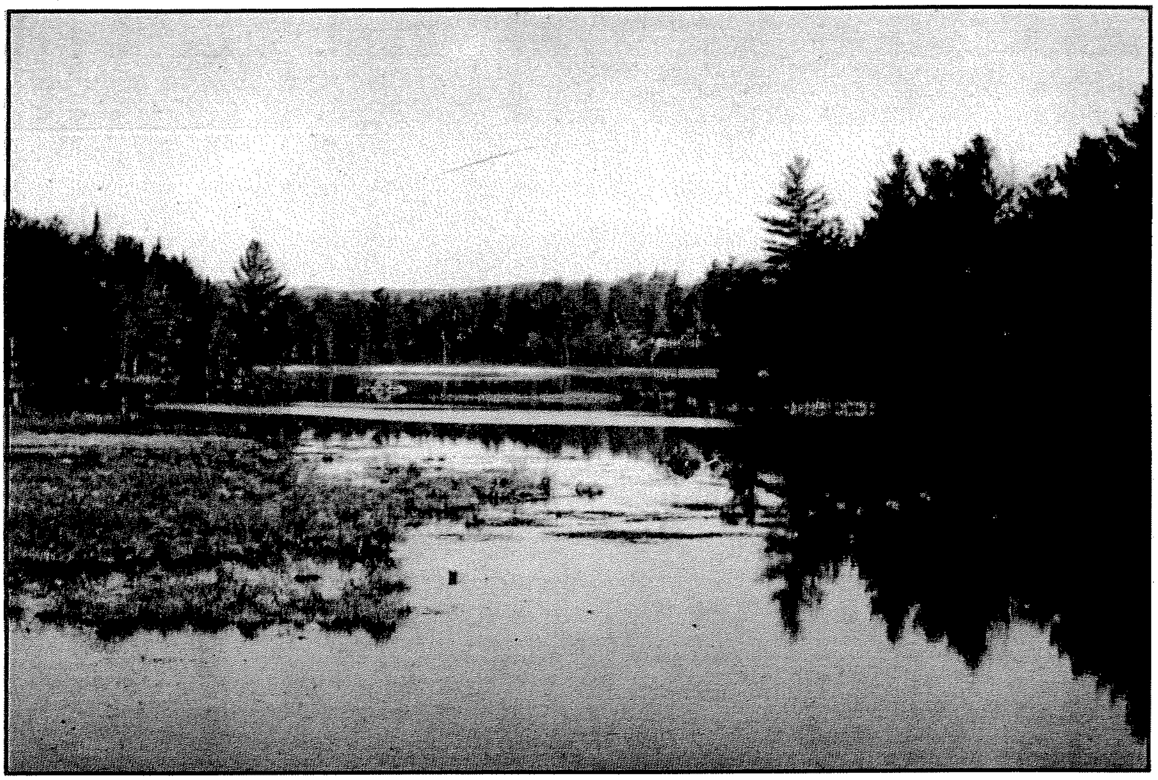
Buffers for Wetlands and Surface Waters

A Guidebook for New Hampshire Municipalities



Audubon Society
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Natural Resource
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N.H. Office of
State Planning

November 1995
Revised May 1997

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A Guidebook for New Hampshire Municipalities

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November 1995

Revised May 1997

Acknowledgments

This document is the result of a cooperative effort. In addition to the authors, the following individuals were members of the Buffers Work Group.

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Jim McLaughlin, The N.H. Office of State Planning
Frank Mitchell and Jeff Schloss, University of New Hampshire Cooperative Extension
Alan Ammann, U.S. Department of Agriculture Natural Resource Conservation Service
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We thank the following individuals, who served on the steering committee for the project.

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Mark Kern	U.S. Environmental Protection Agency
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This manual was revised and reprinted in May of 1997. Revision were done by Richard A. Cook, Laura S. Deming and Miranda Levin of the Audubon Society of New Hampshire

The preparation of this manual was supported by a grant from the U.S. Environmental Protection Agency and the Fund for the Preservation of Wildlife and Natural Areas

This document should be cited as:

Chase, V.P., L.S. Deming, F. Latawiec, 1995. Buffers for Wetlands and Surface Waters: A Guidebook for New Hampshire Municipalities. Audubon Society of New Hampshire.

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I. Introduction

1.1 Background

New Hampshire's landscape is characterized by a complex variety of wetlands, ponds, lakes, and streams. Recent years have brought a greater appreciation for the benefits wetlands provide, such as water quality protection, wildlife **habitat***, and flood control. As understanding of the importance and value of wetlands has increased, so has awareness of how land use in surrounding uplands affects both wetlands and surface waters. A wetland overloaded with nutrients, pollutants, or sediment from adjacent land use loses its ability to filter these substances. Many wetland wildlife species are dependent on upland habitat for some portion of their life cycles. Therefore, development in uplands can jeopardize the viability of both wetland and upland wildlife habitat. Clearly, if wetland and surface water protection is a goal, land managers must consider the effects of human activity in adjacent uplands.

1.2 Purpose of this Guidebook

The purposes of this guidebook are: 1) To assist municipalities by providing a scientific basis for the importance of naturally vegetated buffers next to wetlands and surface waters, and; 2) To provide guidance on ways to protect wetland and surface water buffers, whether through zoning, acquisition, or education.

1.3 Buffer Definition as Used in this Guidebook

The term "buffer" is used in a variety of contexts with different meanings. For the purposes of this guidebook, a buffer is defined as:

A naturally vegetated upland area adjacent to a wetland or surface water.

In this definition, "naturally vegetated" includes the following: uncut or undisturbed forest, minimally disturbed or managed forest, and abandoned pasture or fields.

Buffers reduce the adverse effects of human activities on the wetland or surface water by protecting water quality, protecting and providing wildlife habitat, reducing direct human disturbance from dumped debris, noise, carnivorous pets, and many other possible effects; and maintaining aesthetic diversity and recreational value. A buffer thus provides a mosaic of interdependent functions.

1.4 Definitions of Related Terms

Other related terms used in the scientific literature and regulatory documents are: **riparian buffer, stream corridor, vegetated filter strip, greenbelt** or **greenway, natural woodland buffer, tidal buffer zone**, and **setback**. The use of the term buffer in this guidebook is distinct from these related terms in the following ways:

Riparian buffer and **streamside corridor** are terms used to describe naturally vegetated areas bordering streams and rivers. This guidebook refers specifically to naturally vegetated upland areas. The terms riparian buffer and streamside corridor may refer to both wetland and upland areas bordering watercourses.

Vegetated (also known as **vegetative**) **filter strips** are most commonly used in agricultural literature, where they describe carefully managed areas of **herbaceous** vegetation, as opposed to naturally vegetated areas. However, in the document *Stormwater Management and Erosion and Sediment Control Handbook* (DES, 1992) vegetated filter strips describe either constructed or

* Bolded terms defined in glossary on page 41.

naturally occurring vegetated areas next to either an infiltration trench or a natural channel. Vegetated filter strips in this context are maintained as natural areas, and are not mown.

Greenbelts or **greenways** are generally defined as forested areas encircling urban areas or connecting otherwise fragmented blocks of open space. They are not necessarily associated with wetlands or surface waters.

Setbacks refer to distance requirements from wetlands or surface waters for specific activities, such as construction or septic systems, rather than on maintaining naturally vegetated land around wetlands or surface waters.

The following two terms are regulatory in nature:

Natural Woodland Buffer is defined in the Comprehensive Shoreland Protection Act (RSA 483-B) as:

> . . . a forested area consisting of various species of trees, saplings, shrubs, and ground covers in any combination and at any stage of growth.

Tidal Buffer Zone is defined in the Administrative Rules of the Wetlands Board (Wt 101.76) as:

> . . . the area extending landward 100 feet from the highest observable tide line. This area may contain wetlands, transitional areas, and natural and developed upland areas.

1.4.1 Use of the Terms "wetlands" and "surface waters" in this Guidebook

While wetlands, lakes, ponds, rivers, and streams differ in many obvious ways, the information compiled in this guidebook pertains to wetlands and surface waters of all types. Hereafter, the term "wetlands" includes wetlands as defined by New Hampshire Code of Administrative Rules (Wt 101.82):

> "Wetland" means an area that is inundated or saturated by surface or ground water at a frequency and duration sufficient to support, and that under normal conditions, does support a prevalence of vegetation typically adapted for life in saturated soil conditions. Wetlands generally include, but are not limited to, swamps, marshes, bogs, and similar areas.

The term "surface waters" refers to **deep water habitats** such as rivers, streams, lakes, ponds, and estuaries, as defined in RSA 485-B:

> "Surface Waters of the state" means streams, lakes, ponds and tidal waters within the jurisdiction of the state, including all streams, lakes, or ponds bordering on the state, marshes, water courses and other bodies of water, natural or artificial.

1.5 Existing Regulatoy Buffers and Setbacks in New Hampshie

1.5.1 Septic Setbacks & Tidal Buffers

The administrative rules of Water Supply and Pollution Control Division, Subsurface Bureau, adopted under the Water Pollution and Waste Disposal Statute (RSA 485-A) in New Hampshire currently require setbacks from wetlands only for subsurface wastewater disposal systems. These requirements are: a 50 foot setback from wetlands of predominantly **hydric B** (poorly drained) soils, and a 75 foot setback from wetlands of predominantly **hydric A** (very poorly drained) soils. The administrative rules of the Wetlands Bureau do not require setbacks for construction activities next to wetlands. RSA 482-A:4 does require a 100 foot buffer around tidal wetlands. Within this buffer ". . . need shall be demonstrated by the applicant prior to [Wetlands] Board approval of any alteration of undeveloped tidal buffer zone." (Wt 302.01)

1.5.2 The Comprehensive Shoreland Protection Act

Recognizing the need for shoreland protection on public waters, New Hampshire passed the Comprehensive Shoreland Protection Act (RSA 483-B) in 1991. The law became fully effective on July 1, 1994, after partial funding for implementation was approved. The Comprehensive Shoreland Protection Act requires that ". . . where existing, a natural wooded buffer shall be maintained within 150 feet of the public boundary line". The law affects public water bodies, which are natural ponds or artificial impoundments of ten acres or larger, as well as **fourth order** or higher rivers, and tidal waters (See map on page 9).

1.5.3 Forestry Laws

Forestry is exempt from the Comprehensive Shoreland Protection Act, but the Basal Area Law, RSA 227-J:9, requires that within 150 feet of great ponds and fourth order streams, 50% of the pre-harvest **basal area** must be maintained. The law also requires that 50% of the pre-harvest basal area must be maintained within 50 feet of all **perennial streams**, rivers, and brooks. Areas next to wetlands are not subject to such requirements.

The administrative rules of the Wetlands Board (Wt 304.05 (b)) require adherence to guidelines set in the publication *Best Management Practices for Erosion Control on Timber Harvesting Operations in New Hampshire* (DRED, 1991). The BMP document provides the standards set by the state for minimizing **sediment** flow into wetlands and surface waters. Cutting of vegetation within wetlands is allowed without a permit under the administrative rules, as follows:

> . . . Mowing or cutting of vegetation in a wet meadow, red maple swamp, hemlock swamp, spruce/fir swamp, or white pine swamp, provided that the roots of the vegetation are not disturbed, and that the ground is frozen or sufficiently dry to avoid making ruts and that the area is stabilized once thawed and that the project is not located in prime wetlands. (Wt 303.05 (b))

1.5.4 Municipal Land Regulations

At the local level, a number of municipalities have implemented zoning ordinances for buffers and setbacks around wetlands or surface waters or both. These ordinances have varied from one municipality to another in their requirements based upon local goals and objectives for wetland and surface water protection. Some require setbacks for subsurface wastewater disposal systems beyond those required by the state, while others have construction, forestry, and stormwater management requirements. Some local ordinances require buffers of standard widths (varying from municipality to municipality) ranging from 25 to 400 feet. Other ordinances prescribe a range of possible buffers, and assign a buffer that is determined to be appropriate at the site. Many municipalities in New Hampshire have no buffer provisions in their ordinances.

II. Buffer Functions

2.1 Hydrologic Effects

The ability of buffers to protect wetlands and surface waters is well documented in the scientific literature. A brief review of current knowledge about buffer functions follows.

Vegetation in buffers provides hydrologic stabilization by intercepting rainfall, slowing meltwater and **overland flow**, and promoting **infiltration**. Wetlands and surface waters without vegetated buffers will experience sharper fluctuations in water levels during storm events, which can be disruptive to aquatic life. With runoff flowing more rapidly into wetlands and surface waters during and immediately after storm events, the flood storage capacity of wetlands and surface waters may be exceeded. This could result in flooding of downstream uplands. Wetlands and surface waters with buffers will experience steadier infiltration, and more gradual and natural changes in water levels, minimizing downstream flooding potential.

A buffer around a wetland or surface water may do little to protect against flooding if the streams that feed into the wetland or surface water are unprotected. Unprotected streams, even small, **intermittent streams**, may be sources of sediment and contribute to large fluctuations in water levels (Karr, 1978, Schlosser, 1981). Regions of the United States with highly modified upper watersheds, such as the agricultural lands of the Midwest, contribute to downstream flooding because of the lack of buffered riparian areas high in the watershed (Osborne, 1993).

2.2 Recreation and Aesthetic Enhancement

Vegetation provides a visual and aural screen from human activities in upland areas for people using the wetlands or surface waters for recreation. Recreational activities are likewise enhanced by maintenance of the water quality, wildlife habitat, and ecological integrity of the wetland that buffers facilitate.

Buffers protect the aesthetic value of wetlands and surface waters.

2.3 Wildlife Habitat

Buffers surrounding wetlands and waterbodies provide habitat for many native wildlife species. As transitional habitats between wetlands and uplands, buffers support many species from both communities, and tend to have relatively higher numbers of species of both plants and animals (Porter 1981). Some wetlands, such as marshes, ponds, and swamps, are especially rich habitats, resulting from natural influx of minerals and nutrients from tributary streams. Characteristic lush vegetation attracts both invertebrate and vertebrate herbivores, which provide an abundant prey base for predators, including dragonflies, snakes, mink, hawks, owls, foxes, and black bears. Low nutrient wetlands, such as bogs and fens, support fewer plant and animal species than do more productive habitats, but provide unique habitat for species adapted to such conditions. Many of these species are relatively uncommon, including several types of wild orchid, four-toed salamander, southern bog lemming, Lincoln's sparrow, palm warbler, and rusty blackbird.

Of the 450 or so species of reptiles, amphibians, mammals, and birds that occur in New Hampshire, about 90 species depend on wetlands during some phase of their breeding cycle, and 50 more use wetlands for breeding or foraging habitat (Foss unpubl. doc.). In all, nearly one third of New Hampshire's native wildlife depends on aquatic and wetland habitat. The value of this habitat depends on the condition of the upland area surrounding it.

There are many types of aquatic habitats, including brooks and streams, rivers, marshes, bogs, swamps, lakes, and ponds, each of which support different wildlife communities. Many wildlife species occur only in certain kinds of habitats, whereas others can be found in many habitat types. Within wetland habitats, features such as gravel substrate, submerged debris, and overhanging banks, are essential for various wildlife species and are influenced by the condition of surrounding uplands.

2.3.1 Aquatic habitat

Naturally vegetated uplands help maintain suitable conditions for wildlife species in aquatic habitats. For example, brook trout inhabit only cool, well oxygenated water, which occurs where sufficient shading by trees and other vegetation keeps solar energy from raising water temperatures during the day. Disturbances that significantly alter this upland buffer area can cause severe degradation of the associated wetland or waterbody. For some species, even slight changes in water quality or habitat structure may make an aquatic environment completely unsuitable for breeding, or even for individual survival.

Headwater streams are kept cool by overhanging branches.

(a) **Gravel substrate**

Cold, clear brooks and streams are home to both atlantic salmon and brook trout, which lay their eggs in gravel nests, or "redds", at the bottom of small pools. Egg survival depends on swift currents of cold, well oxygenated water to infiltrate the gravel, where salmon may bury eggs up to 30 cm (12 in) deep (Rutherford 1986). Once the eggs hatch, tiny salmon and trout fry hide in small spaces among gravel stones while slowly absorbing their yolk sacs, relying on constant water flow to supply oxygen and remove metabolic waste. These small spaces, or interstices, also provide refuge for aquatic invertebrates and larval salamanders, which are important prey for fish. Larger spaces offer protection from predators and strong currents during spring thaw or summer storms.

(b) Clear water

Natural vegetation along streams mediates storm runoff and prevents erosion of mineral soils, thus minimizing stream sedimentation. In stream currents, fine sediment particles remain suspended in the water, reducing light transmission and photosynthesis, and ultimately, the natural growth of algae and other plants that form the base of stream food webs for insects that salmon, trout, and other fish prey upon. Murky water further reduces hunting success for salmon, which hunt by sight. In addition, suspended sediments can clog and injure gills enough to kill fish directly. Currents laden with fine particles flow through gravel beds, filling interstices, coating eggs, and preventing emergence of young fry, which suffocate or starve. Larger particles fill in cavities used by small fish, larval salamanders, and invertebrate prey species, thereby reducing food sources and increasing losses to predation.

(c) Shading

Tree canopies and overhanging banks shade small streams effectively, even during summer months. Shaded streams stay colder, and therefore have higher oxygen content than warmer water, and undergo less dramatic daily temperature fluctuations than water exposed to direct sun. Salmon, trout, and other species that require highly oxygenated water and stable temperatures therefore depend on trees, shrubs, and herbaceous growth to maintain water quality.

(d) Organic debris

Organic material falling into streams is the primary source of nutrients to that habitat. The food web in small headwater streams, especially, depends on leaf litter and other debris for input, as currents continually carry away material. Minerals and debris washing downstream collect in wetlands, which are exceptionally rich habitats for wildlife. Leaf litter also provides some shelter for aquatic insects, salamanders, and fish.

Woody debris provides both organic nutrients and structure for aquatic wildlife. Many invertebrates and amphibians lay their eggs in water, attaching them to available substrates, including logs and branches. Some stream salamanders attach their eggs to the undersides of submerged rocks and branches, and may hibernate under or forage among such debris during the winter. Logs and branches also provide refuge from predators.

Logs and branches provide important shelter for turtles and fish, which seek refuge from predators and strong currents caused by spring runoff and summer storms. Such places also offer cover for hunting wary prey. Logs and branches emerging from the surface are used for basking by turtles, such as the painted and musk turtle, which will dive to safety from several feet above the water.

(e) Streambanks

Streambank condition is highly dependent on the presence of certain plant species. Trees that naturally grow along streams possess root structures that can withstand cyclic flooding, ice scour, and natural erosion of the bank. Undercut banks are important for fish, which rest in their shade, undetected by predators above. Wood, spotted, and Blanding's turtles hibernate on the stream bottoms, often choosing sites under root tangles. These places are often inaccessible to predators like mink and otter, which can attack and kill hibernating turtles. Large root masses offer protection from strong currents and crushing ice jams during spring thaw. Upon emerging from hibernation, turtles are weak and slow-moving, unable to swim against stream currents or climb easily onto land. Root masses and undercut banks offer places for them to slowly climb to the surface, where they can quietly bask along the water's edge.

(f) Pools and Riffles

The pattern of currents, pools, and riffles along a stream determines the distribution of many wildlife species within that stream. Trees and branches that fall across or into the stream may help create pools by altering water flow and channeling the current. Natural rates of change within stream and river beds is essential for plants and animals that have evolved to depend on and adapt to disturbance.

2.3.2 Upland habitat

Many wildlife species that depend on wetlands also require surrounding uplands during part of their life cycle. Buffers provide food, cover, habitat for reproduction and rearing of young, and protection from human disturbance. In developed areas, buffers may also be used as travel corridors by wide-ranging species, which need to move among natural habitats safe from exposure to humans and domestic animals (Castelle et al. 1992).

(a) Food

The rich plant life associated with shorelines, floodplains, and wetlands provides the foundation for an extensive food web of invertebrates and vertebrates alike. Trees, shrubs, vines, and other plants produce a variety of nuts, berries, seeds, buds, and vegetation, as well as attracting abundant insects, which are eaten by many vertebrate species. Trees commonly found along floodplains and wetlands, such as oak, hickory, and hornbeam, produce nuts (hard mast) favored by squirrels, deer, grouse, turkey, wood ducks, and bears. Common wetland shrubs, including highbush blueberry, dogwoods, chokeberries, shadbush, wild roses, and vibernums produce berries eaten by many birds and mammals, and are especially important food for migrating birds during late summer and autumn (Foss 1989). Vines of grape and Virginia creeper often found along riverbanks are also important sources of berries (Foss unpubl. doc.).

Diverse plant life and the presence of water attracts a multitude of insect species. Some of these species lay their eggs in water, producing aquatic larvae that are prey for salamanders, fish, turtles, snakes, birds, and mammals. Birds are especially dependent on the high protein content of insects during the breeding season, when they are brooding and raising young. Many studies have shown that bird species richness and density is higher in riparian forests than in adjacent upland forests of similar vegetative structure and composition (Stauffer and Best 1980, Szaro 1980). Avian communities are influenced by several factors, but the high numbers and diversity found near aquatic habitats could not occur without an abundant source of food.

Low elevation wetlands and riparian habitat offer the first greenery in spring, attracting black bears just emerging from hibernation, and white-tailed deer seeking food after a long winter of eating browse. Seeds, buds, and foliage are also important fare for many small mammal species, which, in turn, are important prey for many predators.

(b) Cover

Species that require aquatic habitat for survival may be especially dependent on adjacent uplands for other life needs. Wood ducks, which live in wooded swamps and other shallow waterbodies, feed on aquatic insects and plants, but nest in large cavity trees up to several hundred meters away from water (DeGraaf and Rudis 1986). Cavity trees are essential for other birds and mammals, providing nesting places for mergansers, owls, woodpeckers, nuthatches, wrens, bluebirds, as well as squirrels, raccoons, marten, fisher, bats, porcupines, gray foxes, and black bears. Trees suitable for cavity-nesting species tend to be more abundant in swamps and floodplain forests than in drier sites, due to faster growth and higher incidence of decay.

Species that do not utilize tree cavities depend on thick vegetation of surrounding uplands for concealment. Mallards and black ducks build their nests on the ground, sometimes several hundred meters away from water (Bellrose 1976). Thick shrubs and herbaceous vegetation provide nesting cover for many species of shorebirds, warblers, flycatchers, and sparrows, and tall dead or live trees may support nests of great blue herons, ospreys, and eagles. In all, there are 21 wetland-dependent bird species in New Hampshire, most of which nest in upland habitat adjacent to the wetlands they require for foraging. In addition, there are 18 more bird species that are wetland-associated, that is, they do not require wetlands, but are most commonly found there.

Turtles nest in upland habitat, seeking relatively dry, loose soil with little vegetation. Nest sites may be located along riverbanks and shorelines, in close proximity to aquatic habitat. However, females of many species will travel up to 100 m (328 ft) from water to dig nests. Terrestrial species, such as wood, spotted, and Blanding's turtles, may wander overland for miles during the summer months, returning to home streams and waterbodies only to hibernate. During this time, they rely on thick shrub cover for protection while basking, staying cool, and foraging. Populations of these three species have shown declines in recent years, probably due to direct habitat loss and over-collecting in sites with increased access and reduced protective cover.

(c) Travel corridors

Moose, deer, black bears, and other large mammals use many different types of habitat during the year, wandering constantly in search of food. Buffers provide food and cover for many species, and allow them to travel among different habitats relatively undisturbed by human noise and activity. Unimpeded movement across a landscape increases the likelihood of survival of individuals, and maintains genetic integrity of populations. Buffers also protect the adjacent waterbody from disturbance by limiting human access.

2.4 Conditions influencing the value of buffers for wildlife.

The value of a particular buffer zone for wildlife depends on conditions within the buffer area, as well as surrounding land uses and the associated level of human disturbance. Habitat features within the buffer that are important to wildlife are discussed in Section 2.3. under Buffer Functions, and include both aquatic and terrestrial elements of wildlife habitat. The Appendices of New Hampshire's amphibians and reptiles, mammals, and birds also highlight habitat features important for certain species. Management or disturbance activity within natural habitats may benefit some wildlife species, deprive others of breeding, foraging, or cover requirements, and have relatively little impact on species that are not sensitive to those particular changes.

2.4.1 Location of the Buffer in the Landscape

The location of the buffer on the landscape also determines its use to wildlife species in that area. Buffer habitat enhances the ecological integrity of the wetland it surrounds, by providing food and cover for resident species, and safe travel routes for wildlife dispersing and migrating through the area. To serve as safe travel corridors, buffers should be connected to other protected areas and valuable wildlife habitats. Small wetlands that serve as breeding, feeding, and resting places for many wildlife species are often not legally protected, and easily filled, drained, or otherwise degraded. The loss of such wetlands not only decreases habitat availability for wildlife, but increases travel distances among remaining wetlands, thus reducing migration, dispersal, and genetic interaction among wetland wildlife populations (Gibbs 1993).

2.4.2 Buffer Width

To optimize the value of buffer zones for wildlife, perhaps the most important parameter is width. In general, the larger, or wider a buffer zone is, the more valuable it is as wildlife habitat. Wider upland buffer zones provide a higher degree of water quality for the associated wetland or waterbody, reduce human access to the site, and create a greater distance between wetlands and surrounding human development. More protected upland habitat will have more diverse habitats within it, and can thus support more wildlife species. Table 2.4.2 lists buffer zone widths derived from the literature for different species. It is clear from this list that no one width can accomodate the needs of all species that use a particular wetland. It is also evident that some species use so much habitat that it would be nearly impossible to protect the size buffers they require. For these species, management of buffer zones may minimize drawbacks associated with limited area.

2.4.3 Edge Effects

The primary concern for wildlife with respect to buffer width is that of "edge effects" (Noss 1993). The most significant of these edge effects are predators and nest parasites associated with edge, or ecotone, habitats. Ecotones attract disproportionate numbers of predators such as bluejays, crows, opposums, raccoons, skunks, foxes, and domestic cats and dogs. In their search for prey, these predators often invade forest interior habitats, and can devastate populations of forest -nesting birds that evolved in habitats with fewer predators. Most neotropical migrants, for example, build open, cup-shaped nests on or near the ground. These species are especially vulnerable to predation, and reproduce poorly within several hundred meters of forest edges.

Studies of North American birds show that larger forest tracts support more species than smaller forest tracts (Whitcomb et al. 1981, Ambuel and Temple 1983). Many neotropical migrants will not nest in isolated woodlands of less than 500 acres (Robbins 1979). Throughout much of the original breeding range for most species, however, small fragmented woodlands are all that remain of once extensive forests. Birds that continue to breed in such forest fragments often do not succeed in raising young, and may not survive themselves, because they cannot find safe breeding sites far enough away from edge habitat. Predation by edge species may affect birds breeding in forests of up to 5000 acres (Robbins 1979).

Another component of edge effects on interior forest species is the brown-headed cowbird. Cowbirds are nest parasites, in that they do not build their own nests or raise their own young, but lay their eggs in nests of other species. Cowbird eggs hatch quickly, and the young are much larger than those of their hosts. The parasitized parent birds expend their energy trying to feed the enormous hatchling, which often pushes the host eggs and young out of the nest. Bird species that evolved with the cowbirds on the midwestern plains have evolved behaviours to thwart cowbirds, such as abandoning the nest, or building another nest over the cowbird egg. However, birds native to the eastern forests did not evolve with the cowbird, which moved east as forests were cleared for agriculture during the past century. These species are quite vulnerable to nest parasitism, especially in forest stands that have a high ratio of edge to interior habitat. In heavily fragmented landscapes, some species raise more cowbirds than their own young.

In eastern deciduous forests, nest predation may be significant even 2000 ft from a forest edge (Wilcove 1985, in Noss 1993). To minimize nest predation and parasitism of forest interior birds, buffer zones would have to be about 0.9 miles (4760 ft) wide, which would allow about 700 ft of nesting habitat safe from edge effects on either side (Noss 1993).

2.5 Water Quality

Water quality describes the purity and clarity of water. The ecological integrity of a wetland or surface water body is affected by its water quality. Water quality affects public health where the surface water is a public water supply, or where drinking water reservoirs are located downstream from the wetland or surface water. Therefore, protecting water quality in wetlands and surface waters may be a response to public health concerns.

Buffers help protect water quality in wetlands and surface waters in part by slowing runoff and allowing water to infiltrate. Poor water quality in wetlands and surface waters is most often associated with pollutants carried in **surface runoff**. A brief review of surface runoff and associated pollutants follows.

2.5.1 Surface Runoff

Surface runoff describes the movement of precipitation or meltwater in a natural course downslope. Surface runoff may be in a uniform sheet, as "overland flow", which occurs for short distances at the top of a watershed; or as channelized flow, in small temporary streams and channels further downslope. Surface runoff carries pollutants, as described in table 2.5-1.

(a) Sediment

The transport of sediment downslope and downstream is a natural phenomenon. River deltas are created by the transport of sediment downstream. When flowing water carrying suspended particles meets an open waterbody such as a lake or an ocean, the water decelerates, suspended sediment settles out, and sandy or silty delta deposits are formed. However, construction, logging, agriculture, and other forms of soil disturbance can cause excess sediment to be carried in channelized flow. If sediment laden water flows into wetlands or surface waters, it can lead to the degradation of water quality. Consequently, poor quality water can disrupt the life cycles of aquatic flora and fauna. Excess deposited sediment can smother fish eggs, invertebrate bottom dwelling animals, and leaves of aquatic plants. Suspended (floating) sediment suffocates fish by damaging their gills. By blocking sunlight, sediment inhibits photosynthesis for aquatic plants. Sediment also can transport other pollutants by means of **adsorption**, or temporary chemical attachment to soil particles.

Buffers trap sediment before it reaches wetlands and surface waters. Leaf litter and vegetation slow surface runoff as it passes through the unpaved, vegetated buffer. Water percolates downwards, and sediment is trapped at the soil surface. The root structures of plants in the buffer help to maintain porosity in the soil, which promotes infiltration. By minimizing the entry of sediment into wetlands and surface waters, buffers help to alleviate the problems associated with excess sedimentation.

(b) Nutrients

In addition to water and sunlight, plants need nutrients such as nitrogen, phosphorus, and potassium, along with other minerals. Although wetland plants need nutrients just as upland plants do, an excess of nutrients, especially phosphorus, in wetlands and surface waters causes the accelerated growth of algae, which blocks sunlight and inhibits the growth of other aquatic plants. Because algae are short lived, an algal "bloom", or period of rapid reproduction, quickly gives way to decomposition, which consumes available oxygen in the wetland or surface water. Fish

Table 2.5-1 Pollutants and their Sources

source	pollutant
roads, urban land	sediment, petroleum, road salt, heavy metals, pathogens
lawns, golf courses	lawn fertilizer (nutrients), pesticides
septic systems	nutrients (especially nitrates), pathogens
agricultural activities	nutrients (nitrogen and phosphorus), sediment, pesticides, pathogens
construction	sediment
timber harvesting	sediment

A discussion of these pollutants and how buffers help to alleviate them follows.

and other aquatic organisms suffocate in water depleted of oxygen. Because few species can survive in an oxygen poor environment, this process, known as **eutrophication**, can cause a localized reduction in species diversity.

The two nutrients most responsible for eutrophication are phosphorus and nitrogen. As phosphorus is usually in the shortest supply, it is considered the "limiting nutrient" for most lake, pond, wetland and stream systems and only small additional loadings are necessary to initiate algal blooms. In some river and most estuarine systems nitrogen is the limiting nutrient in the eutrophication process. Increasing the loadings of either nutrient however will usually cause a shift in the natural algae populations to more nuisance forms (mats, scums, blooms).

Nitrogen may exist in the soil in many compounds, but is most commonly found as NH_3 (ammonium) NO_2 (nitrite) or NO_3 (**nitrate**). Taken together, the sum of all nitrogen compounds found in the soil is sometimes referred to as "total nitrogen". Excesses of any of these forms of nitrogen can cause algal blooms as described above. Nitrate is found in agricultural and septic system runoff. Where nitrate makes its way into drinking water, it is harmful to people, especially to young children, because it interferes with the body's ability to absorb oxygen.

Buffers help to reduce the entry of excess nutrients into wetlands and surface waters by slowing the flow of surface runoff. Nutrients adsorbed to sediment particles are trapped in the soil surface as sediments settle out. Dissolved nutrients may be taken up by roots of vegetation in the buffer, or released more slowly into an aquatic environment. Microorganisms in the soil convert nitrate to gaseous nitrogen through the biochemical process of **denitrification**. Gaseous nitrogen is then released to the atmosphere. Denitrification occurs most readily under saturated conditions where there is a source of carbon.

(c) Pathogens

Pathogens are disease causing agents such as bacteria, viruses and parasites. Pathogens may be killed or rendered harmless as they are carried in subsurface flow through the soil. The effectiveness of removal of pathogens depends on the moisture content, particle size, pH, and temperature of the soil (DES, 1991). Pathogens from sources such as septic systems that are situated too close to surface waters or the **water table**, or are not designed or maintained properly, may contaminate drinking water supplies or cause harm to those who come in contact with the water through recreational activities.

(d) Other pollutants

Other pollutants may become stabilized in the buffer by becoming adsorbed to soil particles. For example, buffers may remove some metals, such as copper or zinc, from runoff by binding them to soil particles in the buffer

Nutrient sources such as golf courses can cause eutrophication in adjacent wetlands and surface waters.

substrate. Leaves in the canopy of forested buffers can neutralize acid caused by acid rain (Hornbeck, 1977). Pesticides and petroleum may be slowly broken down by microbial activity, although removal of these substances by natural processes in the buffer is not predictable or recommended as a method of mitigation.

(e) Limits to buffer effectiveness

Buffers have a limited capacity for pollution abatement, and in all cases source reduction of pollutants should be a goal. Pesticides and petroleum may be partially broken down by natural buffer processes, but other pollutants may pass through the buffer unchanged. Neither salt nor heavy metals such as cobalt, lead, or mercury are removed by natural buffer processes. Furthermore, pollutants that are stabilized in the buffer may become mobilized if the buffer is disturbed by flooding, excavation, or soil erosion during periods of high flow.

III. Site Specific Conditions Governing Effectiveness of Buffers for Water Quality

The extent to which water quality in a wetland or waterbody can be protected by a buffer depends on conditions in the buffer, such as the soils, vegetation, topography, and land use in the surrounding upland. A discussion of these features and how they influence buffer effectiveness follows.

3.1 Runoff Velocity

Local and regional variations in soils, slopes, and vegetation relate to buffer effectiveness because of the ways in which they alter the velocity and quantity of runoff. The more a buffer is able to slow runoff, the more infiltration can take place. Runoff velocity is also influenced by the storm event generating the runoff. A heavy intense rain will produce a higher volume of runoff, traveling at a greater speed than a light rain. In unusually heavy storm events, a buffer will be less effective, and sediment and pollutants may be transported into the wetland or waterbody.

Runoff velocity also determines how much sediment will be transported. Fast moving water can carry large particles of sediment; slow moving water can carry only fine suspended sediment, such as clay particles. Fast moving runoff will carry more sediment into wetlands and surface waters.

3.2 Soils

Buffer soils differ in their ability to allow infiltration and bind pollutants. Highly permeable sandy soils, because of their high **percolation** rates, will facilitate rapid infiltration of runoff in the buffer. However, rapid infiltration may not allow enough time for adsorption of pollutants onto soil particles or uptake by plant roots. If the soils do not have a restrictive layer, nutrients and other soluble pollutants can move quickly through the root zone into **aquifers** or streams.

On the other hand, soils with a very high clay content may have poor infiltration, which would cause runoff to flow over the buffer directly into the wetland or surface water. Soils ideal for allowing infiltration of water and retention in the subsurface root zone would be somewhat permeable, with a fairly high organic content to provide carbon for microorganisms that accomplish denitrification, and with some clay content to provide binding sites for metals and other pollutants.

3.3 Vegetation

The functioning of a buffer depends in large part on its vegetative condition. Areas next to wetlands and surface waters with bare soil will quickly become channelized and eroded by incoming surface runoff. Roots of buffer vegetation provide an anchor for soil in the buffer, which help prevent soil erosion. Both naturally vegetated (forested) buffers and herbaceous (grass) buffers have been used in different circumstances for different purposes.

3.3.1 Grass Buffers

Vegetated filter strips (areas of managed herbaceous vegetation) protect riparian areas from nutrient and sediment influxes originating in cropland. These areas are constructed to promote sheet flow through the buffer, and vegetation (usually grass) must be mowed and removed periodically to effectively remove nutrients that the vegetation has absorbed and stored. The use of herbaceous buffers rather than forested buffers next to agricultural fields is a practical measure; tree roots and shade from trees adjoining cropland would adversely affect agricultural production.

In a study comparing naturally vegetated buffers with vegetated filter strips (grass buffers), vegetated filter strips were found to be superior in two respects; grass buffers were more efficient than forested buffers at absorbing phosphorus from shallow groundwater, and grass buffers were better at promoting sheet flow, which is important for enabling infiltration (Osborne, 1993).

3.3.2 Naturally Vegetated Buffers

Naturally vegetated buffers are generally recognized as being superior to grass buffers (Hornbeck, 1994; Osborne, 1993). Forested buffers are more efficient than grass buffers at absorbing excess nitrate (Osborne, 1993). Tree roots in forested buffers improve porosity of the soil by creating spaces, which promote infiltration. Leaf litter provides a rough surface for slowing flow and a source of carbon for denitrification. Overhanging branches provide cooling shade for wetlands and surface waters, which maintains lower temperatures essential for many wildlife species. Forested buffers also provide a screen between wetlands and surface waters and upland activities, which grass buffers do not.

In New Hampshire, natural upland vegetation will usually succeed to forest. (Some examples of exceptions are areas of extreme slope, bare bedrock, and sand dunes.) Therefore, naturally vegetated buffers are assumed to be in some stage of forest succession. Naturally vegetated buffers will have a range of vegetative composition, with varying capacities for protecting water quality and providing wildlife habitat.

3.4 Topography

The speed at which surface runoff travels is partially dependent on slope. Steep slopes promote faster flow, and channelization occurs more readily than on shallower slopes. Steep slopes also may determine to some extent the angle and speed of subsurface flow, depending on the depth to bedrock or a restrictive layer. Slopes steeper than 15% are more prone to channelization of surface runoff, even given ideal buffer vegetation and soils. In areas with steep slopes and large volumes of surface runoff, a buffer alone may not be sufficient to provide adequate water quality protection.

A buffer with undulating microtopography will provide more opportunities for runoff to collect and infiltrate than a straight, smooth slope. For this reason, slope may not be a precise predictor of a buffer's ability to slow runoff.

3.5 Land Use

Some land uses outside the buffer will have a greater impact on surface runoff than others. For example, a high percentage of impervious area, such as pavement or roof areas, will result in a larger volume and higher velocity of surface runoff. Agricultural runoff may include nutrients or pesticides, whereas runoff from residential or urban land use may include petroleum products, lawn fertilizer, heavy metals, or salt. Commercial and industrial land uses may result in the manufacturing, use, or storage of potential contaminants. Land use in the entire watershed of the wetland or surface water will affect the volume and pollutant load of surface runoff, as well as subsurface flow.

A watershed with a high percentage of impervious area, or exposed soil, may produce greater volumes of sediment laden runoff than a buffer can effectively ameliorate. Stormwater management techniques for modifying increased flow should be used in conjunction with buffers in such cases to protect wetlands and surface waters. The publication *Stormwater Management and Erosion and Sediment Control Handbook for Urban and Developing Areas in New Hampshire* (Minnick, E.D., and H. Tillman Marshall, 1992) provides Best Management Practices for stormwater management.

3.6 Seasonal Variation

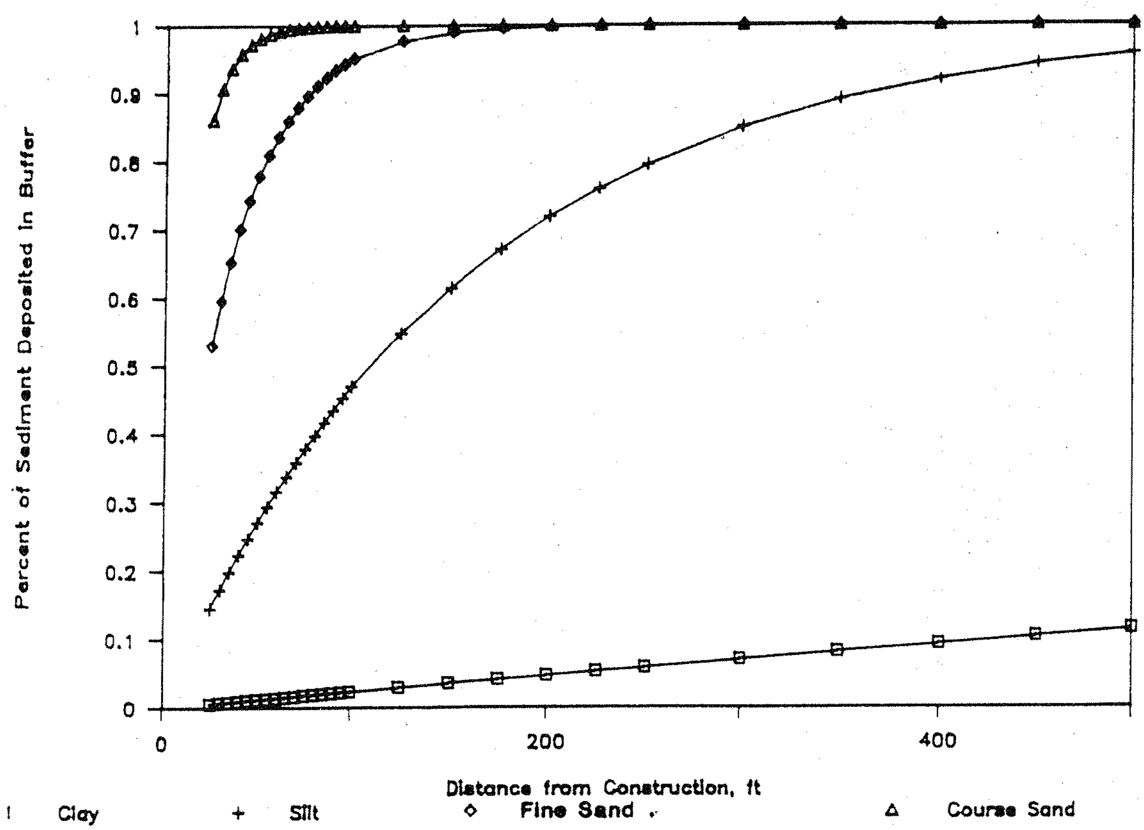
An important consideration in New Hampshire is the influence of spring runoff on the sediment and nutrient load to wetlands and surface waters. In the spring, as winter snow and ice melts, high volumes of water will pass through the buffer. During this time, infiltration is prevented because the ground is frozen. Research suggests that naturally vegetated buffers with leaf litter and a layer of humus retain some ability to slow runoff and trap sediment, even when the ground is frozen. Denitrification may continue in the winter months, although at a much lower rate than during the growing season. Leaf litter provides necessary carbon for this process (Pinay, 1993).

3.7 Buffer Width

A buffer's capacity to capture pollutants depends in part on the width of the buffer, or the distance between the wetland or surface water and the land use from which the wetland or waterbody is being buffered. A wider buffer is generally more effective, both because there is more opportunity for pollutants to be absorbed, stabilized, or chemically altered, and because it prevents the generation of pollutants close to the wetland or surface water.

The relationship between buffer width and sediment and nutrient removal does not appear to be linear. All other factors being equal, the rate of sediment deposition will slow down as buffer width increases. Rates of sediment deposition depend in part on the particle size, surface roughness of the buffer, and runoff velocity. As one example, Figure 3.7-1 shows predicted sediment deposition rates with increased distance from a sediment source for different sized particles. The graph is based on a method, *Technical Release - 55*, developed by the Soil Conservation Service (now the Natural Resource Conservation Service) for predicting runoff volume (U.S.D.A., 1975). This method was adapted by the East Florida Regional Planning Council to determine appropriate buffer widths based on preventing sediment deposition and drawdown in wetlands. The graph was developed for use in East Central Florida, which has different soils and slopes from New Hampshire, and is therefore not directly transferable to conditions in New Hampshire. Nonetheless, the graph illustrates the principle that after the point at which most pollutants have been trapped, additional distances do not contribute significant reductions in pollutants.

Figure 3.7-1 Sediment Trapping & Buffer Width (U.S.D.A., 1975)



IV. Recommended Buffer Widths

4.1 Rationale for Standard Width Buffers in New Hampshire

As discussed earlier, several factors influence buffer effectiveness for water quality protection: particularly soil type, slope, amount of discharge flowing through a buffer, type of vegetation in the buffer, and the buffer width. Of these factors, the buffer width and buffer vegetation are the most easily controlled. Many models and buffer determination methods developed in other states determine appropriate buffer widths based on soils, slopes, vegetation, or land use in the watershed (Brown et al., 1990; Diamond & Nilson, 1988; Phillips, 1989a; Rogers et al., 1988; Roman & Good, 1985; Xiang, 1993; Young, 1989). The concept of using landscape features to determine appropriate buffer widths for water quality protection is logical. However, in practice there are several disadvantages to applying a buffer width determination procedure.

The methods currently available for buffer width determination illustrate that although differences in buffer effectiveness due to features of the landscape are acknowledged, there is no consensus on a single method for predicting appropriate buffer widths for water quality protection. Each buffer width determination method was developed for a specific purpose in a specific location, and may be well suited to the purpose for which it was developed. However, there is no method readily available for buffer width determination in New Hampshire.

Besides the aforementioned difficulties, a site specific buffer width determination model is impractical to implement. Using a prescriptive method would require that the user, who is likely to be a layperson, have some technical expertise in mapping, soils, determining slopes, etc. Such a method would take both time and money to apply. The logistics, legal implications, and monitoring of different buffer widths (if buffers are regulatory in nature) on adjoining lots further complicates such a scenario.

In view of these drawbacks, a site-specific buffer width determination methodology was not recommended for New Hampshire municipalities both because of the lack of an acceptable or easily adaptable method, and because of the impracticality of its application if such a method were available.

4.2 Recommendation for Minimum 100 Foot Wide Buffers

The rejection of a site specific buffer width determination procedure necessitates choosing a standard buffer width which will be appropriate under most circumstances. This standard width must balance the protection of important natural resources with the needs of landowners.

After a thorough review of the current scientific literature and consultation with natural resource professionals and state and federal regulators, 100 feet is recommended as a reasonable minimum buffer width under most circumstances. A review of recommendations found in the scientific literature (Appendix E) indicates that the average buffer recommended is around 100 feet.

4.2.1 100 Foot Wide Buffer — Benefits for Water Quality

The research on removal of sediment and nutrients reveals a wide spectrum of removal rates for different buffer widths, as illustrated in Table 4.2-1 (adapted from Desbonnet et al., 1994). (TSS = total suspended sediment, N = nitrogen, P = phosphorus, NO_3 = nitrate) As shown in table 4.2-1, a narrow buffer of 25 feet may give highly variable results; from 6% phosphorus removal to 99% phosphorus removal, depending on local conditions. In general, however, as buffer size increases, percent removal of pollutants is consistently higher. A 100 foot wide buffer

Table 4.2-1 Summary of Buffer Width and Pollutant Removal

Author	width (feet)	sediment	TSS	N	P	NO3
Doyle et al., 1977	2				9%	0%
Niebling & Alberts, 1979	2	91%				
Niebling & Alberts, 1979	2	37%				
Niebling & Alberts, 1979	4	78%				
Doyle et al., 1977	5				8%	57%
Niebling & Alberts, 1979	8	82%				
Doyle et al., 1975	12			95%	99%	
Doyle et al., 1977	13				62%	68%
Young et al., 1980	13			84%	83%	9%
Dillaha et al., 1988	15		31%	0%	2%	
Dillaha et al., 1988	15		87%	61%	63%	
Dillaha et al., 1988	15		76%	67%	52%	
Magette et al., 1987	15		72%	17%	41%	
Dillaha et al., 1986b	15	63%		63%	63%	
Niebling & Alberts, 1979	16	83%				
Niebling & Alberts, 1979	20	90%				
Doyle et al., 1975	25			96%	99%	
Schellinger & Clausen, 1992	25		4%	15%	6%	
Schellinger & Clausen, 1992	25		27%	16%	18%	
Dillaha et al., 1988	30		58%	7%	19%	
Dillaha et al., 1988	30		95%	77%	80%	4%
Dillaha et al., 1988	30		88%	71%	57%	17%
Dillaha et al., 1986b	30	78%		78%	78%	
Magette et al., 1987	30		86%	51%	53%	
Thompson et al., 1978	39			45%	55%	46%
Bingham et al., 1978	43			28%	25%	28%
Mannering & Johnson, 1974	49	45%				
Doyle et al., 1977	50			95%	99%	
Lake & Morrison, 1977	50	46%				
Gilliam et al., 1988	52	90%				
Haycock et al., 1992	52					84%
Osborne et al., 1993	53					90%
Peterjohn & Correll, 1984	62	90%		62%	0%	60%
Haycock et al., 1992	66					99%
Young et al., 1980	70	81%				
Young et al., 1980	70	75%				
Scwer & Clausen, 1989	85		95%	92%	89%	
Young et al., 1980	90	93%				
Young et al., 1980	90		66%	87%	88%	
Young et al., 1980	90	75%				
Pinay et al., 1993	98					99%
Doyle et al., 1975	100			98%	99%	
Patterson et al., 1977	115		71%			

(Adapted from Desbonnet et al., 1994)

Thompson et al., 1978	118			69%	61%	
Osborne et al., 1993	128					90%
Wong & McCuen, 1982	148	90%				
Woodard, 1988	187	99%				
Edwards et al., 1983	197		87%	83%	84%	
Baker & Young, 1984	259			99%		
Karr & Schlosser, 1978	299	55%	50%			
Karr & Schlosser, 1978	705	97.5	90%			
Karr & Schlosser, 1978	997	99%	97%			

is more reliable, with removal rates generally 60% or higher. If 60% removal is accepted as a minimum pollutant removal rate, a 100 foot buffer will provide an acceptable level of water quality protection.

4.2.2 100 ft Buffer — Benefits For Wildlife

A 100 ft wide buffer would provide food, cover, and breeding habitat for many species, but would provide only some life requisites for others. A buffer of 100 ft would help maintain water quality in wetlands and surface waters, which is important for all wildlife, both aquatic and terrestrial. Buffers of at least 30 m (100 ft) are recommended for headwater streams, to protect trout and salmon habitat (see Table 4.2-2). This size buffer protects species that are aquatic, or that stay very close to the water's edge. However, many species that are dependent on aquatic habitat, such as most salamanders, frogs, turtles, mink, beaver, otter, and many species of birds, also use terrestrial habitats, and may nest or travel several hundred meters away from water. Those species that normally remain within a few feet of water, such as dusky salamanders, bullfrogs, and water snakes, need dispersal routes for individuals, primarily juveniles, to travel to other wetlands. Large mammals, including black bear, lynx, moose, and deer, and many hawks and owls require very large areas for home ranges. A 100 ft buffer can not accommodate such extensive areas, but may offer cover for individuals traveling among various habitats.

4.3 Cases where Buffers Larger than 100 Feet are Appropriate

A 100 foot wide buffer will provide a minimum level of protection for wetlands and surface waters. However, in some cases a higher level of protection may be warranted. A wider buffer will provide a larger measure of insurance for sensitive wetland or surface water resources against the effects of human activity in the upland.

4.3.1 Water Supply Sources

Because of the obvious impacts to human health of tainted water supplies, reservoirs should receive the greatest possible protection. While there is no prescription for an appropriate size buffer to protect water resources under all circumstances, municipalities might consider the factors presented in section III (soils, slopes, and land use in the watershed) when determining appropriate buffers for water supply reservoirs. A buffer larger than 100 feet may be desired to give a larger measure of insurance.

4.3.2 Sensitive Wetlands

Some wetland types in New Hampshire, such as bogs, fens, and Atlantic White Cedar swamps, are extremely sensitive to the addition of nutrients or sediment. Such wetlands are naturally low in nutrients, and the plants they support are adapted to this low nutrient environment. These wetlands are often underlain by a peat mat, which require low nutrient conditions to maintain **anaerobic** stability. Addition of nutrients to such wetlands causes the decomposition of the peat mat, and significantly alters the plant community. (See Appendix D for descriptions of wetlands sensitive to the addition of nutrients.) The hydrology of each wetland is unique. Still, it is safe to assume that wider buffers will give additional protection to more sensitive **ecosystems** from

Table 4.2-2 Wildlife Habitat Within a 100 ft Buffer

Wildlife species	What 100 feet provides	What 100 feet does not provide
Stream invertebrates and fish	shading, bank stability, organic debris, prevention of siltation and nutrient input	adequate floodwater abatement
Eastern newt	maintain water quality of wetlands and surface waters	habitat for terrestrial juveniles (efts)- travel for 2-7 year olds
Four-toed salamander	habitat for breeding (lay eggs within 4.3 in of water) and most activity	dispersal routes to neighboring wetlands beyond 100 ft
Northern dusky salamander	habitat for breeding (lay eggs within 19.5 in of stream edge) and most activity	dispersal habitat
Northern 2-lined salamander	habitat for breeding and most activity	foraging area- adults may wander 330 ft on rainy nights; dispersal of juveniles (only 25% return to natal streams)
Green frog	usually stay within 65 ft of water	dispersal habitat
Wood frog	breeding habitat, if buffer area protects ephemeral woodland pools	habitat for most of terrestrial lifestyle, often well away from water
Spotted turtle	shading, large organic debris, streambank stability, protective cover, invertebrate and small vertebrate prey, winter hibernating habitat	habitat for most terrestrial activity- will travel up to 1/2 mile (2640 ft) from water to find temporary food sources
Wood turtle	see above for spotted turtle; basking habitat in early spring (within 65 ft of water)	habitat for most activities; spend most of their time within 1000 ft of water, but will travel up to 1 mile away to search for food; nest up to 330 ft away; hatchlings stay within 130 ft of water
Northern water snake	habitat for most aquatic activities	habitat for dispersal and hibernation
Eastern ribbon snake	foraging habitat	may travel several hundred meters from water to mate; hibernate in upland sites
Bats	foraging habitat- commonly hunt over open water	roosting sites- prefer to roost within 1300 ft of water
Beaver	habitat for aquatic activity, lodge site, some foraging habitat	enough foraging habitat- most foraging is within 330 ft, dispersal routes
Mink	most foraging habitat and den sites	mink hunt up to 600 ft from water, den sites may be up to 330 ft from water

Black bear	foraging habitat, cover, travel corridors	den sites; enough area for travel- adult male black bears require up to 19 sq. miles depending on habitat and food sources
Bald eagle	foraging, perching, and roosting sites	nest sites- most eagle nests are within 1300 ft of shorelines; protection from human disturbance
Red-shouldered hawk	foraging habitat	nesting sites- this species is found only where buffers are 330 ft or more
Area-sensitive forest birds	some foraging and nesting habitat; problems characteristic of edge habitat (increased predation and nest parasitism)	sufficient breeding habitat for species that need riparian zones wider than 330 ft

the influence of surface runoff and subsurface flow impacts.

Other wetlands may be particularly sensitive to hydrologic impacts caused by the lack of buffers. For example, wetlands that are not naturally permanently flooded may be sensitive to inundation caused by surrounding impermeable surfaces, such as pavement. Inundation of such wetlands may kill vegetation and degrade wildlife habitat (Leibowitz et al., 1992).

Larger buffers will provide greater protection for wildlife using wetlands and surface waters and surrounding uplands. Protection is more critical for wetlands or surface waters that provide habitat for threatened or endangered species. Information on the presence of rare plants or natural communities is available from the New Hampshire Natural Heritage Inventory, and from the New Hampshire Fish and Game Department on the presence of rare, threatened and endangered animals.

4.3.3 Species Specific Wildlife Buffers

Wetlands or surface waters that are particularly important as wildlife habitat may require buffers larger than 100 feet, depending on the species to be protected. Table 4.3-3. lists minimum recommended buffer zone widths, as well as information on distances travelled from water for foraging, nesting, or hibernating by various wildlife species. Most recommended buffers for protecting wildlife habitat are greater than 100 ft, and are usually stressed as representing the minimum distance, rather than the optimal distance to be protected.

4.3.4 Designated Prime Wetlands

New Hampshire wetlands law (RSA 482 - A:15) allows a municipality to designate certain wetlands of extraordinary value within its borders as prime wetlands. Designation of those wetlands as prime assures an added layer of protection in the dredge and fill permitting process. In accordance with Wetlands Boards rules (Wt 701.02(b)), a municipality must complete an evaluation of its wetlands such as the *Method for the Comparative Evaluation of Non-Tidal Wetlands in New Hampshire* (Ammann and Lindley Stone, 1991) in order to designate wetlands as prime. Prime wetlands are locally determined based upon this evaluation.

Municipalities may wish to further protect designated prime wetlands with buffers larger than 100 feet. Many prime wetlands are important wildlife habitat resources. A larger buffer gives an increased measure of protection and, in general, provides better wildlife habitat (Hornbeck, 1994).

Table 4.3-3 Recommended Minimum Buffer Widths for Wildlife

Buffer width	Wildlife species	Reference
10-330 ft	amphibians, forest interior wetland birds, upland dependent reptiles and birds	Eddleman and Husband unpubl. manuscr.
20 ft	small mammal habitat (riparian woods)	Cross 1985
30-70 ft	control temperature in small streams (important for wildlife)	Burton and Likens 1973
100-330 ft	amphibians and reptiles	Rudolph and Dickson 1990
100 ft	stream macroinvertebrates	Newbold et al. 1980
100-200 ft	belted kingfisher roosting sites	White 1953
100 ft	to protect invertebrates in steep mountain streams from siltation	Erman et al. 1977
100 ft	salmon breeding habitat (gravel streambeds)	Moring 1982
150 ft	endangered or threatened spp., or trout production areas	Golet et al. 1993
165 ft	pileated woodpecker nest sites; will nest up to 500 ft away from water	Schroeder 1983
180 ft	squirrel habitat	Dickson and Huntley 1987
200 ft	forest interior birds nesting habitat	Tassone 1981
200 ft	boreal forest birds	Darveau et al. 1995
200 ft	interior forest birds	Tassone 1981
200 ft	marten (riparian habitat)	Spencer 1981
200-300 ft	retain plant structure within this distance for wetland dependent wildlife	Castelle et al. 1992
250 ft	forest birds	Small and Johnson 1985; Johnson 1986
300 ft	waterfowl nesting	Foster et al. 1984
300-330 ft	beaver, mink, dabbling ducks	Roderick and Miller 1991
330 ft	furbearers: coyote, bobcat, red fox, fisher, marten, beaver, otter, mink, muskrat	Dibello 1984
330 ft	beaver feeding habitat	Hall 1970
330 ft	mink den sites and habitat for most activity; use habitat up to 600 ft from water	Melquist 1981, Linn and Birks 1981
330 ft	area-sensitive forest birds	Keller et al. 1993
330 ft	forest interior birds, small mammals, reptiles, amphibians	Golet et al. 1993
450 ft	common loon (nesting), pileated woodpecker	Roderick and Miller 1991
575 ft	breeding bird communities in uplands adjacent to streams	Hooper (unpubl. manuscr.)
660 ft	songbird community	Scheuler 1987
660 ft	breeding bird communities	Stauffer and Best 1980
660 ft	travel corridors for all wildlife but black bears	Forman 1983
600 ft	bald eagle (nesting, roosting, perching); cavity nesting ducks (wood duck, bufflehead, goldeneye, hooded merganser), heron rookery	Roderick and Miller 1991
600 ft	wood duck - most nests within this distance from water	Grice and Rogers 1965
840 ft	average distance of blue-winged teal nests from water	Duebbert and Lokemoen 1976

V. Local Options for Wetland and Surface Water Buffer Protection

The purpose of this section is to provide municipalities with guidance on local actions that can be taken to protect buffers next to wetlands and surface waters. The buffer concept is based upon scientific and technical studies, as described in the current literature cited in this document. Evidence of the importance of naturally vegetated buffers to protect the functional values and natural quality of wetlands and surface waters has been demonstrated in numerous scientific studies.

5.1 Water Resources Protection Component of the Master Plan

The master plan establishes the basis to guide growth and development in a municipality. Any resource protection strategy, involving local regulatory and/or non-regulatory efforts to protect buffers around wetlands and surface waters should be part of the master planning process. The plan should contain the underlying scientific and statistical data to support proposed implementation measures. According to RSA 674:2, VIII, a local water resources management and protection plan should be adopted as part of the conservation and preservation section of the master plan, if it is appropriate or required as a prerequisite for the adoption of local implementation measures. Furthermore, the water resources component of the plan should contain recommendations for both groundwater and surface water protection, including wetlands. It is important that the rationale for requiring protective buffers for wetlands and surface waters be incorporated into that portion of the plan to support the requirements of any implementing ordinances or regulations.

5.1.1 Documentation for the Rationale for Requiring Buffers Adjacent to Wetlands and Surface Waters

Sections II, III, and IV of this guidebook, providing documentation about the valuable functions that buffers perform, can be adopted as an appendix to the master plan or incorporated into the plan by reference to support recommendations for protective buffers. Local officials who choose to develop a comprehensive strategy will want to determine which wetlands and surface waters to protect with buffers. Where there are substantial areas of scattered surface waters and wetlands, requiring a buffer adjacent to all of them may not be justified. There is a need to balance protection of the resource with the rights of private property owners. The master plan should clearly document the planning process that was followed to determine which resources warrant protection. The water component of the master plan is intended to contain information on water quality, water supply, wildlife habitat, recreation potential and resource sensitivity. A municipality which has completed an inventory and evaluation of its wetlands is encouraged to incorporate this information into the master plan to support proposed wetland buffer requirements.

5.1.2 Description of Wetland and Surface Water Resources in the Master Plan

Where a municipality has adopted prime wetlands, as is authorized by RSA 482-A:15, the need to protect them has been approved by an official ballot vote at town meeting and accepted by the New Hampshire Wetlands Board. The inventory and evaluation prepared to designate prime wetlands should be incorporated into the master plan. It is important for the plan to include the maps and a detailed list of the prime wetlands to which a locally selected buffer is to be applied.

Regarding surface waters, the Comprehensive Shoreland Protection Act (RSA 483-B) defines public waters as:

. . . all fresh water bodies listed in the official list of public waters published by DES, whether they are great ponds of ten acres or greater or artificial impoundments; coastal waters, being all waters subject to the ebb and flow of the tide, including the Great Bay Estuary and the associated tidal rivers, and rivers, meaning all year-round flowing waters of fourth order or higher, as shown on the now current (1994) version of the U.S. Geological Survey 7 1/2' topographic maps.

By definition, water bodies less than ten acres and rivers that are not of fourth order or higher are excluded from the protection provided under the Act. There may, however, be additional locally significant surface waters that warrant protection. These resources should be specified in the master plan documented on a map if a locally selected buffer is to apply to them. A municipality is authorized to adopt regulations within the protected shoreland that are more stringent than the Act.

RSA 483-B:9, V(a) establishes a natural woodland buffer that is required to be maintained within 150 feet of the reference line of public waters, as defined in the act. The purpose of the buffer is to protect water quality by minimizing erosion, preventing siltation and turbidity, stabilizing soils, preventing excess nutrients and chemical pollution, maintaining natural water temperatures, maintaining a healthy tree canopy and understory, preserving the fish and wildlife habitat and respecting the overall natural condition of the protected shoreland. Not more than 50 percent of the basal area of trees and a maximum of 50 percent of the saplings are to be removed from the natural woodland buffer within a 20 year period.

5.1.3 Criteria for Determining Where the 100 Foot Buffer May Not be Appropriate

The following criteria may be used as guidance in determining which wetlands and surface waters might be excluded from the locally selected buffer:

(1) The wetland or surface water is limited in size, such as: an isolated wetland or surface water of 3000 square feet or smaller.

The rationale for excluding wetlands smaller than 3000 square feet is for consistency with the Wetlands Board's requirements for minimum impact projects (Wt 303.04 (f), Wt 303.04 (h), and Wt 303.04 (j). Some wetlands smaller than 3000 square feet that are of particular significance should have buffers. Examples include bogs, vernal pools, or other critical resources.

(2) The wetland or surface water is one of the following types: a vegetated swale or roadside ditch; a sedimentation/detention basin; an agricultural/irrigation pond; a septage lagoon; a wetland on prior converted cropland.

The rationale for excluding these wetlands is that these are all examples of constructed or altered wetlands with limited capacity to perform typical wetland functions. The value in such wetlands lies in their ability to perform the functions for which they were designed.

Wetlands and surface waters that meet these criteria should not be identified on the map or included in the list of priority resources in the municipal master plan.

5.1.4 Existing Non-conforming Land Uses Within the 100 Foot Buffer Area

Land uses around wetlands and surface waters which existed before the adoption of wetland buffer zoning requirements will usually continue. Local officials can, however work with landowners to develop measures that will provide for protection of the wetland or surface water. Where possible, partial or remnant buffers should be preserved.

5.2 Wetland / Surface Water Protective Buffer Overlay Zoning Odinance

RSA 674:21 authorizes municipalities to adopt innovative land use controls, including environmental characteristics zoning. This approach can be used to develop an overlay zoning district to protect wetland and surface water buffers. The buffer overlay is superimposed over the conventional existing zoning and adds the special requirements of the overlay zone to the requirements of the underlying zoning district.

The information presented in this guidebook supports the protection of a 100 foot buffer next to priority wetlands and surface waters. Within the buffer, use of land should be required to meet reasonable performance standards. Land uses that pose a particular threat to wetlands and surface waters should be prohibited within the buffer. These include salt storage sheds; automobile junk yards; solid or hazardous waste facilities; use of fertilizer except lime and/or wood ash, on lawns or areas with grass; bulk storage of chemicals; petroleum products or hazardous materials; sand and gravel excavations as defined in RSA 155-E; processing of excavated materials; and dumping or disposal of snow and ice collected from roadways or parking areas. Most of these potential threats to water quality are already prohibited within 250 feet of public waters as defined by RSA 483-B. The Act does not apply to wetlands and many significant surface waters statewide. A buffer overlay zoning district can be used to adopt these requirements locally or to enact local requirements that are more stringent than the state's. The local ordinance can also be designed to protect wetlands and surface waters that are not covered under the Act.

5.2.1 Prohibited Uses

Primary structures should be prohibited in the buffer because they would result in a permanent impact to the valuable functions that a protective buffer provides. Coverage of the natural soil surface with impervious materials, such as pavement, driveways and rooftops, should also be limited. The intent is to minimize increases in run-off. This is particularly important to wetland and surface water protection because one of the most valuable functions that buffers perform is reduction of nutrient and sediment transport.

5.2.2 Special Exceptions to the 100 Foot Buffer

A protective buffer overlay zoning ordinance may provide for the zoning board of adjustment to grant special exceptions to the 100 foot buffer. This allows the flexibility not to require the 100 foot buffer in cases where it is either not practical or not appropriate. To maintain the integrity of the wetland or surface water, only low impact land uses would be granted a special exception within the 100 foot buffer. Accessory structures, such as storage sheds, fences and gazebos should be granted a special exception, provided the applicant could demonstrate that:

(1) The location and construction of the accessory structure is consistent with the intent of the ordinance to maintain a vegetated wetland/surface water buffer;

(2) The accessory structure shall be sited to minimize the potential for a negative impact on wetland / surface water buffer functional values;

(3) The accessory structure is temporary in nature and does not have a permanent foundation;

(4) The accessory structure is a usual and customary use incidental to a legally permitted land use in the underlying zoning district;

(5) Parcel coverage by an accessory structure shall not result in a significant increase in impervious coverage of the natural soil surface.

5.2.3 Permitted Uses

Agricultural activities and operations should be permitted uses in the buffer area, provided they conform to best management practices established by the U.S. Department of Agriculture Natural Resources Conservation Service, Cooperative Extension and/or the New Hampshire Department of Agriculture. This is consistent with the state's efforts to encourage and retain agricultural activities. Persons carrying out agricultural activities and operations in the buffer area should be encouraged to work directly with the local representatives of the above agencies and their county conservation district to develop land management plans that are consistent with resource protection objectives.

Forestry activities should also be permitted uses, provided they conform with the forest practices prescribed by RSA 227-J:9, the Basal Area Law, for areas next to surface waters. Passive use of land for recreational purposes and nature appreciation is permitted as compatible with the intent of the requirement for a wetland/surface water buffer.

One of the goals of the zoning portion of this guidebook is to recommend that local officials strive for consistency between state and local regulation of priority wetlands and surface waters. Detailed requirements, standards, definitions and procedures for wetlands and surface water protection currently exist in state statutes, administrative rules and technical documents that have been endorsed by state agencies. Where current technical standards exist, they are recommended to be included as requirements of the local ordinance or incorporated by reference for the protective wetland/ surface water buffer zone. Professionally accepted standards exist which address issues such as stormwater management, subsurface wastewater treatment and shoreland and wetlands protection.

If the requirements of state regulations and current technical documents are consistent with existing local definitions and procedures, they can be adopted locally as written. Municipalities should, however, carefully review any proposed requirements to assure that there is not a duplication or inconsistency with existing locally adopted language.

5.3 Amendments to Subdivision and Site Plan Review Regulations

The subdivision regulations outline the review procedures the planning board is to follow and the requirements that an applicant must meet in order to gain approval to subdivide land into more than one parcel. The land may be subdivided either for residential purposes or for non-residential or multi-family development of the land. The site plan review regulations provide more detailed site development requirements for non-residential or multi-family proposals. They apply to such changed in land use whether or not there is a subdivision of land. Both the subdivision and site plan review regulations provide the planning board with the opportunity to adopt technical standards that can enhance the protection of wetland and surface waters buffers.

5.3.1 Consistency with Local Zoning Requirements

Amendments to subdivision and site plan review regulations should reference the statutes, rules, and technical documents referred to in the previous section. This will incorporate them as the standards that must be met by applications for local subdivision and site plan approvals and support the requirements of the zoning ordinance. In addition, the subdivision and site plan review regulations will recommend currently accepted criteria for site specific delineation of wetlands and surface waters. These criteria will be consistent with the methodologies required by existing state permitting programs, to remedy current situations where an applicant is often required to provide different delineations of the same resource to obtain local, state and federal approvals.

5.3.2 Boundary Delineation Requirements

The site specific delineations of the wetlands and surface waters should be shown on the final plat with the 100 foot buffer displayed for use by the planning board in the review process. By inclusion on the plan, the resource delineation and the 100 foot buffer would subsequently be recorded in the registry of deeds and "run with the land" as the property passes on to other landowners.

5.3.3 Special Environmental Studies

Amendments to the subdivision and site plan review regulations should also include criteria for special environmental studies that the planning board may require of an applicant as part of the local approval process. This information will make clear to both the planning board and the applicant what the local requirements are. The planning board can use the studies as justification for the final action they take on applications regarding land use activities in the wetland or surface water buffer.

5.4 Land Acquisition as a Measure for Protecting Wetland/Surface Water Buffers

In developing a comprehensive strategy for establishing protective buffers for wetlands and surface waters, municipalities should include protection and management techniques that go beyond the establishment of a local zoning ordinance or subdivision and site plan review regulations. Some municipalities may use only non-regulatory techniques. There are some areas that are not practical or appropriate to regulate; for example, a wildlife corridor that extends far beyond the boundary of the resource.

For a complete discussion of sections 5.4.1 through 5.4.3, please see the *Municipal Guide to Wetland Protection* (State of New Hampshire, 1993) from which the following text has been modified.

5.4.1 Acquisition by a Conservation Commission

A conservation commission is authorized by RSA 36-A:4 to acquire the fee simple (full title) or a lesser interest in land for conservation purposes in the name of the town. A landowner has maximum control over the use of property, but land ownership involves responsibilities that a conservation commission must be prepared to assume. The commission must manage and maintain the property and, if appropriate, provide for public use. These responsibilities should be considered before a commission decides to acquire property.

Another option for a conservation commission is to promote acquisition of an important wetland by a federal, state, or local conservation agency or organization. Each agency or organization has specific requirements for land it acquires, and all are limited by financial and management considerations. A commission can identify the potential owner(s) and work with the present landowner and the agency or organization to protect the wetland.

5.4.2 Acquisition of Easements

A conservation easement, authorized by RSA:45-48, provides permanent protection for significant conservation land without acquiring fee simple title. It places permanent restrictions on certain uses of the land and establishes long-term enforcement for those restrictions. In accepting an easement on behalf of the town, a conservation commission assumes the responsibility for monitoring the property annually to ensure compliance with the restrictions. The landowner continues to use and enjoy the land within the limits of the easement. An easement should include both the delineated wetland and a buffer around the wetland. Restrictions on timber harvesting, land conversion, construction, or road building within the buffer can be written into the easement. These legally binding restrictions will protect the buffer in perpetuity.

5.4.3 Donation of Land

Donation assures the conservation-minded donor of the land's long-term protection without the responsibilities of ownership. The gift, if made to a qualified recipient of tax-deductible contributions such as a municipality, may offer federal income tax benefits provided that IRS criteria are met. A landowner may make a bequest instead of an immediate donation. In such a case, the gift is in the landowner's will and takes effect at the time of his or her death. Such donation ensures eventual, long-term protection and reduces the value of the donor's taxable estate.

Not all landowners are willing or able to make a gift, but a conservation commission might inform the landowner of the importance of the wetland, and encourage him or her to manage the area and a buffer around it for resource protection. A further step would be to enter into a protection or management agreement with the landowner that obligates him or her to manage the land in a particular way for a specified period of time. Such an agreement provides a commitment on the landowner's part, a measure of control for the commission, and may open the door for future negotiations to establish more permanent protection.

Donations of land or conservation easements may be obtained as part of the development review process, especially if zoning ordinances provide for cluster development and restrict development in wetlands. Donations under these circumstances may also provide tax benefits to the developer. In addition, RSA 674:21-a states: "Any open space designation or other development restriction . . ." that is imposed by a local land use board as a condition of approval ". . . shall be deemed to create a conservation restriction as defined in RSA 477:45 I . . ." A developer unable to avoid all wetland impacts, such as in road construction, may be required or persuaded to offer mitigation by preserving other high value wetlands through easements or donations. In such cases the developer should be encouraged to include an appropriately sized upland buffer next to the wetland or surface water in the easement.

VI. Buffer Management

Individual landowners, land trusts, and municipalities may be interested in managing their lands to provide maximum protection to wetlands and surface waters. Conservation commissions, watershed associations, and other conservation groups are encouraged to undertake educational programs which promote sound management practices in buffer areas. This section provides guidance on design considerations for maximizing buffer effectiveness, and discusses the effects of agriculture, forestry, and road building within the buffer.

6.1 Buffer Design

6.1.1 Prioritizing Areas on a Landscape Basis

Where not all water resources can be protected with naturally vegetated buffers, municipalities should make the most of limited resources. Priority areas for protection of water quality and wildlife habitat might include:

- Water supply resources
- Designated prime wetlands
- Wetlands or surface waters which provide habitat for rare, threatened and endangered species
- Wetlands especially sensitive to nutrient and sediment inputs (Appendix D)
- Riparian wildlife corridors
- Steep slopes
- Remaining undeveloped portions of otherwise highly developed uplands surrounding wetlands and surface waters
- Upland areas between small wetlands or surface waters which may provide vital transportation links for wildlife
- Areas connecting large blocks of unfragmented land

Additional information on the protection of wildlife habitat on a landscape basis can be found in *The Ecology of Greenways* (Smith, 1994).

6.1.2 Inclusion of a Grass Filter Strip

For a buffer to function best for water quality improvement, some research suggests that it should be preceded on the upland side by a grass filter strip (Reilly, personal comm.; Osborne, 1993; Welch, 1992). This strip functions to slow runoff initially from impermeable surfaces or agricultural land and to help promote sheet flow. Where possible, a grass filter strip at the edge of the buffer should be included. The U.S. Forest Service publication *Riparian Forest Buffers* (Welch, 1992) gives specifications for designing buffers next to rivers and streams, and recommends a 20 foot ungrazed grass strip on the upland side of a forested buffer.

6.1.3 Minimizing "Edge Effects"

Ideally, a transitional area between the grass filter strip and the naturally vegetated buffer would be included, with shrubs, saplings, and intermediate vegetation. Such a transitional area would minimize the "edge effects" which occurs when open land adjoins forested land. An abrupt edge between these two habitat types allows predators of woodland birds, such as cowbirds, easier access to their nests, and lowers breeding success of woodland birds (Smith, 1994). A transitional area helps to abate this negative effect. (See section 2.4.3 of this guidebook for more information on edge effects.)

6.2 Establishing Buffer Vegetation

In buffers that are not presently naturally vegetated, (but are unpaved) abandonment should provide opportunities for pioneer tree species, such as gray birch, poplar, and white pine. These species will eventually be succeeded by other native tree species. Obviously, in developed uplands next to wetlands it may be impossible to establish a buffer. In areas where the buffer is threatened by erosion, native trees or bank stabilization species recommended by the Natural Resource Conservation Service should be planted. The publication *Planting Shoreland Areas* in Appendix F provides a list of suitable shoreline species and guidelines for revegetating buffer areas. Although this list was developed for shoreland areas, the species listed are suitable for wetland buffers as well. Your local UNH Cooperative Extension office can also advise on appropriate plantings.

A natural forest floor, with leaf litter, is important for the natural functioning of a buffer. Raking or other removal of leaf litter from the buffer is not recommended, as it would allow runoff to accelerate and deprive the soil of its natural organic layer, which helps in denitrification.

6.3 Timber Harvesting in the Buffer

6.3.1 Water Quality Effects

Timber harvesting within the buffer may provide some benefits to the wetland or surface water. Because tree roots may take up excess nutrients passing through the buffer, cutting and removing some of the mature trees within the buffer has been recommended as a way of removing stored nutrients in the buffer (Lowrance, 1985).

However, certain forestry activities within the buffer may contribute to sediment in wetlands or surface waters. The removal of vegetation and construction of cut and fill slopes to create logging roads and landings is generally recognized as the single greatest source of sediment in logging operations (Belt et al., 1992). Logging roads may continue to contribute sediment after the logging operation is complete. Adherence to the guidelines established in *Best Management Practices for Erosion Control on Timber Harvesting Operations in New Hampshire* (1990) will minimize sedimentation in wetlands and surface waters.

Removal of vegetation from the buffer may have only temporary detrimental effects on the water quality of the wetland or surface water (Binkley & Brown, 1993). Short term impacts from cutting are mitigated as regeneration is established. Removal of all vegetation for land use conversion, on the other hand, will alter the condition of the buffer (and therefore its ability to provide buffer functions) permanently.

6.3.2 Wildlife Habitat Impacts

Management or disturbance activity within natural habitats may benefit some wildlife species, deprive others of breeding, foraging, or cover requirements, and have relatively little impact on species that are not sensitive to those particular changes. In streamside buffers, the effects of vegetation removal are well documented. These impacts may include the increase of temperatures in streams due to increased sunlight (Belt et al., 1992), the loss of direct cover given by overhanging vegetation, and the loss of trees available for recruitment for large organic debris that is important for controlling stream flow and creating small impoundments. Further information on the effects of timber harvesting on native wildlife populations may be found in Appendices A, B, and C of this document.

In other cases, timber harvest activities next to some wetlands and surface waters may improve habitat for some species. For example, clearcutting of small areas next to beaver ponds may provide regrowth necessary for a beaver population to survive (Degraaf, 1992). A beaver pond will provide habitat for other native wildlife species. Guidance in the management of forested wildlife habitat is provided in the publication *New England Wildlife: Management of Forested Habitats* (DeGraaf et al., 1992). This publication provides prescriptions for forest management of different habitat types, and gives information about habitat use by different wildlife species.

6.4 Agriculture Within the Buffer

Agriculture in New Hampshire provides benefits to the state's economy, both directly through the sale of agricultural products, and indirectly through tourism encouraged by the rural atmosphere. Open space such as fields preserved through agriculture also provide wildlife habitat for some species, such as bobolinks, red shouldered hawks, and foxes. However, agricultural practices can affect the quality of adjacent wetlands and surface waters by the excess nutrients, pathogens, and sediment that may be contained in runoff from agricultural lands.

The New Hampshire Department of Agriculture has developed *Best Management Practices* (N.H. Dept. of Agriculture, 1993) in which they identify the protection of the state's water resources as a major concern. To protect surface waters from the effects of the use and storage of manure and chemical fertilizers they recommend a filter strip of perennial vegetation.

Minimum width of these strips can be determined by the width of any agricultural equipment used to harvest or otherwise manage the vegetation. The minimum width should be 10 feet for average slope of less than 1% and proportionally up to 20 feet for slopes of 15%.

A 100 foot buffer of natural vegetation, as recommended by this guidebook, will provide considerably more protection to the adjacent surface water, preventing additional nutrients and sediment from entering the water resource. Municipalities looking to protect public water supplies or other important wetlands or surface waters may wish to encourage agricultural interests in the watershed to provide buffers larger than those recommended in the Agriculture BMP's.

6.5 Pathways Within the Buffer

Pathways or roadways in the buffer are potential sources of large amounts of sediment, and should be designed to prevent or minimize the channelization of runoff into the wetland. Such pathways should not run directly downslope, and should use techniques to prevent accumulation of channeled flow as recommended in the forestry BMP's, and in the publication *BMP's for Erosion Control During Trail Maintenance and Construction* (DRED, 1994).

VII. Conclusion

Buffering wetlands and surface waters should make up only one piece of a comprehensive natural resource protection plan. At the municipal level, approaches to natural resource protection will differ according to the needs and objectives of its residents. While some towns may opt for changes in zoning to protect a broad spectrum of water resources with buffers, others may identify key areas for protection through acquisition or easements. Ultimately, municipalities will need to determine the most appropriate buffers to suit their needs, based on the information presented here and the specific resources to be protected.

Glossary

Adsorption The attachment of molecules (gases, solutes, or liquids) to solid bodies or liquids.

Anaerobic The condition of being without oxygen, typical of wetland soils. Anaerobic soils undergo biochemical transformations unique to soils in their condition.

Aquifer A groundwater body which supplies water to wells. Aquifers are found in geological formations such as fractured bedrock, glacial sands, or gravels. Aquifers generally have a large volume in relation to the water withdrawn annually, and have moderate to high porosity.

Basal Area The cross-sectional area of a tree measured four and one half feet from the ground, usually expressed in square feet per acre.

Browse Tender shoots or twigs of shrubs and trees.

Deep Water Habitat Aquatic habitats, such as lakes, rivers, and oceans, where surface water is permanent and deeper than 6.6 feet most of the year.

Denitrification The conversion of nitrate to gaseous nitrous oxide and nitrogen, carried out by microorganisms in anaerobic (oxygen free) conditions. These gases are eventually released into the atmosphere. Nitrogen gas (N_2) makes up approximately 80% of our atmosphere. Nitrous oxide (N_2O) has the potential for causing acid rain, but the amount released through the process of denitrification is far less than that released through the burning of fossil fuels.

Ecology The study of interactions between living things and their environment.

Ecosystem An organic community of plants and animals, viewed within its physical environment (habitat). The ecosystem results from the interaction between soil, climate, vegetation, and animal life.

Eutrophication A high concentration of organic matter and mineral nutrients, such as phosphates and nitrates, can cause the over-fertilization of aquatic ecosystems. This results in excessively high levels of production and decomposition. Eutrophication can hasten the aging process of a lake or pond due to the rapid buildup of organic remains.

Fourth Order Stream Stream order is determined as follows: the highest year round streams in a watershed are first order streams, their juncture yields second order streams, the juncture of two second order streams yields a third order stream, and the juncture of two third order streams yields a fourth order stream.

Habitat An organism's home, including the area used in all parts of its life cycle, such as feeding , breeding, egg laying or bearing young.

Herbaceous Having the characteristics of an herb; a plant with no persistent woody stem above the ground.

Hydric Soil A soil that is saturated, flooded or ponded long enough during the growing season to develop anaerobic (oxygen lacking) growing conditions in the upper part of the soil. Hydric soils are generally poorly drained or very poorly drained.

> **Poorly drained** (Hydric B) Water is removed from the soil so slowly that the soil is saturated periodically during the growing season or remains wet for long periods.
>
> **Very Poorly Drained:** (Hydric A) Water is removed from the soil so slowly that water remains at or on the surface during most of the growing season.

Infiltration The movement of water into the soil. Infiltration capacity of the soil is the maximum rate at which soil can absorb water, which depends on the pore sizes within the soil, and the transmissivity and storage capacity of the soil.

Intermittent Stream Streams which flow primarily during the wet seasons when the water table is high, and remain dry for a portion of the year.

Interstices Small spaces between objects (e.g. gravel, stones, etc.)

Nitrate An ion made up of three nitrogen atoms and one oxygen atom, with one extra electron (NO_3^-). A common by product of septic systems or agricultural operations. Excess nitrates in drinking water supplies are harmful to human health. Nitrates also contribute to eutrophication of ponds and lakes.

Overland Flow Precipitation or meltwater not absorbed by the soil, which moves down slope into streams.

Percolation The movement of water through the soil. Percolation rates of soil are used to determine suitability for septic systems.

Perennial Stream A stream that normally flows year round because it is sustained by groundwater discharge as well as by surface runoff.

Riparian Related to or adjacent to a stream or watercourse, or having a high water table because of proximity to an aquatic ecosystem or subsurface water. This is a term of some confusion, as its original associated meaning was related to rivers and streams, and is now sometimes used to describe wetlands not necessarily associated with rivers or streams.

Sediment Particles of clay, silt, or sand transported by water downslope and eventually deposited in a wetland or trapped by vegetation. Sources of sediment include natural weathering of rocks and soils, as well as disturbance or exposure of soils.

Substrate Substance under which an organism lives, as in soil.

Surface Runoff Water that flows over the surface of the land as a result of rainfall or snow-melt. Surface runoff enters streams and river to become channelized stream flow.

Water Table The upper level of the portion of the ground in which all spaces are wholly saturated with water. The water table may be located at or near the land surface, or at a depth below the land surface and usually fluctuates from season to season. Where the water table intersects the land surface, springs, seepages, marshes, or lakes may occur.

Appendix A
Amphibians and Reptiles of New Hampshie

These appendices provide a brief overview of wildlife species that depend on or are associated with wetlands, surface waters and surrounding upland habitats. A few species are featured in each appendix to show how both aquatic and terrestrial habitats are used throughout the year, and which habitat features are important for survival. When available, information is included on how far from water a species travels while foraging, migrating, or dispersing to new habitats. Appendices cover native terrestrial and semi-terrestrial vertebrates.

New Hampshire's diverse wildlife communities include 40 species of reptiles and amphibians. Many of these species are rarely seen due to secretive habits, such as living underground or wandering primarily at night. Those species most often encountered, such as toads, garter snakes, snapping turtles, and red spotted newts, are common and widespread. Many other species may also be relatively common, but live so inconspicuously or in such inaccessible places that few people are aware of their presence. A few, such as timber rattlesnakes, marbled salamanders, and eastern box turtles, are extremely rare. New Hampshire's amphibian and reptile species include 12 salamanders, 10 frogs, 7 turtles, and 11 snakes (Table A-1.).

Amphibians

Amphibians depend on aquatic and wetland habitats for at least part of their life cycles. Most amphibian species undergo an aquatic and a terrestrial life phase (The Greek word amphibios [amphi = both; bios = mode of life] means "two lives"). All frogs and most salamanders lay their eggs in water. These eggs hatch into aquatic larvae, which eventually metamorphose into either aquatic or terrestrial adults, depending on the species. Some salamander species lay their eggs on land in moist sites. The redback salamander, for example, lays its eggs under rocks, decaying logs, or leaf litter. The developing young go through metamorphosis within the egg, and hatch out as tiny replicas of adult salamanders.

All amphibians have thin, moist skin through which they breathe. Many species also breathe through the linings of their throat and mouth, and all but a few possess lungs. Because amphibians have just a thin epidermis and no protective feathers, scales, or fur, they are especially sensitive to changes in humidity, and must stay in water or in damp environments. Frogs and salamanders overwinter in the deep, soft, muddy bottoms of waterbodies and wetlands or in burrows below ground where they will not freeze.

Amphibian populations have declined in many areas as wetlands have been drained and filled. Acid rain and other pollutants have degraded many aquatic breeding habitats, and road traffic causes heavy mortality.

Salamanders

Salamanders have smooth skin, long bodies and tails, and short legs. Unlike frogs, most salamander species make no sound, but depend on visual and chemical signals for courtship (Tyning 1990, Heyer et al. 1994). The 12 salamander species found in New Hampshire represent four major groups, including mudpuppies, newts, mole salamanders, and lungless salamanders.

Mudpuppies are not native to New Hampshire, and therefore are of concern mainly in terms of their impact on aquatic habitats and native aquatic species. They are aquatic throughout their lives, do not undergo metamorphosis, and retain gills as adults. Mudpuppies prey on many native amphibian species, and compete for insects, crustaceans, small fish, mollusks, and other food sources.

New Hampshire's native salamanders all have at least one terrestrial phase in their life cycle. The eastern newt, which lives in ponds and other shallow water habitats, spends several years of its life on land. The aquatic larvae metamorphose into terrestrial "red efts", which leave the water to travel through surrounding uplands for 2 to 7 years. Eventually, these efts return to water to mate, lay eggs, and spend the rest of their lives as aquatic newts.

Mole salamanders are terrestrial as adults, and live underground throughout most of the year. The Jefferson, blue-spotted, and spotted salamanders emerge from underground tunnels and burrows for a brief spring mating season. On the first warm, rainy nights of early spring, adults migrate through woodlands to temporary "vernal" pools, to mate and lay eggs. Their breeding sites are isolated from permanent waterbodies, and therefore, do not support fish populations. Fish prey on amphibian eggs and larvae, so temporary pools offer relatively safe incubation sites for these amphibian species. Four species of mole salamanders and the wood frog breed almost exclusively in such temporary pools.

After the mating season, adult mole salamanders return to their upland burrows. Males usually leave before females, which stay behind to lay their eggs, which they attach to submerged debris or deposit on the bottom of the pool, depending on the species. Eggs incubate over several weeks, and then hatch into aquatic larvae, which grow and develop over the next few months. They must metamorphose into terrestrial juvenile salamanders before the temporary pool dries up in late summer.

Unlike other mole salamander species, marbled salamanders breed in autumn, migrating to dried-up vernal pools and other low-lying sites. After mating, females lay their eggs under leaf litter or rocks on the floor of the pool, remaining there to incubate them for as long as possible. Females are unable to swim, and when autumn rains eventually flood the pool, they must leave their eggs and migrate back to their subterranean homes.

Once the pool becomes flooded, marbled salamander eggs hatch. The aquatic larvae overwinter in the pool, then transform into terrestrial juveniles in late spring. If there is too little rain to fill the breeding pool, the eggs will not hatch until spring.

Lungless salamanders

Lungless salamanders include northern dusky, eastern redback, slimy, four-toed, northern spring, and northern two-lined salamanders. Lungless salamanders are the most abundant salamander species, and redback salamanders may be the most abundant terrestrial vertebrate in northern hardwood forests (Burton and Likens 1975). These species are important in forest floor food webs, preying on very small invertebrates, such as mites, beetles, and snails, and, in turn, being eaten by shrews, moles, snakes, fish, mink, otters, raccoons, birds, and other larger predators (Pough 1983 in Pough et al. 1987).

As their name implies, lungless salamanders have no lungs, but breathe through their skin and mouth linings. They are restricted to humid environments where their skin will stay moist enough for gas exchange to occur. Dusky, redback, and slimy salamanders lay their eggs on land, concealed in damp, dark nests underground nests or inside rotten logs. Four-toed salamanders lay their eggs under sphagnum moss or in rotten logs located along edges of vernal pools. Larvae drop into the water as they hatch. Spring and two-lined salamanders lay their eggs in running water under logs, stones, and decayed leaves, carrying out their entire breeding cycle without leaving the water.

The three "stream salamanders" are the dusky, spring, and two-lined, all of which live in and along permanent streams and seepages. In general, these species spend their entire lives within a few feet of the water, rarely climbing up into adjacent wooded uplands. Naturally vegetated streambanks and surrounding forest trees help maintain water quality and cool water temperatures within the stream. In addition, both dusky and two-lined salamanders sometimes travel overland on rainy nights, venturing well beyond their typical streamside habitat. Stream salamanders illustrate how primarily aquatic species depend on surrounding upland habitats.

Northern dusky salamander

Habitat

Northern dusky salamanders occur most commonly in clean, cool, streams running through forests with relatively closed canopies (Hunter et al. 1992, Klemens 1993). Optimal sites occur where seepages and springs connect with surface water (Klemens 1993). Duskies hide by day under large flat stones or logs lying along the edge (or partially submerged) in the stream, emerging at night to forage along the stream edge (Hunter et al. 1992, Klemens 1993).

Dusky salamanders may breed during fall, winter, or spring, but females retain the male's spermatophore until summer, when she develops and lays her eggs. Females excavate small hollows in damp soil under logs, bark, rocks, leaf litter, or moss located within 50 cm (19.5 in) of streams, springs, or seepages (DeGraaf and Rudis 1983, Hunter et al. 1992). Each female lays 10 to 30 eggs, which she incubates by encircling them with her body. Five to eight weeks later, the eggs hatch, and within several days, the larvae begin to make their way out to the stream, where they will live throughout the winter (Hunter et al. 1992, Klemens 1993).

Adult dusky salamanders retreat to underground dens for the winter, typically 30 to 50 cm (10-25 in) below the surface. They may remain active throughout the winter in streambeds or deep in unfrozen soil (Ashton 1975 in DeGraaf and Rudis 1986), or they may hibernate under rocks and logs in deeper sections of streams (DeGraaf and Rudis 1983). Individuals remain within a relatively small area of about 1.4 m^2 (15 ft^2) throughout their lives (Ashton 1975 in DeGraaf and Rudis 1983). Although they rarely move far from streams, duskies have been found under rocks 23 m (75 ft) away from water, and may wander overland during rainy weather (Klemens 1993).

Conservation

Changes in vegetation or other features that influence temperature, moisture, and acidity of forest floor habitat may severely affect salamander populations (Wyman and Hawksley-Lescault 1987, Wyman 1988). Removal of streamside vegetation would degrade stream habitat for species that require cool water temperatures. Large scale logging may cause erosion and siltation of streams, as well as increases in water temperature resulting from removal of the forest canopy (Klemens 1993).

Acid deposition threatens salamander species by directly damaging developing eggs, and diminishing overall health and productivity of both forest and stream habitat. Fertilizers, pesticides, and other toxins entering stream channels through runoff and ground water further threaten aquatic species. The use of insecticides to combat insect pests of commercially valuable timber may cause extensive damage to streams and pools in treated woodlands. Chemicals used to kill pest species may also kill nontarget invertebrates that are important prey species, and may also affect nerve function of aquatic organisms (Trial 1986).

Northern spring salamander

Habitat

Northern spring salamanders occur primarily in clean, cold, well oxygenated water, typical of high-gradient mountain streams running through forested habitat. They also occur in lower-gradient seepages, and springs within heavily forested areas (Hunter et al. 1992, Klemens 1993). Spring salamanders are commonly found in streams that originate in perched swamps (Klemens 1993). They are relatively large compared to other lungless salamanders like the dusky and two-lined. Their surface area is small relative to their mass, so they are more restricted to water with high oxygen content, such as cold springs and swift-running streams (Hunter et al. 1992). This species is especially intolerant of habitat disturbances.

Females lay their eggs during spring and summer, fastening them to the underside of stones and logs in running water. Eggs hatch in late summer or early fall, and the aquatic larvae develop for about 4 years before undergoing metamorphosis (Hunter et al. 1992). Once they reach adulthood, spring salamanders may venture out to the stream edge to hunt for smaller salamanders, frogs, millipedes, earthworms, spiders, snails, centipedes, and crustaceans (Hunter et al. 1992).

Conservation

Pollution of cool, clear streams by road run-off, pesticides, and fertilizers is probably the greatest threat to this species. Some populations of spring salamanders live below ground, where polluted groundwater poses serious problems (Klemens 1993). Timber harvesting, agriculture, and development near woodland streams may cause siltation, erosion, increased water temperature, and reduced oxygen content of streams inhabited by spring salamanders. Dams also cause increased water temperature and decreased oxygen content, and spring salamanders are rarely found in streams modified with such structures (Klemens 1993).

Forested buffers along high-quality streams that support spring salamander populations should be wide enough to at least maintain shading of the stream channel, and to minimize erosion, siltation, and pollution by run-off from surrounding disturbances. Dams should not be constructed across the stream, but natural debris, including rocks and fallen trees, should be left in the stream channel.

Northern two-lined salamander

Habitat

Northern two-lined salamanders occur in low elevation rivers and swamps, lakeshores, seepages, damp woodlands (sometimes several hundred feet from open water), edges of vernal pools, and swift-flowing, high-elevation brooks (Hunter et al. 1992, Klemens 1993). Two-lined salamanders may be the only species inhabiting warmer reaches of streams and rivers, as they tolerate a wider temperature range than do dusky or spring salamanders (Layne and Claussen 1982 in Hunter et al. 1992).

Adults breed in streams in autumn or early spring. Females lay their eggs in the stream, attaching them to the bottom of rocks or logs in running water. Several females may use the same site for attaching their eggs, but only one female remains with them for the one or two months of incubation (DeGraaf and Rudis 1983). Many adults leave streams on rainy nights just after the breeding season, sometimes travelling over 300 ft from the water's edge (DeGraaf and Rudis 1983, Klemens 1993). Adults have been found at edges of vernal pools and in damp woodlands, often several hundred feet from the nearest stream (Klemens 1993).

After hatching, two-lined salamanders spend about three years in larval form, feeding on tiny arthropods, molluscs, and worms in the water and on the bottom. Newly metamorphosed juveniles disperse from aquatic habitats in late summer, wandering overland in search of new territory. Of those that disperse, only 25% eventually return to the stream in September (MacCulloch and Bider 1975 in Hunter et al. 1993), which suggests that most juveniles move into neighboring aquatic habitats.

Two-lined salamanders may remain active all winter long, foraging under submerged rocks and logs in unfrozen sections of the stream. Otherwise, they hibernate in unfrozen substrate along streambanks (Ashton and Ashton 1978 in DeGraaf and Rudis 1983).

Conservation

Lungless salamanders tend to breed and lay their eggs after the spring melt, and so are less susceptible to the effects of acid deposition than are mole salamanders and other amphibians that breed earlier in the spring. Two-lined salamanders have greater tolerance for pollution and warm water temperatures than other lungless salamanders, but in general, face similar problems of habitat destruction, degradation, and fragmentation.

Frogs

The three major groups of frogs that occur in New Hampshire include toads, treefrogs, and true frogs. Unlike salamanders, frogs are quite vocal, especially during the spring mating season. Adults have no tails, and the hind legs are long and well developed for hopping. All frogs require aquatic habitat for mating and laying eggs. The larvae, or tadpoles, initially have no limbs, but propel themselves with a long tail. They have small mouths designed for feeding on algae and tiny aquatic organisms. In time, tadpoles grow legs, lose their tails and gills, and metamorphose into adult frogs.

The American toad and Fowler's toad have thick, dry, warty brown skin and relatively short hind legs. As adults, toads spend their lives on land, returning to water only to lay eggs. Their tadpoles metamorphose into very small toads, which then leave the water to feed on land. The gray treefrog and spring peeper have adhesive discs on the ends of their toes that allow them to climb trees, and both are primarily terrestrial as adults.

True frogs are the most aquatic species, possessing long hind legs and large webbed feet. Species belonging to this group are the bullfrog, green frog, mink frog, pickerel frog, leopard frog, and wood frog. Adult bullfrogs, green frogs, and mink frogs are primarily aquatic as adults, and leopard frogs stay relatively close to water, hiding in thick vegetation along the edge. Pickerel frogs and wood frogs are the most terrestrial of this group. Once the aquatic larvae have metamorphosed into juveniles, they spend most of their lives on land, returning to water during the breeding season.

Pickerel frogs

Habitat

Pickerel frogs live along edges of both permanent and temporary wetlands, such as lakes, ponds, reservoirs, wet meadows, marshes, fens, bogs, vernal pools, springs, swamps, rivers, quarries, and sandpits (Hunter et al. 1992, Klemens 1993). Typical breeding sites support thick herbaceous growth, such as cattails, grasses, and sedges, which allow these frogs to hunt along the shoreline with minimal exposure to predators.

From late March through early May, pickerel frogs gather in shallow bogs and woodland ponds to mate and lay eggs. Females attach their egg masses to submerged debris, then leave the water to hunt in fields and damp woods until fall (Hunter et al. 1992). Both males and females may travel far away from water in their search for food (Klemens 1993, Taylor 1993). About 95% of the pickerel frog's diet consists of terrestrial arthropods (Smith 1956), indicating their dependence on upland habitat in the vicinity of aquatic breeding sites. They also eat snails, small crayfish, and aquatic invertebrates (DeGraaf and Rudis 1983).

Conservation

Pickerel frogs occur in unpolluted sites, and are less tolerant of urbanization and disturbance to their habitats than are some species, such as the green frog and bullfrog (Klemens 1993). Thick herbaceous shoreline vegetation is important for species, and should be left along the edge of the shoreline whenever possible. An upland buffer extending from the water's edge into adjacent uplands would provide foraging habitat for pickerel frogs, which hunt in woodlands and open fields.

Wood frogs

Habitat

Wood frogs inhabit heavily forested areas with thick herbaceous vegetation and leaf litter scattered with temporary pools (Klemens 1993). This species is the first amphibian to emerge from hibernation in the spring, typically beginning the mating season in March. Males and females gather at vernal pools and other semi-permanent waterbodies in or near woodlands to breed. Females lay their eggs in globular masses which they attach to submerged sticks and logs before leaving the pool. Because these breeding pools are isolated from permanent waterbodies, they contain no fish populations, and thus offer relatively safe places for the development of eggs and growth of tiny aquatic larvae. The larvae must metamorphose into frogs and leave the pools before they dry up in late summer.

Newly metamorphosed wood frogs leave their pools to spend the rest of their lives on land, returning two or three years later as adults. They range widely through both deciduous and coniferous forests from early spring through fall. Before the ground freezes completely, wood frogs seek hibernation sites in rotting logs and stumps, under rocks, and beneath thick mats of moss and decaying leaf litter.

Conservation

Wood frogs require vernal pools for breeding. Removal of trees and other vegetation surrounding vernal pools can seriously affect their value as breeding sites for wood frogs and other species that depend on them. Forest canopies provide shade, keeping temperatures cool and minimizing evaporation, thus allowing enough time wood frog and other amphibian larvae to metamorphose into terrestrial juveniles. Leaf litter from forest trees provides food for tadpoles and salamander larvae, as well as the invertebrates that tadpoles and salamanders feed on. Accumulated debris also provides shelter for developing invertebrates and amphibians.

Breeding pools are often directly destroyed by draining and filling wetlands for development. Water quality may be severely affected by runoff from roads or agricultural fields. Vernal pools are especially susceptible to Ph fluctuations caused by the inflow of acidic spring runoff, because they are small and lack stream inflow and outflow to dilute or wash away harmful inputs. The wood frog breeding season coincides with the spring melting season, when a winter's worth of acid snow suddenly washes into surrounding waterbodies. Their eggs and developing larvae are subjected to an intense acid "pulse" caused by this sudden release of acid snow, which causes abnormal development and extremely high mortality (Klemens 1993).

Reptiles

New Hampshire's reptiles include 7 species of turtles and 11 species of snakes. Reptiles have relatively dry skin covered with scales, and are less susceptible to dehydration than most salamanders and frogs. All turtles and some snakes lay eggs in nests on land. Other snake species give birth to live young on land. Reptile young look like miniature versions of adults when they hatch, or, as in the case of some species, when they are born. Reptiles do not have larvae or undergo metamorphosis.

Although reptiles have evolved adaptations to terrestrial environments, most of New Hampshire's turtles and snake species depend on aquatic and wetland habitat for some part of their life cycle, such as mating, foraging, and hibernation. Because reptiles are ectothermic, they cannot generate their own body heat, but must regulate their body temperature by basking or seeking shelter. Both turtles and snakes bask in the sun to raise their body temperature in cool weather, seek shelter on land or enter the water during hot weather to stay cool, and, like all amphibians, retreat to underground or underwater sites to hibernate through the winter. Whereas snakes look for subterranean hibernacula (places to hibernate) below the frost zone, turtles tend to hibernate under mud, leaf litter, and other organic debris under water.

Turtles

Seven turtle species occur in New Hampshire, six of which are known to be native species. The few eastern box turtles that have been found may have been released pets (Taylor 1993, Carrol 1993). Native turtle species include wood, spotted, Blanding's, eastern painted, common snapping, and common musk turtles.

Painted turtles and snapping turtles are relatively common and widespread throughout the state. Both are able to live in many types of aquatic environments, and are more tolerant of polluted sites than other turtle species (DeGraaf and Rudis 1983). The musk turtle, or "stinkpot", occurs in permanent waterbodies throughout the southern half of the state. Stinkpots, snapping, and painted turtles are highly aquatic, leaving the water only to bask or to find upland nest sites. Female snapping turtles may travel up to 10 miles while searching for upland nesting sites before returning to their aquatic home ranges (Obbard and Brooks 1980).

Wood turtles, spotted turtles, and Blanding's turtles require aquatic habitats for mating, resting, foraging, and hibernating, but otherwise spend their time traveling through upland habitats to find food and nest sites. Wood turtles, especially, wander extensively on land, often traveling far away from aquatic habitats. Although spotted and Blanding's turtles spend less time out of the water than do wood turtles, they travel frequently among different wetlands and waterbodies near their overwintering sites. Due to their terrestrial habits, these three turtle species require protected uplands surrounding their aquatic overwintering sites.

Populations of wood, spotted, and Blanding's turtles have declined precipitously over the past few decades. These declines have resulted from collection for the pet trade, and the development, pollution, and disturbance of both aquatic and upland habitats used by these species. Turtles living in degraded, fragmented habitats also become victims of increased vehicle traffic and nest predation. Suburban developments bring dogs and cats, which can become effective nest predators. In addition, suburbs attract natural nest predators, such as raccoons, skunks, foxes, and crows.

Turtle conservation will require protection of aquatic habitats, surrounding uplands, and nesting sites. Travel routes among these important habitats should be protected to allow greater survival of individuals, as well as dispersal of turtles among separate populations. Dispersal of individuals is essential for gene flow among populations of turtles in order to maintain genetic heterogeneity. Dispersing individuals may also be able to recolonize habitats where turtle populations has died out.

Wood turtles

Habitat

Deep, slow-moving streams lined with thick vegetation offer suitable foraging and hibernating sites for wood turtles (Hunter et al. 1992, Klemens 1993, Taylor 1993). Important stream features include permanent pools from 1-3 ft deep, sandy substrates mixed with gravel, cobble, or stones, and overhanging shrubs of alder and silky dogwood (Carroll 1993). Wood turtles may also inhabit swiftly-flowing brooks, beaver ponds, fens, swamps, bogs, and wet meadows (Harding and Bloomer 1979, Klemens 1993).

Wood turtles overwinter in soft mud, sand, and leaf litter on the bottom of streams, under overhanging banks and root tangles, or in beaver or muskrat burrows (Bloomer 1978, Kaufmann 1992a). In early spring, they emerge from these hibernation sites and slowly climb to the surface to breathe. Submerged features, such as root masses, logs, and shrub tangles, protect them from being washed downstream in strong spring currents, and provide structures on which they can climb up onto the banks (Carroll 1993). At this time, wood turtles stay close to the water, basking and feeding during the day, and returning to the water at night (Kaufmann 1992a, Carroll 1993).

Courtship and mating take place in the stream from mid-April to mid-May, after which adult wood turtles disperse into surrounding uplands. Females may travel long distances to find suitable nesting habitat, favoring sparsely vegetated sites with well-drained soils that receive full sun throughout the day. Nests have been found in agricultural fields, meadows, railroad beds, woodland roads, forest openings, and sandpits, as well as instream sites such as outwashes, sandy banks, and gravel bars.

Adults establish elongate home ranges along rivers and streams that include adjacent pastures, fields, powerline cuts, and woodlands. Wood turtles forage on land and in the water for algae, leaves, grasses, berries, mushrooms, fish, tadpoles, aquatic and terrestrial insects, spiders, earthworms, snails, slugs, molluscs, carrion, newborn mice, and eggs and nestlings of ground-nesting birds (Harding and Bloomer 1979). During their summer travels, wood turtles frequent small woodland pools, wetlands, and other aquatic habitats to hunt, rehydrate, and seek cover from both predators and hot, dry weather. Adults may travel over a mile from their overwintering streams between spring and fall. Radio-tracking studies have shown that displaced individuals are able to find their way home from as far as 1.25 miles away, indicating that they regularly travel this far from their "home streams". Hatchling and yearling turtles tend to remain much closer to streams, seldom wandering more than 130 ft from the banks (Brewster and Brewster 1991, Carroll 1993).

Conservation

Fragmentation of riverine woodlands should be minimized to protect wood turtle populations. There should be as little clearing and development along streams and rivers as possible, and undisturbed habitat should extend beyond river and stream corridors to surround vernal pools, alder swamps, floodplain pools, and other forested wetlands, as well as pastures, hayfields, and nesting grounds. Floodplain habitats should be allowed to undergo natural disturbances, such as flooding cycles and beaver activity to allow natural reshaping of the physical, hydrologic, and biological functions of rivers and streams (Carroll 1993).

A buffer of at least 300 ft along either side of wintering streams should be established, and the watercourse itself should be left with shoreline and instream debris, beaver dams, and brush piles. Dense tangles of shrubs, especially silky dogwood, should be allowed to grow along the banks. Recreational use of open areas such as sandy banks, sandbars, and washouts should be limited to avoid disturbance, erosion, and destruction of emergent vegetation. Nesting sites in hayfields and pastures may be protected by allowing buffers of natural vegetation to grow around the edges. These areas should not be treated with any herbicides, pesticides, or fertilizers (Carroll 1993).

Spotted turtle

Habitat

Spotted turtles live in shallow wetland and aquatic habitats, including slow-flowing, muddy-bottomed streams, ponds, marshy edges of large lakes, river floodplains, fens, red maple swamps, quarries, vernal pools, bogs, roadside ditches, tidal creeks, and wet meadows (Haskins unpubl. data in Hunter et al. 1992, Klemens 1993). Dense herbaceous and shrubby growth, brush piles, and debris along shorelines and streambanks offer safe basking sites, where turtles can be exposed to the sun with minimal exposure to predators (Carroll 1993). During the winter, spotted turtles hibernate under mud and debris on the bottom of their shallow water habitats (Carroll 1991, Hunter et al. 1992).

After emerging from hibernation in the spring, spotted turtles leave their overwintering sites to travel among neighboring pools and wetlands. They visit vernal pools to eat eggs and larvae of mole salamanders, wood frogs, and spring peepers (Klemens 1993), and hunt for frogs, crayfish, slugs, snails, spiders, insects, millipedes, worms, and plants. Spotted turtles can eat only when submerged, so aquatic habitat is essential for their survival (Hunter et al. 1992). In Maine, radio-tagged turtles travelled up to 1/3 mile (1640 ft) between wetlands to take advantage of temporary food sources, such as eggs and larvae in vernal pools (Hunter et al. 1992).

Mating takes place in the water, after which males and females go separate ways. Females leave the water in May or June to find nest sites, which are typically located in sandy, loose soil with sparse vegetation along roadsides, edges of fens and bogs, well drained embankments, and pastures (Klemens 1993). They also use more disturbed sites, including agricultural fields (Carroll 1991). By mid-June, terrestrial activity subsides, and spotted turtles retreat to aquatic and wetland habitats for the summer (Klemens 1993).

Conservation

The greatest threats to spotted turtles are collection for the pet trade and habitat destruction. Many of their clean, shallow water habitats have been drained, altered, and polluted. Remaining habitats are often small, isolated fragments, surrounded by roads and residential development. Heavy road mortality and nest predation further reduce breeding populations. Buffers surrounding known spotted turtle habitats would not only reduce human disturbance to those sites, but would also allow more space for safe travel among feeding, nesting, and overwintering sites.

Snakes

There are eleven native snake species found in New Hampshire. Nearly all are terrestrial, but two species, the northern water snake and the northern ribbon snake, spend much of their lives in or near the water. Both species require aquatic and surrounding upland habitat for hunting, basking, cover, reproducing, and hibernating.

Northern water snake

Habitat

Water snakes are widely distributed throughout the southern half of New Hampshire (Taylor 1993), occupying many types of aquatic habitat from sea level to mountain slopes. Water snakes commonly inhabit dams, spillways, and impoundments, but can be found in ponds, lakes, marshes, vernal pools, red maple swamps, fens, bogs, rivers, high-gradient streams, beaver swamps, tidal creeks, and golf course ponds. Food and vegetative cover are the most important requirements. Despite their association with spillways, dams, and similar man-made structures, water snakes are intolerant of pollution, and their presence may actually indicate good water quality.

Water snakes are semiaquatic, spending much of their time in shoreline vegetation and in shallow water. Although they mainly eat small fish, water snakes also hunt for frogs, shrews, and mice. They rely on heavy vegetation for protection from predators, and need open sites for basking, such as branches and logs overhanging the water, dead vegetation, boulders, and causeways in reservoirs. Water snakes are uncommon in shady forested wetlands, probably because of less exposure to the sun and fewer basking opportunities (Hunter et al. 1992).

This species hibernates in muddy pond bottoms or inside beaver and muskrat lodges. Water snakes seek overwintering sites below ground in rocky upland ledges located away from the water, where they can reach unfrozen refuges deep beneath the surface (Tyning 1990), but rarely venture more than about 20 ft from the water's edge (Tiebout and Cary 1987 in Hunter et al. 1992).

After emerging from hibernation in March or April, adults travel to nearby aquatic habitats to breed. Females give birth to about 60 live young in late summer or early fall after a 2-month gestation. Young water snakes are on their own immediately, and take to the water to hide among aquatic vegetation.

Conservation

Water snakes fall prey to many different species, including herons, egrets, gulls, hawks, raccoons, skunks, foxes, other snakes, and snapping turtles, and young water snakes may even be eaten by large frogs. The greatest threat to their populations, however, is habitat destruction, especially development of shorelines and riverbanks, and degradation of their aquatic hunting grounds. Road mortality can be high in places where roadways have been built next to rivers, lakes, ponds, and wetlands.

Water snakes require less upland habitat than do many species. Because they typically do not travel more than 20 ft or so from water, even relatively narrow buffers around their aquatic hunting grounds would offer substantial protection.

Ribbon snake

Habitat

Ribbon snakes live in shallow wetlands and waterbodies with shrubby shorelines. Streams, rivers, swamps, fens, bogs, ponds, and vernal pools are typical habitats, but this species may infrequently be found in more disturbed habitats, including damp areas in powerline cuts and sandpits (Klemens 1993). Ribbon snakes rarely venture far from the water's edge, either on land or into open water (Taylor 1993). Amphibians are their primary prey, but they also eat spiders, minnows, and insects.

From October to April, ribbon snakes hibernate in clumps of shrubby vegetation located in well drained pastures, rock ledges, log piles, railroad beds, and other terrestrial sites within several hundred yards of water (Klemens 1993). Adults breed after emerging from hibernation, and live young are born from late July to September.

Conservation

Populations of ribbon snakes are relatively scarce, possibly due to reforestation of grasslands and shrublands over the past several decades (Klemens 1993). More devastating, however, has been the direct destruction of their wetland habitats by draining and filling, as well as degradation of remaining sites through pollution, development, and clearing of vegetation from shorelines.

Table A-1 Native Amphibians and Reptiles of New Hampshire

Amphibians

Salamanders

- Blue-spotted salamander
- Four-toed salamander
- Jefferson salamander
- Marbled salamander
- Northern dusky salamander *
- Northern spring salamander *
- Northern two-lined salamander *
- Redback salamander
- Slimy salamander
- Spotted salamander
- Red spotted newt

Frogs

- American toad
- Fowler's toad
- Gray treefrog
- Spring peeper
- Wood frog *
- Mink frog
- Northern leopard frog
- Pickerel Frog *
- Green frog
- Bullfrog

Reptiles

Turtles

- Wood turtle *
- Spotted turtle *
- Blanding's turtle
- Eastern box turtle
- Eastern painted turtle
- Common musk turtle
- Snapping turtle

Snakes

- Northern black racer
- Northern water snake *
- Common garter snake
- Milk snake
- Eastern hognose snake
- Eastern ribbon snake *
- Smooth green snake
- Brown snake
- Redbelly snake
- Ringneck snake
- Timber rattlesnake

(* = species discussed in detail in appendix)

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Appendix B
Mammals of New Hampshie

New Hampshire's landscape is home to 55 native mammalian species, from the tiny Pygmy shrew (which weighs about as much as a dime and is the smallest mammal in the world), to the moose, which weighs up to 1400 lbs. Two species, the Canada lynx and small-footed myotis (bat), are listed as endangered and one, the American marten, is listed as threatened in the state (Table B-1.).

All mammals are warm-blooded, produce milk to feed their young, and have fur or hair at some stage of development, although whales, seals, and dolphins are nearly hairless. All native species bear live young. As a general rule, mammals are nocturnal creatures, sleeping by day, and emerging at dusk or dark to hunt and forage until dawn. Gray squirrels, red squirrels, and chipmunks are exceptions, being "diurnal", or day-active, as well as having conspicuous habits and relative fearlessness around humans. Glimpses of other species, such as muskrats, woodchucks, white-tailed deer, beavers, red foxes, skunks, raccoons, moose, and black bears are not uncommon, but their presence is more often evidenced by tracks, scat, dens, beaver dams and lodges, browsed vegetation, and clawed or scraped tree bark.

Most New Hampshire mammals are active throughout the year, surviving the long winters by growing thick fur, seeking shelter, and various strategies for finding and/or storing food. Some species have evolved the ability to accumulate thick layers of fat and hibernate, or enter a long, deep sleep. All bats hibernate, although red, hoary, and silver-haired bats migrate south to find hibernacula. Black bears, skunks, woodchucks, Eastern chipmunks, and jumping mice all go into some form of hibernation during the winter.

Many mammal species depend on, or are associated with, surface water and wetland habitats. Water shrews, star-nosed moles, mink, river otters, beavers, and muskrats require aquatic habitat, depending on water and adjacent uplands for all of their foraging, cover, over-wintering, and reproductive needs. Each of these species can swim and dive while hunting for aquatic plants, insects, fish, frogs, and other prey, as well as to escape from predators.

Wildlife species that are not wetland-dependent may spend considerable time in and around aquatic habitats. Black bears and moose travel over extensive mosaics of both upland and wetland habitats in a constant search for food, and although these species use many types of upland habitats, both depend on wetlands for much of their food and cover. Some bat species feed preferably over open water for insects hovering over the water's surface. Raccoons almost always live near water, usually choosing den sites that are close to swamps, ponds, or marshes, where they hunt for frogs, turtles, crayfish, and insects along the water's edge. Raccoons can swim short distances to reach food, such as waterfowl eggs or other prey located offshore. Many other wildlife species that live in terrestrial habitats take advantage of local wetlands and waterbodies to hunt, browse, or seek shelter.

The species featured in this appendix show how different native mammals rely on wetlands, surface waters, and adjacent uplands. These native mammals all depend on aquatic habitat, although some may spend their entire lives in or very near water. Others travel long distances among wetlands and water bodies. Where possible, information has been included describing specific habitat requirements provided by upland buffers.

Northern water shrew

Habitat

The northern water shrew belongs to a group of small mammals are known as "insectivores", or insect-eaters, represented in New Hampshire by six shrew and two mole species. Both shrews and moles have long bodies, short legs, and tiny ears - all adaptations for living underground and burrowing among leaf litter and debris. Although they have poor vision, these small mammals use their acute sense of smell to locate prey. Shrews and moles are active year round, foraging night and day to keep up with their voracious appetites. Shrews especially have such high metabolisms that they must eat almost constantly to avoid starving to death (Godin, 1977).

Although rarely seen, most of these species are relatively ubiquitous and abundant throughout New Hampshire. Three species, the masked shrew, long-tailed shrew, and star-nosed mole, occur in damp to water-logged soils, most often along edges of lakes, bogs, ponds, rivers, marshes and other wetlands and surface waters. The northern water shrew occurs only where there is open water.

The northern water shrew lives along swift-flowing streams lined with rocks, logs, and overhanging banks, but may also be found along slower streams, dry ephemeral creek beds, and near small springs (Beneski and Stinson, 1987). This species is well-adapted for aquatic habitats, possessing large hind feet with webbed toes and a fringe of stiff hairs that aids in swimming. Water shrews lower their metabolic rate when diving in cold mountain streams in order to reduce calories expended on thermoregulation. Their most peculiar adaptation, however, is the ability to run across the water's surface, even in turbulent conditions (Godin, 1977; Beneski and Stinson, 1987). Although water shrews rarely venture far from their home streams, they have been found as far as 330 ft from water (DeGraaf and Rudis, 1986).

Water shrews occur most commonly in forested habitats with enough ground cover to provide a moist microclimate and abundant plant and invertebrate food. Local distribution of water shrews typically coincides with that of beavers, which create habitats characterized by pools, running water, and damp humus (Beneski and Stinson, 1987). In winter, water shrews may move into beaver lodges or muskrat houses to build nests (Godin, 1977).

Conservation

Many small mammal species, including shrews, moles, mice, and voles, are highly insectivorous and probably play a key role in controlling populations of forest insect pests. Their constant tunneling loosens forest soils, allowing air and water to reach below the surface and causing mixing of organic litter and topsoil. Many of these species also eat seeds, which they carry to their burrows or cache for later consumption. In doing so, they help disperse seeds of many trees, shrubs, and other plants in the forest ecosystem.

Studies of small mammal habitat relationships indicate that most species are not closely associated with the age or structure of forest stands. Many small mammals native to northern hardwood forests inhabit a wide range of forest types and age classes. These species do respond to changes in food and cover, and fluctuations in population densities of their own species and of competing species (Gore, 1988). Disturbances that alter the availability of insects, seeds, fruits, and other food will affect small mammal populations. Cover, in the form of rocks, ledges, understory, vines, logs, slash, and accumulated leaf litter are essential for their survival, and should be left whenever possible.

Bats

Bats comprise one of the largest and most widespread groups of mammals in the world, with about 950 species in all continents except the Arctic and Antarctic (Hill and Smith, 1984). The eight species of bats found in New Hampshire include the big brown bat, red bat, hoary bat, eastern pipistrelle, little brown myotis, Keen's myotis, silver-haired myotis, and the endangered small-footed myotis.

All of these species eat primarily insects caught in flight or gleaned from foliage. New Hampshire's bats all have membranes between their back legs and tail, which they use for scooping insects while flying. Bats can catch up to one insect per second, but average about one about every 7 seconds (Barbour and Davis, 1969). Bats prey on a wide variety of insects, including mosquitos, moths, and many pest species. During the winter, many bat species hibernate in caves, abandoned mines, or old buildings. The red bat, silver-haired bat, and hoary bat migrate to warmer areas south New Hampshire to hibernate.

In the White Mountain National Forest, bat flight activity concentrates at edges of trails and water bodies (Stevens, 1993). Within forests, edges formed by trails, timber management activities, and shorelines may be used by bats from a large surrounding area as hunting grounds and travel corridors (Barclay 1991, in Stevens, 1993). Among New Hampshire's bat species, the silver-haired bat, eastern pipistrelle, and little brown myotis commonly hunt over water, and thus, are especially dependent on aquatic habitats.

Silver-haired bat

Habitat

Silver-haired bats live in forested area across most of the United States and up to the treeline in Canada. They typically inhabit woodlands near ponds and streams, hunting over the water and among trees at night (Barbour and Davis, 1969; Saunders, 1988). Adults roost singly in tree cavities, under loose bark, and in abandoned woodpecker holes and bird nests. They are known to eat moths, beetles, and adult aquatic insects (Saunders, 1988), but undoubtedly prey on many other insects as well.

The silver-haired bat is one of three species in New Hampshire that migrates south for the winter, although some may go only as far as southern New York. Individuals hibernate singly or in small groups in tree cavities and under loose bark, in rock crevices, buildings and many man-made structures, but do not commonly use mines and caves (Barbour and Davis, 1969). After migrating north in spring, males and females apparently segregate geographically, with females dominating populations in northern parts of the breeding range, and males being more abundant in southern regions (Barbour and Davis, 1969). Females usually roost singly with their two offspring, but may form small nursery colonies in hollow trees or other protected sites.

Conservation

Forested buffers adjacent to ponds, lakes and rivers provide important roosting habitat for bat species that prefer to feed over water. Older stands, which tend to include more large dead and diseased trees than younger stands, have features such as cavities and loose bark that provide roosting sites for silver-haired bats. Large dead and dying trees are very important for many other wildlife species for shelter and as a source of wood-boring insects eaten by many birds and mammals.

Little brown myotis

Habitat

The little brown myotis is perhaps the most abundant bat in the United States, occurring relatively ubiquitously in both forested and open habitats. During the breeding season, they typically occupy cool, shaded valleys along streams (Godin, 1977). They also live near larger open water sites, where they hunt by skimming the surface for insects (Barbour and Davis, 1969). Little brown bats are capable of catching and eating up to 600 insects per hour, and may feed from 1-5 hours at a time. At this rate, a colony of little brown bats could consume up to 42 pounds of insects in one month (Saunders, 1988). Little brown bats are able to swim (Godin, 1977), an indication of their adaptation to aquatic environments.

From September through April, little brown bats hibernate in caves or mines, crowding into suitable sites by the thousands. Large numbers may migrate to hibernacula located over 200 miles away (Barbour and Davis, 1969). In these sites, bats seek places where the temperature stays above freezing, and humidity remains high. Older, dominant bats secure the best sites, forcing younger individuals to more exposed locations. They survive the winter by reducing their metabolism to a level that just keeps them from freezing to death. Little brown bats may have the greatest range of body temperature of any vertebrate. They are able to cool down to 20 degrees F. during hibernation, and females in maternity colonies survive temperatures of 131 degrees F. (Barbour and Davis, 1969).

In late April, females migrate from their winter refuges to establish maternity colonies in attics and other warm places. Maternity colonies may number up to 1000 bats. Males roost singly or in small groups in cooler locations, such as in tree cavities or behind shutters.

Conservation

Because little brown bats often roost in man-made structures, they are less restricted to forested habitats than are silver-haired bats. However, they do depend on abundant insect populations for food. Buffers that help protect water quality benefit not only aquatic species living in the waterbody, but also many species attracted to the site for hunting and foraging.

Beaver

Habitat

Beavers are the only species able to create their own aquatic habitats, and in doing so, provide habitat for many other wildlife species. Abandoned beaver ponds gradually fill in and regenerate to new forest stands, completing a cycle of disturbance during which many wildlife species find suitable habitat for hunting, nesting, hibernating, cover, and travel.

Beavers establish a new pond by building a dam across a stream, which raises water levels and floods low-lying habitat upstream. Pushing sticks, brush, mud, sod, and stones into place, they continue to lengthen and strengthen the dam until their pond is large enough. They build a lodge as the water rises, heaping sticks and brush into a pile while hollowing out the middle of the growing pile. Beavers need a constant supply of saplings and branches for food. Eventually, colonies build secondary dams upstream and downstream to flood more habitat and ease transport of materials.

Canals are excavated from the pond into surrounding uplands. From these canals, beavers venture onto land to gather branches and small saplings, which they drag back to the pond and store under water for their winter food supply. Food caching begins in late summer and continues until the surface freezes over completely. Cache piles may measure up to 10 ft in height and 40 ft in diameter (Saunders, 1988).

Woods flooded by beaver activity become snag swamps, as trees die and deteriorate. Tall dead trees provide nest platforms for herons and perches for many other birds. Woodpeckers excavate nesting cavities in suitable snags, and dig wood-boring insects out of decaying timber. Abandoned tree cavities later become nest sites, roosts, and overwintering shelters for many other wildlife species, including tree swallows, chickadees, bluebirds, nuthatches, kestrels, owls, wood ducks, mergansers, and flying squirrels, and many insects and spiders.

The newly flooded pond becomes colonized with aquatic plants, which attract insects, waterfowl, turtles, moose, deer, and bear. Insects provide an abundant food source for fish, which eventually move in from the stream. New beaver ponds apparently provide exceptional habitat for native brook trout (Mirick, 1994). Bats, frogs, and many birds also move into beaver-flooded sites to feast on abundant insect populations.

Active beaver colonies have up to 12 animals, including the adult pair, which mate for life, their new litter of one to nine kits, and the previous year's offspring. Two-year-old offspring leave their natal ponds to establish new colonies in unoccupied sites. The entire colony abandons the pond when they have depleted food supplies within about 500 ft of the pond shore (Saunders, 1988). Although this typically occurs after about a decade, some ponds may last much longer.

Once the beaver colony has left a site, the dam breaks down, allowing the pond to drain and the original stream to form a new channel through the accumulated debris in the basin. Thick layers of silt and organic matter provide a rich substrate for new plants, and the beaver pond soon becomes a beaver meadow, a fertile open area where forest regeneration begins and wildlife find abundant food close to the safety of forest cover.

Conservation

Ponds created by beavers are temporary, and upland buffers surrounding these ponds are heavily disturbed by the beavers themselves. However, once a beaver pond becomes established, the surrounding forested uplands within about 500 ft become important for food. Beavers favor small saplings and shrubs, but commonly fell large trees in order to eat the bark and smaller upper branches. Because beaver-created habitats are so important for other native wildlife species, and for natural forest disturbance and regeneration, buffers of at least 500 ft around established ponds should be left for food and construction materials.

Black bear

Habitat

Black bears live in extensive woodlands, where they forage constantly for food from early spring through fall. Bears frequent ponds, wetlands, and small clearings, which provide rich sources of food within the safety of the forest. Although they will visit large openings, bears rarely venture farther than 400 ft from forest cover during the day, preferring instead to travel along the edge (Willey, 1984). In addition to foraging habitat, black bears also require forest stands with closed canopies and large trees for escape (Rogers and Allen, 1987).

Black bears are almost entirely herbivorous, browsing on large quantities of grasses, leaves, seeds, fruits and berries (soft mast) and nuts and acorns (hard mast). They will kill young fawns and moose calves when they find them, but derive most of their animal protein from insects and carrion (dead animals).

Wetlands are especially important feeding areas for bears when they emerge from their dens in the spring. At this time, bears are weak and slow-moving, due to depleted fat reserves. Because they must find food with as little exertion as possible, black bears head for wetlands to browse on the earliest green growth of spring. From early spring through late fall, bears wander from one wetland to another grazing on abundant grasses and berries, and catching insects and frogs. Thick vegetation provides escape cover, well concealed travel corridors, and places to cool off on hot summer days (Alt et al., 1980, Elowe 1984). Den sites are often located in wetland habitat, and in some regions of the black bear's range, about 68% of dens may be found in forested wetlands (Manville, 1986).

Adult males typically occupy home ranges of around 125 square miles. Male ranges usually overlap home ranges of several female bears, each of which utilizes about 25 to 50 square miles. Within these areas, bears travel from one foraging site to another according to plant flowering and fruiting times, insect hatches, and other seasonal events (Johnson and Pelton, 1980). Individuals may travel outside their home ranges, especially during late summer, to take advantage of temporary food sources located far away. During this time, bears may be found up to 125 miles outside their normal territories (Rogers, 1987). Wide-ranging bears nearly always return to their own home ranges in time for hibernation (Rogers and Allen, 1987).

Conservation

Buffers adjacent to wetlands and aquatic habitats offer resting, foraging, and travel cover for black bears. Although even very wide buffers cannot accommodate annual travels of black bears, buffers with features that provide food and cover enhance the quality of the wetland for bears. If possible, buffers should extend to neighboring wetlands, or be established around groups of wetlands, to create large tracts of relatively undisturbed wetland complexes.

Moose

Habitat

Moose inhabit extensive forests with scattered aquatic habitats. They require shallow water foraging sites in spring and summer where they browse on aquatic plants and seek relief from insects and heat. Upland openings, such as old burns and logging sites, provide tender saplings of deciduous and coniferous trees, grass, moss, raspberries, and many species of shrubs. Adults may consume 35 to 60 pounds of vegetation each day, selecting nutrient-rich twigs, buds, foliage, and smaller stems of woody plant species. Favored food plants include willows, aspen, birches, alder, maples, dogwoods, cherries, balsam fir, white cedar, eastern hemlock, and American yew (Chandler, 1988). When preferred browse is scarce, moose scrape bark from trees.

Moose require the largest home ranges of any animal in New Hampshire, with home range sizes averaging about 22,000 acres for bulls, and over 36,000 acres for females (Bontaites and Gustafson, 1993). In Maine, females with calves occupied smaller home ranges of about 4000 acres, but bulls travelled over larger areas during the fall breeding season (Crossley and Gilbert, 1983). Within their extensive annual home ranges, individuals use several smaller seasonal home ranges of 1200 to 2400 acres, foraging intensively in one area for a while before moving to another (Coady, 1982).

In many regions, moose migrate to particular habitats on an annual basis, often travelling only one to six miles to reach more seasonally suitable habitat (Coady, 1982). During the summer, bulls tend to use mature hardwood stands over other habitats, but shift to open areas in the fall. Cows use clearcuts and areas close to wetlands during the summer, moving into mature hardwood stands in the fall. Both males and females prefer mixed coniferous and deciduous forests during the winter (Bontaites and Gustafson, 1993). They are the least social of all deer, remaining solitary for most of the year, with the exception of cows and their calves. However, small groups may gather in sheltered woodlands in winter, and several may feed together in shallow water during the summer. Otherwise, the only other time moose typically gather is during the fall mating season.

Conservation

Moose require extensive woodlands heavily interspersed with aquatic habitat. In the course of a year, a moose may travel many miles among several different wetlands and waterbodies. Upland buffers the provide food and cover are important, and when possible, should extend to neighboring wetlands and aquatic habitats to provide travel routes.

Table B-1. Native Mammals of New Hampshire.

Marsupial
Virginia opossum

Insectivores (insect-eaters)
Masked shrew
Smokey shrew
Long-tailed shrew
Water shrew *
Pygmy shrew
Short-tailed shrew
Star-nosed mole
Hairy-tailed mole

Bats
Little brown myotis *
Keen's myotis
small-footed myotis
silver-haired myotis *
eastern pipistrel *
big brown bat
red bat
hoary bat

Mustelids (weasel family)
American marten
Fisher
Short-tailed weasel
Long-tailed weasel
Mink
River otter
Striped skunk

Canids (dogs)
Coyote
Red fox
Gray fox

Felids (cats)
Canada lynx
Bobcat

Omnivores
Black bear *
Raccoon

Lagomorphs
Snowshoe hare
Eastern cottontail
New England cottontail

Cervids (deer)
white-tailed deer
moose *

Rodents
Woodchuck
Eastern chipmunk
Eastern gray squirrel
Red squirrel
Southern flying squirrel
Northern flying squirrel
Beaver *
Deer mouse
White-footed mouse
Southern bog lemming
Northern bog lemming
Southern red-backed vole
Meadow vole
Muskrat
Meadow jumping mouse
Woodland jumping mouse
Porcupine

* = Species featured in appendix
Species in bold are dependent on freshwater wetland and aquatic habitats

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Appendix C
Birds of New Hampshire

Over 200 species of birds breed and raise their young in New Hampshire (Foss, 1994). Some of these species are year round residents, and others migrate to warmer climes in the southern United States, Mexico, and Central and South America. Several long-distance (neotropical) migrants travel thousands of miles each year in their journeys to and from breeding grounds. The blackpoll warbler, for example, may fly up to 5,000 miles annually from its wintering grounds in South America to spruce-fir forests in North America's mountains and boreal regions (Gross, 1953). Upon their arrival in New Hampshire, migrant birds join resident species in rituals of selecting breeding sites, finding mates, building nests, and raising their young, all of which must be accomplished in just a couple of months.

Most birds are diurnal, leaving overnight roosts at dawn to hunt for food, build nests, and defend territories until dusk. Some species, notably owls, are nocturnal, hunting by night and roosting by day. Unlike reptiles, amphibians, and certain mammals, birds do not hibernate. Resident species stay in New Hampshire year round, surviving on limited winter food sources.

Wetlands and waterbodies provide important food and cover requirements for many bird species. Lakes, ponds, rivers, marshes, and swamps offer critical resting and feeding places for migrating birds during their long northward journeys. Riparian habitats, in particular, are heavily used by spring migrants, which tend to follow river corridors across the landscape. Because such habitats typically yield the first green vegetation and insect life in spring, large numbers of migrants gather in these places on their long journeys north. In the fall, several species of shrubs and trees found along rivers, lakeshores, and wetlands produce berries and nuts that many birds rely on during their southward migration (Foss, 1989).

The following examples are species that are either dependent on or associated with wetlands or aquatic habitat during the breeding season in New Hampshire. Wetland-dependent species breed only in aquatic or wetland habitats. Wetland-associated species favor breeding sites located in or adjacent to open water or wetlands, but can occur in suitable upland habitats.

Species dependent on wetland and aquatic habitats

Pied-billed grebe

Breeding habitat

Pied-billed grebes inhabit fresh water sites with plenty of dense emergent vegetation. Their loud courtship calls may be heard as ice recedes from lakes, marshes, and beaver ponds where these reclusive birds find suitable nesting habitat.

Suitable breeding ponds must be large enough for grebes to take flight from the water. In Maine, pied-billed grebes use wetlands of at least 12 acres (Gibbs and Melvin, 1990 in Vernon, 1994). Their relatively short wings are not powerful enough for them to take flight straight up out of the water or from dry land. Instead, grebes must "run" along the water's surface, flapping their wings until they become airborne. Their legs are placed so far back on their body that they cannot actually walk on land, but push themselves up onto low-lying shores and banks to bask or preen. Grebes build nests that lie just above the surface of the water, so they can slip on and off with little effort.

Open water also provides important hunting habitat, where grebes prey on insects, large tadpoles, frogs, snails, leeches, small fish, crayfish, and aquatic plants (Bent, 1926). Like other grebe species, pied-billed grebes eat their own feathers, a trait thought to be necessary for the digestion of fish bones. Their gizzards are not able to crush all the bones they swallow. Feathers help line and protect the stomach, and slow digestion, so the bones are dissolved before passing into the intestine (Ehrlich et al., 1988).

Suitable breeding habitats support dense patches of reeds, cattails, sedges, and other emergent vegetation which provide cover. Because they are nearly incapable of flying from danger, grebes must dive and swim away, or disappear into the dense vegetation. They can sink into the water by squeezing air out of their feathers and partially deflating their air sacs, adjusting their depth until all that shows is their bill. During migration, grebes rest in small ponds and streams, remaining close to overhanging banks and heavily vegetated shorelines.

Both the male and female build the nest, which resembles a wet mass of floating dead vegetation. Pairs attach their nests to surrounding cattails and reeds in up to 3 ft of water (Bent, 1926), about 50 ft offshore, and within about 20 ft of open water (Vernon, 1994). Females lay their eggs in a small depression on the floating matt, and adults cover them with nest material when they leave to go foraging, or even during brief incubation exchanges. The young hatch after about 23 days, over a period of 3 to 7 days, and leave the nest almost immediately. Although they can swim, small fledglings may ride around on the backs of their parents to rest, and to avoid pickerel, snapping turtles, large frogs, and other aquatic predators.

Conservation

Pied-billed grebe populations have declined throughout the Northeast since the 1800's, although they remain relatively common and widely distributed in other regions of North America (Kibbe, 1985; Connor, 1988). It is listed as a Migratory Bird of Management Concern in the Northeast (Gibbs and Melvin, 1990 in Vernon, 1994), and is an Endangered Species in New Hampshire. Primary threats to the state's small breeding population are water pollution, wetland draining and filling (Connor, 1988; Vernon, 1994), water level fluctuations in dammed waterbodies, and increased predation resulting from human intrusion into breeding habitats (Smith and Choate, 1985 in Vernon, 1994). Wide forested buffers surrounding suitable breeding ponds would minimize human disturbance to these secretive birds.

Northern waterthrush

Breeding habitat

Many different types of forested wetlands provide suitable breeding sites for the northern waterthrush, including red maple swamps, black spruce-tamarack swamps, alder thickets, beaver ponds, woodland streams, and pools within coniferous, mixed, or deciduous woods. In New York, the waterthrush has been found in such habitats of 20 acres or more (Eaton, 1957 in Eaton, 1988), and throughout northern New England and the Adirondacks, it occurs from lowland swamps to mountain ponds at elevations up to 2800 ft (Eaton, 1910 in Eaton, 1988; Ridgely, 1988, in Elkins, 1994). Breeding pairs defend territories of 2 to 4 acres (Eaton, 1957 in Eaton, 1988; Kibbe, 1985).

The northern waterthrush is actually a relatively large warbler with thrush-like plumage and behavior. It forages on the ground, flicking over dead leaves and other debris to uncover small insects, crustaceans, snails, and worms. Waterthrushes also eat mosquitoes, moths, and other flying insects, and catch small fish from shallow edges of pools. They habitually walk along logs slanting from the bank into the water, searching for fish and aquatic insects (Forbush, 1929 in Bent, 1953).

Female waterthrushes construct nests beneath root masses of fallen trees, under overhanging banks, among fern clumps, or in hollows of decayed stumps (Elkins, 1994). Nests are often located just above pools in hollows created by upturned roots, or along edges of springs, ponds and streams. They consist of dead leaves, small roots, sphagnum moss, deer hair, and other fine materials. Waterthrushes and other species that nest on or near the ground, seek protected sites hidden in dense vegetation or under fallen trees and stumps where terrestrial nest predators are less able to find them.

Conservation

The northern waterthrush is widely distributed throughout New England. Populations have been seriously affected, however, by wetland draining and filling, as well as cutting of forested swamps, streambanks, and other woodland aquatic habitats. Dense tree canopies are especially important for shading the understory and keeping the forest floor cool and damp. Waterthrushes also need plenty of dead wood, rotting logs and stumps, root tangles of blowdowns, dense clumps of ferns and other cover, and undisturbed leaf litter for foraging and nest materials.

Wood duck

Breeding habitat

Wood ducks inhabit forested wetlands, such as swamps, beaver flowages, meandering streams and rivers, and many other shallow water habitats, favoring relatively open woodlands rather than dense forests (Levine, 1988). During the breeding season, wood ducks require tree cavities for nest sites, open water for foraging, and thick, shrubby vegetation for cover.

Males and females establish pair bonds on their wintering grounds, fly north together, and arrive on breeding grounds in late March or early April. Courtship continues as males accompany females leaving the water to look for suitable nesting cavities. Wood ducks use both natural cavities created by woodpeckers or tree disease, and man-made duck boxes. Most natural nest cavities are in trees at least 16 in. dbh (diameter at breast height = 4.5 ft). On average, nests are located 20 to 50 ft high,but they have been found from ground level up to 60 ft high (Levine, 1988). Wood ducks nest in live or dead trees up to 1 mile away from water. The closer the nest is to water, the better, and those standing in the water offer nest sites that are safer from terrestrial predators than those nests located in easily accessed trees.

Females typically lay about 12 eggs. Occasionally, a second wood duck or hooded merganser lays its eggs in the same nest, leaving the female to raise a mixed brood (Richards, 1994). As soon as the young hatch, the female flies from the nest, calling to her brood, and waits for them to climb out of the nest and leap to the ground. At one day old hatchling wood ducks survive falls from nests up to 60 ft high, and follow their mother to water, which may be over a mile distant. Females that are able to nest in trees surrounded by water, or at least close to water, give their offspring better chance of surviving when leaving the nest.

For the next 8 to 10 weeks, females and young forage for aquatic insects and plants, acorns, small fish, frogs, tadpoles, snails, and salamanders (Bent, 1923). During this time, shrubby thickets scattered in shallow water habitat provide essential cover in close proximity to feeding areas. Males begin to molt their breeding plumages in early summer, and because they are flightless during part of this phase, they too require thick vegetative cover in easy reach of feeding areas.

Conservation

Excessive market hunting and forest clearing in their native swamps during the 1800's nearly drove wood ducks to extinction. Since the early 1900's, populations have recovered dramatically as a result of hunting restrictions and farm abandonment followed by forest regeneration. Nest boxes placed in suitable habitat to substitute for large cavity trees have allowed wood ducks to recolonize many former breeding sites. Another factor that helped wood duck populations to recover was the return of beavers to northern woodlands. Growing beaver populations over the past several decades has benefitted wood ducks and many other species that depend on forest wetlands.

Wood ducks face many problems common to waterfowl, including water pollution, sediments contaminated with toxins, accumulated lead shot from many generations of hunters, and diseases that claim birds weakened by such environmental stresses. Forested buffers along rivers, streams, lakes and wetlands provide breeding habitat for wood ducks and many other woodland species, and help maintain water quality and the overall health of aquatic ecosystems.

Species associated with wetland and aquatic habitats

Red-shouldered hawk

Breeding habitat

Red-shouldered hawks occupy low-lying deciduous forests near open water, such as floodplain forests and swamps (Stewart, 1949). Optimal breeding habitats have mature and overmature canopy trees and sparse subcanopies, conditions which allow this relatively large hawk to fly through the forest underneath the canopy (Peterson and Crocoll, 1992).

Red-shoulders select extensive forests with scattered wetlands and other natural openings, and may breed only within about 1/4 mile (1300 ft) of floodplain forests (Stewart, 1949). Critical forest size probably depends on how clumped suitable nesting and hunting habitats are (Bednarz and Dinsmore, 1981). Red-shoulders establish breeding territories of about 160 ac (Stewart, 1949), and pairs nest at densities of about 1 pair/mi^2 (640 ac) in mixed forests in New Hampshire (ASNH data, in Gavutis, 1994).

Nest trees are usually large, living deciduous trees, located in stands of sugar maple, beech, and yellow birch (Morris and Lemon, 1983). Nests are built almost invariably in the main fork of the trunk, between 25 and 60 ft above the ground (Bent, 1937; Norse and Fichtel, 1985). Some pairs renovate old nests of crows, other large raptors, or squirrels, and uninhabited red-shoulder nests may be used by barred owls, Cooper's hawks, and great horned owls (Bent, 1937; Norse and Fichtel, 1985; Peterson and Crocoll, 1992). Red-shoulders commonly re-use their own nests, often using alternate nest sites for a few years (Bent, 1937 in Gavutis, 1994).

Small mammals comprise a major part of the diet for this species, and are especially important food for nestlings. Red-shoulder young hatch synchronously with the emergence of chipmunks from their natal burrows (Bent 1937; Stewart, 1949; Portnoy and Dodge, 1979). Adult hawks prey on a variety of species, including birds, fish, amphibians, reptiles, and insects.

Conservation

Declines in red-shouldered hawk populations throughout many regions over the past several decades have been due primarily to loss of breeding habitat. Disturbances within floodplain forests, including dam construction, stream channelization, development, and forest clearing have either destroyed suitable breeding habitats altogether, or so degraded and fragmented forested wetlands that red-shoulders can no longer breed there (Bednarz and Dinsmore, 1981). Timber harvesting practices, such as shelterwood cuts and thinning treatments, open up the canopy and may allow easier access by red-tailed hawks, which compete with red-shoulders (Bryant, 1986 in Titus et al., 1988; Smith 1988).

The most appropriate timber harvesting treatments for red-shouldered hawk breeding habitat may be a combination of single-tree and group selection cuts. Logging areas of 10 ac or less would create suitable openings for hunting within the forest. Such cuts should be scattered throughout the area, and should not exceed 15% of the total wooded habitat (Bednarz and Dinsmore, 1981; Titus et al., 1988). This strategy would allow harvesting of some trees in bottomland hardwood forests while preserving extensive areas of large trees and a closed canopy. Disturbances should be minimized during the nesting season, at least until the young are about 2 weeks old, or until the end of May (Bednarz and Dinsmore, 1981).

Olive-sided flycatcher

Breeding habitat

Olive-sided flycatchers inhabit edges and openings of forest wetlands, such as bogs, swamps, marshy streams, shallow areas of ponds and lakes, old beaver meadows, and backwaters of rivers. Preferred breeding sites have plenty of standing dead trees for perching, and surrounding forests are coniferous or mixed coniferous and deciduous. Breeding sites range in elevation from about 1500 to 3000 ft, with high altitude habitats mainly in remote mountain ponds and bogs.

Optimal breeding habitats have standing dead trees for singing posts and feeding perches. Breeding pairs have been found in recent clearcuts and old burn sites with standing dead trees (Robbins, 1994; Eaton and Curry, 1926 in Fichtel, 1985). Olive-sided flycatchers build their nests in conifers, forming a loose cup of twigs, grasses, lichens, and fine plant materials on horizontal limbs anywhere from 10 to 50 ft from the ground (Peck and James, 1987 in Peterson and Fichtel, 1992). Nests have been found in black spruce, white spruce, jack pine, red spruce, and balsam fir. Males defend a large breeding territory of 4 to 8 acres that includes both the wetland and the surrounding forest (Stewart and Robbins, 1958 in Robbins 1994). Feeding almost exclusively on flying insects, olive-sideds dart out from high exposed perches to grab wild honeybees, flies, beetles, dragonflies, winged ants, grasshoppers, and moths (Beal, 1912 in Peterson and Fichtel, 1992).

Conservation

In precolonial times, olive-sided flycatchers probably found suitable habitat wherever blowdowns, forest fires and beaver activity left openings within extensive woodlands. The extirpation of beaver during the fur trade in the 17th and 18th centuries, extensive logging during the 1800's, and later, suppression of fires in second growth forests combined to reduce breeding habitat for this species. In recent decades, however, reestablished beaver populations have significantly increased the availability of small forested wetlands throughout the state. In the Adirondacks of New York, a large proportion of documented olive-sided flycatcher breeding sites are in beaver ponds (Peterson, 1988).

Forested buffers surrounding wetlands and waterbodies where olive-sideds occur should be preserved as nesting and feeding habitat. Sites dominated by spruce, fir, hemlock, and other conifers offer especially favorable nesting and perching trees. In addition, dead and dying trees should be left standing in such habitats to provide feeding and singing perches

Table C-1 Breeding Birds of New Hampshire's Wetlands and Waterbodies

Dependent species

Common loon
Pied-billed grebe *
Double-crested cormorant
Snowy egret
Great blue heron
Glossy ibis
American bittern
Least bittern
Green heron
Black-crowned night-heron
Canada goose
Wood duck *
Green-winged teal
American black duck
Mallard
Blue-winged teal
Ring-necked duck
Common goldeneye
Hooded merganser
Common merganser
Osprey
Bald eagle
Virginia rail
Sora
Common moorhen
Spotted sandpiper
Common snipe
Herring gull
Belted kingfisher
Fish crow
Sedge wren
Marsh wren
Palm warbler
Northern waterthrush *
Louisiana waterthrush
Sharp-tailed sparrow
Seaside sparrow
Swamp sparrow
Red-winged blackbird
Rusty blackbird

Associated species

Northern harrier
Red-shouldered hawk *
Olive-sided flycatcher *
Alder flycatcher
Willow flycatcher
Eastern kingbird
Purple martin
Tree swallow
Northern rough-winged swallow
Bank swallow
Blue-grey gnatcatcher
Grey catbird
Yellow warbler

* = Species featured in appendix
Species underlined use inland wetlands and aquatic habitats for foraging, but not for nesting

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Appendix D
Sensitive Wetlands

The following hierarchy of sensitivity of wetland types is offered for the purpose of proiritizing local resources from the perspective of managing risk to the natural community type. "Sensitivity" as used here describes the sensitivity of the plant species to influences of human activity, such as nutrient inputs or direct human disturbance (trampling or other destruction of plants) . It does not necessarily take into account the sensitivity of all animal species for which the wetland may provide habitat. Wetlands are divided into four groups (most sensitive, medium sensitivity, least sensitive, and unknown sensitivity) as identified by Dan Sperduto, community ecologist at the New Hampshire Natural Heritage Inventory. These assignments are tentative interpretations based on current information, and may be modified as more information becomes available.

Each community description is followed by its "rank". The ranking sytem used by the New Hampshire Natural Heritage Inventory is used in other states' Natural Heritage programs as well. The rank provides an approximation of rarity in New Hampshire of each community type, with S1 being the most rare, (with five or fewer known occurrences in the state, or other circumstances contributing to imperilment) and S5 being the least rare (demonstrably secure in state). SU communities are those whose rarity is presently unknown, but which may be threatened. A ranking such as S1S2 describes a range of rarity, when distributional information is limited, or that a community has rarity between the two ranks.

Each of the broad categories listed below includes many natural communities, some of which are more rare than others. Descriptions of community types are taken from "summary of ecological Systems and broad physiognomic landform classes", (Speduto, 1995). More complete descriptions of the individual community types including species present and ranking may be obtained from the New Hampshire Natural Heritage Inventory. More sensitive wetlands are often rarer and more threatened by human disturbance than less sensitive wetland types. There is, therefore, some overlap between rarity and sensitivity.

Wetlands most sensitive to impacts of nutrients, and other human disturbance:

Basin marshes and sandy pondshore marshes

Broadly fluctuating ground or surface water levels from spring inundation to nearly dry late summer drawdown. Occurring on porous substrates of sandy pondshores, outwash, glacial lakebed and river plain deposits. Feeding and breeding ground for amphibians and reptiles. S1 or S1/S2.

Fens (groundwater / seepage wetlands)

Sedgey / shrubby peatlands influenced by groundwater seepage and / or water of streams and lakes. More minerotrophic compared to bogs. Water fluctuations are less pronounced than in marshes. Water quality / pH has strong influence. Groundwater basins, drainageways, bases of slopes, sloping upland till positions and riverbanks. S1, S2, or S3, depending on type.

Bogs

Shrubby peatlands of stagnant water basins or drainageways; in till uplands, kettle holes, and stagnant pond or lake margins. S1 or S2, depending on type.

Vernal Pools

Small temporarily flooded basins within forests. Till uplands, valleys, floodplains, outwash and lakebed deposits. Larger, open marshy examples are also called basin marshes. SU.

Wetlands of medium sensitivity:

Basin Swamps

Topographic depressions. Two hydrologic types: 1) Surface water basins (stagnant, "perched" basins with no connection to groundwater; and 2) Groundwater/surface water basins (basins connected to groundwater; usually less stagnant). Upland till and stratified drift landscapes (e.g. kettleholes) and other valley sediment landscapes. S1S2 - S4-S5.

Wetlands least sensitive to nutrients and other impacts:

Streamside / lakeside swamps

Swamps flooded by surface waters associated with streams, lakes, and minor rivers. Two hydrologic types: 1) Surface water swamps and 2) Groundwater / surface water swamps. S3-S5.

Streamside / lakeside marshes

Temporarily to permanently flooded. Three broad types: shallow & deep emergent marshes, and aquatic bed (floating-leaved) marshes. Beavers create successional wetland mosaics of different ages by creating and abandoning dams along drainageways, ponds, and lakes. S5.

Groundwater / (Seepage) Swamps

Groundwater influence is important. Sloping to nearly level headwater areas of drainages and where soil water forced to surface by impervious layer (hillside forest seeps and larger sloping seepage forests in till, outwash and river terrace sediments). S1 - S3.

Shrub thickets

Found in association with and independently of nearly all other wetland types; along streams, rivers, bogs, ponds, and lakes. (Rank variable; depends on associated wetland.)

Wetlands of variable or unknown sensitivity:

Floodplain forests

Temporarily flooded silt and sand terraces of major and minor rivers and major streams. Various flood frequencies and length of inundations create complex mosaics of communities. S1S2 - S2S3.

Appendix E
Buffer Widths

Author	Functions Protected	Range of Buffer Widths Recommended	Average of Range
Rogers, Golden & Halpbern, 1988	Water Quality - Nontidal Wetlands - Intermediate	25' - 50'	37'
Budd et al., 1987	Water quality, temp control, wildlife habitat, Stream corridors	25' - 50'	37'
Swift, 1986	Water quality (sediment) Filter strips for logging, with brush barrier	32' - 64'	48'
Palmstrom, 1991	Water quality (subsurface)	50'	50'
Brown & Brazier, 1972 (in Palfrey & Bradley, 1981b)	Stream temperature	55' - 80'	67'
Castelle et al., 1994	Water Quality, Temperature control Review of other literature	49' - 98'	74'
Trimble, 1957	Water Quality (Sediment) Filter strip for logging, general situation, slope dependent	25' - 165'	95'
Swift, 1986	Water quality (sediment) Filter strips for logging, without brush barrier	43' - 154'	99'
Pinay	Water quality (nitrate removal) Winter Conditions	100'	100'
Stauffer & Best, 1980	Wildlife (breeding birds)	11' - 200'	106'
Rogers, Golden & Halpbern, 1988 NonTidal Wetlands - Exceptional	Water quality	75' - 150'	113'
Welch, 1992	Water quality Riparian Forest Buffer	95' - 150'	123'
Erman et al. 1977 (in Palfrey & Bradley, 1981b)	Water quality (sediment)	150'	150'
Wong & McCuen, 1981	Water quality (sediment)	150'	150'
Phillips 1989 (Nonpoint source....)	Water quality control along a coastal plain river Uses model	49' - 260'	155'
Palmstrom, 1991	Water quality (sediment)	25' - 300'	163'
Roman & Good, 1985	General	50' - 300'	175'
Nieswand et al., 1990	Water quality	45' - 300'	183'
Trimble, 1957	Water Qualtiy (sediment) Filter strip for logging, municipal watershed, slope dependent	50' - 330'	190'
Brady & Buchsbaum, 1989	Scenic value of resource Harvard School of Design	200'	200'
Brown et al. , 1990	Water quality (sediment)	75' - 375'	225'
Clark, 1977 (in Palfrey & Bradley, 1981b)	Nutrient removal	150' - 300'	225'

UNIVERSITY OF NEW HAMPSHIRE COOPERATIVE EXTENSION

Helping You Put Knowledge And Research To Work

Planting Shoreland Areas

by

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Because New Hampshire's scenic beauty contributes to the quality of life for its visitors and residents alike, maintaining environmental quality should be everyone's concern.

Despite increased awareness about environmental issues, the activities of those who live near our lakes and rivers could adversely affect the quality of those waters.

Land use activities within a watershed, especially along shorelines, can have a tremendous impact on the quality of adjacent surface waters. The protection of New Hampshire's shorelands is essential for maintaining the high quality of the state's public waters, and to help maintain that quality, the Comprehensive Shoreland Protection Act (RSA 483-B) was enacted on July 1, 1994.

This act applies to all lands located within 250 feet of the ordinary high water level (reference line) of publicly-owned lakes and impoundments, certain major rivers, estuaries, and coastal waters. It establishes minimum standards for the use and future development of these designated shoreland areas. The New Hampshire Department of Environmental Services has developed a four page synopsis which provides information about the act (technical bulletin # NHDES-CO-1994-2) .

In the spirit of stewardship, people who own land and homes on New Hampshire's lakes, ponds and streams can play an important role in preserving the quality of our public waters. By considering some of the following landscaping techniques, shoreland residents can help protect our ground and surface waters for all to use and enjoy.

Fertilize Properly. The law states that "no fertilizer, except lime or wood ash, shall be used on lawns or areas with grass on residential properties" within this 250 foot zone.

Although vegetable gardens and ornamental plantings are not specifically included in the act, the first step in any fertilization program is to have your soil tested and then follow the recommendation. UNH Cooperative Extension offers a soil testing service that can tell you what your soil needs and the best type and amount of fertilizer to use.

Since lawns within this 250 foot setback are specifically restricted to only applications of lime or wood ashes which can raise soil *p*H, a soil test is even more important for promoting healthy turf. A soil test is invaluable in determining and, if necessary, in raising the soil *p*H, enabling turf to make the best use of available soil nutrients.

Water Wisely. Over-watering can greatly increase the movement of nutrients and other substances into groundwater. For most growing situations, about one inch of rainfall per week, either natural or artificial, is sufficient for adequate growth.

The addition of organic matter to soil, the use of mulches, and the application of xeroscaping techniques, landscaping to minimize water use, can further reduce the need for supplemental water. These practices will help conserve a valuable natural resource and will help reduce the potential for nutrients and sediment to affect our ground and surface waters.

Proper Turf Management. Since fertilizer applications are prohibited on residential lawns within this shoreland zone, proper turf management takes on renewed importance. Grass kept at a height of 2 1/2 - 3" during the months of July and August can withstand heat and drought stress better than closely clipped grass. This higher mowing height encourages deeper rooting, reducing the need for frequent watering. It will also allow turf to more successfully out-compete broad leaved weeds, reducing the need for weed control.

In addition, unmown grass tends to make a very good erosion and nutrient barrier. Its fibrous root system and dense top growth can greatly slow and reduce surface runoff and help intercept nutrients and pesticides.

Other techniques, such as mowing frequently, removing no more than a third of the leaf blade and leaving clippings on lawns, can conserve soil nutrients and help build soil organic matter. Local UNH Cooperative Extension offices have fact sheets available that can help you better manage turf.

Grow Low Maintenance Grasses. Due to lower maintenance requirements, there is increased interest in and research devoted to the development of dwarf turf grasses. These grasses, such as fine leaf fescues and perennial ryes, perform well with lower inputs of fertilizer, water, mowing, and pesticides.

Dwarf turfgrasses are survivors under adverse conditions, including our infertile, acidic soils, and tolerate shade, drought, most pests, and cold temperatures. Several new varieties have been developed for home landscape use.

Since many of these new dwarf turf grasses may only be limitedly available from local suppliers, you may need to contact producers directly. A recent UNH Cooperative Extension publication, *Low Maintenance Turfgrass for Landscapes and Commercial Agriculture*, is now available to assist in successfully using these newer turf types.

Use Alternative Landscaping. Using alternative landscaping techniques, such as groundcovers, rock gardens or shrubs mulched with bark or stones, can greatly reduce the need for turf areas and can help reduce or eliminate fertilizer and water needs, helping to prevent ground and surface water pollution from shoreland areas.

Most perennial plants can make adequate growth with relatively low inputs of additional nutrients. Proper plant selection and the use of organic mulches can greatly minimize the need for applying additional fertilizer.

Maintain Natural Buffer Areas. Keeping a portion of a property between lawns or gardens and any stream, pond, or wetland in native vegetation will help reduce the impact on surface waters.

According to the Comprehensive Shoreland Protection Act, where existing, a natural woodland buffer shall be maintained within 150 feet of the reference line. The act also specifies what type of vegetation management activities may or may not occur in these areas. Buffer areas will help to remove nutrients that might be included in the runoff from lawn areas during intense rain storms and snow melt. These areas also provide food and habitat for birds and other wildlife.

Many native shrubs and ground covers would be good choices for these buffer areas, especially those with dense surface root systems. Trees are important plants for buffers, too, but too much shade at ground level may inhibit the growth of many understory plants.

Good site analysis and evaluation is critical for successful planting of buffer areas. Knowing the existing growing conditions, sunny or shady, dry or moist, is essential for proper plant selection.

The following selected list of native and appropriate non-native plant materials represents some good choices, depending on site conditions, for both buffers and naturalized landscape areas. In some cases, a particular variety or cultivar may be a better choice over the unimproved species. Because of the diversity of available plant materials, other plants not listed may be good choices, too.

Trees

Balsam Fir (*Abies balsamea*)
Fraser Fir (*A. fraseri*)
Red Maple (*Acer rubrum*)
Sugar Maple (*A. saccharum*)
Shadbush (*Amelanchier* sp.)
Yellow Birch (*Betula alleghaniensis*)
Black Birch (*B. lenta*)
Paper Birch (*B. papyrifera*)
White Ash (*Fraxinus americana*)
Green Ash (*F. pennsylvanica*)
Carolina Silverbell (*Halesia carolina*)
Black Tupelo (*Nyssa sylvatica*)
White Spruce (*Picea glauca*)
Red Pine (*Pinus resinosa*)
Scotch Pine (*Pinus sylvestris*)
White Pine (*Pinus strobus*)
White Oak (*Quercus alba*)
Swamp White Oak (*Quercus bicolor*)
Pin Oak (*Quercus palustris*)
Red Oak (*Q. rubra*)
Canadian Hemlock (*Tsuga canadensis*)

Small Trees/Shrubs

Amur Maple (*Acer ginnala*)
Bottlebrush Buckeye (*Aesculus parviflora*)
American Hazelnut (*Corylus americana*)
Pagoda Dogwood (*Cornus alternifolia*)

Silky Dogwood (C. *amomum*)
Gray Dogwood (C. *racemosa*)
Redosier Dogwood (C. *sericea*, formerly *stolonifera*)
Hawthorn (*Crataegus* sp.)
Sweet Pepperbush (*Clethra alnifolia*)
Common Pearlbush (*Exochorda racemosa*)
Large Fothergilla (*Fothergilla major*)
Common Witchhazel (*Hamamelis virginiana*)
Bayberry (*Myrica pensylvanica*)
Ironwood (*Ostrya virginiana*)
Mugo Pine (*Pinus mugo*)
Beech Plum (*Prunus maritima*)
Azalea (*Rhododendron* sp.)
Rhododendron (*Rhododendron* sp.)
Rose (*Rosa* sp., avoid R. *multiflora*)
Snowberry (*Symphoricarpos albus*)
Coralberry (S. sp.)
Winterberry (*Ilex verticillata*)
Highbush Blueberry (*Vaccinium corymbosum*)
Hobblebush (*Viburnum alnifolium*)
Koreanspice Viburnum (V. *carlesii*)
Arrowwood (V. *dentatum*)
Blackhaw Viburnum (V. *prunifolium*)
Nannyberry (V. *lentago*)
Sargent Viburnum (V. sargentii)
American Cranberrybush (V. *trilobum*)

Vines and Ground Covers
Bearberry (*Arctostaphylos uva-ursi*)
Ginger (*Asarum* sp.)
Astilbe (*Astilbe* sp.)
Bunchberry (*Cornus canadensis*)
Sweet Fern (*Comptonia peregrina*)
Barrenwort (*Epimedium* sp.)
Wintergreen (*Gaultheria procumbens*)
Sweet Woodruff (*Galium odoratum*)
Cranesbill (*Geranium* sp.)
Hosta (*Hosta* sp.)
Candytuft (*Iberis sempervirens*)
Allegheny Pachysandra (*Pachysandra procumbens*)
Canby Paxistima (*Paxistima canbyi*)
Virginia Creeper (*Parthenocissus quinquefolia*)
Lowbush Blueberry (*Vaccinium angustifolium*)
Mountain Cranberry (V. *vitis-idaea*)
Ferns (several species)

Note: Numerous herbaceous perennials, both native and exotic, can make excellent naturalized ground covers.

For more information about planting shoreland areas, contact the Belknap County UNH Cooperative Extension office at 524-1737 or write us at P O Box 368, Laconia, NH 03247. The office is located on the second floor of the Historic Belknap Mill in Laconia and is open Monday through Friday, from 8:00 am to 4:30 pm.

Appendix G
Other Publications

Selected Buffer Guidebooks:

A Citizen's Guide to Conserving Riparian Forests: Identifying and Protecting the Values of Riverside Forests in the Northeastern United States
by Susan C. Peterson and Kenneth D. Kimball. May 1995.

AMC Research Department
P.O. Box 298
Gorham, NH 03581

Vegetated Buffers in the Coastal Zone: A Summary Review and Bibliography
by Alan Desbonnet, Pamela Poque, Virginia Lee, and Nicholas Wolff. July 1994.

Coastal Resources Center
Rhode Island Sea Grant
University of Rhode Island Graduate School of Oceanography
Narragansett, RI 02882

New Hampshie Wetland Protection:

Municipal Guide to Wetland Protection
by Amanda J. Stone, Janet M. Bourne, Julie L. Cummings, Marjory M. Swope, Kenneth N. Kettenring, and James F. McLaughlin. September, 1993.

N.H. Office of State Planning
2 ½ Beacon St.
Concord, NH 03301

Method for the Comparative Evaluation of Nontidal Wetlands in New Hampshire
by Alan P. Ammann and Amanda Lindley Stone. March 1991.

N.H. Dept. of Environmental Services
6 Hazen Drive
Concord, NH 03301

New Hampshie Best Management Practices Handbooks:

Stormwater Management and Erosion and Sediment Control Handbook for Urban and Developing Areas in New Hampshire
Prepared by: Rockingham County Conservation District. August 1992.

Rockingham County Conservation District
32 Front St.
Exeter, NH 03833-2705

Best Management Practices for Erosion Control on Timber Harvesting Operations in New Hampshire
by J.B. Cullen, 1990.

Department of Resources and Economic Development
Division of Forests & Lands.
PO Box 1856
Concord, NH 03302-1856

Manual of Best Management Practices for Agriculture in New Hampshire
N.H. Department of Agriculture. 1993.

N.H. Department of Agriculture
10 Ferry St.
P.O. Box 2042
Concord, NH 03302-2402

Best Management Practices to Control Nonpoint Source Pollution: A Guide for Citizens and Town Officials
N.H. Department of Environmental Services. 1994.
N.H. DES
6 Hazen Drive
Concord, NH 03301

Best Management Practices for Erosion Control During Trail Maintenance and Construction
N.H. Dept. of Resources and Economic Development. 1994.

Department of Resources and Economic Development
Division of Parks & Recreation
PO Box 1856
Concord, NH 03302-1856

Wildlife Resources:

Ecology of Greenways: Design and Function of Linear Conservation Areas
by D.S. Smith, 1994.
University of Minnesota Press.
Minneapolis, MN
(can be ordered from your local bookstore)

New England Wildlife: Management of Forested Habitats
Gen. Tech Rep. NE-144, Radnor, PA
by Degraaf, R.M., M. Yamasaki, W. Leak, & J. Lanier, U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station. 1992.
Superintendent of Documents
U.S. Gov. Printing Office
Washington, DC 20402

Enhancing Wildlife Habitats: A Practical Guide for Forest Landowners
by S.S. Hobson, J.S. Barclay, S.H. Broderick. Northeast Forest Resources Extension Service Series. 1993.
Northeast Regional Agricultural Engineering Service
Cooperative Extension
152 Riley-Robb Hall
Ithaca, NY 14853-5701

Wild Mammals of New England
by A.J. Godin. The Johns Hopkins University Press, Baltimore. 304pp., 1977.

The Amphibians and Reptiles of New Hampshire
by Dr. JamesTaylor Ph.D., 1993.
N.H. Fish and Game Dept.,
Concord, NH 03301

Atlas of Breeding Birds in New Hampshire
ed. by C.R. Foss, 1994.
Arcadia, Great Britain.

Appendix H
Agencies

UNH Cooperative Extension

Belknap County
PO Box 368
Laconia, NH 03427
524-1737

Coos County
148 Main St.
Lancaster, NH 03584
788-4961

Rockingham County
113 North Road
Brentwood, NH 03833-6623
679-5616

Carroll County
34 Main St., Box 367
Conway, NH 03818
447-5922

Grafton County
PO Box 191
Woodsville, NH 03785
787-6944

Strafford County
County Farm Road
Dover, NH 03820
749-4445

Cheshire County
PO Box 798
33 West St.
Keene, NH 03431
352-4550

Hillsborough County
Chappell Professional Center
Rt. 13S
Milford, NH 03055
673-2510

Sullivan County
24 Main St.
Newport, NH 03773
863-9200

Merrimack County
327 Daniel Webster Highway
Boscawen, NH 03303
796-2151

State Office (Water Resources)
111 Pettee Hall, UNH
Durham, NH 03824
862-1067

New Hampshie Regional Planning Commissions

Southwest Regional Planning Commission
12 Court St.
Keene, NH 03431
357-0557

Nashua Regional Planning Commission
PO Box 847
115 Main St.
Nashua, NH 03061
863-0366

Lakes Region Planning Commission
Humiston Building
103 Main St.
Suite 3
Meredith, NH 03253-9287
279-8171

Central N.H. Regional Planning Commission
329 Daniel Webster Highway
Boscawen, NH 03303
796-2129

Rockingham Planning Commission
121 Water St.
Exeter, NH 03833
778-0885

Upper Valley - Lake Sunapee Council
RR1, Box 123
Lebanon, NH 03766
448-1680

Southern N.H. Planning Commission
400 Commercial St.
Manchester, NH 03101
669-4664

Strafford Regional Planning Commission
County Court House
County Farm Road
Dover, NH 03820
742-2523

North Country Council
65 Main St.
Littleton, NH 03561
444-6303

Agricultural Stabilization and Conservation Service Offices

Belknap / Carroll Counties
Federal Building, Room 205
Laconia, NH 03246
528-8719

Grafton County
Post Office Building
Woodsville, NH 03785
747-3751

Rockingham / Strafford Counties
Post Office Annex
PO Box 96
Front St., Room 102
Exeter, NH 03833
772-4383

Cheshire County
Federal Building, Room 218
Keene, NH 03431
352-2322

Hillsborough County
Chappell Professional Building
Route 13S
Milford, NH 03055
673-1222

Sullivan County
25 Mulberry St.
Claremont, NH 03743
542-4281

Coos County
Kidder Building, Route 3
Lancaster, NH 03584
788-4602

Merrimack County
525 Clinton St
Bow, NH 03304
225-5931

U.S.D.A. Natural Resource Conservation Service Field Offices and County Conservation District Offices

Belknap County
Forestry Building
719 Main St.
Laconia, NH 03246
528-8713

Coos County
RFD 2, Box 165a
Lancaster, NH 03584
788-4651

Merrimack County
525 Clinton St
Bow, NH 03304
225-6401

Carroll County
PO Box 533
Conway, NH 03818
447-2771

Grafton County
Swiftwater Road
PO Box 229
Woodsville, NH 03875

Rockingham County
32 Front St.
Exeter, NH 03833
772-4385

Sullivan County
25 Mulberry St.
Claremont, NH 03743
542-6681

Cheshire County
196 Main St.
Keene, NH, 03431
352-3602

Hillsborough County
Chappell Professional Building
Route 13S
Milford, NH 03055
673-2409

Strafford County
USDA Agricultural Service Center
County Farm Road
Dover, NH 03820
749-3037

N.H. Department of Resources and Economic Development
172 Pembroke Road
PO Box 1965
Concord, NH 03302-1856
271-2411
Division of Forests and Lands,
271-2214
N.H. Natural Heritage Inventory,
271-3623
Division of Parks and Recreation,
271-3556

N.H. Department of Environmental Services
6 Hazen Drive
PO Box 95
Concord, NH 03301
Water Resources, 271-3406
Wetlands Bureau, 271-2147
Water Supply and Pollution
Control Division, 271-3503

N.H. Fish and Game Department
2 Hazen Drive
Concord, NH 03301
271-3421

N.H. Office of State Planning
2 ½ Beacon Street
Concord, NH 03301
271-2155

Appendix I
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