Appendix L

Planner's Guide to Wetland Buffers for Local Governments

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Planner's Guide to Wetland Buffers for Local Governments

America's local governments know their lands and are familiar with their critical role as the primary regulators of land use and development activities. Many local governments also know their waters and wetlands, and most have authority to regulate land uses in order to conserve and protect these important community assets. While many publications assist local governing boards with land use planning and zoning, this publication compiles the scientific literature on wetland buffers (the lands adjacent to wetland areas) and identifies the techniques used and legislative choices made by local governments across the United States to protect these lands.

This guide for planners is based on detailed examination of approximately 50 enacted wetland buffer ordinances and nine model ordinances, and upon several hundred scientific studies and analyses of buffer performance. This guide identifies both the state-of-the-art and the range of current practice in the protection of wetland buffers by local governments. Local governments considering enacting or amending a wetland buffer ordinance will find here what they need to know to manage land use and development in these important areas.

Why Should Local Governments Adopt Wetland Buffer Controls?

The term "wetlands" encompasses a variety of landscape features that contain or convey water and support unique plants and wildlife. Wetlands often serve as a transitional zone between dry lands and areas dominated by water, including ponds and rivers, oceans and estuaries, and their floodplains and tributaries. Federal regulations define wetlands as "areas that are inundated or saturated by surface or ground water at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions. Wetlands generally include swamps, marshes, bogs and similar areas." (40 C.F.R. §230.3(t)) An extensive body of scientific literature, classification systems (Cowardin et. al. 1979) and legal opinions make important distinctions in wetland types and delineation methods.

Wetlands form part of the natural system of land and water that helps to make human communities livable. Many wetlands help control flooding and reduce damage from storm surges. They trap sediments and pollutants that otherwise might enter waterways. They help to recharge groundwater in some areas, and in tidal zones they provide nurseries for shellfish and fish. They also serve as habitat for birds, amphibians, and other wildlife and provide scarce natural areas in urban and suburban environments.

Attention to these functions is essential to governance of the community's land uses, public health, safety, and welfare. But these functions cannot be sustained without care for the uplands adjacent to wetlands—wetland buffers.

Well-designed buffers protect and maintain wetland functions by removing sediments and associated pollutants from surface water runoff, removing, detaining, or detoxifying nutrients and contaminants from upland sources, influencing the temperature and microclimate of a water body, and providing organic matter to the wetland. Buffers also maintain habitat for aquatic, semi-aquatic, and terrestrial wildlife, and can serve as corridors among local habitat patches, facilitating movement of wildlife through the landscape.

> Wetland buffers in urban areas are particularly important in helping to moderate the impacts of altered hydrologic regimes and flooding.
>
> —City of Boulder, 2007

Local government interests in wetland buffer lands often include concern for management of stormwater, avoidance of hazards from flooding, protection of water supplies, and protection of property from future hazards that may be associated with global climate change. Protection of vegetated buffers may reduce the severity of water fluctuations and flooding due to storms (FIFMTF 1996) as buffers may increase

the flood storage capacity of wetlands by better attenuating storm runoff before it reaches the wetland (Wenger 1999).

As many as 5,000 local governments have taken some actions to protect at least some wetlands within their borders (Kusler 2003). Some local governments regulate activities in wetlands, and all local governments have clear jurisdiction over actions on the buffer lands that surround wetlands. In many important ways, local governments are better situated than state and federal environmental authorities to control activities on the lands that surround wetland resource areas, because they are not just concerned with wetland functions, but also with surrounding land uses and the benefits wetlands provide for their communities.

Federal regulations require developers and others to obtain permits from the U.S. Army Corps of Engineers to dredge or fill many wetlands. But many activities that affect small acreages, or that involve particular kinds of construction or development activities, are authorized under generic "general permits" or "nationwide permits" with minimal scrutiny and standard conditions. Further, some wetlands that are isolated or that lack sufficient connection to navigable waters and tributaries may be totally unregulated federally under recent Supreme Court decisions (*SWANCC v. U.S. Army Corps of Engineers* (2001) and *Rapanos v. United States* (2006)). And while about a third of the states have regulatory programs affecting one or more types of wetland, coverage varies substantially by wetland type, acreage, activity, and potential impact.

Where federal and state regulatory programs do not apply, local governments remain the sole source of protective authority. And even where federal or state programs provide for review and permitting of activities in wetlands, local governments still have an interest in ensuring the compatibility of the land use that occurs on and around these lands in order to maintain control of their patterns of development, community character, tax base, demand for services, and response to hazards (McElfish 2004).

The functions and services that wetlands provide may diminish if wetlands are surrounded by parking lots, buildings, and pollution-generating or other incompatible land uses that reduce their hydrologic functions, alter vegetation, and degrade habitat values. Relying on regulations and conservation measures that deal only with the wetland is like trying to operate a municipal swimming pool without any attention to the pipes, the deck, the lifeguard stations, and the condition of areas draining into the water. Such an approach is like operating a roadway with no shoulders, no sidewalks, no signals, no management of the right-of-way, and no provision for the water sheeting onto the road surface.

Wetland Buffers and Climate Change

Wetland buffers will enable local communities to protect themselves from known hazards associated with global climate change. In some regions, climate change will produce more extreme storm events, increase the number and intensity of floods, and alter the infiltration and conveyance capacity of stormwater and natural wetland systems. Sea level rise will threaten coastal communities, which depend upon the storm-buffering effects of coastal wetlands. Climate change will also change the volume and timing of snowmelt, alter groundwater supplies, and produce drought effects, making healthy wetland function even more critical for water supply and watershed resilience. An ordinance that protects wetland buffers will moderate the effects of drought and protect private and public property.

The upland area surrounding the wetland is essential to its survival and functionality. If a wetland area cannot absorb the stormwater it normally absorbs, the chances of flooding will increase further downstream; if the wetland cannot serve as home for wetland species and vegetation, community values and quality of life will be impaired. Local governments that have wetlands within their boundaries have the opportunity to conserve these resource lands and to control or compensate for activities and development that might impair their benefits to the community and the environment.

Elements of Wetland Buffer Ordinances

Local governments should address the following elements when drafting a wetland buffer ordinance or bylaw:

- ☐ Purpose of the Ordinance
- ☐ Wetlands Covered
- ☐ Definition of Buffer
- ☐ Activities Prohibited/Permitted
- ☐ Procedures for Review

- ☐ Affirmative Requirements
- ☐ Monitoring, Reporting, and Enforcement

Within each of these elements, local governments have used many approaches to achieve wetland buffer protection. Alternative approaches allow governments to address particular environmental concerns, property development issues, differing land uses, and practical and political constraints. Each element is discussed below, together with examples from local governments that have employed the alternatives. (All citations are to the relevant section numbers of the local ordinances referenced.)

☐ Purpose of the Ordinance

The ordinance should have an explicit statement of the purposes for which it is enacted. First, such a statement makes the scope of the ordinance clear. It informs the elected decision maker's choice about the type of regulatory approach that will accomplish the desired outcome, and it avoids both regulatory overreach and under reach (failure to include sufficient protection measures to achieve objectives). The purpose definition is particularly important in determining the size of a wetland buffer and defining the activities that will be prohibited, conditionally permitted, exempted, or authorized by right under the ordinance. It will define the extent to which the ordinance regulates the wetland area and the buffer, or whether it is primarily aimed at the buffer while leaving wetland regulation to federal or state oversight alone.

Second, the statement of purpose aids in the interpretation of the ordinance by those charged with carrying it out, such as zoning administrators and permitting authorities, inspectors, and code enforcement officers. It also assists landowners, developers, and citizens in understanding the ordinance and in conforming their proposals and activities to its provisions. This is particularly useful where the ordinance includes provisions that require application of performance standards, mitigation of authorized impacts on the buffer, and use of alternative design solutions.

Third, the statement of purpose defines the legal authority upon which the ordinance rests and so helps courts and administrative bodies sustain both its legality and its application to specific actions. The ordinance may draw on explicit state authorizations, such as in those states that authorize local governments to adopt wetland regulations or critical area protections; or it may draw on a broader array of public health, safety, and welfare justifications supported by the local government's police power. The ordinance may aim at a specific subset of issues within the local government's authority, such as prevention and control of flooding, prevention of water pollution, or protection of habitat, open space, recreation, and other issues. Where applicable, the ordinance may draw on "home rule" authority to supplement other legal authorizations.

Type of Ordinance

Defining the purpose of the ordinance will help the local government and its legal advisors determine the type of ordinance that will be most useful. Most local wetland buffer ordinances are part of the zoning code or land development regulations. In some cases they are contained in a separate natural resources code, or they implement state-enacted wetlands or critical areas laws. A few are included in subdivision regulations together with setback and dimension requirements. Some wetland buffers are part of local erosion control or stormwater management regulations. The local government may include buffer protection as part of an ordinance that specifies protections for the wetland itself, or it may adopt an ordinance regulating the buffer area while relying on federal or state provisions to address activities within the wetland.

Purposes for wetland buffer ordinances include natural resource protection, hazard avoidance, and public health and safety, among others. Commerce City, Colorado, specifies that its ordinance, which covers a number of resource concerns, is designed "to protect significant natural, historical, and agricultural resource features on the development site." (§21-43(b)(1)) Bay County, Florida's, ordinance declares that "wetlands are a valuable natural resource worthy of protection," and that its ordinance establishing a setback distance from wetlands is intended:

> to provide a buffer between wetlands and development, preserve water quality, limit sediment discharges, erosion, and uncontrolled stormwater discharges, and provide wildlife habitat. (§1909)

Some ordinances specify concern for mitigation

of hazards and protection of property. The purpose of Schaumburg, Illinois' wetlands, streams, and aquatic resources protection ordinance:

> shall be to protect persons and property within and adjacent to wetlands from potentially hazardous geological and hydrological conditions; prevent environmental degradation of the land and water; and ensure that development enhances rather than detracts from or ignores the natural topography, resources, amenities, and fragile environment of wetlands within the village. (§154.196)

Belle Isle, Florida, finds that "the preservation and protection of property rights of the people of the city require that mechanisms be established which will provide for the orderly regulation and preservation of environmentally significant and productive wetlands." (§48-62(a)(3))

Very comprehensive statements of purposes are found in the LaPorte, Indiana, ordinance, "to require planning to avoid or minimize damage to wetlands and lakes; to require that activities not dependent upon a wetland or shoreline be located at other sites;…to make certain that activities affecting wetlands and lakes must not threaten public safety or cause nuisances by: blocking flood flows, destroying flood storage areas, or destroying storm barriers, thereby raising flood heights or velocities on other land and increasing flood damages; causing water pollution through any means [including application of pesticides, increasing erosion, or increasing runoff of sediment and surface water]; and that activities in or affecting wetlands do not destroy natural wetland functions important to the general welfare [listing habitat, groundwater recharge, education and research, public rights in waters and recreation, and aesthetic and property values.]" (§82-563 to -565)

A model ordinance prepared by the Northeast Ohio Areawide Coordinating Agency provides a significant list of purposes that can be used by local governments considering their own ordinances:

> Establish consistent, technically feasible and operationally practical standards to achieve a level of storm water quantity and quality control that will minimize damage to public and private property and degradation of water resources, and will promote and maintain the health, safety, and welfare of the residents of the Community. Preserve to the maximum extent practicable the natural drainage characteristics of the community and building sites and minimize the need to construct, repair, and replace enclosed storm drain systems. Preserve to the maximum extent practicable natural infiltration and ground water recharge, and maintain subsurface flow that replenishes water resources, wetlands, and wells. Prevent unnecessary stripping of vegetation and loss of soil, especially adjacent to water resources and wetlands. Reduce the need for costly maintenance and repairs to roads, embankments, sewage systems, ditches, water resources, wetlands, and storm water management practices that are the result of inadequate storm water control due to the loss of riparian areas and wetlands. Reduce the long-term expense of remedial projects needed to address problems caused by inadequate storm water control.
>
> The specific purpose and intent of this part of these regulations is to regulate uses and developments within wetland setbacks that would impair the ability of wetland areas to: Reduce flood impacts by absorbing peak flows, slowing the velocity of floodwaters, and regulating base flow. Assist in stabilizing the banks of watercourses to reduce bank erosion and the downstream transport of sediments eroded from watercourse banks. Reduce pollutants in watercourses during periods of high flows by filtering, settling, and transforming pollutants already present in watercourses. Reduce pollutants in watercourses by filtering, settling, transforming and absorbing pollutants in runoff before they enter watercourses. Provide watercourse habitats with shade and food. Provide habitat to a wide array of aquatic organisms, wildlife, many of which are on Ohio's Endangered and/or Threatened Species listings, by maintaining diverse and connected riparian and wetland vegetation. Benefit the Community economically by minimizing encroach-

ment on wetlands and watercourse channels and the need for costly engineering solutions such as dams, retention basins, and rip rap to protect structures and reduce property damage and threats to the safety of residents; and by contributing to the scenic beauty and environment of the Community, and thereby preserving the character of the Community, the quality of life of the residents of the Community, and corresponding property values.

Nashua, New Hampshire's, purpose statement is:

in the interest of public health, safety and general welfare, to: Insure the protection of valuable wetland resources; prevent the harmful filling, draining, sedimentation, or alteration of wetlands; Prevent the destruction or significant degradation of wetlands which provide flood and storm control by the hydrologic absorption and storage capacity of the wetland; Protect fish and wildlife habitats by providing breeding, nesting, and feeding grounds for many forms of plant and animal life including rare, threatened, or endangered species; Protect subsurface water resources and provide for the recharging of ground water supplies; Provide pollution treatment to maintain water quality; Prevent expenditures of municipal funds for the purpose of providing and/maintaining essential services and utilities which might be required as a result of misuse or abuse of wetlands; Provide for those compatible land uses in and adjacent to wetland or surface waters which serve to enhance, preserve, and protect wetland areas as natural resources. (§16-571)

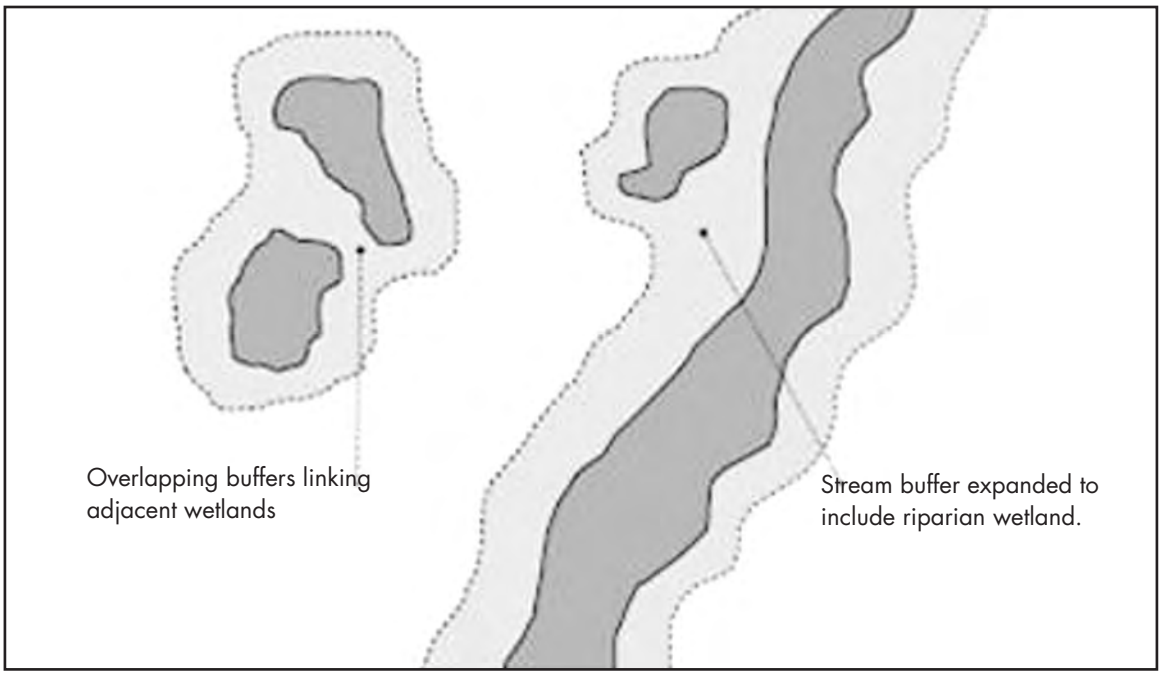
☐ **Wetlands Covered**

Local governments must determine which wetlands and waters to include within their buffer ordinances. Ordinances tend to exhibit ***four*** approaches to defining the wetlands to which local buffer requirements will be applied:

(1) The ordinance may cover ***all wetlands and waters***, as broadly defined in the ordinance, or it may reference the definitions of "waters of the state" or definitions of wetlands found in state laws or federal regulations. For example, the buffer ordinance may specify "wetlands," as in Chipley, Florida (§14.5-21), or "wetlands as defined by state law," as in Woodbury, Minnesota (§27-1).

(2) The ordinance may define ***specific wetland types or classes of wetlands*** that are protected under the ordinance. This approach may provide certain protections for tidal wetlands and different protections for nontidal wetlands. It may provide for protection of wetlands over a particular size (such as wetlands over one-half acre in area, as in Charlotte County, Florida, or wetlands over one-quarter acre in area, as in Lake County, Illinois). The ordinance may determine that buffer protections should be afforded to all wetlands over which federal jurisdiction exists under the Clean Water Act or under state wetlands laws, or it may specifically extend coverage to wetlands that *do not* receive protection under state and federal regulations. For example, Summit County, Colorado, protects wetlands as defined in the County ordinance, "notwithstanding any contrary determination by the U.S. Army Corps of Engineers."(§7105.1(A)) Some towns in New York offer protections for wetlands under 12.4 acres, the lower limit of the state's wetland program jurisdiction. Some of the ordinances we reviewed (although less than a quarter) provide different buffer protections for different classes of wetlands, using either state or local wetland quality or vulnerability ranking schemes. For example, Nashua, New Hampshire, prescribes a 75-foot nondisturbance buffer for "primary wetlands" as defined under state law, 40 feet for "critical wetlands," and 20 feet for other wetlands over one acre. (§16-575).

(3) The ordinance may be primarily aimed at the protection of ***stream and river corridors and floodways*** (riparian corridors), but provide for the inclusion and protection of wetlands where they are found within or adjacent to these areas. Most such ordinances provide for the expansion of the riparian buffer distance to a greater extent than would be required were such wetlands not present. For example, Summit County, Ohio's, riparian buffer ordinance provides that whenever wetlands protected under federal or state law are identified within the riparian setback (which is itself 30-300 feet depending on the size of the drainage



After *Cappiella* et al. *2005*

area), "the riparian setback shall consist of the full extent of the wetlands plus the following *additional* setback widths" from the outer boundary of the wetland —50 feet, 30 feet, or zero additional feet, depending upon the type of wetland. (§937.05(e3))

(4) Some local government wetland ordinances protect ***specifically identified, mapped wetlands*** within the jurisdiction, rather than relying on definitions. Schaumburg, Illinois', wetlands, streams, and aquatic resources overlay district applies to areas designated on the town's zoning map. (§154.196) Pickens County, Georgia's, ordinance applies to developments within 50 feet of a defined "wetlands protection district" boundary, as defined by the County's Health Department. This district specifically includes all land mapped as wetlands by the federal government's National Wetlands Inventory Maps. (§§12-26-124, 12-26-125) Oregon City, Oregon, applies wetland buffer protection to "Title 3 wetlands," defined as those wetlands of metropolitan concern as shown on the water quality and flood management area map and other wetlands added to city or county-adopted water quality and flood management area maps. (§17.49.040) Lewiston, Maine, applies its 250-foot regulatory review buffer (and 75 foot minimum setback) to "ten (10) acre or greater wetlands, located in the City of Lewiston, as shown" on a specifically-referenced set of Maine Department of Environmental Protection maps dated 1989, and identified by specific identification numbers on those maps. (§34.2(B)(2)) Strommen et al. (2007) advise using an adopted local wetland map.

☐ **Definition of Buffer**

Local governments use numerous approaches when defining wetland buffers. Ordinances may define a regulated area where scrutiny will be exercised over activities near wetlands, or define a non-disturbance area where natural vegetation must be maintained. Sometimes these are the same—so that there will be no disturbance, with limited exceptions by permit, throughout the entire defined regulatory buffer. In other instances, the ordinance will define a larger area of regulatory scrutiny, with limited uses by permit, and then define a smaller non-disturbance area nearest the wetland margins. Some ordinances prescribe a non-disturbance buffer area, but then establish an additional setback distance for buildings from the outer edge of the buffer. Because of these variations, simply comparing the number of feet prescribed in various buffer ordinances is not informative by itself. What matters

is how the buffer ordinance defines what activities are allowed and not allowed in the defined areas.

The Science of Buffers for Wetlands

In adopting a buffer and defining its dimensions, the local government must rely on good science, both to achieve effective results and to meet any legal challenges. A large scientific literature examines effective buffer sizes for water quality and wildlife habitat. In general, wide and densely vegetated buffers are better than narrow and sparsely vegetated buffers. However, the buffer size necessary to provide a particular level of function depends on the functions of the wetland, the wetland's relative sensitivity (as influenced by water retention time and other factors), the characteristics of the buffer, the intensity of adjacent land use, and watershed characteristics. A multi-function buffer should be sized to meet all of the functions identified as being locally important.

Water Quality & Buffers

Wetland buffers protect the water quality of wetlands by preventing the buffer area itself from serving as a source of pollution, as well as by processing pollutants that flow from upland areas. Water quality benefits vary not just with the size of the buffer, but also with the flow pattern, vegetation type, percent slope, soil type, surrounding land use, pollutant type and dose, and precipitation patterns (Adamus 2007, Wenger 1999, Sheldon et al. 2005). Both the type and intensity of surrounding land uses are key factors determining the effectiveness of wetland buffers in protecting water quality. Variations in water quality have been correlated over extended distances with quantity of intense urban land use in the contributing area, forest cover, and proximity of road crossings (Houlahan and Findlay 2004, Wilson and Dorcas 2003). Intense urbanization, agriculture, and concentrated timber harvests can increase the amount of sediments and contaminants in surface runoff, cause changes in hydrology, and increase the severity of water fluctuations in a wetland during storm events. Vegetation and deep permeable soils in the buffer slow down surface flow, allow for infiltration before runoff reaches valuable wetlands, and inhibit the formation of channelized flow, improving removal of sediments and nutrients. Buffers that include both forested and grassy vegetation may be most effective at removing both sediments and nutrients, especially in agricultural areas. Buffer effectiveness, however, can be reduced over the long term by activities that destroy vegetation or compact or erode soils, causing rills and gullies. Effectiveness in the short term may diminish if sediment and nutrients are added too quickly or in chronically high concentrations.

Depending on site conditions, much of the sediment and nutrient removal may occur within the first 15-30 feet of the buffer, but buffers of 30-100 feet or more will remove pollutants more consistently. Buffer distances should be greater in areas of steep slope and high intensity land use. Larger buffers will be more effective over the long run because buffers can become saturated with sediments and nutrients, gradually reducing their effectiveness, and because it is much harder to maintain the long term integrity of small buffers. In an assessment of 21 established buffers in two Washington counties, Cooke (1992) found that 76% of the buffers were negatively altered over time. Buffers of less than 50 feet were more susceptible to degradation by human disturbance. In fact, no buffers of 25 feet or less were functioning to reduce disturbance to the adjacent wetland. The buffers greater than 50 feet showed fewer signs of human disturbance. Cooke concluded that the effectiveness of buffers to protect adjacent wetlands is increased when fewer lots are present, buffers are larger and vegetated, and buffers are owned by landowners who understand the purpose of the buffer. Tougher monitoring and enforcement of buffer requirements should also help.

Wildlife Habitat & Buffers

Wetland buffers maintain or serve directly as habitat for aquatic and wetland-dependent species that rely on complementary upland habitat for critical stages of their life-history (Chase et al. 1997). Buffers also screen adjacent human disturbance and serve as habitat corridors through the landscape. The appropriate buffer size for habitat functions will depend on the resident species, the life-history characteristics of the species, the condition of the wetland and the wetland buffer, the intensity of the surrounding land use, and the function the buffer is to provide. Adamus (2007) suggests that the buffer size determination consider

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Science of Water Quality Buffers

A considerable amount of research addresses the size of buffers needed to remove sediments, phosphorous, nitrogen, and other pollutants.

Sediments

Buffers remove sediments and attached nutrients, toxics, and pesticides by reducing the velocity of surface flow, allowing the suspended solids to settle out on the surface and/or filter through the soil. A significant percent of the sediment in surface flows may be removed in a 15-30 foot buffer, but sediments may be more consistently removed by buffers of 30-100 feet (Dillaha et al. 1988, 1989, Magette et al. 1989, Schoonover et al. 2006). Progressively larger buffers may be required to filter out incrementally greater amounts of sediments (Wong and McCuen 1982, as cited in Wenger 1999, EOR 2001). From their review of the literature, Sheldon et al. (2005) suggest that coarse sediments are likely removed efficiently in the first 16-66 feet of a buffer, and removal of finer particles may require buffers of at least 66 feet. Locations with high sediment loads and steep slope may also require wider buffers, as sediment removal efficiency decreases as slope increases (Wenger 1999, Sheldon et al. 2005). Wider buffers also may be necessary to maintain sediment removal efficiencies over time as buffers become saturated with sediments (Wenger 1999). The ability of a buffer to remove sediment is highly dependent on sediment-laden water entering the buffer surface via sheet flow rather than via highly focused flows (Wigington et al. 2003, and references in Sheldon et al. 2005). Water confined mainly in ditches, incised channels, subsurface pipes, and other types of highly focused flows does not allow much contact with buffer vegetation and often is not sufficiently slowed to allow sediment removal, reducing the pollution-filtering capability of the buffer. Riparian vegetation, litter, and woody debris on the surface can reduce the velocity of surface flow, allowing more contact with vegetation and soils and inhibiting the formation of incised channels and gullies (Lowrance and Sheridan 2005, Sheldon et al. 2005). In addition, buffers with low gradient slope are more effective for the same reasons. The use of level spreaders, grass filter strips, or other structural techniques also can encourage sheet flow through buffers (Wenger 1999). If stormwater pipes cross a buffer entirely underground before emptying into a wetland, the runoff purification purpose of the buffer will obviously be defeated.

Phosphorous

Much of the phosphorous entering a buffer is attached to sediments, which can be removed as suspended solids are filtered by the buffer (Wenger 1999). Much of the phosphorous may be removed within the first 15-30 feet of the buffer, but phosphorous may be more consistently removed by buffers of 30-100 feet (Dillaha et al. 1988, 1989, EOR 2001, Kuusemets and Mander 1999, Lowrance and Sheridan 2005, Syverson 2005). Buffers can become saturated with phosphorous and generally cannot provide long term storage of phosphorous, but they can help to regulate the flow of phosphorous and prevent large pulses of the nutrient from reaching the wetland (Wenger 1999). Vegetation management (haying, grazing) may help to permanently remove some phosphorus from the system (Wenger 1999).

Nitrogen

Subsurface flow is the dominant water flow route through many buffers and wetlands. Nitrogen is removed primarily through conversion of nitrate to nitrogen gas by denitrifying bacteria and by vegetative uptake. This occurs primarily in the upper few feet of a buffer's soil or a wetland's sediment. Removal efficiencies are generally high (see Table 1 in Mayer et al. 2005). However, nitrogen removed via vegetative uptake can be released back to the system as plants die and decompose. Nitrogen also enters a buffer as particulate nitrogen attached to sediments, which can be removed as suspended solids are filtered by the buffer. Mayer and colleagues (2005) recently completed a comprehensive review and synthesis of the literature pertaining to the nitrogen removal function of riparian buffers. From their interpretation of that literature, they suggested that narrow buffers, 3.3 – 49.2 feet, can be effective at removing nitrogen, but wider buffers, >164 feet, more consistently remove significant amounts of nitrogen. They suggest 50%, 75%, and 90% nitrogen removal efficiencies (through both surface and subsurface flow) would occur in buffers of approximately 10 feet, 92 feet, and 367 feet wide, respectively, depending on buffer characteristics and nitrate loading rates. Based on a review of some of the same literature, Wenger (1999) suggested that a minimum of 50 feet is necessary for effective nitrogen removal, and depending on the soils (wet organic soils being the best), 100 feet or more would include more areas of denitrification activity and provide more nitrogen removal. Buffers of various vegetation types may be temporarily effective in retaining nitrogen being carried in the *subsurface* flow. High levels of organic carbon in the soil, saturated soil, anoxic or low oxygen conditions, and extended contact of the groundwater with the root zone of riparian vegetation are necessary for effective microbial denitrification and plant uptake of nitrogen. Removal of subsurface nitrate is highest when these soil conditions are maintained (Correll 1997, Wenger 1999), and these criteria may be more important than width in determining the effectiveness of the buffer (Mayer et al. 2005). For example, Vidon and Hill (2004) found that a 50 foot buffer was effective at removing 90% of the nitrate at locations with loamy soils, but at locations with sand and cobble sediments (soils with less organic matter), the buffer width required for 90% nitrate removal ranged from 82 ft to 577 feet. In order to maintain the nitrogen removal effectiveness of buffers, soil compaction, gullying, increases in impervious surfaces in the buffer, and exces-

sive removal of leaf litter or ground cover should be minimized (Mayer et al. 2005).

Other Pollution

A few studies have shed some light on effective buffer widths for removing fecal coliform and other pathogenic microorganisms. In one study, a 30 foot buffer that had been treated with poultry manure was able to remove 34-74 % of the fecal coliform. However, the resulting runoff still exceed the primary contact standard (Coyne et al. 1995). Toxics (pesticides and metals) may also be partially removed through filtration of sediments by the buffer (Sheldon et al. 2005), and temporarily, through vegetative uptake (Gallagher and Kibby 1980). Urban buffers are thought to be generally good at removing hydrocarbons and metals from surface runoff (Herson-Jones et al. 1995, as cited in Wenger 1999).

Limitations

There are many limitations to the conclusions about buffer widths that can be drawn from the scientific literature on buffers. More studies focus on buffers to protect stream and river functions than on wetlands. Also, many buffer studies are not conducted year-round, although water quality effects vary across seasons. Further, much of the science examining the effectiveness of buffers to remove pollutants describes the percentage of pollutant reduced by the buffer, but more rarely whether the buffer enabled the receiving water body to meet water quality standards. Finally, most studies tend to evaluate effects of specific buffer sizes rather than to derive buffer distances from conditions. Nevertheless, the scientific literature, if interpreted cautiously by experts in biogeochemistry and wildlife, can help municipalities determine the dimensions and characteristics of an effective wetland buffer (Sheldon et al. 2005).

Science of Wetland Habitat Buffers

Many of the buffer studies in the scientific literature make conclusions on appropriate buffer sizes for wildlife habitat based on how far individuals range from the wetland or water body for breeding or other life-cycle needs. The Environmental Law Institute's (2003) review of the science found that effective buffer sizes for wildlife protection may range from 33 to more than 5000 feet, depending on the species. Specific information on ranges for birds, mammals, reptiles, and amphibians has been developed:

Birds: from 49 to over 5000 feet (ELI 2003, Fischer 2000).
Mammals: between 98 and 600 feet (ELI 2003).
Reptiles & Amphibians: In a review of the literature, Semlitsch and Bodie (2003) found that core terrestrial habitat for reptiles associated with wetlands ranged between 417 and 948 feet, and for amphibians 521and 951 feet. They suggest preserving core habitat plus an additional 164 foot (50 meter) buffer to minimize edge effects. However, little guidance is given concerning what type and density of buffer vegetation is acceptable for protecting particular species.

The type and intensity of surrounding land uses will affect the wildlife habitat function of a buffer. For example, studies have shown that amphibian species richness declines with increasing urban land use and road density (Rubbo and Kiesecker 2005, Houlahan and Findlay 2003). Marsh bird community integrity has been shown to decline significantly when the amount of urban/suburban development within 500 m and 1000 m of the marsh exceeds 14% and 25%, respectively (DeLuca et al. 2004). Well designed buffers must be employed in combination with comprehensive land use planning that maintains a landscape containing relatively large, intact habitat areas in order to further habitat conservation goals.

Buffers can screen light, noise, domestic pets, and human presence from wetland wildlife (Castelle et al. 1992). The level of human disturbance in a buffer will likely depend on the intensity of adjacent land uses (Cooke 1992), thus buffer sizes should be increased with increasing intensity of land use. Buffers of at least 50 feet are likely necessary to maintain buffer effectiveness over time (Cooke 1992).

In general, forested buffers will be best around forested and scrub-shrub wetlands for forest species, but grassy and herbaceous vegetation may be most effective in other locations and for other species (Adamus 2007). Buffers with greater structural complexity will usually support more species (Shirley 2004), although buffers with less complexity can be more favorable to particular species that may be locally rare. Native vegetation is more likely to be effective at conserving native wildlife (Wenger 1999). Parkyn et al. (2000, as cited in Parkyn 2004) suggest that a buffer of 33–66 feet is necessary for sustaining native vegetation in some wetlands.

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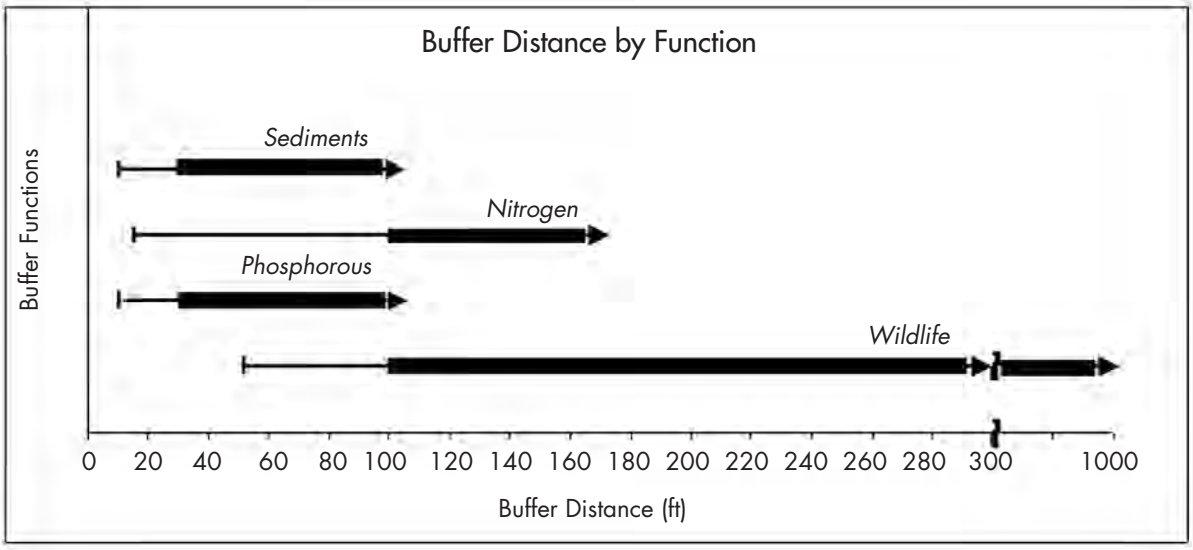

Effective buffer distance for water quality and wildlife protection functions. The thin arrow represents the range of potentially effective buffer distances for each function as suggested in the science literature. The thick bar represents the buffer distances that may ***most*** *effectively accomplish each function (30 - > 100 feet for sediment and phosphorous removal; 100 - > 160 feet for nitrogen removal; and 100 - >300 feet for wildife protection. Depending on the species and the habitat characteristics, effective buffer distances for wildlife protection may be either small or large.*

all of the buffer functions relevant to habitat including removing pollutants, limiting disturbance by humans, limiting the spread of non-native species into wetlands, helping maintain microclimatic conditions, and providing habitat for native wetland-dependent species that require both wetland and upland habitats. The Environmental Law Institute's (2003) review of the science found that effective buffer sizes for wildlife protection may range from 33 to more than 5000 feet, depending on the species. The State Wildlife Action Plans (www.teaming.com), developed by fish and wildlife agencies in all fifty states, are good sources of relevant information on native species, species of conservation concern, and their habitat requirements. These data can be supplemented by consulting local biologists to tailor buffer sizes to specific habitat types, species, and landscapes.

Approaches to Setting Buffer Distances

There are a number of alternative approaches to setting the buffer distance—usually defined in feet measured horizontally from the edge of the defined wetland. Many ordinances simply prescribe a fixed buffer distance for all wetlands subject to the ordinance (*e.g.*, 75 feet or 100 feet). Others vary the prescribed distance depending upon the type of wetland or the quality of wetland from which the buffer is extended (*e.g.*, 75 feet from least vulnerable wetland type; 100 feet from most vulnerable). Others further vary the buffer distance to account for slope toward the wetland—requiring wider buffers where slopes are steeper because negative impacts from land-disturbing activities, including concentrated water flows, are likely to increase with increasing slope. Some ordinances vary the buffer distances based on the type or intensity of land use—requiring larger buffers for more intensive land uses potentially affecting the wetland area. In contrast, some ordinances require or allow the zoning administrator to establish or vary buffers on a case-by-case basis. These ordinances usually prescribe the factors that must be taken into account and the information to be supplied by an applicant, but then rely on performance standards in the ordinance to drive the buffer distance decision. In another approach, Strommen et al. (2007) suggest an ordinance that regulates the entire drainage area contributing surface or subsurface

flow to sensitive wetlands, with defined buffer protections within this area.

Enacted local government buffer ordinances show a wide range of wetland buffer dimensions. The lowest we found was 15 feet measured horizontally from the border of the wetland, with the highest approximately 350 feet. Several ordinances set 500 feet as a distance for greater regulatory review of proposed activities, but do not require nondisturbance at this distance. Often the ordinances provide a range of protections, with nondisturbance requirements nearest the wetland and various prohibitions and limitations as the distance from the wetland increases. Among the ordinances we examined, the largest number of ordinances clustered around nondisturbance or minimal disturbance buffers of 50 feet or 100 feet, with variations (usually upward variations) beyond these based on particular wetland characteristics, species of concern, and to account for areas with steeper slopes. The largest ordinance-prescribed buffer distances (350 feet or more) tended to be for tidal wetlands and vernal pool wetlands.

Local governments, in general, use five approaches in defining buffer distances.

(1) Fixed Nondisturbance Buffer. Some local ordinances provide for a fixed buffer distance within which disturbance activities are prohibited (or strictly limited). For example, Casselberry, Florida, requires wetland buffers of 50 feet. (§3-11) Virginia cities and counties subject to the state's Chesapeake Bay Preservation Act establish "resource protection areas" of a 100-foot vegetated buffer landward of tidal and certain nontidal wetlands, as in Petersburg, Virginia (§122-76) and Henrico County, Virginia (§24-106.3). Some local buffer ordinances are "setback" ordinances. For example, Bay County, Florida, prohibits construction of any building or structure within 30 feet of any wetland. (§1909) The Northeastern Ohio Model Ordinance provides for a 120-foot or 75-foot "setback" from Ohio EPA Category 3 and 2 wetlands, respectively. Summit County, Colorado, and LaPorte, Indiana, each provide that soil disturbances and structures are prohibited within 25 feet of a wetland. (§7105.1(A); §82-561)

(2) Nondisturbance Buffer plus Additional Setback. Some ordinances prescribe a fixed nondisturbance wetland buffer, and then prescribe an *additional* setback distance for structures from the edge of the wetland buffer. The idea is that the prescribed nondisturbance buffer protects the wetland, and that buildings should not be constructed on the buffer's edge if a functional buffer is to be maintained. Baltimore County, Maryland, provides for a nondisturbance buffer of 25 feet from nontidal wetlands in accordance with the state nontidal wetlands law (75-100 foot buffers apply if associated with a stream, and 100-300 feet if a tidal wetland), but then further provides that residential buildings must be set back an *additional* 35 feet and commercial buildings an additional 25 feet *from the edge of the buffer*. (§§33-2-303, 33-2-401, 33-2-204(c), 33-3-111(d)) Charleston, South Carolina, defines "critical line" wetland buffers of a minimum of 25 to 40 feet based on zoning districts, but then further provides that all buildings must be set back a minimum of ten feet from the edge of the required buffer. (§54-347.1a3)

(3) Regulated Buffer Area with Minimum Nondisturbance Area. Another approach defines the buffer in terms of the area within which *regulatory scrutiny* will be applied to limit uses by permit or other review. Monroe County, New York, regulates a 100-foot "adjacent area" to freshwater wetlands. (§377-1 *et seq.*) Permits are required for activities within this area. Many jurisdictions supplement this regulated area with a prescribed minimum nondisturbance zone immediately adjacent to the wetland. Polk County, Wisconsin, provides for regulation of shorelands within 1000 feet of the ordinary high water mark of any navigable lake or pond or flowage, and within 300 feet of any navigable river or stream or floodplain including wetlands. It then provides *within* these fairly substantial regulated areas for a 75-foot minimum setback with a 35-foot vegetated protective area immediately adjacent to the wetlands or waters. (Art.7, 11(C)) New Lenox, Illinois, provides for the regulation of all lots lying wholly or in part within 100 feet of the edge of a wetland, while requiring a minimum nondisturbance set-back of 75 feet from the edge of the wetland (with only very minimal activities allowed by permit) and a minimum natural vegetation strip of 25 feet from the edge of the wetland. (§§38-131 to -133) Lewiston, Maine,

regulates all areas within 250 feet of the upland edge of all ten-acre or larger wetlands, and requires that all structures must be set back at least 75 feet from the wetland edge with no variances, and that a "natural vegetative state" must be maintained for the first 50 feet. (§34.2) Croton-on-Hudson, New York, does this in reverse by first specifying a mandatory nondisturbance area of 20 feet adjacent to the wetland, and then the regulatory "minimum activity setback" extending an additional 100 feet from the edge of the nondisturbance buffer. (§227-3).

Massachusetts' state wetlands protection act, which is locally administered by municipal conservation commissions, provides for a 100-foot regulated buffer area, and a permit process that applies to both the buffer and the wetland. (110 Mass. Gen. L. 131 §40) Many municipalities have adopted variations on this regulatory approach. Barnstable, Massachusetts, using home rule authority as well as the state wetlands law, has added a provision that requires an undisturbed area of 50 feet adjacent to the wetland, and further provides that any structures permitted within the 100 foot regulated buffer must be located within the 20 feet of the landward margin of the buffer (viz. 80 feet from the wetland). (§704-1) Sturbridge, Massachusetts, specifies various regulatory buffer areas greater than the state-required 100 feet (e.g. 200 feet for freshwater wetlands), and prescribes minimum nondisturbance areas ranging from 25 feet to 200 feet, depending upon the wetland resource. (§1.4)

(4) Matrix Based on Listed Factors. Some ordinances include a matrix of wetland types, slopes, habitats, and land use intensities, which are then used to define the extent of the buffer. For example, Sammamish, Washington, prescribes a set of buffers based on four distinct categories of wetlands initially defined by their wetland functions, and further modified by the habitat scores for each of these wetlands (see Table below).

Under the ordinance, Sammamish's development department may further increase the required buffer distance by the greater of 50 feet or a distance necessary to protect the functions and values of the wetland as well as to provide connectivity whenever a Category I or II wetland with a habitat score of 20 or greater is located within 300 feet of another Category I or II wetland, a fish and wildlife conservation area, or a stream supporting anadromous fish. Required buffers may be reduced if the impacts are mitigated and result in equal or better protection of wetland functions. (§21A.50.290)

Since 1984, Island County, Washington, has had an ordinance that takes into account wetland type, wetland size, and land use zones. The County has recently revised the ordinance for new development proposals

Wetland Category		Standard Buffer Width (ft)
Category I:	Natural Heritage or bog wetlands	215
	Habitat score 29-36	200
	Habitat score 20-28	150
	Not meeting above criteria	125
Category II:	Habitat score 29-36	150
	Habitat score 20-28	100
	Not meeting above criteria	75
Category III:	Habitat score 20-28	75
	Not meeting above criteria	50
Category IV:		50

Sammamish, Washington, ordinance: Wetlands rated according to the Washington State Wetland Rating System for Western Washington (Washington Department of Ecology, 2004, or as revised).

to base buffer distance which can range from 15 to 300 feet in width, primarily on intensity of surrounding land uses, habitat structure within and around a wetland (as scored with a simple checklist that landowners may use), and wetland sensitivity. The ordinance considers depressional "isolated" wetlands that lack outlets to be more sensitive to degradation due to accumulating sediment and bioaccumulation of contaminants and requires these wetlands to have wider buffers. Some wetlands surrounded by steep slopes or highly erodible soils are also required to have wider buffers. Island County also requires wider buffers for several carefully-defined wetland types, due to their high ecological value or sensitivity: (A) bogs, coastal lagoon wetlands, delta estuary wetlands, mature forested wetlands, (B) large non-estuarine ponded wetlands, anadromous fish stream wetlands, wetlands associated with a bog, coastal lagoon or delta estuary, (C) other estuarine wetlands, resident salmonid stream wetlands, mosaic wetlands, and (D) native plant wetlands and small ponded wetlands. The County prepared a series of tables that show buffer widths required for various combinations of these factors (e.g., intensity of surrounding land use, wetland structure, and slope). (§17.02B.090). See Appendix II.

Another example is Bensalem, Pennsylvania, which prescribes varying wetland buffer distances within natural resource protection overlay districts based on the underlying land use zoning. The buffer distance ranges from 20 feet in agricultural zones, to 100 feet in general industrial zones. (§ 232-57) The ordinance's standards require the buffer to be maintained in 80 percent natural vegetative cover.

(5) Case by Case Buffer Determinations. A number of wetland buffer ordinances do not specify a numerical distance, but require the applicant to submit information sufficient to allow the local government to specify the buffer distance based on performance standards. For example, Commerce City, Colorado, requires that the buffer must be sized to ensure that the natural area is "preserved" and expressly provides that the director of community development may increase or decrease the buffer to meet the goals of the ordinance; however, it further provides that the buffer for wetlands will in no case be less than 25 feet. Woodbury, Minnesota, provides for a minimum natural vegetated buffer of 15 feet, but further provides that the city reserves the right to require up to a 75-foot undisturbed buffer where "in the opinion of the city" the area contains "significant natural vegetation in good condition," or up to a 25-foot buffer where "useful for water quality improvement, wildlife habitat, a greenway connection, or any other wetland function or value."(§27-4(b))

Alachua County, Florida, provides for a case-by-case performance standard buffer, but also provides for a numerical default value when sufficient information is not available to support a case-by-case determination. The buffer:

> shall be determined on a case-by-case basis after site inspection by the county, depending upon what is demonstrated to be scientifically necessary to protect natural ecosystems from significant adverse impact. (§406.43)

The county requires the following factors to be considered in making the case-by-case determination: 1) Type of activity and associated potential for adverse site-specific impacts; 2) Type of activity and associated potential for adverse offsite or downstream impacts; 3) Surface water or wetland type and associated hydrological requirements; 4) Buffer area characteristics, such as vegetation, soils, and topography; 5) Required buffer area function (*e.g.,* water quality protection, wildlife habitat requirements, flood control); 6) Presence or absence of listed species of plants and animals; and 7) Natural community type and associated management requirements of the buffer. (§406.43) Where sufficient scientific information is not available, the ordinance prescribes default values with an average buffer distance of 50 feet, and minimum of 35 feet for wetlands less than or equal to a half acre; 75/50 feet for wetlands greater than half acre; 150/75 feet where listed species are documented; and 150/100 feet where the wetland is an outstanding resource water. (§406.43(c))

Crestview, Florida's, ordinance provides:

> The size of the buffer shall be the minimum necessary to prevent significant adverse effects on the protected environmentally sensitive area. §102-202(e)(1).

Fife, Washington's, ordinance specifies buffer distances, but further provides that:

> The community development director shall require increased standard buffer zone widths on a case by case basis when a larger buffer is necessary to protect wetlands functions and values based on local conditions. This determination shall be supported by appropriate documentation showing that it is reasonably related to protection of the functions and values of the regulated wetland. Such determination shall be attached as a permit condition and shall demonstrate that: A. A larger buffer is necessary to maintain viable populations of existing species; or B. The wetland is used by species proposed or listed by the federal government or the state as endangered, threatened, rare, sensitive or monitor, critical or outstanding potential habitat for those species or has unusual nesting or resting sites such as heron rookeries or raptor nesting trees; or C. The adjacent land is susceptible to severe erosion and erosion control measures will not effectively prevent adverse wetland impacts; or D. The adjacent land has minimal vegetative cover or slopes greater than 15 percent. (§17.17.260)

This approach requires more information at the application stage and also requires the administrator to have sufficient technical capacity to make a legally sufficient and sustainable choice.

Transitional Provisions

Some buffer ordinances have imposed more stringent requirements on new development than on existing development or subdivisions previously recorded. This may, in some cases, recognize "vested rights" in development conditions, but more often it represents a way of avoiding potential legal contests over the applicability of newer environmental regulations while still asserting some controls over prior and pending developments. Casselberry, Florida, for example, requires a 50 foot buffer; but provides that "buffers shall be 25 feet on lots less than five acres created prior to February 17, 1992."(§3-11.1(C)) Summit County, Colorado, exempts single family and duplex residential construction (but not other construction) on lots platted before the 1996 adoption of the county's first wetland regulations. (§7105.1(A))

Buffer Averaging and Minimum Distances

Some buffer ordinances that set specific and minimum buffer dimensions allow the local government to accept buffer averaging in order to accommodate variability in terrain or to accommodate development plans. For example, a wetland normally entitled by ordinance to a 75-foot minimum buffer may be able to tolerate a 50-foot buffer over part of its margin if a wider buffer is provided along another part. This may depend upon such issues as water flow, topography, habitat and species needs, and other factors that can best be assessed on a case-by-case basis. Port Townsend, Washington allows buffer averaging if the applicant demonstrates that the averaging will not adversely affect wetland functions and values, that the aggregate area within the buffer is not reduced, and that the buffer is not reduced in any location by more than 50 percent or to less than 25 feet. Woodbury, Minnesota allows buffer averaging where averaging will provide additional protection to the wetland resource or to environmentally valuable adjacent uplands, provided that the total amount of buffer remains the same.

☐ **Activities Prohibited/Permitted**

Many ordinances simply prohibit all disturbance, excavation, or building within the buffer, and then provide a separate list of activities that may be authorized by permit, or that are exempt from the ordinance. Massachusetts local ordinances typically provide that except as permitted by the local conservation commission or as provided in the local ordinance, "no person shall commence to remove, fill, dredge, build upon, degrade, discharge into, or otherwise alter" the protected wetland and buffer area.

Many wetland buffer ordinances also include outright prohibitions of particular activities, such as solid waste facilities, dams, and septic systems. LaPorte, Indiana, provides that "no building, structure, street, alley, driveway, or parking area shall be placed within a wetland district;" and further prohibits placement of any development that will allow "surface water runoff" to be "directed or flow into a wetland district," except by permit allowing such flow, and excepting a single-family dwelling that may result in such flow. (§82-606)

Many ordinances prohibit the use of wetland buffers for stormwater retention ponds, requiring that

such structures be located outside the buffer. Oregon City, Oregon, allows new stormwater quantity and quality control structures to encroach "a maximum of 25 feet" upon a required buffer, but requires the area of encroachment to be replaced by an equal area of buffer on the property, requires good water quality at the outfall, and requires a determination of no significant negative impact as a result of the changes. (§17.40.050(H)(6))

Some buffer ordinances do not list prohibited activities (or all prohibited activities), but state that buffer conditions must remain sufficient to protect the wetland or its functions. This requires the administrator of the ordinance to make findings supported by information on the anticipated impacts. For example, the Cape Cod Commission's Model Wetlands and Wildlife Bylaw provides that "No project shall be permitted which will have an adverse effect on a vernal pool or any naturally vegetated land area within 350 feet of a vernal pool by altering topography, soil structure, plant community composition, hydrologic regime and/or water quality in such a way as will result in any short-term or long-term adverse effect upon the vernal pool. No diversion of any new stormwater runoff into the vernal pool shall be permitted." (§IB2)

New Lenox, Illinois, allows only the following activities, by permit, within the 75 foot buffer: 1) limited filling and excavating necessary for the development of public boat launching ramps, swimming beaches, park shelters or similar structures, 2) land surface modification for the development of stormwater drainage swales between the developed area of the site (including a stormwater detention facility on the site) and a stream, lake or pond, or wetland, 3) installing piers for the limited development of walkways and observation decks, subject to mitigation by an equal area of wetland habitat improvement, and 4) modification of degraded wetlands for purposes of stormwater management where the quality of the wetland is improved and total wetland acreage is preserved. The ordinance requires that where such modification is permitted, wetlands shall be protected from the effects of increased stormwater runoff by measures such as detention or sedimentation basins, vegetated swales and buffer strips, and sediment and erosion control measures on adjacent developments, and that the direct entry of storm sewers into wetlands shall be avoided. (§38-132) [*See* Appendix for full text.]

Many buffer ordinances identify a limited number of essential or water-dependent uses that are allowed as conditional uses by permit. For example, Charlotte County, Florida, provides that wetland buffers shall be maintained in a completely natural state except for the minimum disturbance necessary to provide: shoreline access to riparian property owners; the construction of utility crossings and shoreline stabilization structures permitted by federal and state regulatory agencies; the construction of bridges, drainage conveyances, and fences; and the removal of exotic vegetation. (§3-5-348(b)) Polk County, Wisconsin, allows limited uses within the buffer by permit; these include roads essential for agriculture or silviculture where no alternative alignment is practicable, water dependent uses, recreation, utility crossings, and aquatic uses compatible with wetland preservation. (Art.7(D)(4))

Many ordinances also identify a set of limited-impact activities that are allowed within the buffer without review or permit. Pickens County, Georgia's, ordinance exempts conservation activities, outdoor passive recreation, forestry or agriculture conducted under state-approved Best Management Practices, education, science research, and nature trails. (§26-126) The Cape Cod Commission's model ordinance authorizes planting of native vegetation and habitat management to enhance the wetland values, unpaved pedestrian access paths no wider than 4 feet, maintenance of existing utility crossings and stormwater structures, new utility lines where the proposed route has been determined to be the best environmental alternative, and accessory structures for existing houses where there is no feasible alternative and placement is as far from the wetland as possible, subject to review and approval by the Commission. (§IIB2)

☐ Procedures for Review

A wetland buffer ordinance should not just define the buffer and prohibited and authorized activities, but should also provide for procedures that trigger the applicability of the ordinance and allow for necessary determinations, specify standards for review, define mitigation of authorized impacts, and specify whether and under what circumstances variances can be granted.

Administration of Ordinance

Responsibility for applying the ordinance to landowners and land development activities must be clearly assigned to a local government unit or body. If the ordinance is part of the zoning code, this will ordinarily be the zoning administrator. Alternatively, responsibility may be assigned to a specialized board or commission, such as a wetland commission (as in Massachusetts). Baltimore County, Maryland, assigns these responsibilities to its Department of Environmental Protection and Resource Management. If the ordinance is a wetland protection ordinance including regulation of activities in the wetland itself as well as in the buffer, it may be desirable to adopt a review process that is congruent with federal and state review procedures for wetlands. If the ordinance requires site-specific findings, such as variable buffer distances based on listed factors, it is desirable to have a technically trained professional staff or consultants available to the administrator charged with carrying out the ordinance.

> Green Development Standards
>
> In 2007, the U.S. Green Building Council finalized pilot rating standards for the new Leadership in Energy and Environmental Design – Neighborhood Development (LEED – ND) certification program, which set standards for environmentally superior development practices. Among the credits towards certification that may be earned for neighborhood location and design and green construction, developers can earn credit for preserving in perpetuity a buffer around all wetlands and water bodies located on site. Buffer distances, minimum of 100 feet, are to be calculated based on the functions provided by the wetland or water body, contiguous soils and slopes, and contiguous land uses. Local governments that adopt buffer ordinances encourage LEED-ND developments.

Submittals

Nashua, New Hampshire, specifies what triggers review under the ordinance:

> A review process and procedure for applicability to this article shall be caused by the following proposed land use applications or required approvals: Building permit applications; zoning board of adjustment applications; planning board applications; board of health application; any other land use requiring a permit or approval as required by and within the Nashua Revised Ordinances. The initial review of any of the above-mentioned items shall cause a determination as to whether the land area in which the proposed use or activity is or is not within or abutting a wetland. (§16-574(a))

Many ordinances that allow some regulated activities or conditional uses within the wetland buffer, or that authorize variable buffer distances based on site-specific conditions and proposed land uses, provide that the applicant must submit detailed information concerning the site. Summit County, Colorado, requires submission of a detailed "wetlands disturbance plan" including mitigation improvements, revegetation plan, grading and erosion control measures, "and a narrative explaining how a proposed activity in the wetland setback or a wetland area will meet the criteria" set forth in the ordinance. (§7105.04) Schaumburg, Illinois, requires an applicant seeking to conduct an activity by special use permit within the 100-foot wetland buffer to supply a report of geological and soil characteristics, site grading and excavation plan, vegetation and revegetation description and plan, wetland delineation report, and stormwater management plan. (§154.196(d)) Many local jurisdictions in the State of Washington require applicants to submit a wetland's function scores as estimated using the Department of Ecology's Rating System or an acceptable alternative.

Casselberry, Florida, requires an applicant seeking an alternative buffer methodology to submit information addressing: erodibility of soils upland of the wetland line; depth of the water table below the soil surface in the zone immediately upland of the wetland line; and habitat requirements of aquatic and wetland-dependent wildlife based on habitat suitability, spatial requirements, access to upland habitat, and noise impacts. (§3-11.1(C)(2))

Standards

Nashua, New Hampshire's, ordinance provides that in addition to enforcing the use and activity prohibitions and limitations for which a permit is required: "Any use or activity proposed within one hundred (100) feet of a wetland shall be reviewed administratively by the zoning administrator for compliance with the following performance standards:

(1) That no significant impact on the aquatic habitat of rare or endangered species, as listed by the State of New Hampshire or the Federal government, will result.
(2) That the filtration of stormwater runoff is adequately provided for and controlled both during and after construction.
(3) That the topography and required regrading of the subject property accounts for and adequately reflects the proximity of a nearby wetland area.
(4) All landscaping requirements and maintenance regiments for a project will ensure that fertilizer and chemical run-off shall not enter the wetland.
(5) Any wetland area utilized for water run-off shall demonstrate that excess flow on wetlands shall not cause excessive ponding and retention, thereby causing environmental damage to existing flora.
(6) Where land is proposed to be subdivided, the applicant shall demonstrate that there is adequate non-wetland area to contain all proposed uses, structures, and utilities in accordance with these regulations.
(7) No more than fifty (50) percent of the open space required by the underlying zone shall be classifiable as wetlands under the provisions of this article.
(8) No part of a wetland may be counted in minimum lot area requirements. (§16-575(d)).

Mitigation
Virtually all buffer ordinances that provide for permitted uses or conditional uses within the buffer also require compensatory mitigation to offset unavoidable impacts to the buffer area. Compensatory mitigation involves the replacement of wetland acreage and wetland functions through restoration, creation, enhancement, or (in some cases) preservation of other wetlands, onsite or offsite. Mitigation may be required both for the wetland itself and for impacts to wetland buffers protected by local ordinance. For example, the Port Townsend, Washington, critical areas ordinance requires compensatory mitigation for any development proposal within a critical area or required buffer, and specifies mitigation replacement ratios. (§19.05.110(F1-F9)) Oregon City, Oregon, requires a mitigation plan and feasibility assessment. (§17.49.050(G)) Kusler (2007) identifies factors that a local ordinance providing for compensatory mitigation should include.

Variances
Some wetland buffer ordinances include provisions for hardship variances, while others that are part of the zoning or land development codes rely on the jurisdiction's normal variance standards and procedures. Because of the health and safety aspects of wetlands buffer protections, variances are disfavored. Bay County, Florida, has a fairly typical provision, allowing a hardship variance in those situations where, "due to the size, shape, topography, location(s) of wetlands, or similar factors, application of the wetland buffer would preclude reasonable use of the property involved." (§1909(3)(d),(e)) The ordinance, however, limits variances for "accessory uses" to no more than 20 percent of the buffer.

☐ Affirmative Requirements
Buffer ordinances are not limited to prohibiting disturbances and encroachments. Many also set standards for the establishment and maintenance of buffer conditions. Belleaire, Florida, provides that natural buffers must be retained or "if a natural buffer does not exist an equivalent buffer shall be created." (§74-414(b)(3)(c)) Woodbury, Minnesota's buffer ordinance provides:

> Buffer areas must be established in appropriate vegetation such as native grasses, forbs, shrubs, and trees. The buffer area cannot consist primarily of common or noxious weeds. After becoming established, the vegetation in wetland buffer areas must be left undisturbed…The requirement to leave the buffer area undisturbed does not prohibit the removal of dead, diseased, or dying vegetation, or the control of noxious or common weeds. (§27-4(b)(5),(6))

The Northeastern Ohio Model Ordinance prohibits mowing, allows planting consistent with the buffer's functions, but also limits landowner affirmative obligations:

> There shall be no disturbance, including mowing, of the natural vegetation, except for such conservation maintenance that the landowner deems necessary to control noxious weeds; for such plantings as are consistent with this regulation; for such disturbances as are approved under the "Uses Permitted…" section of these regulations; and for the passive enjoyment, access, and maintenance of landscaping or lawns existing at the time of passage of this regulation. Nothing in this regulation shall be construed as requiring a landowner to plant or undertake any other activities in riparian and wetland setbacks.

The Commerce City, Colorado, ordinance includes performance standards relating to the buffer's function on the landscape and its potential connection to other natural areas:

> If the development site contains existing natural areas including floodplains that connect to other off-site natural areas with natural areas, to the maximum extent feasible the development shall preserve the natural area connections. Such connections shall be designed and constructed to allow for the continuance of existing wildlife movement along the natural areas. (§ 21-43 (b)(3)(c))

☐ Monitoring, Reporting, and Enforcement

Even the most comprehensive and scientific ordinance will not protect community interests if it is not enforced. Enforcement requires information, so local jurisdictions that have adopted buffer ordinances must allocate sufficient personnel to monitor approved buffers to identify possible violations. Some types of violations not visible from roadsides can be identified during flyovers or from existing high-resolution aerial photographs from different points in time. To help maintain public support, the disposition of all investigated potential violations, as well as all approved or denied permits and variances, should be documented in a regularly updated database or report available to all citizens.

Many wetland buffer ordinances do not specify their own enforcement provisions because they are part of the zoning code or subdivision regulations and are enforced by the usual array of enforcement tools provided in those ordinances—including authority to enter, stop work orders, notices to correct, cease-and-desist orders, injunctions, criminal prosecution, nuisance abatement, and penalties. It may be worthwhile to consider adding particular provisions for wetland buffer enforcement that address the vulnerabilities of these landscape features. For example, the ability of the local government to enter and monitor wetland and buffer condition, or to conduct restoration activities, may be important. This can prevent loss of the habitat and hydrological functions if a violator does not promptly take corrective action; similarly, provision for daily accrual of penalties may provide an important incentive to act promptly.

Another issue is how the ordinance deals with encroachments or degradation affecting the wetland buffer that is not caused by the developer at the time of a permitting decision, but later. Ordinances that are expressed solely in terms of setbacks or land development permit reviews may not sufficiently address affirmative obligations to maintain the buffer in a functional condition and prevent encroachments by homeowners or third parties.

Where establishment and maintenance of the buffer requires affirmative action by a landowner or developer, the ordinance may require the posting of a performance bond or similar financial guarantee. Summit County, Colorado, provides that a financial guarantee must be posted to ensure compliance with its wetlands regulations, and that the term of the guarantee must extend for at least three years in order to ensure the success of vegetation plantings. (§7105.06)

Sturbridge, Massachusetts, provides that the town may require recordation of a restrictive covenant to ensure that long term recognition and function of the buffer are protected. (§3.10) Similarly, the Northeastern Ohio model ordinance provides:

> Upon completion of an approved property subdivision/property/parcel split, commercial development or other land development or improvement, riparian and wetland setbacks shall be permanently recorded on the plat records for the Community and shall be maintained as open space thereafter through a per-

manent conservation easement. A third party, not the landowner or permittee or the Community, which is allowed by state law, shall be given the conservation easement. If no third party will accept the conservation easement, the Community shall accept it and protect it in perpetuity.

Whenever possible it is desirable to monitor not just compliance with buffer requirements, but also changes in the condition of the wetlands. A few local governments, such as Island County, Washington, have enacted and funded a long term water monitoring program that will help evaluate buffer performance and allow for adaptive management to address any water quality issues related to buffer underperformance or other changes in the surrounding environment.

Conclusion: Adopt a Local Wetland Buffer Ordinance

Wetland buffers protect communities from foreseeable hazards and enhance community values. As such, wetland buffers reinforce many of the Smart Growth Principles, including compact design, distinctive communities with a strong sense of place, critical environmental and natural areas, and predictability in development decisions.

A community considering a wetland buffer ordinance should be clear about its objectives. Spending time on developing the purpose statement will help clarify what the ordinance is intended to do, and will guide the process of defining what wetlands are to be protected, the appropriate buffer dimensions, allowable activities, review procedures, affirmative obligations, and enforcement provisions.

Science should serve as the foundation for buffer protection. But this does not mean that communities need to commission an elaborate scientific study. A great deal of information is available from state environmental protection agencies, state natural heritage programs, and from other communities that have adopted wetland ordinances. The key lessons from wetland science are summarized in this publication and the sources cited in the References section. Two simple wetland buffer ordinances adopted by local governments, and an example of a more detailed matrix approach to buffer size, are reproduced in the Appendix.

The steps for adopting a local wetland buffer protection ordinance are:

- data gathering,
- planning to connect the wetland buffer protection to other community plans and goals,
- drafting the regulation or ordinance,
- notice of public hearings,
- adoption of the regulation or ordinance,
- provision for administration of the requirements, and
- enforcement. (Kusler & Opheim 1996).

Buffer ordinances may be simple or complex, but they serve a critical role in maintaining community quality of life, management of stormwater and flooding, protection of water quality and quantity, habitat conservation, and resilience to the future effects of global climate change on local communities.

Smart Growth Principles

1. Mix land uses.
2. Take advantage of compact building design.
3. Create a range of housing opportunities and choices.
4. Create walkable neighborhoods.
5. Foster distinctive, attractive communities with a strong sense of place.
6. Preserve open space, farmland, natural beauty and critical environmental areas.
7. Strengthen and direct development towards existing communities.
8. Provide a variety of transportation choices.
9. Make development decisions predictable, fair and cost effective.
10. Encourage community and stakeholder collaboration in development decisions.

Smart Growth Network: www.smartgrowth.org

Appendix I. Simple Buffer Ordinances

Chipley, Florida:
"§14.5-21. Buffer required. A thirty-foot buffer of native vegetation, subject to site plan approval, shall be required around and along all wetlands. Such buffer shall be measured from the [Department of Environmental Resources] wetlands jurisdictional line. The property owner may create a pathway through the buffer for visual or authorized pedestrian access to the wetland provided that the pathway is limited to a five-foot wide swath."

Village of New Lenox, Illinois:
"Sec. 38-131. Intent. This article applies to development in or near streams, lakes, ponds, and wetlands within the Village of New Lenox. Streams, lakes, and ponds (including intermittent streams) are those which are shown on the United States Department of the Interior Geological Survey (USGS) 7.5 minute quadrangle maps and those additional streams, delineated on the village's comprehensive plan. Those maps are hereby made a part of this article, and two copies thereof shall remain on file in the office of the village administrator for public inspection. Within the jurisdiction of the Village of New Lenox, those waterbodies and watercourses that are named and are subject to the provisions of this article are Jackson Creek, Jackson Branch Creek, Sugar Run Creek, Hickory Creek, Marley Creek, and Spring Creek. Wetlands are those designated in the U.S Fish and Wildlife Service/Illinois Department of Conservation wetland inventory.

The procedures, standards and requirements contained in this article shall apply to all lots within wetlands and streams, and all lots lying wholly or in part:

(1) Within the special flood hazard area (SFHA) designated by the federal emergency management agency (FEMA); (2) Within 100 feet of the ordinary high water mark (OHWM) of a perennial stream or intermittent stream, the ordinary high water mark of a lake or pond, or the edge of a wetland; or (3) Within depressional areas serving as floodplain or stormwater storage areas.

Sec. 38-132. Minimum setback of development activity from streams, lakes, ponds, and wetlands. Absolutely no development activity (except as provided below) may occur within the minimum setback which is defined as 75 feet from the ordinary high water mark of streams, lakes, and ponds, or the edge of wetlands, or within a designated depressional area. In no case shall the setback be less than the boundary of the 100-year floodway as defined by FEMA. These setback requirements do not apply to a stream in a culvert unless the stream is taken out of a culvert as part of development activity. If a culvert functions as a low-flow culvert, where water is intended to periodically flow over it, the setback requirements apply. Review waiver of this article for proposed development activity within the minimum setback area will consider the following:

(1) Only limited filling and excavating necessary for the development of public boat launching ramps, swimming beaches, or the development of park shelters or similar structures is allowed. The development and maintenance of roads, parking lots and other impervious surfaces necessary for permitted uses are allowed only on a very limited basis, and where no alternate location outside of the setback area is available.

(2) Land surface modification within the minimum setback shall be permitted for the development of stormwater drainage swales between the developed area of the site (including a stormwater detention facility on the site) and a stream, lake or pond, or wetland. Detention basins within the setback are generally discouraged, unless it can be shown that resultant modifications will not impair water quality, habitat, or flood storage functions.

(3) No filling or excavating within wetlands is permitted except to install piers for the limited development of walkways and observation decks. Walkways and observation decks should avoid high quality wetland areas, and should not adversely affect natural areas designated in the Illinois Natural Areas Inventory or the habitat of rare or endangered species.

(4) Wetland area occupied by the development of decks and walkways must be mitigated by an equal area of wetland habitat improvement.

(5) Modification of degraded wetlands for purposes of stormwater management is permitted where the quality of the wetland is improved and total wetland acreage is preserved. Where such modification is permitted, wetlands shall be protected from the effects of increased stormwater runoff by measures such as detention or sedimentation basins, vegetated swales and buffer strips, and sediment and erosion control measures on adjacent developments. The direct entry of storm sewers into wetlands shall be avoided.

The applicant shall present evidence, prepared by a qualified professional, that demonstrates that the proposed development activity will not endanger health and safety, including danger from the obstruction or diversion of flood flow. The developer shall also show, by submitting appropriate calculations and resource inventories, that the proposed development activity will not substantially reduce natural floodwater storage capacity, destroy valuable habitat for aquatic or other flora and fauna, adversely affect water quality or ground water resources, increase stormwater runoff velocity so that water levels on other lands are substantially raised or the danger from flooding increased, or adversely impact any other natural stream, floodplain, or wetland functions, and is otherwise consistent with the intent of this article.

In addition to locating all site improvements on the subject property to minimize adverse impacts on the stream, lake, pond, or wetland, the applicant shall install a berm, curb or other physical barrier during construction, and following completion of the project, where necessary, to prevent direct runoff and erosion from any modified land surface into a stream, lake, pond, or wetland. All parking and vehicle circulation areas should be located as far as possible from a stream, lake, pond or wetland. The Village of New

Lenox may limit development activity in or near a stream, lake, pond, or wetland to specific months, and to a maximum number of continuous days or hours, in order to minimize adverse impacts. Also, the Village of New Lenox may require that equipment be operated from only one side of a stream, lake, or pond in order to minimize bank disruption. Other development techniques, conditions, and restrictions may be required in order to minimize adverse impacts on streams, lakes, ponds, or wetlands, and on any related areas not subject to development activity.

Sec. 38-133. Natural vegetation buffer strip required. To minimize erosion, stabilize the stream bank, protect water quality, maintain water temperature at natural levels, preserve fish and wildlife habitat, to screen manmade structures, and also to preserve aesthetic values of the natural watercourse and wetland areas, a natural vegetation strip shall be maintained along the edge of the stream, lake, pond or wetland. The natural vegetation strip shall extend landward a minimum of 25 feet from the ordinary high water mark of a perennial or intermittent stream, lake, or pond and the edge of a wetland. These guidelines are outlined in the publication "Native Plant Guide for Streams and Stormwater Facilities in Northeastern Illinois" jointly published by the Fish & Wildlife Service, NRCS, IEPA, and Army Corps of Engineers.

Within the natural vegetation strip, trees and shrubs may be selectively pruned or removed for harvest of merchantable timber, to achieve a filtered view of the waterbody from the principal structure, to control the spread of undesirable invasive species such as buckthrow or box elder, to restore a balanced community of native plant species, and for reasonable private access to the stream, lake, pond or wetland. Said pruning and removal activities shall ensure that a live root system stays intact to provide for stream bank stabilization and erosion control. The vegetation must be planned in such a way that access for stream maintenance purposes shall not be prevented."

Appendix II. Matrix Approach to Buffer Distance

Island County, Washington:
This excerpt is based on Island County's *draft ordinance* from November 2007, which reflects a sophisticated use of the matrix approach to buffer distance. The ordinance first prescribes buffers for a few types of particularly sensitive wetlands (especially bogs, coastal lagoons and estuarine wetlands), with wider buffers for more intensive land uses. Then it establishes matrices to calculate buffers for *other* wetlands based on land use intensity, habitat condition, and wetland sensitivity (as predicted by slope and presence or absence of a surface water outlet). Wetlands that lack outlets and are adjoined by steep slopes are presumed to be more sensitive to accumulation of sediment and contaminants, so receive larger buffers. For most wetlands both habitat and water quality buffers are calculated separately and the *larger* buffer (usually habitat) is applied. (The numbers below should be taken as illustrative). The habitat calculation is:

Habitat Buffers					
Land use Intensity	Habitat Functions Score				
	50 or higher	42-48	39-41	32-38	Less than 32
Low	150 ft	125 ft	100 ft	75 ft	Use Water Quality & Slope Tables
Moderate	225 ft	175 ft	150 ft	110 ft	
High	300 ft	200 ft	175 ft	150 ft	

The water quality calculation includes differing buffers based on wetland type (A-E) and whether there is a surface water outlet from the wetland.

Water Quality Buffers						
Land Use Intensity	Wetland Category					
	Wetland Outlet	A	B	C	D	E
Low	Yes	40 ft	35 ft	30 ft	25 ft	20 ft
	No	75 ft	50 ft	40 ft	35 ft	25 ft
Moderate	Yes	90 ft	65 ft	55 ft	45 ft	30 ft
	No	105 ft	90 ft	75 ft	60 ft	40 ft
High	Yes	125 ft	110 ft	90 ft	65 ft	40 ft
	No	175 ft	150 ft	125 ft	90 ft	50 ft

The water quality value is then adjusted for slope:

Slope Adjustment	
Slope Gradient	Additional Buffer Multiplier
5-14%	1.3
15-40%	1.4
>40%	1.5

This matrix approach is more complex than a single number, but can better reflect scientific understanding, particularly with diverse wetland types and land use conditions in a locality. With appropriate public outreach and technical support, a matrix-driven buffer can gain public support and achieve good results.

Ordinances Chiefly Consulted

Ordinances: Boulder, CO, Commerce City, CO, Summit County, CO, New Castle County, DE, Alachua County Land Development Regulations, FL, Bay County Development Code, FL, Bellaire Land Use Regulations, FL, Belle Isle Land Development Code, FL, Bunnell Land Development Code, FL, Casselberry Preservation of Wetlands Ordinance, FL, Charlotte County Surface water and wetland protection ordinance, FL, Chipley Wetlands Resource Protection Ordinance, FL, Crestview Environmentally Sensitive Lands Ordinance, FL, Forsyth County Soil Erosion and Sediment Control ordinance, GA, Lumpkin County Soil Erosion and Sediment Control ordinance, GA, Pickens County Wetlands Protection Ordinance, GA, Lake County Uniform Development Ordinance, IL, New Lenox Wetland Protection Ordinance, IL, Schaumburg Biodiversity Zoning Overlay, IL, LaPorte, Indiana, Lexington-Fayette Riparian Buffer Ordinance, KY, Biddeford Shoreline Zoning Ordinance, ME, Eliot Shoreline Zoning Ordinance, ME, Lewiston Shoreline ordinance, ME, Baltimore County Environmental Protection and Resource Management Ordinance, MD, Barnstable Wetlands Protection Ordinance, MA, Holyoke Wetland Protection Code, MA, Sturbridge Wetland Bylaw, MA, Woodbury Preservation of Waterbodies and Wetlands Ordinance, MN, Nashua Wetlands Ordinance, NH, Croton-on-Hudson Wetlands and Watercourses Ordinance, NY, Monroe County Freshwater Wetlands Protection Law, NY, Summit County, OH, Oregon City Water Quality Resources Overlay District, OR, Bensalem Natural Resources Preservation Districts Overlay, PA, Charleston Zoning Ordinance, SC, Mount Pleasant Critical Line Buffer Ordinance, SC, Henrico County Chesapeake Bay Preservation Overlay, VA, Petersburg Chesapeake Bay Overlay, VA, Fife Wetlands protection ordinance, WA, Island County Critical Areas Ordinance, WA, King County Shoreline Management ordinance, WA, Port Townsend Critical Areas Ordinance, WA, San Juan County Shoreline Management Ordinance, WA, Polk County Shoreland Protection Zoning Ordinance, WI.

Model Ordinances: Association of State Wetlands Mangers Inc. Model Ordinances for Regulating Wetlands and Riparian/Stream Buffers (http://www.aswm.org/propub/jon_kusler/model_ordinance_051407.pdf), Cape Cod Commission Model Wetlands Bylaw (http://www.capecodcommission.org/bylaws/wetandwild.html), Center for Watershed Protection : A Local Ordinance to Protect Wetland Functions (http://www.cwp.org/wetlands/articles/WetlandsArticle4.pdf), MACC Model Wetlands Protection Bylaw/Ordinance (http://www.maccweb.org/documents/MACC_Model_Bylaw.doc), New Jersey Model Riparian Buffer Ordinance (http://www.state.nj.us/dep/watershedmgt/DOCS/pdfs/StreamBufferOrdinance.pdf), Northeast Ohio Areawide Coordinating Agency Ordinance Controlling Riparian Setbacks and Wetland Setbacks (http://www.noaca.org/reglmodord.html), Stormwater Center Model Forest Buffer Ordinance (http://www.longislandsoundstudy.net/riparian/Buffer_Model_Ordinance_Rhode_Island.pdf), U.S. Environmental Protection Agency Aquatic Buffer Model Ordinance (http://www.epa.gov/nps/ordinance/mol1.htm), Westchester County Model Wetland Protection Ordinance (http://www.longislandsoundstudy.net/riparian/Wetland_Ordinance_Westchester.pdf).

References

Adamus, P.R. 2007. Best Available Science for Wetlands of Island County, Washington: Review of Published Literature. A Report Prepared in Response to Critical Areas Ordinance Updating Requirements for Wetlands. http://www.islandcounty.net/planning/criticalareas/BestAvailableSciencePhaseII.pdf.pdf

Cappiella, K., T. Schueler, J. Tasillo & T. Wright. 2005. Adapting Watershed Tools to Protect Wetlands. Center for Watershed Protection, Ellicott City, MD.

Castelle, A.J., C. Conolly, M. Emers, E.D. Metz, S. Meyer, M. Witter, S. Mauermann, T. Erickson, and S.S. Cooke.1992. Wetland Buffers: Use and Effectiveness. Washington Department of Ecology. Publication No. 92-10.

Chase, V.P., L.S. Deming, F. Latawiec. 1997. Buffers for Wetlands and Surface Waters: A Guidebook for New Hampshire Municipalities. Audubon Society of New Hampshire.

City of Boulder. 2007. Wetland and Stream Buffers: A Review of the Science and Regulatory Approaches to Protection.

Cooke, S.S. 1992. Wetland Buffers: Use and Effectiveness. Appendix A: Wetland buffers - A Field Evaluation of Buffer Effectiveness in Puget Sound. Washington Department of Ecology. Publication No. 92-10.

Correll, D.L. 1997. Buffer Zones and Water Quality Protection: General Principles. *In*: Buffer Zones: Their Processes and Potential in Water Protection. The Proceedings of the International Conference on Buffer Zones September 1996. Haycock, N.E., T.P. Burt, K.W.T. Goulding, and G. Pinay (Eds). Quest Environmental. UK.

Cowardin, L. M., V. Carter, F. C. Golet, and E. T. LaRoe. 1979. Classification of Wetlands and Deepwater Habitats of the United States. U. S. Department of the Interior, Fish and Wildlife Service, Washington, D.C.

Coyne, M. S., R. A. Gilfillen, R. W. Rhodes and R. L., Blevins. 1995. Soil and Fecal Coliform Trapping by Grass Filter Strips During Simulated Rain. Journal of Soil and Water Conservation 50(4): 405-408.

DeLuca, W. V., C. E. Studds, and P. P. Marra. 2004. The Influence of Land Use on the Integrity of Marsh Bird Communities of the Chesapeake Bay. Wetlands 24: 837-847.

Dillaha, T. A., J. H. Sherrard, D. Lee, S. Mostaghimi, and V.O. Shanholtz. 1988. Evaluation of Vegetative Filter Strips as a Best Management Practice for Feed Lots. Journal of the Water Pollution Control Federation 60(7):1231-1238.

Dillaha, T.A., R.B. Reneau, S. Mostaghimi, and D. Lee. 1989. Vegetative Filter Strips for Agricultural Nonpoint Source Pollution Control. Transactions of the ASAE 32:513-519.

Emmons & Olivier Resources (EOR). 2001. Benefits of Wetland Buffers: A Study of Functions, Values and Size. Prepared for: Minnehaha Creek Watershed District, Deephaven, MN.

Environmental Law Institute. 2003. Conservation Thresholds for Land Use Planners. Washington DC.

Federal Interagency Floodplain Management Task Force (FIFMTF). 1996. Protecting Floodplain Resources: A Guidebook for Communities. Federal Emergency Management Agency (FEMA 268/June 1996).

Fischer, R. A. 2000. Width of riparian zones for birds. Ecosystem Management and Restoration Research Program Technical Notes Collection, U.S. Army Engineer Research and Development Center, Vicksburg, Mississippi. www.wes.army.mil/el/emrrp.

Gallagher, J.L. and H.V. Kibbey. 1980. Marsh Plants as Vectors in Trace Metal Transport in Oregon Tidal Marshes. American Journal of Botany 67:1069-1074.

Herrmann, H.L., K.J. Babbitt, M.J. Baber, and R.G. Congalton. 2005. Effects of Landscape Characteristics on Amphibian Distribution in a Forest-Dominated Landscape. Rangeland Ecology & Management. 57:58-65.

Herson-Jones, L. M., M. Heraty and B. Jordan. 1995. Riparian Buffer Strategies for Urban Watersheds. Washington, DC: Metropolitan Washington Council of Governments.

Houlahan, J.E. and C.S. Findlay. 2003. The Effects of Adjacent Land Use on Wetland Amphibian Species Richness and Community Composition. Canadian Journal of Fisheries and Aquatic Sciences 60:1078-1094.

Houlahan, J.E. and C.S. Findlay. 2004. Estimating the 'Critical' Distance at which Adjacent Land-Use Degrades Wetland Water and Sediment Quality. Landscape Ecology 19: 677–690.

Island County, Washington. PLG-011-07. Wetlands Ordinance. http://www.islandcounty.net/planning/documents/PLG-011-07%20Wetlands%20Update.pdf

Kusler, J. 2003. Wetlands and Watershed Management – A Guide for Local Governments. Pub. No. 28. Association of State Wetland Managers. Berne, NY.

Kusler, J. 2007. Model Ordinances for Regulating Wetlands and Riparian Habitats/Stream Buffers – Discussion Draft. Association of State Wetland Managers, Inc. *Available at* http://www.aswm.org/propub/jon_kusler/model_ordinance_051407.pdf.

Kusler, J, & T. Opheim. 1996. Our National Wetland Heritage: A Protection Guide (2d ed.) Environmental Law Institute, Washington, D.C.

Kuusemets, V. and U. Mander 1999. Ecotechnological Measures to Control Nutrient Losses from Catchments. Water Science and Technology 40(10): 195-202.

Lowrance, R. and J.M. Sheridan. 2005. Surface Runoff Water Quality in a Managed Three Zone Riparian Buffer. Journal of Environmental Quality 34:1851-1859.

Magette, W. L., R. B. Brinsfield, R. E. Palmer and J. D. Wood. 1989. Nutrient and Sediment Removal by Vegetated Filter Strips. Transactions of the ASAE 32(2): 663-667.

Mayer, P.M., S.K. Reynolds Jr., and T.J. Canfield. 2005. Riparian Buffer Width, Vegetative Cover, and Nitrogen Removal Effectiveness: A Review of Current Science and Regulations. EPA/600/R-05/118. Cincinnati, OH, U.S. Environmental Protection Agency.

McElfish, J. 2004. Nature-Friendly Ordinances. Washington D.C. Environmental Law Institute.

Parkyn, S. 2004. Review of Riparian Buffer Zone Effectiveness. MAF Technical Paper No. 2004/05. New Zealand Ministry of Agriculture and Forestry. Wellington, New Zealand. http://nzfsa.net/mafnet/rural-nz/sustainable-resource-use/resource-management/review-riparian-buffer-zone-effectiveness/techpaper-04-05-riparian-effectiveness.pdf

Parkyn, S., W. Shaw, and P. Eades. 2000. Review of Information on Riparian Buffer Widths Necessary to Support Sustainable Vegetation and Meet Aquatic Functions. NIWA Client Report ARC00262.

Rapanos v. United States, 126 S. Ct. 2208 (2006).

Rubbo, M.J. and J.M. Kiesecker. 2005. Amphibian Breeding Distribution in an Urbanized Landscape. Conservation Biology 19:504-511.

Schoonover J.E., K.W. J. Williard, J.J. Zaczek, J.C. Mangun and A.D. Carver 2006. Agricultural Sediment Reduction by Giant Cane and Forest Riparian Buffers. Water, Air, and Soil Pollution 169: 303–315.

Semlitsch R.D. and J.R. Bodie. 2003. Biological Criteria for Buffer Zones around Wetlands and Riparian Habitats for Amphibians and Reptiles. Conservation Biology 17(5): 1219-1228.

Sheldon, D., T. Hruby, P. Johnson, K. Harper, A. McMillan, S. Stanley, and E. Stockdale. 2005. Freshwater Wetlands in Washington State - Vol. 1: A Synthesis of the Science. Washington Department of Ecology, Olympia.

Shirley, S.M. 2004. The Influence of Habitat Diversity and Structure on Bird Use of Riparian Buffer Strips in Coastal Forests of British Columbia, Canada. Canadian Journal of Forest Research 34:1499-1510.

Solid Waste Agency of Northern Cook County (SWANCC) v. U.S. Army Corps of Engineers, 531 U.S. 159 (2001).

Strommen, B., K. Cappiella, D. Hirschman, and J. Tasillo. 2007. A Local Ordinance to Protect Wetland Functions. Ellicott City, MD: Center for Watershed Protection. *Available at* http://www.cwp.org/wetlands/articles/WetlandsArticle4.pdf.

Syversen, N. 2005. Effect and Design of Buffer Zones in the Nordic Climate: The Influence of Width, Amount of Surface Runoff, Seasonal Variation and Vegetation Type on Retention Efficiency for Nutrient and Particle Runoff. Ecological Engineering 24:483-490.

USDA Natural Resources Conservation Service. 2003. Where the Land and Water Meet: A Guide for Protection and Restoration of Riparian Areas. First Edition. *Available at* ftp://ftp-fc.sc.egov.usda.gov/CT/water/complete-bufferbook.pdf.

U.S. Environmental Protection Agency. n.d. Model Ordinance: Aquatic Buffers. *Available at* http://www.epa.gov/owow/nps/ordinance/mol1.htm.

Vidon, P.G.F., and A.R. Hill. 2004. Landscape Controls on Nitrate Removal in Stream Riparian Zones. Water Resources Research 40: W03201.

Wenger, S. 1999. A Review of the Scientific Literature on Riparian Buffer Width, Extent, and Vegetation. *Available at* http://www.rivercenter.uga.edu/service/tools/buffers/buffer_lit_review.pdf.

Wigington, P.J. Jr, S.M. Griffith, J.A. Field, J.E. Baham, W.R. Horwath Owen, J.H. Davis, S.C. Rain and J.J. Steiner. 2003. Nitrate Removal Effectiveness of a Riparian Buffer along a Small, Agricultural Stream in Western Oregon. Journal of Environmental Quality 32:162-170.

Wilson, J.D. and M.E. Dorcas. 2003. Effects of Habitat Disturbance on Stream Salamanders: Implications for Buffer Zones and Watershed Management. Conservation Biology 17(3): 763-771.

Wong, S.L. and R.H. McCuen. 1982. The Design of Vegetative Buffer Strips For Runoff and Sediment Control. A Technical Paper Developed as Part of a Study of Stormwater Management in Coastal Areas Funded by Maryland Coastal Zone Management Program.