15%) and soils are highly erosive.

There have been dozens of studies conducted on the effectiveness of buffers in capturing pollution and providing wildlife habitat, and their results are varied. Most scientific studies focus on a very select site and collect detailed data. Some of the findings are transferable to other sites and situations and others are not. A summary of some of these studies, their findings and their complete references can be found at the end of this appendix. As can be seen in the table, the recommended widths for sediment removal alone range from 25 to 375 feet.

One of the most important scientific criteria for determining buffer size and vegetative mix is to identify the impacts that the buffer is expected to mitigate. Proper buffer size to mitigate different types of nonpoint source pollution or to provide wildlife habitat varies widely. For example, a relatively narrow buffer of forest will help to stabilize banks and shorelines and provide some shading of the water, but it will not have the area needed to retain stormwater for pollution removal or the width to allow a canopy diverse enough to create a self-sustaining

ecosystem. A general summary of minimum buffer widths needed to perform specific functions is found below. Please note that these estimates are very general and are meant to provide a comparative overview of functions and buffer width recommendations. These estimates should not be accepted as absolute truths.

General Summary of Recommended Buffer Widths



Adapted from CRJC, 2000.
Source: http://www.crjc.org/buffers

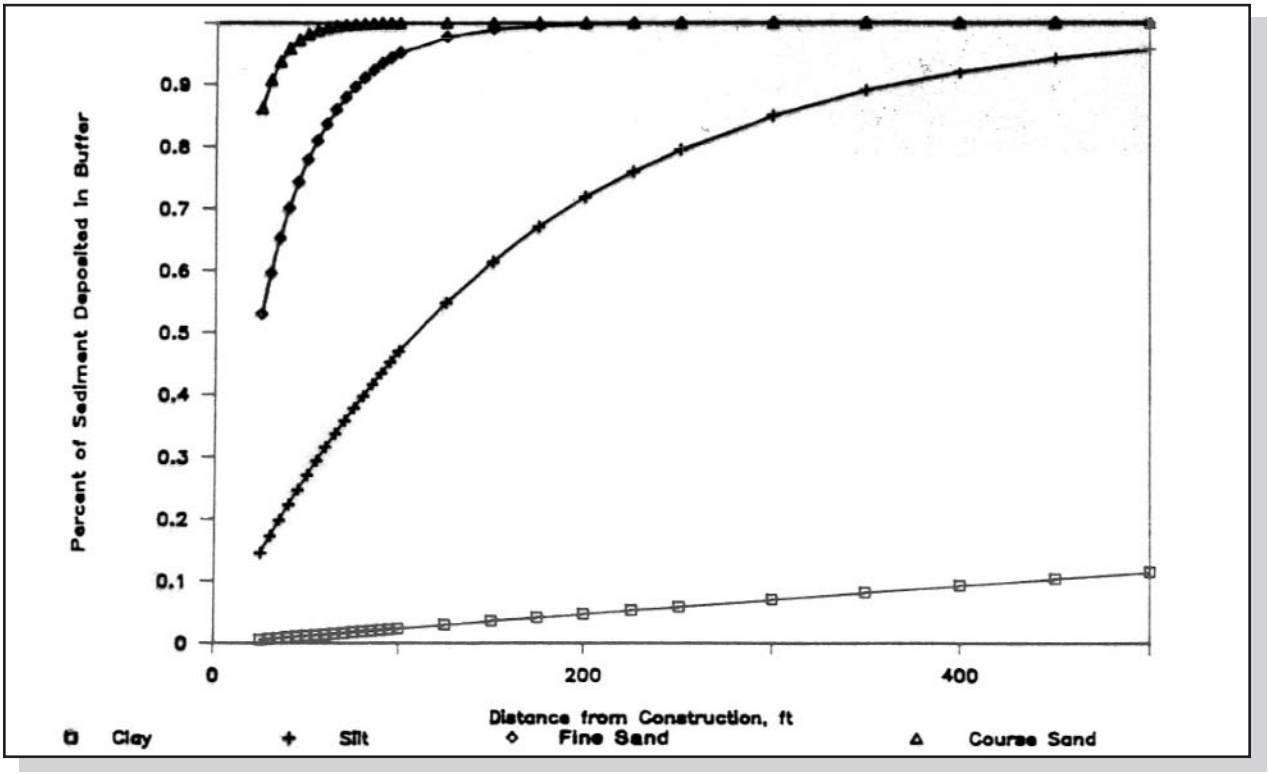
The true effectiveness of a buffer in removing pollutants varies, depending on site-specific conditions, such as land use, pollutant content, soil, slope, and vegetated cover. The interaction of all these things influences how water flows through the buffer (surface and subsurface) and how long it is detained within the buffer before reaching the water body. The dynamic interrelationship between these conditions is complex and not easily determined without long and thorough research. The effectiveness of a buffer in supporting wildlife habitat depends on the needs of the target species or community.

Width and Sediment Removal

In general, sediment capture (and inherently its adhered nutrient and pesticide load) will increase with the width of the buffer, as runoff is impeded by vegetation and leaf litter. However, the exact amount of deposition depends in part on runoff volume, particle size and roughness of the ground's surface. The East Florida Regional Planning Commission developed a predictive methodology to determine buffer width based upon sediment composition. Although soils and topography of Florida and Massachusetts may not be identical, the commission's work does illustrate the correlation between particle size and buffer width. For instance, coarse sand,

which is relatively large and heavy, is the first to settle out, and vegetated buffers are often able to capture almost all of it within 100 feet. The coarser grades of sediment are those often generated during the construction phase of development. In sharp contrast, clays, which remain suspended in water longer due to their minute size, require almost 500 feet for a mere 10% capture rate.

Sediment Trapping and Buffer Width (USDA, 1975)



Source: Chase et al., 1997.

The vast majority of phosphorus within stormwater runoff is carried on sediment particles; most pesticides in common use also adhere to sediment. It is for this reason that sediment removal is the main focus of the Massachusetts Stormwater Management Policy, which requires that development projects incorporate measures to retain or remove 80% of total suspended solids from post-construction stormwater runoff. The illustration above clearly illustrates that the first 100 feet of buffer is the most critical for retaining sands and silts, and that the second 100 feet remains important for retaining silts and clays but not so much sands.

As discussed earlier, stormwater has a tendency to concentrate and flow in channels, most seriously as the slope of the site increases. While studies have shown that 100-foot buffers are adequate for retaining sediment, this efficiency decreases as slope increases. This is because channeled stormwater flows rapidly through the buffer, bypassing the physical, biological and chemical processes that retain pollutants within the buffer area. Buffers of 100-feet are often 3

to 5 mature trees wide. One-hundred-foot buffers that have a mixture of trees at different stages of development can be as many as 8 to 10 trees in width (Palone & Todd, 1998). As stated earlier, a complex mixture of trees, saplings, shrubs and forbs has the highest capacity for retaining nonpoint pollution and supporting wildlife.

Designing a buffer with a grassed filter strip upland of the buffer, between it and developed areas, will help to deliver runoff to the buffer as sheet flow. Therefore, modest-sized lawns around residential or commercial development are not necessarily inappropriate when a vegetated buffer along the waterfront is maintained. It is important, however, that the lawns themselves not become sources of pollution, so the use of fertilizers and pesticides should be minimized.

Width and Wildlife

Plant communities can be viewed in terms of their internal complexity. Complexity includes the number of layers of vegetation and the species composing each layer, competitive interactions among species, and the presence of detrital components, such as litter, downed wood, and snags. Complexity also includes a variety in plant height. Simple vegetative structure, such as an herbaceous layer without woody overstory or canopy, creates fewer niches for wildlife. Similarly, canopy with little ground cover or with few lower branches or foliage provide fewer niches. Low-level branches provide cover and a place for songbirds to escape from predators. The fewer niches there are, the fewer wildlife species there are. Thus, the more complex the vegetation, in species and height, the more opportunities there are for viewing a variety of wildlife.

Buffer widths for providing habitat for wildlife vary greatly, depending on the species. In general, the wider the buffer and the more complex the vegetation, the more valuable it is to wildlife. Buffers of 100 feet have been shown to provide adequate travel corridors for migratory songbirds when the buffers are connected to existing patches of woodland (Palone & Todd, 1998). However, buffer widths of 100-300 feet are needed to provide reliable habitat for migratory songbirds or to provide travel corridors for large mammals, such as deer, moose and bear. The table on page A-16 summarizes what a 100-foot forested buffer is likely to provide for several commonly found Massachusetts animals.

There are many animal species that normally remain within 100 feet of the water's edge, such as painted turtles, dusky salamanders, green frogs and bullfrogs. However, the buffer should be wide enough to provide cover and food for those animals, especially juveniles, who need to disperse to new territories. Upland-dwelling amphibians that spend the vast majority of their lives in the forest (wood frogs, spring peepers and several salamander species) travel several hundred feet or more from their breeding pool. The Jefferson salamander, for example, will travel as far 1 mile to forage. Many large mammals (black bear, bobcat and moose) and many raptors (hawks, owls, and falcons) require very large areas for home ranges. The average 100-foot buffer cannot accommodate such extensive areas, but may provide travel corridors for animals traveling between larger expanses of unbroken habitat (Chase et al, 1997).

Overview of wildlife habitat functions within a 100-foot Buffer

Wildlife	What a 100' buffer provides	What a 100' buffer does not provide
Stream invertebrates (bottom of the food web) and fish	shading; bank stability; organic debris; prevention of siltation and excess nutrients	adequate floodwater abatement
Eastern spotted newt	probably maintain water quality of wetlands and surface waters; habitat for breeding	habitat for dispersing terrestrial juveniles (efts); travel for adults
Four-toed salamander	habitat for breeding and most activity	cover for dispersal routes to neighboring wetlands
Northern dusky salamander	habitat for breeding and most activity	dispersal habitat
Northern two-lined salamander	habitat for breeding and most activity	foraging area – adults may wander 330 ' on rainy nights; dispersal of juveniles (only 25% return to natal waters)
Green frog	habitat for breeding and most activity	dispersal habitat
Wood frog	breeding habitat (if buffer protects vernal pool)	habitat for most of terrestrial lifestyle, which is often several hundred feet from water
Spotted turtle	large organic debris; invertebrate and small vertebrate prey; streambank stability; protective cover near water; winter hibernating habitat	habitat for most terrestrial activity – will travel up to ½ miles (2,680') from water to find temporary food sources
Wood turtle	large organic debris; invertebrate and small vertebrate prey; streambank stability; protective cover near water; spring basking and winter hibernating habitat	habitat for most activities; hatchlings usually stay within 130' of water; spend most of time within 1,000' of water, but will travel up to 1 miles to search for food; nests up to 330' away from water
Mink	most foraging habitat and den sites	hunt up to 600' from the water; den sites can be up to 330' away from water
Black bear	foraging, especially in lowland wet areas which provide early spring greens; cover; travel corridors	den sites; habitat for most activities – males need up to 19 square miles (depending on habitat & food sources)
Bald eagle	foraging; perching; roosting sites	protection from human disturbance; nest sites - most eagle nests are within 1,300' from water

Source: Chase, et al., 1997.

Fixed or Variable Widths

There are two principal ways by which most buffer widths are defined: 1) the width may be set as a fixed distance from the water or 2) the width may be variable depending on specific site features or needs. Standard "fixed width" buffers are typical in the context of protective regulatory programs, because they are simple to understand and relatively simple to implement and administer. Minimum width protective areas, such as the 100-foot buffer zones and the 200-foot Riverfront Area cited in the Massachusetts Wetland Protection Act, have been developed using scientific evidence on vegetated buffer functions and public acceptance of their legitimacy. Fixed buffer widths in common use across the country range from 25 to 300 feet or more (Palone & Todd, 1998). Where political compromise has resulted in the establishment of narrow minimum buffer widths, the public may be given a false perception that a stream or lake is protected when, in fact, serious threats from pollution and loss of habitat still exist. Unless fixed-width approaches are conservative and establish buffer widths that would be effective under the worst-case scenario (e.g. steep slopes, erosion-prone soils, land uses generating high concentrations of pollutants), they will offer inadequate protection for some water bodies. On the other hand, if they are too conservative, it may result in unnecessarily wide buffers for many situations and may be rejected by the public (Haberstock, et al., 2000).

"Variable width" approaches attempt to integrate scientifically acknowledged buffer functions with local and site-specific conditions. Variable width buffers are better able to protect desired buffer functions in a customized and flexible manner when incorporating local site conditions. The width of the buffer depends not only on the minimum width needed for a specific function, but also on the sensitivity and characteristics of the water body on which it located. However, the vast majority of development within a water body's watershed occurs on private land and, because variable buffer design is based on the scientific evaluation of each situation, it is unrealistic to determine variable minimum widths for each situation. Probably more realistic is the adoption of a minimum buffer width, such as 100 feet, with the understanding that additional width may be required under unusual or extreme conditions relating slope, soils, and intensity of land use.

In sum, vegetated buffers are a relatively cost-effective way to protect water quality and provide wildlife habitat. In addition, they can provide waterfront property owners with an array of benefits, including added privacy, determent of geese and increased property values. Entertain the idea of planting a buffer on your property or on a public property to protect your river, stream, lake or pond.

Summary of Studies conducted on Buffer Width and Effectiveness

Author(s) and citation	***Functions Protected***	***Range of Buffer Widths Recommended (in feet)***	***Average Range (feet)***
Rogers, Golden, Halpern, 1988. *Wetland Buffer Delineation Method*, NJ Dept. of Environmental Protection, Pub. No. CN 401, Trenton, NJ.	Water Quality – nontidal. Wetlands - intermediate	25 – 50	37
Budd, W.W., Cohan, P.L., Saunders, P.R., 1987. "Stream Corridor Management in the Pacific Northwest: I. Determination of Stream Corridor Widths," *Environmental Management*, Vol. 11, No. 5:587– 597.	Water quality, temp. control, wildlife habitat, stream corridor	25 – 50	37
Swift, L.W. 1986. "Filter Strip Widths for Forest Roads in the Southern Appalachians," *Southern J. of Applied Forestry,* 10: 27-34.	Water quality (sediment), filter strips for logging w/ brush barrier	32' – 64	48
Palmstrom, N. 1991. *Vegetated Buffer Strip Designation Method Guidance Manual.* I.E.P., Inc. Consulting Environmental Scientists.	Water quality (subsurface)	50	50
Brown, Brazier, 1972. (in Palfrey, R., Bradley, E., 1981. *Natural Buffer Areas: An Annotated Bibliography*. Coastal Resources Div., Tidewater Admin., MD Dept. of natural Resources.).	Stream temp.	55 - 80	67
Castelle, A.J., et al., 1992. *Wetland Buffers: Use and Effectiveness*. Adofson Assoc. Inic., Shoreland and Coastal Zone Management Program, Wash. Dept. of Ecology, Olympia, Pub. No. 92-10.	Water quality, temp. control, review of other literature	49 - 98	74
Trimble, G.R. Jr., Sartz, R.S., 1957. " How Far from a Stream Should a Logging Road be Located?", *J. of*	Water quality (sediment), filter strip for logging, general situations, slope dependent	25 - 165	95

Summary of Studies conducted on Buffer Width and Effectiveness

Author(s) and citation	***Functions Protected***	***Range of Buffer Widths Recommended (in feet)***	***Average Range (feet)***
Swift, L.W., 1986. "Filter Strip Widths for Forest Roads in the Southern Appalachians," *Southern J. of Applied Forestry,* 10: 27-34.	Water quality (sediment), filter strips for logging, w/out brush barrier	43 - 154	99
Pinay, G., Roques, L.., Fabre, A.. 1993. "Spatial and Temporal Patterns of Denitrification in a Riparian Forest," *J. of Applied Ecology* 30: 581-591.	Water quality (nitrate removal), winter conditions	100	100
Stauffer, D.F., Best, L.B., 1980. "Habitat Selection by Birds of Riparian Communities: Evaluating Effects of Habitat Alteration," *J. Wildlife Management*, 44: 1-15.	Breeding birds	11 - 200	106
Rogers, Golden, Halpern , 1988. *Wetland Buffer Delineation Method*, NJ Dept. of Environmental Protection, Pub. No. CN 401, Trenton, NJ.	Water quality	75 - 150	113
Welsch, 1991. *Riparian Forest Buffers, USDA, Forest Service*, NA-PR-07-91, Radnor PA.	Water quality, riparian forest buffer	95 - 150	123
Erman, 1977 (in Palfrey, R., Bradley, E., 1981. *Natural Buffer Areas: An Annotated Bibliography*. Coastal Resources Div., Tidewater Admin., MD Dept. of Natural Resources.)	Water quality (sediment)	150	150
Phillips, J.D. 1989. "Nonpoint Source Pollution Control effectiveness of Riparian Forests along a Coastal Plan River," *J. of Hydrology*, 110:221-127.	Water quality control along a coastal plain river (uses model)	49 - 260	155
Palmstrom, N. 1991. *Vegetated Buffer Strip Designation Method Guidance Manual.* I.E.P., Inc. Consulting Environmental Scientists.	Water quality (sediment)	25 - 300	163

Summary of Studies conducted on Buffer Width and Effectiveness

Author(s) and citation	***Functions Protected***	***Range of Buffer Widths Recommended (in feet)***	***Average Range (feet)***
Roman, C.T., Good, R.E., 1985. *Buffer Delineation Method for New Jersey Pineland Wetlands*, Rutgers, State Univ. of New Jersey. New Brunswick, NJ.	General	50 - 300	175
Nieswand, G.H, et al., 1990. "Buffer Strips to Protect Water Supply Reservoirs: A Model and Recommendations," *Water Res. Bull.,* 26: 959-966.	Water quality	45 - 300	183
Brown, M.T., Schaefer, J.M., and Brandt, K.H. 1990. *Buffer Zones for Water, Wetlands, and Wildlife*. CFW Pub. #89-0, Florida Agricultural Experiment Stations Journal Series No. T-00061. East Central Florida Regional Planning Council.	Water quality (sediment)	75 - 375	225
Clark, 1977 (in Palfrey, R., Bradley, E., 1981. *Natural Buffer Areas: An Annotated Bibliography*. Coastal Resources Div., Tidewater Admin., MD Dept. of Natural Resources.)	Nutrient removal	150 - 300	225
Castelle, A.J., Johnson, A.W., Conolly, C., 1994. "Wetland and Stream Buffer Size Requirements – a Review," *J. of Environmental Quality*, 23: 878-882.	Review of buffer literature	varies	varies

Source: Chase, et al, 1997.

Appendix

B

Native Plant List For Vegetated Buffers in New England

NATIVE TREES for Riparian Buffers in the Upper Connecticut River Valley of New Hampshire and Vermont

NAME	DECID/ EVERGR	MATURE HEIGHT	GROWTH RATE	ROOTING	LIGHT PREFERENCE		SOIL PREFERENCE			WILDLIFE HABITAT & FOOD VALUE	ORNAMENTAL VALUE	BANK STABILIZING VALUE	HARDINESS ZONE
					full/ part shade	full sun	dry	moist	flood tolerant				
Silver maple *Acer saccharinum*	d	60'	moderate	shallow	x	x		x	x	low - moderate; provides cover	silvery foliage	very good, esp. for flood chute	4
Box elder *Acer negundo*	d	40-70'	very fast	deep lateral		x	x	x	x	low - seeds eaten; provides cover		very good, esp. for flood chute	3
Pagoda dogwood *Cornus alternifolia*	d	15'	fast	shallow	x	x		x		high - fruits eaten by many birds inc. bluebirds, turkey, grouse	elegant branching habit; white flowers	very good	3
Black willow *Salix nigra*	d	50'	very fast	very shallow		x		x	x	high - cover for nesting	new foliage is attractively colored	excellent, esp. for flood chute	3
Red maple *Acer rubrum*	d	40-75'	moderate to fast	very shallow		x	x	x	x	high - seeds, buds eaten by birds & mammals	early red flowers, bright fall color	very good	3
Striped maple *Acer pensylvanicum*	d	20-35'	moderate	shallow	x			x		low - moderate	white striped bark attractive all seasons		3
Sugar maple *Acer saccharum*	d	60-100'	slow	shallow	x	x		x		moderate - seeds and buds eaten by large & small mammals, seeds eaten by grosbeaks & finches	excellent fall color, attractive shape		3
American beech *Fagus grandifolius*	d	70-90'	slow	shallow	x	x	x	x		high - nuts valued by large and small mammals, turkey; favorite tree for black bears	smooth gray bark in winter, copper fall color		3
Black cherry *Prunus serotina*	d	40-60'	moderate	deep taproot	x		x			high - berries eaten by many songbirds, mammals, inc. thrushes, foxes, bears, raccoons; avoid planting near areas used by livestock	flowers, attractive reddish brown bark; *however,* prone to tent caterpillar		3
Wild plum *Prunus nigra*	d	25'	moderate	shallow	x	x	x	x		moderate	early white flowers, attractive black bark; handsome fall foliage		3
American mountain ash *Sorbus americana*	d	25'	fast	shallow	x	x	x	x		high - early fruit eaten by grosbeaks, bluebirds	attractive shape, good for small lawns; brilliant orange red fall foliage, showy white flowers, clusters of bright red or orange berries		3
Shadbush, serviceberry *Amelanchier laevis*	d	15-25'	slow	shallow	x	x	x	x	x	high - berries eaten by many songbirds; bluebirds, cardinals, orioles, thrushes	masses of early white flowers, berries, bright fall color; effective screening		4
Black walnut *Juglans nigra*	d	50-75'	moderate	very deep	x			x		high - nuts eaten by mammals; plant away from edge of water and from gardens: a chemical in the roots and husks of nuts affects fish and many garden plants	edible nuts, attractive shape		4
Northern red oak *Quercus rubra*	d	60-80'	moderate	deep lateral	x	x	x	x		high - acorns for bear, raccoon, turkey, grouse; favored by hawks for nesting	attractive shape, fine fall color		3
Yellow birch *Betula allegheniensis*	d	60-90'	slow	shallow/ moderate	x		x	x		high - seeds favorite winter food of pine siskins and redpolls; also snowshoe hare; used by hawks for nesting	shining golden bark		3

NAME	DECID/ EVERGR	MATURE HEIGHT	GROWTH RATE	ROOTING	LIGHT PREFERENCE		SOIL PREFERENCE			WILDLIFE HABITAT & FOOD VALUE	ORNAMENTAL VALUE	BANK STABILIZING VALUE	HARDINESS ZONE
					full/ part shade	full sun	dry	moist	flood tolerant				
Paper birch *Betula papyrifera*	d	50-75'	fast	shallow		x	x	x		moderate - seeds eaten by grouse, siskins; buds by small mammals	attractive white bark (avoid planting in public areas to avoid problem of bark stripping)		3
Grey birch *Betula populifolia*	d	20-35'	fast	shallow			x	x		moderate - seeds, buds	gray bark		3
Black birch *Betula lenta*	d	50-75'	moderate	shallow	x			x		moderate - catkins, seeds	reddish brown bark		4
Hophornbeam *Ostrya virginiana*	d	25-50'	slow	shallow	x	x	x	x		moderate - seeds	yellow fall color; red bark		4
American hornbeam *Carpinus caroliniana*	d	20-30'	slow	moderate	x	x	x	x	x	moderate - seeds eaten by birds, squirrels	gray bark, fall color		3
White ash *Fraxinus americana*	d	70-100'	moderate	shallow	x	x		x	x	moderate	purple fall color		3
Green ash *Fraxinus pennsylvanica*	d	60-80'	fast	shallow	x	x		x	x	low	purple fall color	very good	3
Black ash *Fraxinus nigra*	d	60-80'	moderate	shallow	x			x	x	moderate	wood used for splint baskets	excellent	3
Basswood *Tilia americana*	d	70-80'	moderate	deep	x	x		x		moderate	attractive foliage and shape		3
Balsam poplar *Populus balsamea*	d	60-80'	fast	shallow		x	x	x		low	can be brittle and drop branches	very good	3
Eastern cottonwood *Populus deltoides*	d	80-100'	fast	shallow		x	x	x	x	low - grouse browse catkins	can be brittle and drop branches		3
Quaking aspen *Populus tremuloides*	d	40-60'	fast	shallow		x	x	x		moderate - beaver, porcupine, deer; favorite food of beaver and snowshoe hare; buds important to grouse	can be brittle and drop branches; fluttering gray-green leaves		3
White pine *Pinus strobus*	e	70-100'	moderate	shallow		x	x	x		high - food & cover for birds & mammals, inc. crossbills and cardinals	feathery foliage; good year-round screen		3
Red pine *Pinus resinosa*	e	50-80'	moderate	shallow		x	x	x		moderate	orange-red bark; good year-round screen		4
White spruce *Picea glauca*	e	40-70'	moderate	shallow	x	x	x	x		moderate - seeds	foliage; windbreak, screen		3
Balsam fir *Abies balsamea*	e	50-75'	fast	shallow		x		x	x	high - seeds; bird roosting, nesting	fragrant, glossy foliage, attractive habit, Xmas trees		3
Hemlock *Tsuga canadensis*	e	40-70'	moderate	shallow lateral	x		x	x		moderate - winter deer cover, seeds eaten by small mammals, chickadees, siskins, crossbills, grouse; nesting cover for warblers	attractive foliage, habit; screen		3
Northern white cedar *Thuja occidentalis*	e	25-50'	slow/mod	shallow		x		x	x	moderate - winter cover	attractive foliage; screen		3
Tamarack *Larix laricina*	d	40-80'	variable	moderate		x		x	x	high	pale new foliage; yellow fall color		3

from *Riparian Buffers for the Connecticut River Watershed*, Connecticut River Joint Commissions, 2000

NATIVE SHRUBS for Riparian Buffers in the Upper Connecticut River Valley of New Hampshire and Vermont

NAME	DECID/ EVERGR	MATURE HEIGHT	GROWTH RATE	LIGHT PREFERENCE		SOIL PREFERENCE			WILDLIFE HABITAT & FOOD VALUE	ORNAMENTAL VALUE	BANK STABILIZING VALUE	HARDINESS ZONE
				full/ part shade	full sun	dry	moist	flood tolerant				
Silky dogwood *Cornus amomum*	d	6-10'	fast	x	x	x	x	x	high - fruits eaten by birds & mammals; cover	purple twigs	excellent	4
Grey dogwood *Cornus racemosa*	d	10'	moderate	x	x	x	x		very high - fruit eaten by grouse and pheasant	small whitish flower cluster, white fruits	very good	4
Red osier dogwood *Cornus sericea, ssp. stolonifera*	d	4-8'	fast	x	x		x	x	high - whitish fruit eaten by birds	bright red stems attractive in winter; white flowers	very good	3
Willows *Salix spp.*	d	4-10'	fast		x		x	x	high - provides good cover	foliage	excellent	3
Pussy willow *Salix discolor*	d	20'	fast		x		x	x	moderate - nesting; buds eaten; male flowers attract butterflies	early buds are used in horticultural arrangements	excellent	3
Buttonbush *Cephalanthus occidentalis*	d	6-12'	moderate	x	x		x	x	moderate - high; nectar used by hummingbirds; waterfowl eat seed	white pom-pom like flower clusters; glossy foliage	excellent	4
Highbush blueberry *Vaccinium corymbosum*	d	6-12'	slow	x	x	x	x	x	high - fruits eaten by birds & mammals; favorite of scarlet tanagers, bluebirds, grouse	flowers, fruits, bright fall color, attractive habit		3
Lowbush blueberry *Vaccinium angustifolium*	d	1 -2'	slow	x	x	x	x		high - fruits eaten by birds and mammals	flowers, fruits, scarlet fall color, good ground cover		3
Black chokeberry *Aronia melanocarpa*	d	10'	moderate	x	x	x	x	x	very high - fruits	purple fruits, purple fall color		4
Pin cherry, bird cherry *Prunus pennsylvanica*	d	30'	fast		x	x			high - fruits used by birds	shining dark red bark, white flower clusters, red fruits		3
Chokecherry *Prunus virginiana*	d	15-25'	moderate	x	x	x	x		moderate - fruits, cover	flowers, fruits, good fall color		3
American cranberry bush *Viburnum trilobum*	d	10'	slow to moderate	x	x	x	x	x	high - fruits persist into winter	white flower clusters, scarlet fruits, good fall color		3
Wild raisin, witherod *Viburnum cassinoides*	d	6-10'	moderate	x			x	x	high - fruit eaten by grouse, songbirds; rabbits & deer browse twigs	white flowers, edible blue-black fruits, good fall color		4
Nannyberry *Viburnum lentago*	d	10-20'	moderate	x	x	x	x		high - fruits remain into winter	fruits, good fall color		3
Northern arrowwood *Viburnum recognitum*	d	10-15'	moderate	x	x		x	x	moderate - fruits eaten by birds; nesting	flowers, blue fruits, good fall color		3
Maple-leaf viburnum *Viburnum acerifolium*	d	3-6'	moderate	x	x		x		moderate - fruits eaten by birds	fruits, attractive foliage, good fall color		3
Hobblebush *Viburnum alnifolium*	d	10'	moderate	x			x	x	moderate - fruits eaten by birds	very showy white flower clusters in halo arrangement; purple fall color; open habit		4
Winterberry holly *Ilex verticillata*	d	6-10'	slow	x	x		x	x	high - fruits eaten by flickers, thrushes, cedar waxwings, also birds in winter	attractive bright red berries persist into winter, make excellent Xmas decorations		3
Inkberry holly *Ilex glabra*	e	6-8'	slow	x	x		x	x	high - fruits eaten by songbirds, turkey, grouse	leathery evergreen foliage; black fruits		4

NAME	DECID/ EVERGR	MATURE HEIGHT	GROWTH RATE	LIGHT PREFERENCE		SOIL PREFERENCE			WILDLIFE HABITAT & FOOD VALUE	ORNAMENTAL VALUE	BANK STABILIZING VALUE	HARDINESS ZONE
				full/ part shade	full sun	dry	moist	flood tolerant				
Sheep laurel *Kalmia angustifolia*	semi-e	4'	slow	x	x	x	x	x	(poisonous to livestock)	very showy pink-red flowers		3
Elderberry *Sambucus canadensis*	d	12'	moderate	x	x		x	x	very high - berries an important summer food for songbirds inc. bluebirds, rose-breasted grosbeaks, pileated woodpeckers, thrushes	showy white flower clusters; blue berries; jelly and wine can be made from berries	very good	3
Sweet pepperbush *Clethra alnifolia*	d	8'	moderate	x	x		x	x	high - fruits	white flowers		4
Hazelnut *Corylus americana*	d	10'	moderate	x	x		x		high - nuts eaten by mammals, grouse, pheasant	edible nuts		3
Beaked hazelnut *Corylus cornuta*	d	6-10'	moderate	x	x		x		high - beaked nuts used by both mammals & birds	good for hedges; edible nuts		5
Speckled alder *Alnus rugosa*	d	15-25'	fast		x		x	x	moderate - buds & twigs browsed by muskrat, rabbits, moose, deer, beaver, grouse	tiny cones make Xmas decorations	very good	3
Spicebush *Lindera benzoin*	d	12'	moderate		x		x	x	high - many mammals and birds eat fruits, buds, & twigs; attracts swallowtail butterflies	spicy scented flowers and leaves; shiny red fruits		5
Witch hazel *Hamamelis virginiana*	d	20-30'	slow	x	x		x		moderate	yellow flowers in autumn after leaves fall		4
Rhodora azalea *Rhododendron canadense*	d	3-4'	slow		x		x	x	low	very showy rose purple flowers before leaves		3
Swamp azalea *Rhododendron viscosum*	d	5'	moderate	x	x		x	x	low	glossy leaves, very showy white - pink flowers		5
Early azalea *Rhododendron roseum*	d	10'	slow	x		x	x		low	very showy white or pink flowers		4
Blackberry *Rubus allegheniensis*	d	6'	fast		x	x	x	x	very high - fruits eaten by over 40 species of birds inc. woodcock, turkey, grouse; also by many mammals	makes good barrier		3
Raspberry *Rubus idaeus*	d	6'	fast	x	x	x	x		same as above - fruits eaten by many mammals & birds	makes good barrier		3
Meadowsweet *Spiraea latifolia*	d	5'	moderate		x		x		low	white or pale pink flowers	very good	2
Steeplebush *Spiraea tomentosa*	d	4'	moderate	x	x		x	x	low	spires of pink flowers		3
Staghorn sumac *Rhus typhina*	d	20'	fast	x	x	x			very high - fruits late winter survival food for mammals and migrating songbirds; twigs eaten by moose, deer, N E cottontail rabbit	colorful fruit clusters, brilliant fall color; velvet covered branches	good	3
Smooth sumac *Rhus glabra*	d	9-15'	fast		x	x			high - fruits	red fruit clusters, orange-red fall color		3
Sweet gale *Myrica gale*	d	2-4'	slow		x		x	x	moderate - grouse eat buds and leaves; deer browse	aromatic foliage		3
Sweetfern *Comptonia peregrina*	d	2-4'	slow-moderate	x	x	x			moderate - grouse, deer feed on foliage	gray green aromatic fern-like leaves		3
Pasture juniper *Juniperus communis*	e	1-4'	slow		x	x			moderate - food for grouse, pheasant, deer, moose, small mammals, & birds	foliage; good ground cover		3

from *Riparian Buffers for the Connecticut River Watershed*, Connecticut River Joint Commissions, 2000

NATIVE GROUND COVERS, Vines, and Herbaceous Perennials for Riparian Buffers in the Upper Connecticut River Valley of New Hampshire and Vermont

NAME	DECID/ EVERGR	HT	LIGHT PREFERENCE		SOIL PREFERENCE			WILDLIFE HABITAT & FOOD VALUE	ORNAMENTAL VALUE
			full/part shade	full sun	dry	moist	flood tolerant		
Riverbank grape *Vitis riparia*	d	25'	x	x		x	x	very high - fruits a favorite of turkeys, grouse, wood duck, pileated woodpeckers, & mammals inc. bear	vines useful for making wreaths
Virginia creeper, woodbine *Parthenocissus quinquefolia*	d	25'	x	x	x	x		moderate - provides cover; pileated woodpecker, crested flycatcher, vireo	foliage - good cover for walls and rockpiles when leafed out
Partridge berry *Mitchella repens*	e	2"	x		x	x		high - berries eaten by grouse & mammals	dark green, glossy foliage; paired white flowers in June; bright red berries in late summer, fall
Bearberry *Arctostaphylos uva-ursi*	e	1'		x	x			high - fruits	handsome foliage; good ground cover
Wintergreen *Gaultheria procumbens*	e	4"	x			x		high - fruits	flowers, fruits, glossy aromatic foliage
Blue flag iris *Iris versicolor*	d	1-3'		x		x	x	low	showy purple-blue flowers in late spring
Milkweed *Asclepias tuberosa*	d	2		x		x		very high - one of most important butterfly plants; monarchs rely exclusively on it; hummingbirds & many other insects use flower nectar	fragrant pink-purple flowers; distinctive seed pods useful for decorations
Blue-eyed grasses *Sisyrinchium spp.*	d	1'		x	x	x		low	stiff, grass-like plants with blue-violet flowers
Ginseng *Panax quinquefolius*	d	8-16"	x			x		low	woodland wildflower of pharmaceutical interest. Wild populations are suffering from over-collecting, but cultivated plants could be harvested from a forested riparian buffer.
Bunchberry *Cornus canadensis*	e	6"	x			x		high - fruits eaten by birds and mammals	showy white spring flowers and red summer berries, purplish fall color; excellent ground cover
Foamflower *Tiarella cordifolia*	d	1'	x			x		low	small star-like flowers in a loose spike
Twinflower *Linnaea borealis*	e	6"	x			x		low	trailing plant; white and pink paired flowers
Marsh marigold *Caltha palustris*	d	1-2'		x		x	x	low	early yellow flowers
Whorled loosestrife *Lysimachia quadrifolia*	d	4'	x	x	x	x		low	yellow flowers with red markings; attractive foliage; not related to invasive purple loosestrife
Cardinal flower *Lobelia cardinalis*	d	2-4'		x		x	x	moderate - hummingbirds attracted to flowers	brilliant red flowers
Blue false indigo *Baptisia australis*	d	3-4'	x	x	x	x		low	large dark blue or violet flowers
Joe pye weed *Eupatorium purpureum*	d	5-6'		x		x	x	high - butterflies are attracted to flowers	large flat-topped cluster of fuzzy purple flowers
Boneset *Eupatorium perfoliatum*	d	4-6'		x	x	x		high - attracts butterflies & other insects	white flowers

NAME	DECID/ EVERGR	HT	LIGHT PREFERENCE		SOIL PREFERENCE			WILDLIFE HABITAT & FOOD VALUE	ORNAMENTAL VALUE
			full/part shade	full sun	dry	moist	flood tolerant		
Wild lupine *Lupinus perennis*	d	1-3'		x	x	x		low	purple-blue flower spires in June; attractive foliage
Harebell *Campanula rotundifolia*	d	1'	x		x			low	delicate wildflower with blue-lavender bell shaped flowers
Jewelweed *Impatiens capensis*	d	1-3'	x	x		x	x	high - favored by hummingbirds, butterflies	orange flowers in summer; seed capsules burst when touched; juice of plant said to help defend against exposure to poison ivy
Daisy *Chrysanthemum leucanthemum*	d	1-4'		x	x	x		moderate - seeds favored by finches; common nectar source for butterflies	familiar white ray flower with yellow center
Goldenrod *Solidago* spp.	d	1-5'		x	x	x		moderate - seeds eaten by finches; nectar by butterflies	many species of wildflowers in midsummer to early fall; all except silverrod are yellow
New England aster *Aster novae-angliae*	d	5'		x	x	x		high - seeds used by songbirds; attracts butterflies	late summer/fall purple flowers with yellow centers
Christmas fern *Polystichum acrostichoides*	e	1'	x			x		low	evergreen ground cover; glossy foliage
Hay-scented fern *Dennstaedtia punctilobula*	d	2'	x	x	x	x		low	fragrant light-green foliage; spreads well, forms pure stands; tolerates full sun
Bracken fern *Pteridium aquilinum*	d	2-3'	x	x	x			low	sturdy foliage; tolerates full sun
Cinnamon fern *Osmunda cinnamomea*	d	3-4'	x			x	x	low	vase-shaped clusters; handsome foliage; cinnamon colored fertile fronds
Royal fern *Osmunda regalis*	d	6'	x	x		x	x	low	handsome foliage; new crosiers edible as Òfiddle headsÓ
Interrupted fern *Osmunda claytoniana*	d	3-4'	x			x		low	vase-shaped clusters
Sensitive fern *Onoclea sensibilis*	d	2'	x			x	x	low	fertile fronds used in dried arrangements
Cattail *Typha latifolia*	d	6'		x		x	x	high - seed heads valuable food for birds	strap shaped leaves; brown seed head is distinctive and often used in horticultural arrangements
Reed grass *Calamagrostis canadensis*	d	5'		x		x	x	moderate	attractive grass forms clumps, stabilizes soils well
Pennsylvania sedge *Carex pensylvanica*	d	2'		x	x			low	forms low turf on sunny dry soils
Tussock sedge *Carex stricta*	d	4'		x		x	x	moderate - food for sparrows, grouse, snipe, others	forms clumps or tussocks
Rattlesnake manna grass *Glyceria canadensis*	d	3'		x		x		moderate	grass with delicate and distinctive inflorescence; plant in clusters where no competition by others is likely
Rice cutgrass *Leersia oryzoides*	d	5'		x		x	x	high - food for waterfowl; cover for fish, reptiles, amphibians	attractive seed head
Tufted hair grass *Deschampsia caespitosa*	d	4'				x		moderate	attractive seed head

Appendix

C

Invasive Plant Species Found in Massachusetts

Invasive Plant Species Found in Massachusetts

Many popular plants commonly sold in nurseries and garden centers are actually invasive species, including Norway maple, burning bush, Japanese barberry and Japanese rose. As you design your vegetated buffer, avoid these plants and the plants listed below. This invasive plant list is adapted from *A Guide to Invasive Plants in Massachusetts*, written by Pamela B. Weatherbee, Paul Somers and Tim Simmons and published by the Massachusetts Division of Fisheries and Wildlife

Common Name	Scientific Name
Amur honeysuckle	*Lonicera maackii*
Autumn olive *	*Elaeagnus umbellata*
Barnyard grass	*Echinochloa crusgalli*
Black locust *	*Robinia pseudoacacia*
Black swallow-wort *	*Cynanchum louiseae*
Bittersweet nightshade	*Solanum dulcamara*
Broad-leaved or tall pepper weed	*Lepidium latifolium*
Burning bush or winged enonymus	*Euonymus alata*
Bushy rock-cress	*Cardamine impatiens*
Canada bluegrass	*Poa compressa*
Chervil	*Anthriscus sylvestris*
Coltsfoot	*Tussilago farfara*
Common barberry	*Berberis vulgaris*
Common buckthorn *	*Rhamnus cathartica*
Common or hedge privet	*Ligustrum vulgare*
Common mullein	*Verbascum thapsus*
Common reed *	*Phragmites australis*
Creeping buttercup	*Ranunculus repens*
Curly pondweed *	*Potamogeton crispus*
Cypress spurge	*Euphorbia cyparissias*
Dame's rocket *	*Hesperis mantronalis*
Eurasian water-milfoil *	*Myriophyllum spicatum*
Fanwort *	*Cabomba caroliniana*
Five leaved akebia	*Akebia quinata*
Garlic mustard *	*Alliaria petiolata*
Giant waterweed	*Egeria densa*
Glossy buckthorn *	*Rhamnus frangula*
Goutweed or Bishop's weed *	*Aegopodium podagraria*
Hair fescue	*Festuca filiformis*
Hairy willow-herb	*Epilobium hirsutum*
Japanese barberry *	*Berberis thunbergii*
Japanese honeysuckle *	*Lonicera japonica*
Japanese hop	*Humulus japonicus*
Japanese knotweed or bamboo *	*Polygonum cuspidatum*
Japanese privet	*Ligustrum obtusifolium*
Japanese rose	*Rosa rugosa*
Kiwi vine	*Actinidia arguta*
Kudzu	*Pueraria montana*
Lesser naiad	*Najas minor*

Common Name	Scientific Name
Live-forever or orpine	*Sedum telephium*
Moneywort or creeping Jenny *	*Lysimachia nummularia*
Morrow honeysuckle *	*Lonicera morrowii*
Multiflora rose *	*Rosa multiflora*
Norway maple	*Acer platanoides*
Oriental bittersweet *	*Celastrus orbiculata*
Porcelain berry	*Ampelopsis brevipedunculata*
Princess tree	*Paulownia tomentosa*
Purple loosestrife [1]	*Lythrum salicaria*
Reed canary grass	*Phalaris arundinacea*
Reed sweet-grass	*Glyceria maxima*
Russian olive	*Elaeagnus angustifolia*
Sea or horned poppy *	*Glaucium flavum*
Sheep fescue	*Festuca ovina*
Sheep sorrel	*Rumex acetosella*
Silver lace vine	*Polygonum aubertii*
Silver poplar	*Populus alba*
Spotted knapweed	*Centaurea blebersteinii*
Sycamore maple	*Acer pseudoplatanus*
Tatarian honeysuckle	*Lonicera tatarica*
Tree of heaven *	*Ailanthus altissima*
True forget-me-not	*Myosotis scorpioides*
Water chestnut	*Trapa natans*
Watercress	*Rorippa nasturtium-aquaticum*
Western catalpa	*Catalpa speciosa*
White mulberry	*Morus alba*
Wild thyme	*Thymus pulegioides*
Variable Water-milfoil *	*Myriophyllum heterophyllum*
Yellow or Chinese catalpa	*Catalpa ovata*
Yellow floating heart	*Nymphoides peltata*
Yellow iris *	*Iris pseudacorus*

** Acknowledged as invasive by the Massachusetts Invasive Plant Working Group, which includes representative from the Mass. Nursery and Landscape Assoc.*

[1] Note: Some nurseries are offering a "sterile" loosestrife. Avoid these, as they may be able to cross-pollinate with wild loosestrife and aid in the spread of this very invasive species.
Source: Weatherbee, et al., 1999

Examples of Invasive Plants Species Commonly Found in Massachusetts Nurseries and Garden Centers

*Japanese barberry (*Berberis thunbergii*)*
Source: MassWildlife photo, taken from Weatherbee, et al, 1996.

*Norway maple (*Acer plantanoides*)*
Source: MassWildlife photo, taken from Weatherbee, et al, 1996.

Appendix

D

“Deer-Resistant” Native Plants

"Deer-Resistant" Native Plants

This is a list of plants that have been identified as those that are less preferred by deer. This list is a compilation of lists adapted from the University of Rhode Island Horticulture Program www.uri.edu.ce/factsheets/sheets/deerplants.html and the Parker River Clean Water Association www.parker-river.org/PRCWAbookstore/Publications/Guides/BufferGardens/guide.pdf.

Please note that no plant can be guaranteed deer-resistant, because every deer and every herd are different, and dietary preferences will change as deer adapt to weather conditions and available food supply.

Common Name	Scientific Name
Trees	**Trees**
American holly	*Ilex opaca*
Common alder	*Alnus serrulata*
Eastern hemlock	*Tsuga canadensis*
Eastern red cedar	*Juniperus virginiana*
Green ash	*Fraxinus pennsylvanica*
River birch	*Betula nigra*
Silver maple	*Acer saccharinum*
Tupelo	*Nyssa sylvatica*
Washington hawthorn	*Crataegus phaenopyrum*
White pine	*Pinus strobus*
White spruce	*Picea glauca*
Shrubs	**Shrubs**
Inkberry holly	*Ilex glabra*
Meadowsweet	*Spiraea latifolia*
Pussy willow	*Salix discolor*
Red osier dogwood	*Cornus sericea*
Shrubby cinquefoil	*Potentilla fruticosa*
Sweet pepperbush	*Clethra alnifolia*
Herbaceous Ground Cover	**Ground Cover**
Bearberry or kinnick kinnick	*Arctostaphylos uva-ursi*

Appendix

E

Exempt Minor Activities in Riverfront Areas and Buffer Zones

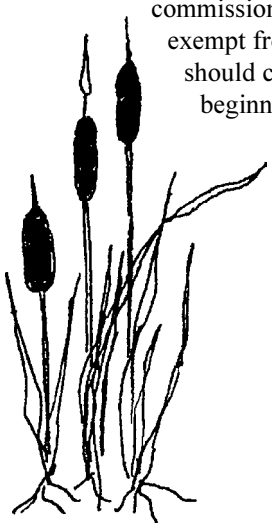
Exempt Minor Activities in Riverfront Areas and Buffer Zones

Under the Wetlands Protection Act

In October 1997, the Massachusetts Department of Environmental Protection (DEP) revised the wetlands regulations primarily to incorporate new standards for the Rivers Protection Act, but also to remove certain minor activities from review by local conservation commissions. The exemption applies to certain minor activities – common landscaping tasks and home improvements – which are conducted solely in the buffer zones of wetland resource areas and in riverfront areas. Please note that the same minor activities proposed in other wetland resource areas are *not* exempt.

Why Create Minor Activities?

DEP has determined that certain minor activities, based on their type, size, and location, will not cause impacts to any of the protected interests under the Wetlands Protection Act. DEP exempted these minor activities from review to lessen permitting responsibilities for potential applicants and to ease administrative burdens on conservation commissions. (Please note these activities may not be exempt from review under local bylaws. Landowners should check with the conservation commission before beginning work to see if the activity is subject to a local wetlands bylaw.)



Where are Riverfront Areas and Buffer Zones?

The **riverfront area** is a 200-foot wide corridor on each side of a perennial river or stream, measured from the mean annual high-water line of the river. However, the riverfront area is 25 feet in certain communities (Boston, Brockton, Cambridge, Chelsea, Everett, Fall River, Lawrence, Lowell, Malden, New Bedford, Somerville, Springfield, Winthrop, and Worcester) and in "densely developed areas," as designated by the Secretary of Environmental Affairs.

A **perennial river** is any natural flowing body of water (including a stream or brook) that empties into any ocean, lake, or other river and that flows throughout the year.

The **buffer zone** is an area of land extending outward 100 feet horizontally from a bank, marsh, swamp, freshwater or coastal wetland, beach, dune, or flat.

What About Activities That Are Not Exempt?

Activities that do not meet the requirements of the exemption (310 CMR 10.58(6)(b)) may still be permitted after the conservation commission reviews the proposed project. If the commission determines that the work will not alter a resource area, it will issue a Negative Determination of Applicability and work may proceed. The commission also may issue a permit (called an Order of Conditions) that describes how the work must be done to protect the resource areas and their public benefits. To streamline the review of smaller projects, DEP has issued a new policy (#99-1) that allows projects in the buffer zone and meeting certain criteria to proceed under a Negative Determination of Applicability rather than an Order of Conditions.

Exempt Minor Activities

The following minor activities are exempt from local conservation commission review as long as they are located in the riverfront area or buffer zone, but not within any other resource area. These activities are described in the wetlands regulations (310 Code of Massachusetts Regulations 10.00, section 10.58(6)). The landowner can proceed with these tasks without prior Wetlands Protection Act review by the conservation commission.

- Unpaved pedestrian walkways for private use
- Fencing that does not create a barrier to wildlife movement
- Stonewalls
- Stacks of cordwood
- Vista pruning – the selective thinning of tree branches or understory shrubs to create a "window" to improve visibility – as long as it occurs more than 50 feet from the mean annual high-water line within a riverfront area or from a bordering vegetated wetland, whichever is farther. (This activity does not include the cutting of trees which reduces the leaf canopy to less than 90 percent of the existing crown cover or the mowing or removal of understory brush.)

- Plantings of native trees, shrubs, or groundcover, but not turf lawns
- Conversion of lawns to decks, sheds, patios, and pools that are accessory to single family homes, as long as:
  - house existed prior to August 7, 1996
  - activity located more than 50 feet from the mean annual high-water of the riverfront area or bordering vegetated wetland (whichever is farther) and
  - sedimentation and erosion controls used during construction
- Conversion of patios, pools, sheds, or other impervious surfaces to lawn or natural vegetation
- Activities, such as monitoring wells, exploratory borings, soil sampling, and surveying, that are temporary, have negligible impacts, and are necessary for planning and design purposes

Note: Maintenance of existing landscaping, including lawn mowing and pruning, is exempt from review regardless of location in the buffer zone or any wetland resource area.

For more information . . .

Contact the local conservation commission or visit DEP's Web site: www.state.ma.us/dep/brp.

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Selected Internet Resources on Vegetated Buffers

This internet resource list was prepared by Russ Cohen of the Riverways Program, within the Massachusetts Department of Fisheries and Wildlife and Environmental Law Enforcement. Russ has graciously provided comments on the merits of each website. Enjoy your search.

- Riparian Buffers fact sheets, prepared by the Connecticut River Joint Commissions (CRJC) of VT/NH.: <http://www.crjc.org/riparianbuffers.htm> [NOTE: These are excellent. If you don't look at any other reference materials listed in this document, be sure to check out this one.]
- Riparian buffer fact sheets on the functions and values of naturally vegetated riparian areas, prepared by Russ Cohen, Riverways Programs: <http://www.state.ma.us/dfwele/river/rivfstoc.htm.>
- Impacts of Development on waterways. Center for Watershed Protection (CWP) and the Stormwater Manager's Resource Center (SMRC) <http://www.cwp.org> and <http://www.stormwatercenter.net> [CWP is one of the country's best resources on protecting streams and watersheds from the adverse impacts of development. CWP's web site provides advice on buffer design as well as model ordinances requiring the establishment and/or retention of vegetated buffers along waterways. It is also worth looking at two articles on CWP's web site entitled "The Architecture of Urban Stream Buffers" and "Invisibility of Stream/Wetland Buffers: Can Their Integrity be Maintained?".]
- Massachusetts Wetlands Protection Act Regulations: <http://www.state.ma.us/dep/brp/ww/files/310cmr10.pdf> [Note: The section referring to the Riverfront Area resource area is at pp.81-92; the preface discussing the 12/20/02 amendment to the WPA regulations relating to "perennial vs. intermittent" can be found at pp.1-4.]
- "A Homeowner's Guide to Nonpoint Source Pollution", also put out by the Connecticut River Joint Commissions: <http://www.crjc.org/pdffiles/homeguide.pdf>
- Riparian Forest Buffer information from the Chesapeake Bay Program: <http://www.chesapeakebay.net/info/forestbuff.cfm> [NOTE: under the "Publications" section on this page you will find a link to a .pdf version of a 481-page document entitled "Chesapeake Bay Riparian Handbook: A Guide for Establishing & Maintaining Riparian Forest Buffers". An excellent resource, often cited in this manual.]
- "Why Restoring Shoreland Vegetation is Important" [and how to do it] - from Wisconsin Cooperative Extension: <http://www.uwex.edu/ces/shoreland/Why2/whyres.htm.>
- Research on Shoreland Systems, from Wisconsin DNR - a wealth of information + hot links to research papers on the value of vegetated shorelines for water quality and other functions: <http://www.dnr.state.wi.us/org/water/wm/dsfm/shore/research.htm>

- "Riparian Areas: Functions and Strategies for Management" <http://books.nap.edu/books/0309082951/html/index.html> [This is the title of a new book produced by the well-respected National Academy Press and National Research Council. An on-line version of the book may be viewed for free on-line at this Web address. A description of the research project that led to the publication of this book can be read at <http://www4.nas.edu/webcr.nsf/ProjectScopeDisplay/WSTB-U-98-01-A>. I have not yet had a chance to review this information in detail, but from the looks of it, it is a carefully and extensively researched publication put together by an impressive team of experts on the topic.]
- "The Use of Riparian Buffers to Reduce Nonpoint Source Pollution from Development", a report to the Maine Legislature's Joint Standing Committee: <http://www.state.me.us/dep/blwq/report/buffer.pdf>
- "Width of Riparian Zone for Birds", a very good research paper prepared by the U.S. Army Corps of Engineers: <http://www.wes.army.mil/el/emrrp/pdf/si09.pdf>
- "Streamside Science" information from the state of Oregon: <http://www.oacd.org/fs05stbu.htm> and <http://www.planning.ci.portland.or.us/pdf/hps_sci_sum.pdf>
- "The space between: Lying at the edge of land and water, riparian habitats play a crucial role in the ecosystem" - article appearing in the Gulf of Maine Times, Fall 2002: <http://www.gulfofmaine.org/times/fall2002/science_insights.html>
- "Understanding the Science Behind Riparian Forest Buffers: Effects on Water Quality", from Virginia Cooperative Extension: <http://www.ext.vt.edu/pubs/forestry/420-151/420-151.html>
- Buffer fact sheets and other source materials from the State of Maryland: <http://www.riparianbuffers.umd.edu/home.html> and <http://www.agnr.umd.edu/MCE/Publications/Category.cfm?ID=8&top=32> (see documents FS 724-FS 733)
- "Riparian Forest Revegetation for Water Quality Improvement" - from Minnesota: <http://www.hort.agri.umn.edu/h5015/97papers/hanson.html>
- Healthy lawns and gardens without chemicals brochure and demonstration plot, Marblehead, MA: <http://208.56.92.121/community.old/PDF/Lawn.pdf >
- Why Phosphorous is a problem and what to do about it, from the New York State Federation of Lake Associations: <http://www.nysfola.org/phosphorus/>

And, last but not least:

- List of Native Plant Species Suitable for Planting in Riparian Areas in Mass., prepared by Russ Cohen: <http://www.state.ma.us/dfwele/river/pdf/rivSp01NL.pdf> [Note: A similar document prepared by Michael Abell of DEP is awaiting final approval by DEP Boston.] If you are interested in edible native plants, visit this site.

Glossary

Glossary

Ecosystem: an environmental community, based upon the interaction between climate, soil, topography, plants and animals. When functioning, this system is self-sustaining.

Edge habitat: the area where two or more habitat types, such as forestland, grassland, or wetland, meet is called edge. Edge habitat is a place where plants and animals from each of the adjoining habitats mix.

Effluent: wastewater from a septic system or wastewater treatment plant that enters a water body.

First flush: the first half inch to 1 inch of precipitation that accumulates and becomes stormwater runoff. First flush runoff gathers pollution as it washes the earth's surface, and as such it carries the highest concentration of pollutants.

Food chain: a sequence of organisms in which each is the food of the next organism in the sequence. For example, in an aquatic system, a young mosquito is food for a trout, which is food for an osprey.

Food web: all the interconnected and circular food chains in an ecosystem. This system is more inclusive and reflective of an ecosystem than the simpler food chain. For example, if the young mosquito mentioned above escapes the trout, it may later be food for a frog, which is food for a fox. Or the mosquito may escape all of the above and prey upon humans, which then allows it to complete its life cycle and lay eggs in the nearest water body.

Forbs: non woody vegetation including grasses, flowers and ferns.

Habitat: an organism's home, including areas that provide cover, food, shelter, water and breeding sites.

Infiltration: percolation of water and chemicals through the soil.

Ion: an atom or molecule that carries a net charge (negative or positive).

Microorganisms: organisms so small that they are invisible to the human eye.

Nonpoint Source Pollution: diffuse pollution being delivered to a waterbody with no discernible pathway. Whereas "point" sources of pollution, such as pipes or ditches, can be easily pointed to, Nonpoint Source Pollution often travels in runoff and is invisible, so that it is not so easily pointed to.

Retention time: the time it takes for water to travel from its original source to a receiving waterbody or other specific point. The water can travel in surface runoff, streams, rivers, or subsurface flows.

Sheet flow: runoff that flows over the ground as a thin, even layer rather then concentrated in a channel.

Soluble nutrients: nutrients dissolved in water or other solution. Soluble nutrients such as phosphorus and nitrogen are in forms that can readily be used by plants. The presence of soluble nutrients can have an immediate effect on algae and plant growth in water bodies.

Stormwater runoff: overland flow of water due to rainstorms or snowmelt

Subsurface flow: the underground flow of water through soil or bedrock. This flow moves down gradient, often heading toward surface water bodies. It is often an important source of recharge water in times of low rainfall or drought.

Transpiration: the uptake of water by plants, which they then use in life processes and give off as moisture through their pores.

Vegetated buffer: an area of natural vegetation along the shoreline of a water body or wetland, buffering that resource from human activity

Velocity: speed of movement.

Vernal pool: Vernal pools (also known as ephemeral pools and temporary woodland ponds) typically fill with water in winter due to rising groundwater and rainfall and remain filled through the spring and into summer. Vernal pools usually dry completely by the middle or end of summer each year, or at least every few years. Occasional drying prevents fish from establishing permanent populations. Many amphibian and invertebrate species rely on breeding habitat that is free of fish predators.

Water bodies: a generic term used throughout this manual, referring to rivers, streams, lakes and ponds

Watershed: The area of land from which all surface water and groundwater flows from higher elevations to a common body of water