HABITAT MANAGEMENT GUIDELINES FOR AMPHIBIANS AND REPTILES OF THE NORTHEASTERN UNITED STATES

Technical Publication HMG-3

PARTNERS IN AMPHIBIAN AND REPTILE CONSERVATION

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Front cover photos by James Gibbs (background) and Lynda Richardson (Spotted Salamander), Mark Bailey created the front cover illustration.

Back cover by Joe Mitchell

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PURPOSE AND INTENDED USE OF THIS DOCUMENT

The *Habitat Management Guidelines for Amphibians and Reptiles* series (hereafter Guidelines) is intended to provide private landowners, state and federal land agencies, and other interested stakeholders with regional information on the habitat associations and requirements of amphibians and reptiles, possible threats to these habitats, and recommendations for managing lands in ways compatible with or beneficial to amphibians and reptiles. The general information and specific management guidelines presented are based on best available science, peer-reviewed expert opinion, and published literature. The "Maximizing Compatibility" and "Ideal" management guidelines are recommendations made and reviewed by groups of professionally trained herpetologists and wildlife biologists from private, state, and federal organizations. Because of the taxonomic and ecological diversity of amphibians and reptiles, some recommendations may not apply to every species in every situation. The authors and editors of the Guidelines suggest consulting a local herpetologist before significant land-use changes are implemented. These Guidelines are not legally binding, regulatory, or in any way an attempt to limit landowner rights. They can be regarded simply as recommendations from the PARC community for landowners and managers to consider the needs of amphibians and reptiles in the course of their land management activities.

Amphibian and reptile populations are declining in the United States and will continue to do so as long as human populations and associated developments expand. When applied on the ground as general management principles, these Guidelines will promote conservation of amphibians and reptiles by:

- keeping common species common,
- stemming the decline of imperiled species,
- guiding the restoration of amphibian and reptile habitats while benefiting many other wildlife species, and
- reducing the likelihood that additional species will be added to endangered species lists.

Joe Mitchell

The Box Turtle is a well-known species to most people in the Northeast. They live for several decades and occur in hardwood forests, grasslands, and agricultural areas.

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American Toads are the amphibian comics. Males arrive first at breeding ponds in early spring and call for females. Once there, females are often mobbed by males seeking a mating position, a phenomenon called a toad orgy. Kurt Weiskotten

PREFACE

Habitat Management Guidelines for Amphibians and Reptiles of the Northeastern United States is a production of Partners in Amphibian and Reptile Conservation (PARC). PARC's mission is "to conserve amphibians, reptiles, and their habitats as integral parts of our ecosystem and culture through proactive and coordinated public/private partnerships." The emphasis is on partnerships, as we are seeking to work with everyone to find solutions to common issues. PARC is not a funding or government agency. It does not create or dictate policy. Rather, it provides recommendations and guidelines based on sound science. It is intended to increase communication and cooperation with many diverse groups who have a common interest in amphibians, reptiles, and their habitats. Through documents such as this, PARC will give individuals a better idea of how they or their agencies, companies, or organizations can contribute to the conservation and management of habitats on the landscape. The diversity of partners makes PARC the most comprehensive conservation effort ever undertaken for these two groups of wildlife. At the core of PARC is the philosophy that we all must work together. There is no "us versus them." It is all "us." This publication is the product of extensive efforts of many people and contains the contributions of many individuals from academic, private, government, and industrial backgrounds.

Development of the PARC Habitat Management Guidelines began shortly following the organization of PARC in 1999. The initial PARC Habitat Management Technical Working Group consisted of Kurt Buhlmann, Erin Clark, Robert Fisher, Whit Gibbons, Randy Gray, John Jensen, Bruce Kingsbury, Laura Mazanti, Joe Mitchell, Earl Possardt, Klaus Richter, and Monica Schwalbach. This group conceptualized the need for *Habitat Management Guidelines* as a PARC product and agreed that at least five regional documents would be needed for the United States, including the Midwest, Southeast, Northeast, Southwest, and Northwest. Kurt Buhlmann, Joe Mitchell, and Whit Gibbons drafted a model document using the Savannah River Site in South Carolina as "the region." The Technical Working Group, chaired by Monica Schwalbach, organized a workshop in Chicago that was held in February 2001. At that meeting, 85 individuals representing the five regions worked for three days on concepts, habitats, and early drafts of the documents for each region. Subsequently, the Midwest document was the first to be completed, followed by the Southeast document in 2006. Habitat Management Guidelines for the Northeast is the third in the series.

Ken Nemuras

Spotted Salamanders have become well-recognized by Northeast residents because of their association with woodland vernal pools. Spotted Salamanders live most of their lives in hardwood forests, but must make annual migrations, usually in late winter, to woodland vernal pools where they lay eggs and the aquatic larvae develop.

Joe Mitchell

The Wood Turtle is a large semi-aquatic species of rivers and floodplains in the Northeast. It is declining in many areas due to habitat loss and fragmentation, and road mortality. Wood Turtles, like Box Turtles, are long-lived, reaching 50+ years.

Lead writers for this book were Joseph C. Mitchell, Alvin R. Breisch, and Kurt A. Buhlmann. Mitchell is founder of Mitchell Ecological Research, LLC, Chair of the PARC Habitat Management Working Group, and Research Biologist with the University of Richmond. Breisch is the state herpetologist for New York within the Department

Will Brown

Joseph C. Mitchell

Kirstin Breisch

Alvin R. Breisch

Evan Castner

Kurt A. Buhlmann

of Environmental Conservation and was co-chair of NEPARC. Buhlmann was Coordinator for Turtle Conservation Programs with Conservation International's Center for Applied Biodiversity Science, is a Research Scientist at the University of Georgia's Savannah River Ecology Laboratory, and is the founder of Buhlmann Ecological Research and Consulting, LLC. Mark Bailey and Jeff Holmes supplied additional writing. The Northeast PARC working group provided valuable guidance and insights on this publication.

The Acknowledgments section at the back of this booklet lists those who have helped with text, photos, and production of these guidelines. Contributors retain copyright ownership of their photographs. Copying and distribution of this document is encouraged, but please provide credit to the original sources of information.

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INTRODUCTION

To address observed declines in our native amphibian and reptile fauna (herpetofauna), the Management Working Group of Partners in Amphibian and Reptile Conservation (PARC) has developed this booklet containing collaboratively derived, scientifically based Habitat Management Guidelines for the 155 (see list in Appendix) species of amphibians and reptiles in the Northeast region (Connecticut, Delaware, District of Columbia, Maine, Maryland, Massachusetts, New Hampshire, New Jersey, New York, Pennsylvania, Rhode Island, Vermont, Virginia, West Virginia). Note that amphibians and reptiles do not adhere to state boundaries, thus, land managers in surrounding states and southern Canada may also find these guidelines applicable to their needs. PARC's goal was to use the best science available to produce habitat management and conservation guidelines that are easily understood and practical to include with other management objectives on the landscape.

The habitat management guidelines included in this document have been derived from an extensive body of published information on amphibians and reptiles of the northeastern United States, as well as on the extensive experiences of concerned biologists/scientists. These guidelines are meant to be general enough that applications can be adapted for the location or habitat of interest. We do not describe the needs of every species of amphibian and reptile in this document. Instead, we provide guidelines for managing habitats in each region in ways that have general positive benefits for the associated amphibians and reptiles.

Amphibian and reptile populations are declining in the United States and will continue to do so as human populations and associated development continue to expand. These guidelines are not regulations, nor are they in any way an attempt to limit landowner rights. They can be regarded simply as recommendations from the PARC community for landowners and managers to consider the needs of amphibians and reptiles in the course of their land management activities.

Conservation needs for North American amphibians and reptiles were the focus of the first PARC meeting held in Atlanta, Georgia, in June 1999. The PARC partners recognized that Habitat Management Guidelines for amphibians and reptiles could be compiled from the available scientific literature and scientists' experiences/expertise, and summarized for landowners and land managers. The goal is to create several colorful, photo-filled publications, each specific to one

Linh Phu

An appreciation and love of nature most often begins in childhood and may generate an interest in amphibians and reptiles.

Kurt Weiskotten

Exploring wetlands with a dip net and a keen curiosity connects one to nature and helps to develop a feeling of responsibility for the environment.

Karyn Molines

Catching amphibians and reptiles usually requires use of trapping techniques like this turtle trap. We encourage land owners and managers to work with herpetologists to develop plans for their properties.

of five geographic regions of the United States. Each identifies the important habitats used by amphibians and reptiles. Each also provides landowners and land managers with options for incorporating specific conservation efforts towards managing, improving, and/or protecting known amphibian and reptile habitat within their management program. Therefore, this book is primarily intended for northeastern landowners and public/private managers interested in including amphibian and reptile habitat conservation in their land management strategies.

Implementing some of these guidelines should diminish the likelihood of additional species being added to endangered species lists. Landowners and land managers will benefit from these guidelines because their implementation will provide ecological benefits beyond amphibian and reptile conservation. Habitat conservation is preventative maintenance. Thus, if many landowners and land managers each implement some of these guidelines, the cumulative effect will be positive.

AMPHIBIANS AND REPTILES OF THE NORTHEAST

Joe Mitchell

The large basking turtle one sees on logs in portions of the Northeast may be the Red-bellied Cooter, one of the few herbivorous turtles.

Joe Mitchell

Frogs, such as this Spring Peeper, are widespread in the Northeast and their presence or absence may be indicative of environmental and landscape changes. They require ephemeral pools for breeding.

The Northeast region of the United States supports at least 88 species of amphibians and 67 species of reptiles. A complete list of species by scientific name and common name, along with their occurrence by state, primary habitats, and rarity status, is presented in Appendix A. Common names vary regionally, so users may wish to consult with regional and state guides for other names applied to these species.

With the exception of lizards, which are more abundant in the West, each of the other groups of North American reptiles (snakes, turtles) and amphibians (salamanders, frogs,) are well represented in the Northeast region of the United States. Salamander diversity in the Appalachian Mountains is the highest in the world. Despite their abundance and diversity, amphibians and reptiles have only recently received consideration in many wildlife management programs. Their ecological importance has become more recognized as management objectives have begun to focus on non-game species, biodiversity conservation, landscape-level ecology, and the role of all plants and animals in ecosystems.

NATURAL HISTORY OF AMPHIBIANS AND REPTILES

The 31 frog species, 57 salamanders, 25 turtles, 9 lizards, and 33 snakes native to the Northeast illustrate a range of life histories and adaptations to various habitats in the region. Understanding their basic natural history is essential to effective management of their habitats and populations. Sources of information on amphibians and reptiles in the Northeast are included in the list of resources at the end of this guide.

Amphibians and reptiles (often called “herps” and “herpetofauna” from the branch of science called herpetology) are vertebrates like birds and mammals, but they are fundamentally different in one very important way. Herps are “cold blooded,” whereas birds and mammals are “warm blooded.” This means that the source of body heat is external for herps and internal for the other two groups. Why is this important? Being warm blooded (= endothermy) requires birds and mammals to eat regularly to fuel the biochemical mechanisms that produce body heat. Most are therefore active year-round or nearly so.

Not so with herps. Because body heat is derived from external sources (= ectothermy), these animals do not need to feed regularly and can be inactive for extended periods of time. Some large snakes, for example, need only one large meal per year. Terrestrial salamanders feed primarily during several warm, wet nights within their active season. Given a few exceptions, herps are inactive during cold periods and dry environmental conditions. They do not have protective covers of feathers or fur to protect them from cold or dryness. Thus, the combined conditions of temperature and moisture regulate when and where amphibians and reptiles are active. This, in turn, greatly affects when and where we see them actively moving about or basking. Spadefoot toads, for example, may stay buried in the ground for several years before they appear during or following heavy rainfall.

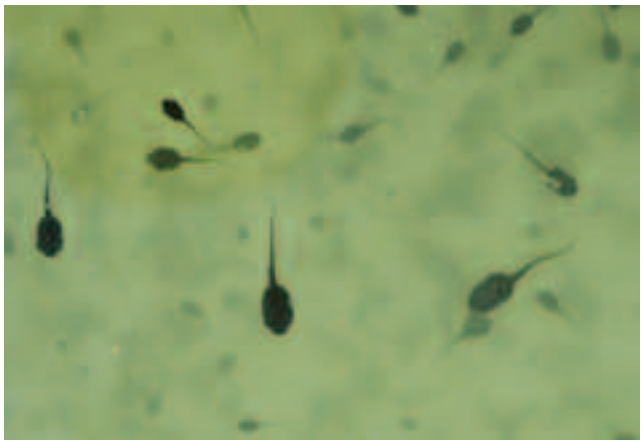
Most amphibians require both an aquatic and terrestrial habitat during their annual cycle. Most use many habitats during the course of a single year and throughout their lives. Many frogs and some salaman-

Lynda Richardson

Shelled eggs, such as this one from which the baby Mud Turtle emerged, must be laid on land. Therefore, managing for aquatic turtles includes considering aquatic and terrestrial habitats.

Joe Mitchell

Open canopy areas, such as blow-downs within the forest, fields, abandoned gravel pits, and powerline ROWs represent areas where aquatic turtles may dig a nest to deposit their eggs. Warmed by the heat of the sun, most turtle eggs will hatch in 60-90 days.



Joe Mitchell

Tadpoles are the juvenile stage of frogs. These Cope's Gray Treefrog tadpoles will metamorphose, emerge from the wetland, and seek surrounding hardwood forest habitat.

Joe Mitchell

The smaller of the two American Bullfrogs has not yet completed metamorphosis as evidenced by the remaining tail that has yet to be re-absorbed. The larger frog has completed metamorphosis and is demonstrating its defensive posture.

ders in the Northeast breed for only a few weeks to months in ponds or vernal pools but otherwise spend the rest of the year in the terrestrial environment, usually in association with hardwood forests. Many freshwater turtles live in ponds and lakes but lay eggs on land and often spend long periods buried in the ground. Movement between habitats like ponds and forests may occur over distances of several hundred meters or more. During movements across the landscape herps may encounter roads or other human-made structures, which can be barriers or death traps. Millions of herps are killed on roads annually. Such adverse features on the landscape should be kept in mind when managing habitats for these animals.

Amphibians are considered sensitive environmental indicators because they produce unshelled eggs that must be in water or kept moist and they have moist skin across which chemicals can enter their bodies. Because most amphibians have an aquatic larval stage (frog tadpole, salamander larva) before transforming into an adult, each individual may encounter chemicals and other pollutants in water, on land, and in the air throughout its lifetime. Habitats that have harmful substances at any developmental stage may not support amphibian populations no matter how healthy the habitat appears otherwise. The prey they eat serve as sources of energy for growth and reproduction and sometimes as harmful chemicals that can be passed on to offspring or to other predators.

Reptiles lay shelled eggs or produce offspring via live birth, and have scales that serve as a protective barrier to moisture loss and chemicals. Thus, they are able to exist in drier habitats that exclude many amphibians; however, no reptile can withstand long periods without water. Indeed, most are active when conditions are moist (e.g., during rainfall or high humidity) and stay concealed when they are dry.

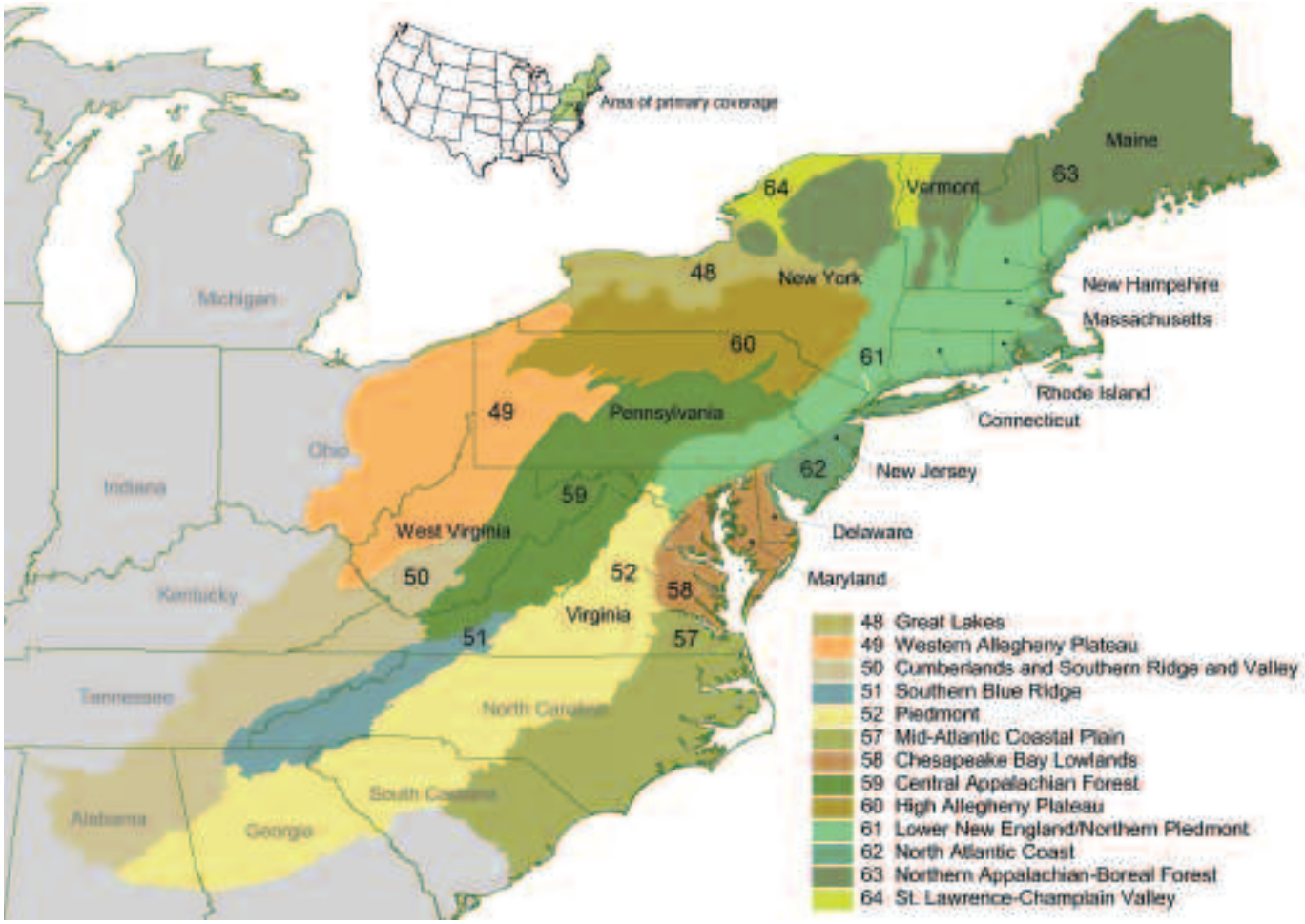
Understanding key biological characteristics of amphibians and reptiles is important if management is to have the desired beneficial effect. Longevity has important management implications. Most turtles and many salamanders take years to reach maturity and live much longer than most game species. Thus, long-lived, late-maturing species require different management strategies. Sustainable harvest of amphibian and reptile populations is often not a realistic option.

ECOREGIONS OF THE NORTHEAST

The thirteen northeastern states and District of Columbia span 13 ecoregions, as defined by The Nature Conservancy. An ecoregion is a portion of the country that is characterized by one or more plant community types, major soil types and underlying geology, and a suite of environmental variables (e.g., temperature, rainfall patterns). Ecoregions are presented to help identify where various *habitats* are located on the landscape. Some habitat types occur in multiple ecoregions. For example, pine forests of one kind or another occur in virtually every ecoregion, but caves are most prevalent in the Cumberland Plateau and Southern Ridge and Valley. Isolated seasonal wetlands such as vernal pools and sinkhole ponds occur in all of the ecoregions of the Northeast. Spruce-fir forests are found in the Northern Appalachian-Boreal Forest in the northern portion of the region. The flat Coastal Plain is separated from the geologically older Piedmont and western mountainous regions by the Fall Line. This geological feature with abrupt falls and rocky zones has influenced the distributions of many species.

HABITATS IMPORTANT TO AMPHIBIANS AND REPTILES

The Northeastern Working Group at the 2001 Workshop identified six aquatic and eight terrestrial habitats in the Northeast that are intuitively recognizable from each other and can be associated with certain assemblages of amphibians and reptiles that characterize these habitats. Very few species of either group occur exclusively in any one habitat type, however. Many species occupy several of these habitat types. Some of these habitats are relatively small (e.g., seeps, seasonal wetlands, caves) and are often embedded within larger habitats (e.g., mesic hardwood forests, pine forests). Each of these habitats is described in detail in the *Management*



Ecoregions of the Northeast

Guidelines by Habitat Type section.

Aquatic habitat types include
A. Seasonal Isolated Wetlands
B. Wet Meadows, Bogs, and Fens
C. Permanent Wetlands
D. Small Streams, Springs, and Seepages
E. Rivers
F. Estuarine and Coastal

Terrestrial habitat types include
G. Hardwood Forests
H. Spruce and Fir forests
I. Xeric Upland and Pine Forests
J. Grasslands and Old Fields
K. Rock Outcrops and Talus

Joe Mitchell

Eastern Box Turtles reach adulthood in their teens, lay 1-9 eggs in most years, and in the absence of human hazards, may live as long as a century. However, they are killed in large numbers on roads in spring and summer, especially after rains.

Phillip deMaynadier

Herpetologists at local universities and government organizations may be able to lend assistance to help determine the species present on your property. A commonly-used method to catch terrestrial amphibians and reptiles is the drift fence with pitfall traps. This technique allows researchers to catch herps as they move across the forest substrate.

L. Caves and Karst
M. Agricultural Lands
N. Urban and Residential

HOW TO USE THESE GUIDELINES

We recognize that landowners and land managers have multiple goals and objectives for managing their land. PARC also recognizes that, depending on your land management objective(s), not all of our recommendations will be feasible. Nevertheless, we hope to foster an appreciation and understanding of amphibians and reptiles and their needs. If each landowner and land manager can implement some of these recommendations, then the net benefit to amphibians and reptiles across the Northeast landscape will be significant and positive.

Thus, each of the habitat sections contains two sets of guidelines: 1) Maximizing Compatibility and 2) Ideal.

"Maximizing Compatibility" guidelines are for landowners and land managers who wish to contribute to the conservation of these animals while primarily managing their land for other uses, such as timber production, hunting, recreation, grazing, development, agriculture, and others.

"**Ideal**" guidelines are for landowners and land managers desiring to make amphibian and reptile conservation a primary objective, as might be desired on nature preserves, wildlife refuges, and private lands whose owners wish to optimize herpetofaunal diversity and abundance.

What we have provided in this book are recommendations. Not every land manager or landowner can be expected to implement all of the guidelines.

Using the information in this handbook, you will be able to:
1. Identify the habitats on which you wish to focus.
2. Gain an understanding of which species are likely to occur and live in those habitats.
3. Establish your management goal for each habitat:
   a. Review the recommended guidelines for that habitat and determine if they will work on your land.
   b. Work with regional experts to implement the guidelines you have selected.

Once you have implemented the guidelines that are feasible for your land, you may wish to conduct follow-up evaluations to determine if the guidelines are working. Depending on your resources, these could range

Joe Mitchell

The Northern Dusky Salamander is commonly found in seepages and springs, but is easily eliminated by pollution and siltation.

Joe Mitchell

Large scale urban sprawl is a major cause of habitat loss for amphibians and reptiles. Opportunities for animals and plants to move across this inhospitable landscape are limited.

Joe Mitchell

The Northern Cricket Frog lives in the grassy margins of permanent wetlands. A once common northeastern species, it has been declining in recent years.

from the most general field observations ("I'm seeing more box turtles than I used to") to implementing vigorous monitoring projects. If the guidelines succeed, then continue to use this approach. If they do not, then reevaluate the guidelines to determine where the problem is located. Successful land management is a mix of land-use history, art, and science.

DEVELOPING A MANAGEMENT PLAN

An important first step in managing habitats for amphibians and reptiles, no matter what the designated land-use, is development of the management plan.

1. ***Know what you have.*** Conduct an inventory of the amphibian and reptile populations on your property. At the same time conduct an inventory of habitat types and map their relative locations and sizes. Once such information is organized, it will be easier to identify features of habitats that need alteration, restoration, or other management actions to benefit amphibians and reptiles. Identify current habitat conditions before initiating changes. If other land-uses are your primary focus, then you can identify ways to maximize compatibility between your land-use goals and habitat suitability for amphibians and reptiles.

2. ***Use maps and aerial photos***. One of the most important first steps for landowners is to obtain available maps and imagery of their lands. Maps and imagery may be available at the Natural Resources Conservation Service (NRCS), the U.S. Geological Survey, the Forest Service, and on the Internet. Topographic maps are very informative, as roads, streams, outcrops, and other unique features of the land are apparent. Comparison of current aerial photos with older images provides a valuable historical perspective (i.e., what the habitats looked like). Aerial photographs are available for some parts of the Northeast dating back to the 1930s. A good map allows the landowner to visualize the arrangement of certain habitats, such as waterholes, wetlands, and forests, and can help the landowner locate the important amphibian and reptile habitats. Management needs may include buffers along waterways, construction of artificial wetlands, corridors between disconnected habitats, and reintroduction of natural fire regimes. With some forethought, private landowners can achieve all of their land-use goals while simultaneously benefiting amphibians, reptiles, and other wildlife.

3. ***Find compatibility with other wildlife and land management goals.*** Incorporation of habitat management guidelines for amphibians and reptiles into current management plans can provide significant benefits to other native species of animals and plants. Both private and agency landowners can incorporate many of these habitat management guidelines easily and at little cost.

4. ***Collaborate with experts***. Landowners and managers may benefit from the insights of an experienced local or regional biologist who understands the ecology, natural history, and behavior of amphibians and reptiles. Ecologists and land managers who know the local ecosystems and habitats may also be valuable sources of information and insights.

5. ***Measure your success***. Management plans should be dynamic instruments. They allow you to visualize what the impacts of a project might be and how one can make beneficial changes. Periodic monitoring of amphibian and reptile populations and habitat quality will gauge whether or not your management actions have achieved the desired effect. If so, continue doing what you were doing. If not, adjust your management plan accordingly and try again.

Kurt Buhlmann

Kurt Buhlmann

Joe Mitchell

Joe Mitchell

Joe Mitchell

Ken Nemuras

Examples of amphibians and reptiles that occur in the northeastern United States: top L: Painted Turtle, top R: Blue-spotted Salamander, middle L Upland Chorus Frog, middle R: Eastern Milk Snake, lower L: Rough Green Snake, lower R: Marbled Salamander.

Purple Loosestrife was introduced into the United States and established in estuaries by the early 1800s; it is Eurasian in origin. It invades wetlands and changes the habitat by forming monotypic tangles that exclude native species. It is particularly detrimental in wet meadows and bogs where it shades out tussock sedges and skunk cabbage, thus changing habitat suitability for amphibians and reptiles, including rare Bog Turtles. An introduced beetle has been used with varying success to control loosestrife. Chuck Landrey

NASA

Widespread development and urbanization of the landscape is evident in this satellite view of the United States at night. Urban sprawl reduces habitat availability for amphibian and reptiles. The Northeast has obviously lost large amounts of habitat formerly used by wildlife.

The Northeast United States is a resource-rich region where a variety of land-uses are needed to sustain economic and social prosperity. Some of these land-uses are more challenging to herpetofaunal conservation than others. Although it is obvious that roads, development, and other challenges are facts of life in the Northeast, by recognizing the impacts of these land-uses on amphibians and reptiles, we hope to give land managers realistic options that can minimize adverse effects and maximize conservation potential.

Amphibians and reptiles in the Northeast are threatened by a host of factors, most of which are human-caused. Most species have experienced population extirpations and declines since European colonization nearly 400 years ago. This mini-review provides the backdrop for land owners and managers to understand why biologists, naturalists, and herpetologists are concerned about these animals.

In developing guidelines for the 14 habitat types covered in this book, several common challenges arose repeatedly. These are discussed in some detail here, and will be presented briefly in subsequent sections where appropriate.

- Habitat Alteration, Fragmentation, and Loss
- Impacts of Roads and Trails
- Exploitation
- Fire Suppression
- Use of Herbicides, Insecticides, and Fertilizers
- Invasive Exotic Species
- Subsidized Predators

HABITAT ALTERATION, FRAGMENTATION, AND LOSS

Habitat alteration changes the suitability of an area for herpetofauna. Amphibian and reptile species often respond differently to habitat alteration (i.e., abundance of some species may increase while others may decline). Species associated with habitats that take long periods of time to develop may be particularly sensitive to habitat alteration.

Habitat fragmentation results in the isolation of places where amphibians and reptiles live. Consequently, species may be forced to move across areas of unsuitable habitat to reach other patches of suitable habitat that are required to complete seasonal movements, e.g. overwintering habitat to breeding habitat. Immigration, necessary for genetic diversity, may be impeded.

When habitat is severely altered and fragmented, as with urban and suburban development, herpetofaunal populations may decline to the point of extirpation.

Virginia Division of Natural Heritage

Habitat fragmentation is a difficult concept to grasp from ground level. In this aerial photograph, the disarticulation of sinkhole ponds and forested habitat from each other as a result of land clearing is evident.

Naturalists, scientists, and land managers agree that ***local habitat alteration*** is a major cause of reptile and amphibian declines in the Northeast. Any land-use management activities such as agriculture, industrial complexes, urbanization, some forms of recreation (e.g., ski slopes, golf course construction), road building, stream channelization, filling and draining wetlands and the creation of impoundments can contribute to habitat loss and fragmentation. As a result, there are many opportunities to modify land management practices in order to improve compatibility with these animals.

The size of habitat patches suitable for species of interest, distances to other such patches containing populations, and barriers to dispersal in zones between patches all affect whether an amphibian or reptile population remains viable. Inbreeding and other genetic problems may occur in small populations. Amphibians and reptiles are more vulnerable to single catastrophic events such as extreme weather or disease outbreaks. Simply finding one another for mating and reproduction is a challenge without dispersal and migration corridors across expanses of inhospitable habitats. Small, isolated habitat patches seldom support viable populations in the long-term.

LANDSCAPE SCALE AND CONNECTIVITY

The **Landscape** is the geographic scale of the management area in question and includes all the interactive habitats in that area. This can be an entire watershed defined by natural boundaries or the area under management. **Landscape matrix** refers to the complex of different habitat types, including the altered or unsuitable land, between intact habitat fragments. Viewed from the animal's perspective, the matrix includes all the barriers and sources of mortality in the landscape through which they must move in order to reach essential habitats.

Think landscape scale and landscape matrix. Integrating a landscape perspective into your **Management Plan** will greatly enhance the long-term persistence of amphibians and reptiles. These animals use uplands and wetlands in complex ways and move extensively among them. They have specific seasonal activity patterns that are tied to their use of these two primary habitat types. Understanding the natural history of these animals, their seasonal movements between habitats, and the natural dynamics of the habitats themselves is crucial for management at the landscape level. For example, the traditional concept of "buffering" streams with narrow forested strips may contribute to maintaining water quality but may not meet the needs of associated amphibians and reptiles.

Most amphibians and reptiles need two or more habitats during their lifetimes. Habitat requirements change seasonally due to reproductive and foraging behavior, and may change annually as individuals shift areas that they use over time. Integrate the concepts of multiple habitat use, their juxtaposition to one another, and the types of corridors between them into

Phillip deMaynadier

A large clearcut in Maine creates a completely different environment from the original, and likely impacts species needing the structure, canopy, moisture, and humidity of a forest. Considering the needs and limitations of amphibians and reptiles on a landscape scale will help manage the needs of humans and biodiversity.

Joe Mitchell

Human habitat alterations, such as construction of interstate highways, divide landscapes into two or more fragments. Amphibians and reptiles and many other animals are therefore unable to move successfully between fragments, and long-term population persistence is jeopardized.

Kurt Buhlmann

Railroad tracks often act as barriers to movements of turtles. Box Turtles enter the tracks at road crossings and get trapped between the rails. They die from overheating or dehydration.

your vision of how to manage your land. Think about what amphibians and reptiles face on your land. Envision their world.

The core habitat, the "buffer zone" around a habitat fragment, and the gradient between the two are critical to the survival of reptile and amphibian populations. So think about the "matrix" on a "landscape

Mike Torocco

Logging activities can compact the soil and eliminate terrestrial salamanders. Logged forests may require long periods of time for populations of amphibians to return to original levels. Logging practices that allow population remnants to persist on the site are preferable to the expectation that populations will become reestablished from adjacent sites.

Kurt Weiskotten

Linking habitats at the landscape level with corridors for dispersal and immigration help animal populations maintain connectivity and gene flow.

scale," and consider all possible habitats when creating management plans. For example, how much upland habitat is needed for non-breeding activities by species that breed in wetlands, ponds, or streams? If a patch of land has insufficient habitats required by a target species, then consider cooperating with adjacent landowners with properties that contain the missing pieces.

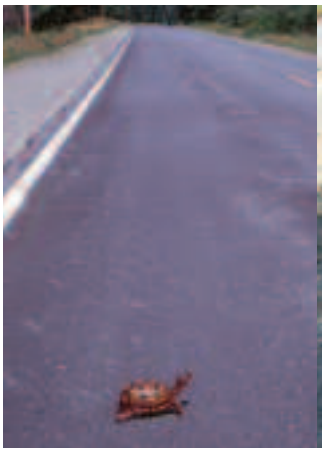
Think connectivity. What habitats would amphibians and reptiles have to move through when migrating from one area to another? Patches of suitable habitat will enhance survival during migration and are essential for the conservation of many species, and corridors of habitat linking these patches are probably important.

Think impacts. How do various human activities impact each habitat type on your land? Knowing how such activities may impact these habitats and what it takes to manage them in a natural state will provide valuable insights into how to manage your landscape. Such an approach, some of it intuitive, will help to ensure that amphibian and reptile populations on your land will remain healthy. A well thought out **Management Plan** with all these considerations will greatly enhance success.

IMPACTS OF ROADS AND TRAILS

Some ideas to consider …

- Roads contribute pollutants to adjacent streams and wetlands.
- Roads may provide corridors for invasive plant species.
- Consider the impacts of roads on a landscape or watershed level. "Managing the National Forest Transportation System," Misc. Rep. FS-643, explains the process. This is a U.S. Forest Service roads analysis handbook available in PDF from www.fs.fed.us. Using the concepts illustrated in the handbook can enable you to develop a transportation management plan that incorporates reptile and amphibian conservation measures.
- New permanent road construction should be minimized or avoided where possible.
- Road placement should take into account the locations of sensitive habitats and migration routes. Avoid these sensitive areas by rerouting road corridors.
- Planting native grasses, mulching, liming and fertilizing on closed trails and dirt roads can minimize soil erosion. Restricting access by gating or permanently closing nonessential roads can be very effective and is easily accomplished on some public and private lands.
- Seasonal road closures using gates can help protect species and habitats. Gates may be opened selectively to maintain traditional uses such as hunting and fishing.
- Reducing speed limits, installing speed bumps, and adding cautionary signage may encourage motorists to avoid hitting migrating amphibians and reptiles, especially where migration routes have been identified.
- A combination of fencing, overpasses, and under-



Phillip deMaynadier

Joe Mitchell

Many Eastern Box Turtles are killed on roads by vehicles every year. Driver's apparent inability to see them and the turtles' relatively slow rate of movement hinder their ability to cross safely.

Curbing in many suburban areas is often too tall to allow small amphibians and reptiles to get off of the pavement. In addition, water drainage gates trap animals inside and do not allow for their escape.

Mike Marchand

Many roads in the Northeast have high volumes of traffic. Such roads effectively prevent the movement of animals on the landscape. Populations become isolated which does not bode well for species health in the long-term.

USGS Patuxent Wildlife Research Center, Northeast ARMI team

Mortality of Spotted Salamanders is usually high during spring migrations when roads separate their upland forested retreats from vernal pool breeding sites.

Joe Mitchell

This large Snapping Turtle was killed as it was trying to walk to a nearby pond in Virginia. The unique defensive body armor that has protected turtles for millions of years is no match against automobiles.

Kurt Buhlmann

Spotted Turtles are colorful and interesting animals that have awakened an interest in natural history and ecology in many biologists and naturalists. Unfortunately, that interest has often fueled commercial collection leading to declines in wild populations.

passes can be used in some cases to funnel wildlife safely from one side of a roadway to the other.

- The number and width of roads that amphibians and reptiles must cross in the landscape under management should be minimized.

- Consider installation of ecopassages in areas of high mortality.

- Use no curb or sloping "Cape Cod style curbing" where possible and especially along known migration routes and movement corridors.

EXPLOITATION

Exploitation is the removal of individual amphibians and reptiles from their native habitats for commercial, recreational, or aesthetic benefit to individual humans.

Commercial trade in live amphibians and reptiles and their skins is a multimillion-dollar business. Although most states in the Northeast have laws regulating commercial take of these animals, many are illegally removed from their natural populations. Laws protecting amphibians and reptiles vary from state to state and enforcement is often lax where adequate laws exist. Eastern Box Turtles, Wood Turtles, some snakes, and some frogs and salamanders are still being collected and sold legally or illegally. The demand for turtle meat in Asian food markets and dwindling turtle populations in Asia is causing increased collection of freshwater turtles in the Northeast and elsewhere in the United States to supply these markets. Snakes and other herpetofauna are killed as a result of fear, hatred, and ignorance. People still remove animals, especially turtles, from state and national parks and recreation areas.

The Challenges

- People still kill snakes and other amphibians and reptiles due to fear, hatred, and ignorance. (Ophidiphobia: an excessive and irrational fear of snakes).

- Removal of adults from populations will likely cause population declines. Amphibians and reptiles cannot withstand harvest like short-lived deer or turkey.

Laws

- Laws protecting amphibians and reptiles vary from state to state. Check with your local state and federal wildlife conservation agencies. (see Appendix C)

- Where adequate laws exist, enforcement may be inadequate due to lack of identification expertise on the part of some enforcement officers and because courts often do not place high priority on herp-related legal cases.

Awareness

- Hunters, fishermen, hikers, loggers, farmers, and others who interact regularly with the outdoors are seldom provided with amphibian- and reptile-related educational materials.

What Can Land Managers Do?

- Incorporate protective measures, such as limiting access, to prevent recreational visitors and commercial collectors from harming amphibians and reptiles and their habitats.
- Educate recreational visitors about the problems with taking amphibians and reptiles, and altering or damaging habitats.
- Provide recreational visitors with herpetofauna-specific educational opportunities and materials.
- Encourage enforcement agencies to patrol your land for possible violators of state and federal laws and local ordinances.

COMMERCIAL TRADE IN AMPHIBIAN AND REPTILES

An often hidden and rarely discussed commercial industry exists in the northeastern United States in wild-caught reptiles and amphibians. This includes collecting animals for the pet trade, for human consumption, and for body parts and skins. Collecting, both legal and illegal, at the market level can have tremendous negative effects on local and regional populations of targeted species. The life histories of many of these species (e.g., delayed sexual maturity, low fecundity), particularly in reptiles, cannot sustain long-term and continual removal of breeding-age adults without resultant population declines. Snapping Turtles and Diamond-backed Terrapins are two prime examples of species legally harvested for food in some northeastern states. However, population monitoring is often lacking to determine if this is sustainable, though some states have recently banned commercial harvest due to these concerns. Snakes, particularly venomous species, are also collected for food and skins (e.g., novelty belts), not to mention persecution in the form of rattlesnake roundups that still occur in Pennsylvania. Certain frog species are collected for food and increasingly the pet trade, as are lizards and salamanders.

As land owners and managers, whether public or private, you may be approached by citizens for permission to collect or trap reptiles and amphibians on lands under your care. These collectors may be local children or their parents interested in a few animals as educational pets for the home; they may be university researchers; or they may be professional commercial collectors interested in harvesting large numbers of animals for the food or pet trade. There is great educational value of allowing the removal of a few animals for use as pets where collecting is legal. Of equal or greater educational value is legitimate herpetological research by students and faculty. Collecting of relatively few animals for these purposes generally does not pose a threat to their populations, particularly when the more common species are involved. Conversely, if you are approached by anyone asking for permission to collect on your property, it would be wise to require background information on them and determine their motivations. If they are commercial collectors, they will likely want to take large numbers of animals for the food and or pet trade. Check your state's laws and regulations before giving anyone permission. Be sure they have a permit, as most require them. Also, be on the lookout for illegal collecting on your lands. This can be evidenced by use of various animal capture techniques, such as aquatic hoop traps, fyke nets, and baited funnel traps for turtles; cover boards (large pieces of plywood or tin) and passive funnel traps for snakes, lizards and salamanders; and seines for frogs and turtles. Be aware that the presence of seemingly innocuous "garbage" on your lands, such as boards and tin, may actually be the work of unscrupulous collectors, who regularly "flip" this debris looking for animals to capture and sell. Legitimate citizens will always ask for permission. Contact your local natural resource police or game wardens if you think illegal activities are occurring on your lands. You are the best and often last line of defense these creatures have.

— Scott Smith, MD DNR

Kurt Buhlmann

Distributing cover objects, such as wood boards and tin sheets, can benefit local snake populations by providing shelter and sources of prey. However, they also provide an easy window for unscrupulous collectors. Therefore, land managers should conceal the locations of these micro-habitat improvements.

FIRE SUPPRESSION

Prescribed fire is a tool used by land managers to alter forest or grassland habitats in such a way as to restore or maintain desired forest stand structure, remove undesirable or introduced vegetation, stimulate natural growth of the native understory plants, and to maintain a natural ecosystem.

Fire was a natural part of some Northeastern forests long before European settlement and fire suppression policies. Depending on regional drought cycles, lightning-sparked fires would burn for weeks or months. When American Indians set fires to clear undergrowth and stimulate herbaceous growth, rivers, large streams, and some wetlands served as natural firebreaks. As a result, many reptiles and amphibians, their habitats, and their prey are tolerant of or even dependent on fire and its effects on habitats. For example, amphibians and reptiles in parts of the Cumberland and Southern Ridge and Valley, Southern Blue Ridge, Piedmont, Central Appalachian Forest, High Allegheny Plateau, and Lower New England/ Northern Piedmont ecoregions are adapted to open woodlands interspersed with grasslands and balds.

Modern habitat management uses prescribed or controlled fires to eliminate undesirable plants and to help stimulate growth of desirable plant species. Such fires also reduce fuel supplies for unplanned wildfires that can cause extensive property damage and loss of life.

Most of our terrestrial ecosystems have burned occasionally throughout history. Some habitats, like the New Jersey Pine Barrens and the Albany Pine Bush, require fire for forest health. Even wetlands and swamps burn during times of extreme drought. The "ideal" frequency, intensity, and seasonality of prescribed fire is highly variable depending on climate, slope, aspect, elevation, soil characteristics, and the moisture retention capacity of native vegetation.

"Restore natural fire regimes" frequently appears in the following management sections. Determining natural historic fire frequencies can be a challenge, and requires input from fire ecologists in your area. Although long recognized as part of pine forest ecology, fire also plays a role in the maintenance of certain hardwood-dominated habitats. Wildlife of much of the Ridge and Valley, Piedmont, and Coastal Plain ecoregions were adapted to more open woodland and savanna conditions than exist today. Recent fire suppression has contributed to the declines, rarity, and extirpation of many species, such as Northern Pine Snakes, even on publicly managed forestlands. Modern habitat management uses prescribed or controlled fires to eliminate undesirable plants, help stimulate growth of desirable plant species, and enhance wildlife habitat.

In Shenandoah National Park, a prescribed burn was effective in reducing invasive species like oriental bittersweet, Japanese honeysuckle, and tree of heaven. Although the fire did reduce fuel loading, these invasives returned even after two prescribed burns. Fewer Red-backed Salamanders were found in this area after the burns than before the burns.

— Robin Jung-Brown

Late winter prescribed burns have been used in a Putnam County, New York wetland to remove dead standing stems of purple loosestrife and phragmites to subsequently increase basking and nesting opportunities for turtles. When used alone, fire must be repeated every 2 to 5 years. It would be more effective if used in conjunction with livestock grazing or herbicides.

— Al Breisch

What Can Land Managers Do?

- Determine the natural historic fire frequency in your region by consulting fire ecologists or forest managers in your area.
- Determine if prescribed fire is possible on your land given state and local fire ordinances.
- Work with forest and wildlife biologists and qualified fire ecologists to determine when fires would cause the least mortality on local wildlife, including amphibians and reptiles.

CAUTION! Excessive or poorly planned fire can do more harm than good. Even where burning is used, there is often a dependence on dormant-season fire over growing-season fire. Before you strike a match, consult a qualified prescribed fire specialist. Your local state forestry agency or a local NRCS, USFS, or Nature Conservancy office can provide information on when, where, and how to burn, as well as when, where, and how NOT to burn. Some state forestry agencies will not only build fire lines on your property for an extremely reasonable fee, but may actually conduct the burn for you. This may be conducted in a NRCS or USFWS or other cost-share program (See Appendix B).

USE OF HERBICIDES, INSECTICIDES, AND FERTILIZERS

Chemicals such as herbicides, insecticides, and fertilizers are useful for achieving many habitat management objectives. For example, herbicides can be used to control invasive species, create snags, and diminish oak encroachment in pine habitats. Herbicides can be especially effective for meeting some objectives (e.g., diminishing oak encroachment) when combined with prescribed fire. All chemicals should be used cautiously and in consultation with trained experts.

Mike Marchand

Chemicals are introduced into ponds and streams when people carelessly dump household and industrial waste. Some forms of water pollution cause death and deformities in amphibian larvae.

Although fire is the preferred vegetation management tool where amphibians and reptiles may be concerned, burning may not be permitted or feasible under some circumstances. Use of herbicides may thus be warranted in some cases. Controlling oak encroachment, for example, may require a combination of fire and herbicides.

When chemicals are used:

- FOLLOW INSTRUCTIONS ON THE CONTAINER LABELS.
- Consult a trained forester, extension agent, or licensed pesticide applicator for determining the correct chemical and application rate for your situation.
- When used improperly, chemicals may be directly toxic to amphibians and reptiles (aquatic species in particular), and may alter habitats and food supplies in unintended ways.
- Insecticides may reduce the abundance of valuable invertebrate prey species eaten by amphibians and reptiles, as well as birds, bats, and other wildlife. Healthy populations of these insectivores may reduce the need for insecticides.
- Herbicides should be used selectively in order to retain as much wildlife food as possible while still eliminating unwanted plants.
- Fertilizers may cause excessive algal blooms and alter dissolved oxygen and carbon dioxide levels if improperly applied near aquatic systems. Carefully adhere to regional and state Best Management Practices (BMPs) to minimize this possibility.
- Know the biological effects of the herbicides and pesticides used on your land.
- When feasible, give preference to native plants that require minimal chemicals. Seek ways to implement bio-control measures and use non-chemical methods to manage undesirable growth after management activities.
- In summary, be careful with chemicals.

INVASIVE EXOTIC SPECIES

Joe Mitchell

Phragmites is a non-native, invasive plant that destroys natural wetland habitat structure. Originally an invader of brackish marshes, it has expanded its range into freshwater systems. Clonal stems of this plant can reach densities of 200 per square meter. Amphibians and reptiles are unable to live in places choked with this difficult-to-remove plant.

Introduced (non-native, exotic) species, once they become established, typically have no predators or other organisms that limit their numbers. Thus, their populations reach dramatically high numbers that overwhelm native populations and species and may compete with them for resources. The most successful (and threatening) exotics are highly adaptable, rapidly-reproducing habitat generalists that can quickly

overwhelm, displace, and even extirpate native species and communities, and hence are known as "invasive" species. Purple loosestrife, a plant introduced from Europe, has choked wetlands and reduced habitat for reptiles such as the endangered Bog Turtle. The chestnut blight that wiped out an entire dominant hardwood tree (the American Chestnut) in the Appalachians almost certainly affected woodland salamanders by the elimination of a prime source of woody debris and hibernacula in stump holes. Domestic free-ranging and feral cats, first introduced in the 1600s, kill many thousands if not millions of amphibians and reptiles annually. Feral hogs are destroying many coastal habitats. Coyotes are rapidly becoming serious predators of amphibians and reptiles in the Northeast.

DON'T TURN IT LOOSE!

For PARC's policy on release of captive herps (often from unknown places of origin), including those used as teaching aids, refer to the ***Don't Turn it Loose*** brochure available online through the PARC website (www.parcplace.org). This publication contains information on how to properly dispose of unwanted classroom or laboratory specimens. This is a useful resource for land managers who may be unaware of the problems with "releasing animals into the ecosystem."

What Can Land Managers Do?

- Use native browse for wildlife food plots.
- Use native plants (grasses, flowers, shrubs, trees, etc.) for commercial and residential landscaping and erosion control.
- Find alternatives to the introduction of non-native wildlife species on game ranches.
- Avoid establishment of plant species beyond their native range.
- Spay or neuter cats and dogs, and keep them indoors. *Uncontrolled pets kill amphibians, reptiles, songbirds and other wildlife.*
- Learn to identify the most common and aggressive introduced plants in your area.
- Where invasive exotic plant species are already established, consult a qualified invasive species specialist (i.e., your state forestry agency or local NRCS or USFS office) for the safest, most effective means of eradication or control.

Kurt Buhlmann

Conflicting natural resource management objectives often arise. A seasonal sinkhole pond and its emergent vegetation was "drowned" when a nearby stream was dammed and the landscape flooded by beaver. Removal of the beaver and introduced fish may allow for restoration of the sinkhole pond and its ecology, including Spotted Turtles and Tiger Salamanders. (2004)

Kurt Buhlmann

The same sinkhole pond as it originally appeared before being "drowned" by beaver. (1988)

SUBSIDIZED PREDATORS

Subsidized predators are native species whose populations have increased in parts of their range due to resources provided directly or indirectly by humans. Their population sizes are likely higher than they would be in natural conditions without human subsidies and reduced natural predators.

Subsidized predators include raccoons, opossum, foxes, crows, ravens, skunks, and now coyotes. These animals, especially the raccoon, are well-known predators of adult turtles, hatchlings, and their eggs in nests. Studies have documented 100% mortality of eggs in all nests in some Painted Turtle populations by raccoons. Crows and foxes eat eggs as they are deposited into nest holes by female turtles. Such predators also kill and eat frogs, small snakes, and lizards. Populations of subsidized predators are usually uncontrolled in urban areas and flourish in state and

Mike Marchand

Raccoons have adapted all too well to humans and are often subsidized by our garbage. With large predators, namely wolves and cougars, no longer present to control their numbers and a decline in the fur trade, raccoons exert heavy predation pressure on amphibian and reptile populations, most notably the destruction of turtle nests.

USGS Patuxent Wildlife Research Center, Northeast ARMI team

An adult male Spotted Salamander that was likely killed and partially eaten by a raccoon in a vernal pool in Maryland.

Chuck Landrey

A turtle nest that was destroyed by a raccoon. In many areas, turtle populations are likely unable to produce enough offspring to maintain stable populations because of nest predation.

Chuck Landrey

Finding Eastern Box Turtles emerging from their nests is highly unusual and almost never seen under natural conditions. Hatchlings and juveniles are vulnerable to native and subsidized predators. Their survival is crucial to population persistence.

national parks. In many parts of the Northeast, furbearing predators such as opossum, raccoon, and fox are at higher numbers due to the decline of trapping in recent decades.

What Can Land Managers Do?

- Reduce the availability of food sources associated with humans.
- Consider removing subsidized predators by humane means.
- Control subsidized predator populations by reducing the subsidies (refuges, food sources), controlling their reproductive output, or by removal of individuals by humane means.
- Recognize that subsidized predators occur at unnaturally high population levels in most areas. Thus, evaluations of their behavior, effects, population sizes, and sources of subsidy could help identify ways to curb their impact on native amphibians and reptiles.
- Discourage direct or indirect feeding of subsidized wildlife.

Sarah Schute

THE BASICS: MANAGEMENT GUIDELINES FOR ALL HABITAT TYPES

The guidelines in this section are pertinent to amphibian and reptile conservation in all or most habitat types.

MAXIMIZING COMPATIBILITY: Timberlands, Hunt Clubs, Farmlands, Recreation Lands, and other Integrated Land-uses
When benefiting amphibians and reptiles is secondary to other management objectives:

- **Fence livestock out of rivers, streams, wetlands, and other water bodies. Consider alternative watering sources or concentrate livestock watering and shading needs in a small area, leaving the majority of habitat intact.** *Livestock can graze and trample native plants, depriving amphibians, reptiles and their prey of vital habitat. Hoof prints can disturb and compact soil, increasing erosion and sediment. Excessive concentrations of nutrients (manure) in aquatic systems may cause unnatural algal blooms, altering dissolved oxygen and CO_2 levels, possibly harming aquatic amphibians, reptiles, fish, and invertebrates.*

- **Restore natural fire frequency, intensity, and seasonality to the extent possible. Where possible, favor fire as a vegetation management tool, especially in drier upland ecosystems.** *The vegetation in which many reptile and, amphibians forage, nest, and shelter is often fire-dependent or fire-adapted. Without fire, canopies tend to close and shade out herbaceous groundcover, which is often the critical first link in many food webs.*

- **Where herbicides, pesticides, or fertilizers are used**:
  - *Use the minimum amount required to achieve management objectives.*
  - *Follow label instructions carefully and precisely.*
  - *Use only chemicals approved for the habitats to be treated.*
  - *Make sure that sensitive habitats, especially aquatic systems, are adequately buffered to minimize impacts of chemicals beyond the targeted area.*
  - *Give preference to individual stem treatment or*

Kurt Buhlmann, both pictures

Open areas, such as old abandoned borrow pits, are often used as nesting areas by freshwater turtles. Maintaining suitable conditions may be as simple as cutting back invading vegetation, such as the white pine trees that are colonizing the slope in this photograph.

Besides being unsightly, piles of trash likely leak contaminants such as household cleaners, oils, and paints into habitats used by amphibian and reptiles.

spot application. Banded herbicide application, rather than broadcasting, can be used when appropriate, to reduce the amount of herbicide used and the area treated.

- **Identify and protect embedded, adjacent, and sensitive habitat features such as seasonal wetlands, seeps, coves, and rock outcroppings. For example, leave forested buffers around amphibian breeding sites.** *These habitats are often critical to these sensitive species, particularly salamanders. Many forest-related species require these habitats for part of their life history and seasonal migration patterns. Both the embedded habitat and the surrounding matrix must be present for them to survive. Consult a qualified ecologist or herpetologist to help identify special habitat features and determine which management practices will best benefit your local amphibians and reptiles.*

- **Minimize soil disturbance (e.g., tire ruts, soil compaction) when using heavy equipment. Use low-pressure tires and limit equipment use to drier seasons or when ground is frozen.** *Heavy equipment can disturb and compact soil, increase erosion and sediment, disrupt vegetative succession, and provide distribution corridors for invasive exotic plants. Although some amphibian species may be able to breed successfully in tire ruts on low-traffic roads, the detrimental effects of excessive soil compaction and disturbances may outweigh the benefits.*

- **Minimize or exclude agricultural, residential and industrial waste near aquatic habitats**. *Pollution can introduce toxins that adversely affect aquatic plants and animals, and may contribute to poor water quality or groundwater contamination.*

- **Meet or exceed state recommended Best Management Practices (BMPs) including recommendations for and Streamside Management Zones (SMZs). Where appropriate, consider establishing wide SMZs.** *In some cases, SMZs are adequate to protect aquatic-related amphibians and reptiles; however, in other cases, these practices may need to be modified, especially for species that migrate or disperse in and out of adjacent upland habitats. For links to each state's BMPs, visit www.forestrybmp.net.*

- **Allow dead trees and woody debris to decompose naturally. After timber harvests, leave stumps, blowovers, logs, dead standing snags, and other woody debris.** *Many amphibians and reptiles nest, forage, or seek shelter inside or underneath rotten logs. Wind blown trees and stump holes are critical hibernation habitats for some pine-adapted amphibians and reptiles (New Jersey and southeastern Virginia). Dead standing snags provide important habitat for some snake and lizard species.*

- **During timber stand establishment, plan for a future prescribed fire program.** *Planted or disked firebreaks are less disruptive than freshly plowed lines.*

- **Formulate forest regeneration plans before har-**

USGS Patuxent Wildlife Research Center, Northeast ARMI team

Although generally beyond the ability of local landowners and land managers to influence effectively, air quality poses a threat to forest ecosystems with a trickle-down effect to the inhabitants, including amphibians and reptiles.

USGS Patuxent Wildlife Research Center, Northeast ARMI team

Timber harvesting can be done destructively or sensitively with forethought. Careful selection of techniques that minimize compaction of the soil and loss of non-target trees in the forest will help ensure that herp populations persist after the disturbance.

vesting activities start. *Diverse vegetation means diverse wildlife. Consult your state forestry agency or a forest ecologist to determine the most appropriate composition of next-generation stands and how to best manage for regeneration.*

- **Maintain a diversity of forest age classes, densities, and structures either within the same stand or among adjacent stands. Consider thinning, burning, and extended rotations to optimize the time herbaceous and shrub layer vegetation is available; consider a mosaic of smaller, adjacent patches of varying management regimes.** *Large expanses of even-aged, closed canopy stands where herbaceous and shrub layer abundance and diversity are suppressed, may not sustain many amphibian and reptile populations.*

- **When possible, forested blocks should be planned to help maintain connectivity. Place roads and fields carefully to avoid fragmenting forests. When establishing wildlife food plots, stay within the footprint of previous disturbances to avoid additional impacts.** *Stands that are separated from other forested stands by unfavorable habitat may limit the movement of amphibians and reptiles between stands. In some cases, corridors may be an appropriate way to maintain connectivity for dispersal and migration of reptiles and amphibians between larger forest stands.*

- **Follow natural contours when designing and conducting timber sales.** *Soil erosion can be minimized when disturbances such as skidder trails run parallel to slopes. Minimize stream crossings.*
- **Leave large cull trees or patches of trees on harvested sites whenever practical**. *In addition to providing mast for regeneration, these patches may also sustain pockets of shade-dependent species until the surrounding harvest area achieves later successional stages.*

- **When timber is harvested, consider harvesting techniques such as group selection, single-tree selection, or small clearcuts.** *Where shade-dependent species or mature forest obligates are a concern, consider leaving patches of large trees. Forested habitat that can serve as refugia for forest-dwelling animals from which they can more easily disperse and repopulate harvested areas as they mature. Where early successional obligate species are a concern, large clearcuts may be preferred. Where both late- and early successional-related species are present, consider a patchwork of medium-sized clearcuts and similar-sized older forest stands.*

Mike Torocco

The use of ATVs in wetlands damages the vegetation and may potentially kill rare animals, such as Bog Turtles. Landowners and managers can help protect these habitats by preventing ATV access.

- **Minimize construction of new roads and ATV trails where possible. Gate existing roads when not in use. Keep sensitive habitats, especially wetlands and stream channels, free of vehicle traffic, including ATVs. Where hunting and fishing access is an issue, encourage vehicle operators to limit their traffic to the minimum necessary and follow marked trails. Elsewhere, limit off-road traffic to official business and discourage "recreational" (for example, racing, stunt driving, "mud-digging") off-road traffic.** *Excessive motorized vehicle traffic can compact and disturb soil, increase erosion and sediment, provide corridors for invasive plant species along trails, elevate vehicle-related mortality rates of amphibians and reptiles, and disrupt animal activities. ATVs can severely degrade seasonal wetlands.*

Chuck Landrey

Closing roads for short periods of time to allow amphibians and turtles to access breeding or nesting sites can be a valuable management strategy to minimize mass road mortality. The sign above provides information to motorists about Spotted Salamanders.

- **Use seasonal road closures to provide balance between species and habitat protection and maintaining traditional uses such as hunting and fishing.** *Seasonal road closures can reduce vehicle-related mortality by limiting traffic during time periods when herps are moving across the landscape (e.g., breeding dispersal, turtle nesting).*

Margaret Liszka

Turtles make seasonal movements to access open and sunny nesting areas or to find other sources of water during dry periods. Road-kills are high where roads bisect frequently used movement corridors. Alerting motorists that a turtle may be crossing the road in front of them may reduce turtle mortality.

- **In areas managed for recreation, locate regularly used roads, trails, landings, and recreational facilities away from sensitive habitats, migration corridors, and transitional zones between adjacent habitats. Limit recreational access to as few points as is feasible.** *Vehicle-related mortality, illegal collecting (e.g., turtles) and killing (e.g., Hellbenders, snakes), and noise-related disruptions of natural behaviors are unfortunate side effects of recreational access.*

- **Provide conservation-related educational materials to boaters, fishermen, hunters, loggers, hikers, campers, farmers, and other people who regularly interact with the outdoors. Discourage field personnel and recreational visitors from shooting turtles, or killing snakes.** *An informed public benefits everyone. People are often unaware of conservation issues related to amphibians and reptiles.*

IDEAL: Refuges, Sanctuaries, and Preserves
When benefiting amphibians and reptiles is a PRIMARY objective, as with nature preserves, wildlife refuges, and private lands whose owners wish to optimize herpetofaunal diversity and abundance:

- **Maintain or restore native vegetative structure and composition. Remove or contain the spread of invasive plant species.** *Many reptiles and amphibians are specifically adapted to forage, bask, hibernate, and nest exclusively in native vegetative communities.*

- **Avoid residential, commercial or agricultural development in areas where natural forests**

FOREST PRODUCTS COMPANY INITIATIVES

International Paper's professional foresters and wildlife biologists manage company forests with great care in accordance with the Sustainable Forestry Initiative® program. IP was a leader in the development of the SFI program, which ensures the perpetual planting, growing and harvesting of trees while protecting wildlife, biodiversity, plants, soil, water and air quality. In the U.S. alone, IP has protected more than 1.5 million acres of unique and environmentally important habitat through conservation agreements and land sales to environmental groups. Our forestry team is dedicated to managing trees, protecting biodiversity and growing more and more forests. Under our Special Places in the Forest program, International Paper has voluntarily managed and provided protection for nearly 750 sites (totaling more than 114,000 acres) that have unique biological, ecological, geological, cultural or historic significance. International Paper protects eagles and other threatened or endangered animal and plant species on its forestlands in cooperation with conservation groups, state agencies and the U.S. Fish & Wildlife Service.

In fact, in terms of herpetofauna, International Paper was the first in the paper and forest products industry to develop a Habitat Conservation Plan (HCP) for the Red Hills Salamander (*Phaeognathus hubrichti*), a federally threatened species endemic to Alabama. International Paper protects approximately 20% of the remaining *P. hubrichti* habitat in Alabama. IP was a founding entity of PARC and continues to be a strong supporter.

— Mark Danaher, International Paper Company

occur and maintain native groundcover vegetation. *Seek out those areas that have been severely disturbed for such landscape changes while protecting relatively intact natural habitats.*

- **Identify, restore and maintain natural fire frequency, intensity, and seasonality in fire-dependent habitats.** *Many reptiles and amphibians rely on native fire-dependent vegetation, in which they forage, nest, and shelter. Without fire, canopies in some forests tend to close and shade out herbaceous groundcover, which is often the critical first link in the food chain. Composition of dominant canopy trees may also be altered by fire suppression, limiting mast diversity and disrupting predator-prey cycles. Even wetlands burn during times of extreme drought. In some cases, fire will naturally skip or "spot" through areas where conditions are too moist. Too much fire can be as harmful as too little fire. Consult your state forestry agency before implementing any burn.*

- **Direct recreational use (for example, foot traffic, trails, boat landings) away from sensitive habitat features such as hibernacula, wetlands, turtle nesting sites, seeps, ravines, and coves.** *Soil disturbances and noise-related disruptions of natural behaviors are among the unfortunate side effects of recreational access, as is facilitating access to illegal collectors..*

- **Install culverts or tunnels in conjunction with barriers to direct animals under or away from roads.** *Barriers and ecopassages have been successful in certain instances to mitigate highway mortality near breeding sites or along seasonal migration corridors (see Roads section).*

Kurt Buhlmann

Roadside ditches often attract amphibians and reptiles. Creating passageways under roads may reduce mortalities. Planning such passageways should be done as new roads are designed, thereby reducing costs.

- **Maintain or restore natural hydrological cycles of wetlands by filling old drainage ditches and allow for the natural development of stream bank dynamics and associated vegetation.** *Natural flood cycles are critical in maintaining the natural communities in which amphibians and reptiles forage, breed, and bask.*

- **Limit motorized vehicle (including All Terrain Vehicles [ATVs] and motorboats) access to official conservation-related traffic.** *Excessive motorized vehicle traffic can compact and disturb soil, increase erosion and sediment, provide corridors for invasive plant species along trails, elevate vehicle-related mortality rates, and cause noise-related disruptions of faunal activities. ATVs can severely degrade seasonal wetlands.*

Cindy Cragland

Restoring a vernal pool wetland to its original hydroperiod, and using native vegetation will probably be the most effective way to benefit local amphibian species.

Joe Mitchell

As unsuitable as it may seem, puddles and ruts along seldom-used roads often provide breeding areas for amphibians whose larvae can metamorphose in short periods of time. American Toads, Spadefoot Toads, and even Spotted Salamanders use road ruts successfully. Land managers can protect these sites by limiting unnecessary vehicle access.

Rolf Kamp

If off-road vehicle driving is to be permitted, careful planning can minimize the impacts to sensitive wetland habitats that are used by amphibians and reptiles.

- **Avoid introduction of game and non-game fish where fish-free wetlands, ponds, or waterholes are present. Restricting vehicular public access may discourage unauthorized fish stocking. Remove introduced fish where necessary.** *Fish feed on amphibians, their eggs, and tadpoles.*

- **Maintain contiguous habitat gradients (unfragmented transition zones between adjacent habitat types).** *Ensure that land-use practices do not render seasonal migration and natural dispersal patterns between complementary habitats difficult or impossible.*

- **Ensure the availability of essential complementary habitat types.** *Most amphibian and reptile*

NEW YORK STATE'S FIRST AMPHIBIAN TUNNEL

Al Breisch

In October 1999, Albany County incorporated a tunnel-barrier fence system into a roadway reconstruction project in an area previously demonstrating high amphibian diversity and abundance, as well as high road mortality associated with movements between hibernating, breeding, and foraging sites. The project, the first of its kind to be implemented in New York, was designed to limit movements by amphibians and other non-target species onto the road surface while directing movements toward one of two tunnels under the highway. The system design included two concrete box culverts with a bottom surface of native soil traversing the full width of a two-lane county highway. The 0.5 m x 1.2 m tunnel openings were connected with 90± m of permanent, pressure-treated lumber barrier fencing on each side of the roadway. Post-construction monitoring of the project area showed that most amphibian movements had been successfully directed along the barrier fence, while movements onto or over the road surface were nearly eliminated. In an adjacent control area, approximately 40% of over 600 individuals observed were road-kills. Only 2% of almost 300 individuals observed in the tunnel area were road-kills. Monitoring also revealed nine amphibian species and three non-target species using the tunnels.

— Alvin R. Breisch and Mark Fitzsimmons

Ken Nemuras

Amphibian larvae are very sensitive to water quality. Pollutants and sediments may render isolated wetlands inhospitable.

USGS Patuxent Wildlife Research Center, Northeast ARMI team

Appropriate use of silt fencing may help protect stream systems from sedimentation during construction activities

species require two or more habitats for their life history and annual activity patterns. Reducing the suitability of any one of these habitats for sensitive amphibians or reptiles, even if the others are in ideal condition, may lead to declines and even local extirpation.

- **Use the minimum amounts of fertilizers, herbicides, and pesticides necessary to achieve management objectives.** *When chemical application is needed (for example, to remove invasive plants or competing vegetation), use selectively and follow instructions very carefully.*

- **Remove old cars, tires, electrical appliances, and other items that may leak contaminants into wetlands and streams**.

- **Close unneeded roads and avoid construction of permanent roads wherever feasible.** *Where high-traffic roads are present, installation of culverts, tunnels, and "drift fence" barriers (to direct animal traffic through safe passageways) has been successful in certain instances to mitigate highway mortality near breeding sites or along seasonal migration corridors (see Roads section).*

MANAGEMENT GUIDELINES BY HABITAT TYPE

The following 14 habitat modules contain management recommendations pertinent to their respective habitat. These modules are accessible individually on ww.parcplace.org.

1 **Biologists discuss strategies with land managers for re-vegetating riparian areas that will provide better stream habitat for Wood Turtles.** Kurt Buhlmann

2 **Unusual things happen to amphibians and reptiles during the developmental process like they do in other vertebrates, including humans. This Eastern Fence Lizard has both scoliosis (curved backbone) and kyphosis (humped backbone).** Joe Mitchell

3 **Eastern Gray Treefrogs call and breed in summer in the Northeast. Shallow pools of water are required for deposition of several clusters of eggs on the water's surface.** USGS Patuxent Wildlife Research Center, Northeast ARMI team

4 **Look for opportunities for restoration. Many seasonal wetlands have been drained or their natural hydroperiods altered as a result of ditching. Restoration to original condition may be as simple as re-filling the old ditch. Blocking the ditch may also be effective. In some cases, the clay lens of the wetlands may have been damaged during ditch construction, and water may still drain out the bottom.** Kurt Buhlmann

USGS Patuxent Wildlife Research Center, Northeast ARMI team

SEASONAL ISOLATED WETLANDS

Seasonal wetlands include isolated depressions in the landscape (sinkhole ponds, vernal pools, low swales, road ruts and ditches) that hold water in winter and spring but usually dry by mid-summer or fall. There are no permanent surface connections to flowing water and fish are usually absent. Vernal pools in riparian floodplains may contain fish periodically. Seasonal wetlands are critical breeding habitats for reptiles and amphibians, especially those vulnerable to fish predation. Water sources include rainfall, snowmelt, elevated water tables, or flooding in riparian pools. Vegetation in these wetlands depends on soil type, hydroperiod, latitude, elevation, and historic land-use. Seasonal wetlands in areas with no or sparse forest canopies support herbaceous plants, including grasses, shrubs, sedges, and rushes. Those under tree canopy have little emergent non-woody vegetation.

Species assemblages of amphibians and reptiles in the Northeast often vary from one pond to the next due to differences in vegetation, latitude, elevation, adjacent habitat type, canopy cover, and past land-

Woodland vernal pools are important breeding sites for Spotted Salamanders, Wood Frogs, and other amphibians. The woody debris and emergent grasses provide attachment sites for egg masses.
USGS Patuxent Wildlife Research Center, Northeast ARMI team

use. Most seasonal wetland-breeding amphibians spend their entire lives within a few hundred meters of the wetland-used for breeding. Frogs generally disperse over longer distances (well over a kilometer) than salamanders (to over 1000 meters) but both require appropriate habitat (usually closed canopy forest in the Northeast) adjacent to their breeding pools.

The surrounding upland forest supports vernal pool amphibians for about 11 months of the year. The time spent in the pool is short. Such terrestrial habitat around pools may be better viewed as a "life zone" and not a "buffer zone." Areas of loose soil, deep litter, logs, and patches of canopy shade are important for maintenance of a suitable forest floor.

Re-colonization of new or restored wetlands takes longer for salamanders than for frogs. Once a population has been destroyed, it may take decades for full re-colonization of the original assemblage. This time frame assumes that source populations are present and near enough to provide immigrants. Forested habitats between wetlands allow dispersal and help populations reduce the risk of complete isolation, loss of genetic diversity, extinction from drought and exposure to pathogens, or catastrophic event.

CHARACTERISTIC SPECIES
Four-toed Salamander, Jefferson Salamander, Blue-spotted Salamander, Marbled Salamander, Spotted Salamander, Red-spotted Newt, American Toad, Fowler's Toad, Upland Chorus Frog, Eastern Gray Treefrog, Spadefoot Toad, Wood Frog, Spring Peeper, Blanding's Turtle, Spotted Turtle, Northern Water Snake

MANAGEMENT GUIDELINES

MAXIMIZING COMPATIBILITY: Timberlands, Hunt Clubs, Farmlands, Recreation Lands, and other Integrated Land-uses
When benefiting amphibians and reptiles is secondary to other management objectives:

- **Identify seasonal wetlands and the forest cover around them on the property being managed.** *Maintaining forest cover around seasonal wetlands may make movements easier for amphibians that breed in isolated ponds.*

- **Consider timing of current and planned land-use practices to minimize conflicts with animals**

USGS Patuxent Wildlife Research Center, Northeast ARMI team

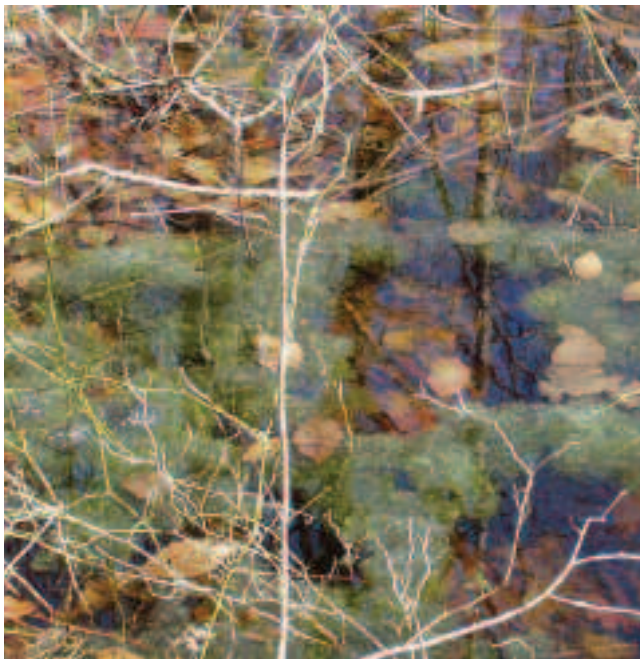
Marbled Salamanders arrive in the fall and mate on land when vernal pools are dry or nearly so. Females lay eggs under logs or leaves in the pool basin and wait with them until rains fill the pool. Females then leave the pools and return to the forest while the eggs hatch and the larvae become aquatic.

Kurt Buhlmann

Searching for winter-breeding amphibians, such as Tiger Salamanders and Jefferson Salamanders, sometimes requires breaking the ice on the pools to see them.

Alan Dorfman

Spotted Turtles use isolated wetlands and vernal pools as temporary foraging sites or as over-wintering sites. The same turtles often return to the same sites in subsequent years. These colorful and gentle turtles forage on tadpoles and insects.



Chuck Landrey

Wood Frogs lay their eggs communally. As the egg masses age, they accumulate a symbiotic alga that helps to keep the developing embryos oxygenated. The metamorphs can be very abundant and provide a rich source of protein to predators. This process allows energy from the aquatic system to be transferred to the terrestrial system.

when they are active. *Land-use activities such as tilling and timber harvest conducted during adult and juvenile migrations could result in mortality.*

- **Where feasible, maintain natural habitat connectivity between wetlands or ensure that the landscape between wetlands does not impede movements.** *Movement between wetlands by amphibians and reptiles is enhanced if the corridor or pathway used is natural habitat.*

- **Maintain canopy cover where appropriate to encourage cool, moist forest floor in terrestrial buffer and life zones.** *Amphibians need to be constantly moist. Such habitat conditions in these areas will minimize mortality due to desiccation.*

- **Establish buffers and life zones in agricultural areas around the core wetland's terrestrial zone.** *Amphibians and reptiles use the core terrestrial zone extensively, thus the real buffer is located around the outside of this terrestrial life zone. Lack of buffers creates abundant edges and reduces the size of the core terrestrial habitat.*

- **Where feasible, minimize soil disturbance when using heavy equipment around wetlands and limit the number of access roads and staging areas.** *Such equipment and vehicles may have negative impacts on amphibians and reptiles. Limiting the areas impacted will reduce the number of negative impacts in the area.*

- **When possible, avoid grazing and watering livestock in and near seasonal wetlands.** *Livestock will trample eggs, and waste products will cause eutrophication, oxygen depletion, and amphibian larval death.*

- **Limit ATV and other recreational impacts on unpaved roads containing pools during amphibian breeding and larval development seasons.** *ATVs and other vehicles displace eggs and larvae from the pool and throw them up on shore where they dry out.*

- **When in or near seasonal wetlands, use the minimum amount of fertilizers, herbicides, and pesticides required to achieve management objectives.** *Follow all directions on container labels.*

- **Locate high-intensity roads, trails, landings, and recreational facilities away from seasonal wetlands and transitional zones into upland habitats.** *Locate roads well away from these wetlands.*

- **Avoid diverting surface water from existing roads or facilities into wetlands.** *Surface run-off from roads may contain oil and other pollutants, as well as sediments that can fill seasonal wetlands, detrimentally affecting the quality of these important amphibian and reptile habitats.*

Kurt Buhlmann

Seasonal isolated wetlands support a diversity of plants and animals, many of which are rare and unique, such as Swamp Pink.

USGS Patuxent Wildlife Research Center, Northeast ARMI team

A woodland vernal pool in Maryland has recently been filled by rain and will be used by several species in the winter and early spring.

IDEAL: Refuges, Sanctuaries, and Preserves *When benefiting amphibians and reptiles is a PRIMARY objective, as with nature preserves, wildlife refuges, and private lands whose owners wish to optimize herpetofaunal diversity and abundance:*

- **Where feasible, avoid creating permanent farm ponds by altering seasonal wetlands.** *Create farm ponds elsewhere while retaining natural seasonal wetlands. Creation of farm ponds will destroy seasonal wetlands and eliminate species that requires seasonal wetlands.*

- **Consider constructing artificial wetlands or ponds where natural wetlands have been degraded or destroyed.** *A series of wetlands on the landscape can facilitate dispersal and accelerate recolonization of amphibians in reforestation sites.*

IMPORTANCE OF ADJACENT UPLANDS

Protect small isolated wetlands while also incorporating adjacent upland habitats and promoting a forested landscape connection to other wetlands. A seasonal wetland without appropriate surrounding upland habitat will lose its amphibian and reptile fauna. Amphibians and many reptiles spend most of their lives in a zone of 450 feet or more around the wetland. This is the core terrestrial zone. The buffer around the wetland should be considered the zone outside of this core.

- **Maintain natural wetland wet-dry cycles — no drainage, excavations, or diversions into or out of the wetland.** *Wet-dry cycles with winter fill and summer drying keep fish predators out of these pools. Such annual variation in natural hydrological cycles is critical for amphibian breeding success.*

- **Maintain forested canopy conditions around portions of seasonal wetlands as adult amphibians spend the non-breeding season in the surrounding forest, up to 450 feet from the wetland.** *This is the core terrestrial habitat necessary for population survival outside the breeding season.*

- **Maintain water quality and avoid input of sediment, chemicals, and livestock runoff.** *These pools are usually shallow bodies of water, thus small inputs of such pollutants may harm amphibian larvae.*

Mike Marchand

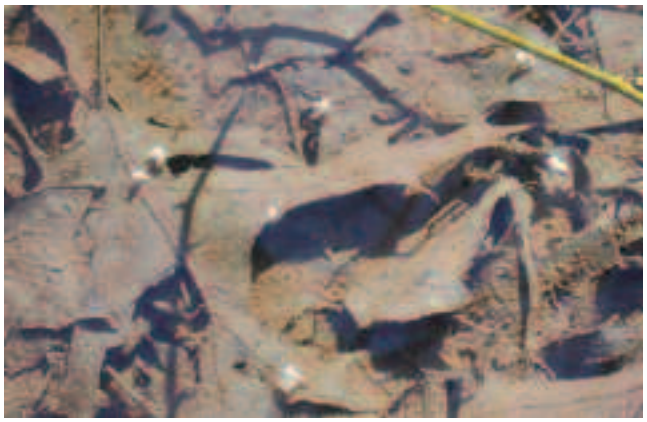
Wood Frogs are the poster amphibian for vernal pools in the Northeast. They migrate to the pools in late winter, mate and lay eggs, and then return to the surrounding hardwood forest. Wood Frogs require fish-free vernal pools in which to breed.

- **Allow native vegetation to provide physical structure and organic inputs.** *Vegetative cover around the margins of these pools will provide cover for adults and emerging juveniles.*

- **Ensure that the natural integrity of the basin is maintained — do not fill or alter contours.** *Basin integrity is related to hydrological dynamics. Contours and depths vary considerably due to soil type, underlying substrate, and vegetation input from the surrounding forest.*

- **Remove fill or unnatural debris (e.g., tires, trash) as necessary to maintain the natural basin.** *Trash and other discarded items may contain chemicals and oil-generated pollutants that may kill or harm amphibians.*

- **Do not stock fish.** *Fish of all kinds eat eggs, larvae, tadpoles, and small frogs. Several amphibian species cannot breed successfully in pools containing fish.*



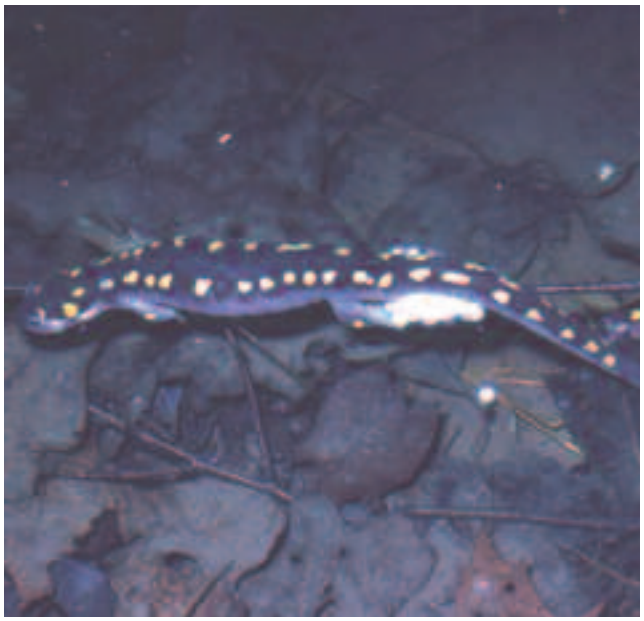
USGS Patuxent Wildlife Research Center, Northeast ARMI team

The first sign of salamander mating activity in a vernal pool is the presence of spermatophores. Males lay down these gelatinous stalks, each topped with a sperm packet, before the females arrive. Each male courts a female to entice her to pick up a sperm packet in her cloaca. Fertilization takes place soon thereafter.

- **Remove or control invasive exotic species, both plant and animal.** *Invasive plants can alter wetlands to the point where they cannot support amphibians and reptiles, and exotic animals can act as predators or parasites, or interfere with food resources.*

- **Maintain ground cover such as coarse woody debris in the terrestrial life zone.** *Emerging juvenile amphibians require terrestrial cover to avoid exposure to predation and desiccation. Adults need cover during breeding periods and for survival.*

- **Encourage individual movement between wetlands and the landscape by minimizing barriers, such as ditches, curbs, rock, rip-rap, horticultural netting, and wells.** *Barriers to dispersal increase the chances of mortality and prevent individuals and hence genes from being exchanged among populations.*



Steve Roble

Spotted Salamanders are widely recognized as the classic vernal pool salamander. They arrive at vernal pools in late winter, often with snow on the surrounding ground, mate, and lay eggs. Once they have completed their tasks, they return to the forests, often some distance away, and live the rest of the year underground in small mammal burrows and decaying root systems.

- **Construct and maintain tunnels with directional barriers under roads to allow dispersal and reduce mortality.** *Installation of tunnels (ecopassages) and barriers has been successful in some places to reduce or prevent highway mortality near breeding sites.*

- **Increase awareness of animal crossings and mortality on roads through outreach and education programs; post road signs.** *Local and regional education has many benefits to amphibians and reptiles, as well as to landowners who will often gain support and recognition from neighbors and others.*

- **Avoid placement of improved or permanent roads within the terrestrial life zone.** *Seek to avoid this important area that surrounds the actual aquatic breeding site. Roads of any kind in this zone will cause mortality and reduce population survivorship of several species.*

- **Exclude vehicle traffic, including ATVs, from wetlands, especially during peak breeding and larval development periods.** *Any vehicle will alter wetland substrates and potentially kill amphibians and reptiles directly. Vehicles may release petroleum products, thus causing pollution.*

Mike Marchand

Female Blandings Turtles travel long distances to find nesting sites. They often use vernal pools as "stepping stones" to reach freshwater marshes. While visiting the vernal pools, they forage on crayfish and tadpoles. Thus, the density of vernal pools in the landscape is critical to their survival. Loss of any vernal pool is detrimental.

- **Use the minimum amounts of chemicals necessary to achieve management objectives in or near seasonal wetlands.** *Make sure there is an adequate buffer between places where fertilizers and pesticides are used.*

- **Restore connectivity among seasonal wetlands by restoring corridors of natural habitat between wetlands and uplands**. *Movements of amphibians and reptiles between aquatic habitats ensure genetic mixing and avoidance of inbreeding. Corridors of appropriate habitat will likely reduce mortality during dispersal and movements.*

- **Consider constructing artificial wetlands with seasonal wet-dry cycles where natural wetlands have been lost or degraded.** *Guidelines are available to direct proper construction of artificial pools for amphibian breeding. Such properly constructed wetlands can enhance amphibian and reptile diversity and survival on your land.*

- **For open wetlands embedded in fire-maintained habitats, permit occasional fires to burn into pond basins when ponds are dry**. *Occasional fires will burn away organic sediment and encourage plant diversity.*

This is the Seasonal Isolated Wetlands module of the PARC publication, HMG-3. ISBN 0-9667402-3-8. Please visit www.parcplace.org for further information, copies of the complete document, or a web-based version of these guidelines.

Steve Roble

Spotted Salamander metamorphs emerge from vernal pools in late spring or summer depending on elevation and latitude. They become food for numerous predators, including wild turkey. Vernal pool quality influences the numbers of larvae surviving to this stage.

Steve Roble

A pair of mating Wood Frogs in a vernal pool in Pennsylvania. The female lays eggs as the male clasps her from behind and sheds sperm over them, a behavior called amplexus. These frogs are only found in the vernal pools during the winter mating season. They live under leaves and decaying logs on the surrounding moist forest floor during the majority of the year.

Mike Torocco

An acidic, boggy, open canopy wetland in the New Jersey Pine Barrens supports a select group of amphibians, including Carpenter Frogs and Pine Barrens Treefrogs.

WEST NILE VIRUS

Health concerns regarding West Nile Virus (WNV) has in some cases resulted in the assumption that many types of standing water, including natural and created wetlands, may be producing dangerous numbers of virus-infected mosquitoes and that the wetlands should be drained, filled, or sprayed to eliminate the possibility of WNV transmission to humans.

Not all mosquitoes transmit WNV, not all mosquitoes feed on humans, and habitats vary for mosquito species. Species of *Aedes* are typically produced in floodwaters in the spring and early summer. Species of *Culex* will deposit eggs in a variety of water-holding containers such as old tires, birdbaths, buckets, and wading pools. *Culex pipiens*, the northern house mosquito, is a common household mosquito and the primary vector of WNV. *Culex* larvae thrive in pooled water in areas not normally wet, which do not support their predators.

Mosquitoes are a vital part of wetland food chains, and healthy wetlands have balanced predator-prey relationships that provide natural mosquito control. Salamander larvae are major predators of mosquito larvae. Altered or degraded wetlands often have stagnant water, increased nutrient levels, and fewer natural mosquito predators. Maintaining natural functions of seasonal wetlands and restoring impaired wetlands should be goals of private and public land managers, as well as mosquito control agencies.

For more information:
Centers for Disease Control
http://www.cdc.gov/ncidod/dvbid/westnile/index.htm

American Mosquito Control Association
www.mosquito.org

The USDA Regional Pest Management Centers
National Pest Alert brochure on WNV
http://www.ncpmc.org/NewsAlerts/westnilevirus.htm

—Mark Bailey and Jeff Holmes

USGS Patuxent Wildlife Research Center, Northeast ARMI team

One of the more common species of frogs in temporary and permanent wetlands in the Northeast is the Green Frog. These two are in amplexus with the male atop the female. Note the difference in tympanum diameter behind the eyes; it is much larger in males.

Wayne Jones

Although most amphibians are not active in icy cold weather, some such as Northern Dusky Salamanders can be found under the ice in small streams in the Northeast.

Kurt Buhlmann

WET MEADOWS, BOGS, AND FENS

Wet meadows occur in poorly drained areas, such as low-lying depressions, are fed by precipitation, and often dry in summer. Bogs are acidic, freshwater wetlands with no inlet or outlet, spongy peat deposits and varying densities of evergreen trees and shrubs. Sphagnum moss usually occurs in abundance. Water sources are rainwater, snow, and occasionally seepages. Fens are ancient open wetlands that are fed by groundwater and seepages. They are less acidic than bogs and have higher nutrient levels, thus they support diverse plant and animal communities.

These habitats usually occur on flat to gently sloping areas and range from small and isolated to relatively extensive areas connected by streams. Wet meadows, bogs, and fens are characterized by open to intermittent canopy, layers of peat muck or sand and high or perched water tables, and abundant, specialized vegetation including sphagnum, cranberry, and sedge tussocks. Zones of vegetation can usually be distinguished in bogs and fens from dry edges to wet and open water in the center. Soils and hydrology affect the nature of the substrate, which in turn influence the species that can use these habitats. In some regions, grazing by bison (historically), colonization and abandonment by beaver, and, more recently, livestock grazing have helped to maintain or restore sedge tussock and sphagnum-dominated wet meadows.

Human and natural processes in the surrounding landscape affect wetland functions and processes directly or indirectly. Sediments, pesticides, fertilizers, and other chemicals may flow into these wetlands from upslope. Many of these wetlands have been drained and lost to agriculture, mining, and urbanization.

CHARACTERISTIC SPECIES

Pine Barrens Treefrog, Green Frog, Carpenter Frog, Four-toed Salamander, Mud Salamander, Bog Turtle, Spotted Turtle, Box Turtle, Garter Snake, Ribbon Snake

Joe Mitchell

Wet meadows like this one in northern New Jersey occur as patches in the landscape. Through natural succession, the encroaching forest will eventually shade the site and make it site less attractive to Bog Turtles and other herps that require more sunlight. Land managers can work with herpetologists to retard succession and maintain the needed site characteristics.

Kurt Buhlmann

The federally threatened Bog Turtle occurs in wet meadows and bogs in several parts of the Northeast. The decline of wet meadow habitats, collectively through succession to forest, cessation of farming, outright destruction via housing developments, and commercial collection of the turtles themselves for the pet trade has led to their endangerment.

MANAGEMENT GUIDELINES

MAXIMIZING COMPATIBILITY: Timberlands, Hunt Clubs, Farmlands, Recreation Lands, and other Integrated Land-uses
When benefiting amphibians and reptiles is secondary to other management objectives:

Kurt Buhlmann

Ditching wet meadows channelizes the water, dries the surrounding soil, and makes the site unsuitable for rare species like the Bog Turtle. Landowners and managers should avoid such activities.

- **Where feasible, avoid filling, draining, ditching, damming, and excessive groundwater withdrawal in and around wet meadows, bogs, and fens.** *Alteration of the hydrological regime that maintains these wetlands will eliminate its unique flora and fauna.*

- **When possible, mow grasslands around wet meadows at high blade settings when cutting hay.** *Mow during dry periods to minimize soil disturbance and machinery-related mortality of amphibians and reptiles. Begin in the center and use a back-and-forth approach to avoid concentrating animals where they may be killed. Raising the mowing deck height to 8 or even 12 inches will reduce mortality and leave important cover.*

- **When planning roads, avoid wet meadows, bogs, and fens.** *(See the "Roads" section under "Threats") Avoidance of these wetlands will prevent many unforeseen problems with permitting and damage to these systems.*

- **Control woody plant encroachment and succession.** *Woody plant encroachment into these wetlands alters local hydrological cycles and affects the physical conditions that are needed by wetland*

Kurt Buhlmann

Management of wet meadows and bogs may require manual removal of successional species such as red maple trees. Simply cutting red maple will result in vigorous sprouting. Girdling trees and leaving them standing achieves better results. Restoring open canopy will help sedges and other wetland plants to persist.

Joe Mitchell

Four-toed Salamanders often occur in wet meadows and bogs that have an abundance of sphagnum. Lower nutrient conditions favor sphagnum growth, whereas runoff of fertilizers and animal waste will favor other weedy plant species.

plants and animals. Open conditions are a requirement of many bog-, fen-, and wet meadow-associated species.

- **Limit livestock grazing in wet meadows to the number that can maintain but not degrade this habitat.** *In some areas moderate livestock grazing can assist in maintaining desired vegetative composition and structure and help keep out woody plants.* (*See box insert on cattle grazing in wet meadows*)

- **Prohibit collection of native species in these wetlands on your land.** *Collection of native plants and animals from these wetlands for commercial sale is a serious threat in the Northeast. Private and public land managers can help minimize this problem by their own enforcement actions.*

Kurt Buhlmann

Many wet meadows and bogs in the Northeast are located along small meandering rivulets and streams on farms. Straightening of these streams destroys the wet meadows, likewise, restoring the curves may be a proactive management activity.

- **Avoid introduction of non-native invasive plants and animals on your property.** *Species like purple loosestrife, phragmites, and reed canary grass can destroy natural wetlands. They and non-native animals can cause native species to decline.*

- **Where feasible, avoid plowing firebreaks in wet meadows, bogs, and fens.** *A firebreak in a wet meadow, bog, or fen will act as a ditch and cause unwanted drainage. It is better to let the fire burn through the wetland, as it will recover. Cutting and raking by hand in these firebreaks is effective.*

LIVESTOCK AND BOGS

Recent studies have shown that light to moderate grazing by cattle and other livestock may be vital to maintaining habitat suitability for Bog Turtles and other rare species in bogs. **Warning**: Excessive grazing by can be harmful as they may trample the vegetation and habitat structure managers and land owners wish to promote. Goats will help control woody vegetation and are less damaging to bog plants and substrates. Consult a Bog Turtle biologist in your state to help with management of these wetlands in ways that are compatible with agricultural needs.

IDEAL: Refuges, Sanctuaries, and Preserves
When benefiting amphibians and reptiles is a PRIMARY objective, as with nature preserves, wildlife refuges, and private lands whose owners wish to optimize herpetofaunal diversity and abundance:

Joe Mitchell

Green Frogs occupy wet meadows as long as surface water is available for the lengthy duration, up to one year, of the tadpole stage.

Kurt Buhlmann

Numerous isolated depressions in the Northeast, many formed by melting blocks of glacial ice, represent unique fen and bog habitats. Often floating mats of shrub vegetation and small trees cover these unusual sites, such as this one in Massachusetts. Blandings Turtles may use these habitats.

Kurt Buhlmann

Natural ecological succession was a part of the dynamics of these wetlands for eons. Species could once move easily to adjacent wetlands, but humans have limited such opportunities. Thus, in-situ management of these wetlands has become necessary.

- **Control encroachment of woody plants and ecological succession.** *Open canopy conditions are a requirement of many bog-associated species.*

- **Restore natural surface water and groundwater hydrology using ditch plugs or temporary dams if necessary.** *Restoration of the natural hydrological cycle will restore the unique vegetation and animal communities in these wetlands.*

- **Restore herbaceous vegetation using tools such as prescribed burning, low-impact mechanical removal of woody vegetation, and low-impact controlled grazing.** *Under ideal conditions, these habitats and their inhabitants respond favorably to occasional natural disturbances.*

- **Do not plow firebreaks in wet meadows, bogs, and fens.** *Inform local and regional fire control officials of the presence of ecologically sensitive areas and clearly delineate boundaries with flagging tape, tree paint, or signs. Bogs and fens are very fragile systems. Soil and vegetation disturbances can result from poorly planned firebreaks.*

- **Provide a native vegetative buffer zone between the wetland and adjacent uplands to help minimize input of fertilizers and pollutants from the surrounding landscape.** *Such a buffer will act as a barrier in which the vegetation will take up the unwanted chemicals and serve as cover for amphibians, reptiles, and other animals.*

- **Prohibit commercial collection of native species on your property.** *The commercial trade in some plants and animals, including protected species, is a major threat. Landowners and managers can support efforts to minimize this activity.*

- **Avoid the introduction of nonnative species.** *Invasive plants are well known to alter wetland habitats so much that unique native species can no longer exist there. Released non-native animals, such as the Red-eared Slider, will compete with native species.*

Joe Mitchell

Wet sedge meadows and bogs support numerous amphibians and reptiles, including the endangered Bog Turtle. Keeping these marshes free of encroaching hardwoods and shrubs is often a necessary management activity, especially where grazing animals such as dairy cows, are no longer present to help with the task.

Kurt Buhlmann

A Spotted Turtle basks on a sphagnum-covered tussock sedge in a New England wet meadow.

Kurt Buhlmann

Beavers were historically abundant in the Northeast and their damming activities created numerous wet meadow habitats. These meadows often have mucky soils, and support rare plants and animal species. Wet meadows eventually succeed into forest following abandonment by beaver. The creation of new wet meadows on the landscape, as others disappear, is a process necessary to maintain long-term ecosystem health.

- **Manage beaver activities to attain desired vegetation and open canopy conditions in bogs.** *Beavers in the Northeast often flood existing bogs and fens, but their actions may help restore older wetlands that have been ditched or filled with encroaching woody vegetation. The value of beaver activity may not be seen until after they have abandoned the wetland or have been removed.*

This is the Wet Meadows, Bogs, and Fens module of the PARC publication, HMG-3. ISBN 0-9667402-3-8. Please visit www.parcplace.org for further information, copies of the complete document, or a web-based version of these guidelines.

USING LIVESTOCK TO MANAGE BOG TURTLE HABITAT

Various types of livestock, including cows, sheep and goats, have been used in New Jersey to manage habitat for the Federally Threatened, State Endangered Bog Turtle. Invasive plants such as phragmites, purple loosestrife, multiflora rose and reed canary grass can quickly turn bog turtle habitat into problematic monocultures. Specific livestock eat these non-native species and consequently break dense root mats with their hooves. They also create depressions in the muck that are later used by the turtles. Introduced livestock theoretically take the place of prehistoric grazers and other natural forces that once served to keep vegetation low and at an early successional stage in fens and wet meadows. Portions of open canopy in bog turtle habitat are crucial for reproductive success and basking.

— Brian Zarate

Kurt Buhlmann

Cattle grazing in wet meadows can be beneficial if cattle numbers are not too high. The area on the right is grazed. Trial and error experimentation may be necessary to achieve the management goal of maintaining a functional wet meadow, while minimizing trampling. Goats are less damaging to the soil, browse invasive woody vegetation, such as multi-flora rose, but require more secure fencing.

Kurt Buhlmann

Dumping of farm and yard waste into wet meadows and bogs serves only to contaminate the water and soil used by plants and animals.

Steve Roble

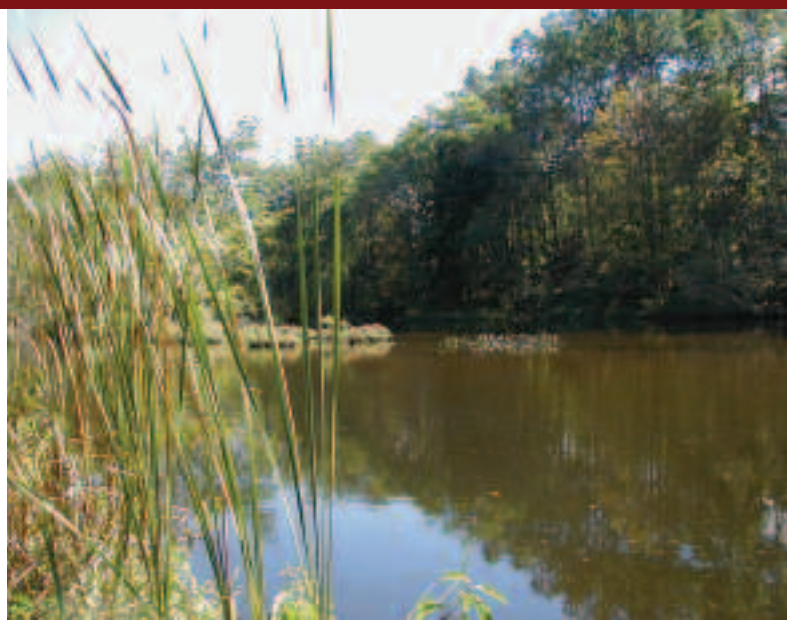
One of the early-breeding frogs in the Northeast is the Pickerel Frog. The male is in amplexus with the larger female and will shed his sperm over her eggs as she is releasing them.

Matt Aresco

PERMANENT WETLANDS

Permanent wetlands differ from seasonal wetlands primarily because they hold water throughout the year and host populations of fish and other predators. They include natural lakes, ponds, wooded swamps, marshes, and impoundments whether made by beavers or humans. We consider permanent wetlands in a different category than streams and rivers because running water provides different physical challenges to amphibians and reptiles. Water depth varies greatly among permanent wetland types. Shallow wetlands allow vegetation to grow throughout much of the basin, whereas deeper ponds and lakes have vegetation usually confined to their perimeters. Some amphibians and reptiles occur in deep, open water, but not all of them. Emergent vegetation that commonly occurs along shallow shorelines provides refugia from predatory fish. Thus, the physical structure of permanent wetlands dictates which species may occur in each type.

The Northeast has numerous natural permanent wetlands, many of which were formed as the glaciers receded over 10,000 years ago. Many are relatively deep and cool with vegetation confined to narrow lake or pond margins. Impoundments of varying sizes, from



Harriet Forrester

Permanent wetlands are ponds, lakes, and other large bodies of still water that do not dry out. They usually have fish populations and a suite of amphibians and reptiles. Water depth and the types of vegetation lining the shores influence which species occur.

Kurt Buhlmann

A glacially-carved northern marshland supports a population of Blandings Turtles, as well as the more common Painted Turtle.

lakes to ponds, abound in the Northeast. Although artificial, these wetlands offer habitats to several species of turtles, snakes, frogs, and salamanders. Ponds and lakes in the Northeast are impacted by pollution and siltation from the surrounding landscape and by invasive species, like purple loose-strife and phragmites. Active management of these wetlands may be necessary in some cases to ensure that they continue to support amphibian and reptile populations.

CHARACTERISTIC SPECIES

American Bullfrog, Green Frog, Mink Frog, Mudpuppy, Red-spotted Newt, Blanding's Turtle, Common Map Turtle, Musk Turtle, Painted Turtle, Snapping Turtle, Spiny Softshell Turtle, Northern Water Snake

MANAGEMENT GUIDELINES

MAXIMIZING COMPATIBILITY: Timberlands, Hunt Clubs, Farmlands, Recreation Lands, and other Integrated Land-uses
When benefiting amphibians and reptiles is secondary to other management objectives:

- **When possible, do not lower water levels during winter when hibernating amphibians and reptiles would become exposed to freezing temperatures.** *Time management activities to the biological needs of the animals.*

- **Maintain connectivity among wetlands. If necessary maintain naturally vegetated corridors.** *Movements of amphibians and reptiles among aquatic habitats ensure genetic mixing and avoidance of inbreeding. Maintaining connectivity among appropriate habitats will likely reduce mortality during dispersal and movements.*

Joe Mitchell

The deep jug-o-rum call of male American Bullfrogs is often heard in permanent wetlands in summer throughout the Northeast. Bullfrogs are voracious and will eat almost any animal they can fit into their mouth, including juveniles of their own species. Juveniles disperse to other wetland types well away from the breeding sites to avoid cannibalism.

- **If possible, avoid complete change in land-use. Consider concentrating development or other activities in a portion of the landscape.** *Completely changing the landscape and hence its habitats will likely eliminate amphibian and reptile populations. Placement of high impact construction and activities away from wetlands, core terrestrial habitats, and sensitive areas will help ensure that some or all species will survive. Construction activities that raise or lower water levels can severely impact many species of amphibians and reptiles.*

- **Maintain natural plant succession patterns in adjacent terrestrial habitats.** *Manage your land in such a way that invasive species cannot become established. Learn the types of environments that are favored by problematic invasives.*

- **Encourage conservation tillage and establish forest buffers in agricultural areas around permanent wetlands**. *A combination of conservation tillage and natural forest buffers of adequate width around permanent wetlands will ensure that natural populations of amphibians and reptiles will thrive.*

- **When using fertilizers and pesticides, be sure to follow label directions and adequately buffer permanent wetlands.** *The directions on the labels are government mandated and have been tested for safety. Use the minimum amount of chemical necessary to achieve management objectives. Ensure there is an adequate buffer to prevent runoff.*

USGS Patuxent Wildlife Research Center, Northeast ARMI team

Northern Cricket Frogs are small frogs that can be abundant around the grassy margins of permanent wetlands. However, they are declining in abundance in the Northeast for unknown reasons.

Steve Roble

Pickerel Frogs often prefer permanent wetlands, such as beaver ponds and man-made ponds. The males produce a snoring sound while hidden under leaves at the waters edge.

- **Where feasible, avoid road building and related activities adjacent to wetlands**. *Construction of roads can cause siltation, alter hydrological cycles, or directly damage wetlands. Roads of any kind adjacent to wetlands will often reduce herpetofauna population sizes and species diversity. When roads must be built adjacent to wetlands, carefully design and construct them to minimize these potential impacts.*

- **Maintain at least partial canopy cover where feasible for adjacent terrestrial habitat.** *Amphibians and reptiles use adjacent terrestrial lands around permanent wetlands extensively. Canopy cover density can be variable but some cover will ensure that these animals will be able to use both aquatic and terrestrial habitats.*

Joe Mitchell

Permanent ponds created for wildlife support a wide variety of amphibians. This one in the George Washington National Forest in Virginia is a breeding site for Jefferson's Salamanders and Red-spotted Newts.

- **Follow existing Best Management Practices to control sediment and erosion associated with construction; enhance these practices.** *Use native wood chips and hay bales to slow or prevent intrusion into wetlands. Sediment deposits in wetlands choke microhabitats used by amphibians and reptiles.*

- **Minimize scarification and rutting of adjacent habitat and restore the landscape when the project is complete**. *Minimize long-term impact of roads and other construction by restoring the landscape to natural conditions after completion of the project.*

- **Meet or exceed forestry and agricultural Best Management Practices and Streamside Management Zones.** *If your situation is not covered by these guidelines, consider contacting PARC, NRCS, your state forestry commission, or your state Natural Heritage Programs to determine what riparian zone management practice will best benefit your local amphibians and reptiles.*

- **Minimize or exclude undesirable nutrients or contaminants, such as residential and industrial waste, from wetlands**. *State or local laws usually regulate such problems but operating in a responsible manner on one's property will ensure that the common good — the permanent wetland — will remain functional for the long term*.

- **Limit recreational access completely or to as few points as is feasible, avoiding areas with existing aquatic vegetation. ATV activities should be avoided in and around permanent wetlands**. *Some recreational activities, especially those that use ATVs, can destroy wetlands and natural vegetation*.

Kurt Buhlmann

The Blandings Turtle is a large freshwater turtle associated with vernal pools, fens, glacial marshes, and other permanent natural wetlands of the northern United States and Canada.

- **Provide conservation-related educational materials (kiosks, posters, brochures) to boaters, skiers, fishermen, and other recreational visitors.** *User education and acting as an example often increase awareness and conservation-mindedness in others.*

- **Avoid creating permanent farm ponds by altering natural wetlands such as swamps and marshes.** *Destroying a natural wetland to create an impoundment causes the loss of many natural populations and increases the potential for introduced species. If a pond must be created, then seek places where its placement will not alter other wetlands.*

IDEAL: Refuges, Sanctuaries, and Preserves
When benefiting amphibians and reptiles is a PRIMARY objective, as with nature preserves, wildlife refuges, and private lands whose owners wish to optimize herpetofaunal diversity and abundance:

- **Maintain the natural hydrology of wetlands and prevent unnatural drainage.** *Amphibians and reptiles in the Northeast are adapted to natural hydrological cycles. Alteration is likely to reduce survivorship and cause population decline.*

- **Maintain native vegetation in and throughout shallow wetlands and around the margins of large, deep lakes and ponds.** *Amphibians and reptiles use native vegetation extensively for hiding places and egg attachment sites. Vegetation also acts as a natural sewage treatment plant and helps to maintain clean water.*

- **Maintain the integrity of wetland basins. Allow no fill, intrusion, drainage, damming, or excavation.** *Alteration of the basin is likely to affect hydrological regimes and hydroperiod, two aspects of water presence important to amphibians and reptiles.*

Joe Mitchell

Snapping Turtles are large omnivores that are primarily scavengers. They eat aquatic vegetation, crayfish, and other animals. They help maintain pond health by eating dead or perhaps dying fish. They reportedly capture ducklings, but it is likely a small part of their overall diet. Snapping Turtles are important components of food webs in permanent wetlands.

Kurt Buhlmann

Large reservoirs can support populations of amphibians and reptiles adapted to permanent water. Snapping Turtles, Painted Turtles, Redspotted Newts are usually found in these wetlands in the Northeast. Maintenance of basking sites for turtles and shallow littoral zones with emergent vegetation will enhance herp populations.

- **Prevent input of sediment, chemicals, and livestock runoff in order to maintain or improve water quality**. *Such sources of input may directly or indirectly impact amphibians and reptiles and can be prevented by creative landscape and livestock management.*

- **Avoid introduction of exotic species, and remove exotic species already present**. *Invasive plants alter wetland habitat structure and function and exotic animals act as uncontrolled predators and sources of parasites and disease.*

- **Maintain habitat structures such as snags, basking logs, rocks, and overhanging vegetation**. *Management of permanent wetlands with these structures ensures the presence of amphibians and reptiles because they offer basking sites and hiding places.*

- **Do not use heavy machinery within wetland boundaries or in sensitive riparian areas.** *Such weight and scouring of the land surface alters wetland habitats and invites invasive plants to establish a foothold. They can also crush amphibians and reptiles already present.*

- **Provide natural buffer zones around or adjacent to wetland edge.** *A buffer of several hundred feet is ideal and will help ensure that populations will remain healthy. Amphibians and reptiles use the surrounding uplands extensively.*

- **Maintain or add natural ground cover (e.g., coarse woody debris) in core habitats, buffer zones, and wetland edges.** *These structures of various sizes are used for hiding from predators and avoiding desiccation.*

- **Minimize barriers (ditches, curbs) to movement of individuals into and out of permanent wetlands.** *Barriers to amphibians and reptiles migration may limit exchange of individuals between wetlands and reduce genetic variation in populations.*

- **Maintain open, sunlit areas with little vegetation for turtle nesting adjacent to or near wetlands.** *Turtles in the Northeast require open sunny areas so that the nest temperature will be high enough for successful development and hatching.*

- **Restore basins and hydrological cycles by removing fill, filling ditches and breaking substrate drainage tiles.** *Restore permanent wetlands that have been altered in the past to make these habitats more attractive to amphibians and reptiles.*

- **Avoid placement of new roads near wetlands and consider closing existing roads that act as sources of mortality to animals moving to and from these wetlands.** *Vehicular traffic on roads is a prime source of mortality of many amphibians and reptiles. Construction of roads usually alters the hydrological cycles of adjacent wetlands.*

- **Increase awareness of wildlife road crossings through outreach, education, and local signage.** *Promote local education. Act as an example to others.*

Kurt Buhlmann

Permanent, water lily-choked ponds are favorite habitats of Red-bellied Cooters. They need basking sites for regulation of body temperatures. The addition of logs and snags benefits most aquatic turtles by providing basking sites.

Cheryl Tanner

Juvenile Red-spotted Newts (called Red Efts), are terrestrial, have toxic skin glands like their parents, and are brightly colored to presumably deter predation by visual predators. Once they become adults in 5-8 years, they reenter the pond or lake and become fully aquatic. Fish do not eat newts because of their toxicity.

Joe Mitchell

Permanent wetlands in many parts of the Northeast support populations of large basking turtles, like the herbaceous Red-bellied Turtle. Submergent aquatic vegetation, such as elodea, is a critical component of their habitat.

Kurt Buhlmann

The Mink Frog is a species of the far north, including eastern Canada. They typically inhabit permanent lakes and ponds with an abundance of water lilies.

- **Restore connectivity between wetlands with natural terrestrial habitats.** *Ensure that amphibians and reptiles do not have to run a gauntlet of obstacles and open spaces that expose them to predators just to move between habitats they need.*

- **Restrict animal movement into hazardous wetlands or upland zones (e.g., retention basins contaminated by chemicals or radioactivity).** *Amphibians and reptiles will absorb chemicals and radioisotopes. Their movements across the landscape also move contaminants to other areas.*

- **Restore natural shoreline habitat (e.g., remove retaining walls, rip rap).** *Unnatural objects around the shoreline inhibit use of these areas and interfere with movements.*

- **Consider contouring restored wetlands with irregular edges and uneven bottom elevations.** *Such variation in restored or created permanent wetlands helps to maintain diverse vegetation zones and habitat structure that promotes greater amphibian and reptile diversity.*

- **Encourage enforcement of regulations designed to control and prevent illegal dumping.** *Such illegal actions introduce chemicals into wetlands that can kill amphibians. It is against the law in most states.*

- **Avoid introduction of game fish or non-native species, if fish are not present naturally.** *Restricting vehicular public access may discourage unauthorized stocking. Fish eat amphibian eggs and larvae. Some amphibians will avoid wetlands with fish. The introduced Chinese snakehead fish is a voracious predator that will undoubtedly harm amphibian and reptile populations.*

Kurt Buhlmann

Excavation of a depression in an old field on a Pennsylvania farm created this permanent pond. Filled primarily by surface runoff and rainfall, the pond has become home to a small assemblage of common amphibians and reptiles, including Bullfrogs, Green Frogs, Red-spotted Newts, Painted Turtles, and Northern Watersnakes. Shoreline emergent vegetation provides cover.

Kurt Buhlmann

Glaciers in parts of the Northeast carved many depressions in the landscape that filled with water. Some are deep, while others are shallow and have extensive marsh edges with emergent vegetation. This one in Massachusetts is home to Painted Turtles, Snapping Turtles, Blandings Turtles, and Bullfrogs, to name a few.

INFORMATION FOR FISHERMEN

Snapping turtles and aquatic snakes occasionally prey on fish, including some game and bait species. More often than not, however, large healthy fish are too fast and strong to be caught by reptiles. As a result, reptiles feed primarily on fish weakened or slowed by poor genetics, disease, or starvation due to overstocking. The presence of fish-eating reptiles in the vicinity of fishing waters can enhance the size and health of game fish by preventing the spread of disease, weeding out genetically inferior strains, and reducing overpopulation.

This is the Permanent Wetlands module of the PARC publication, HMG-3. ISBN 0-9667402-3-8. Please visit www.parcplace.org for further information, copies of the complete document, or a web-based version of these guidelines.

Daniel Hocking

SMALL STREAMS, SPRINGS AND SEEPAGES

Stream habitats in the Northeast include headwater streams, as well as the springs and seepages that occur within their often-narrow floodplains. They are usually shallow and have water flow except during drought years. Streams in natural landscapes usually have a canopy provided by at least a line of trees along the margins. Flow rates depend on elevation gradients, seepage volume production, rain and snowmelt, and the physical structure of the stream basin and channel. Temperatures are usually cooler and dissolved oxygen levels greater in headwater streams than larger streams. Streams usually have fish populations, many of which prey on amphibians and some reptiles, although headwater streams often lack fish. Physical structures in streams such as rocks and debris dams provide microhabitat for salamanders and frogs and their larvae to hide from fish.

Springs and seeps are integral parts of stream ecosystems. Springs are primary sources of cool, clean water for headwater streams. Seepages are shallow, usually muddy habitats that develop adjacent to springs and have unique floras and faunas, including several species of salamanders. In part, the biotic uniqueness is due to the characteristically cool tem-

Mike Torocco

Small streams, seeps, and springs are important habitats for many amphibians, most notably salamanders. Dusky, Northern Spring, Red, and Two-lined Salamanders are generally restricted to these habitats. Seeps and springs are generally embedded within other habitats such as hardwood or spruce and fir forests. Elimination of forest cover increases temperature and sedimentation, and changes the character of these sensitive habitats.

peratures of these systems. Care should be taken that land-uses such as agriculture, silviculture, road construction, and development do not have unintended consequences on small streams, springs, and seepages. Springs and their associated seepages are usually small and vulnerable, but their size also allows for simpler measures of protection than some larger habitats. In the past, these "gullies" were often used as dumping places in residential and agricultural areas for debris, old equipment, and trash leading to slow discharge of contaminants into the streams.

CHARACTERISTIC SPECIES

Northern Two-lined Salamander, Northern Red Salamander, Northern Dusky Salamander, Seal Salamander, Spring Salamander, Green Frog, Pickerel Frog, Wood Turtle, Queen Snake, Northern Water Snake

MANAGEMENT GUIDELINES

MAXIMIZING COMPATIBILITY: Timberlands, Hunt Clubs, Farmlands, Recreation Lands, and other Integrated Land-uses
When benefiting amphibians and reptiles is secondary to other management objectives:

- **Meet or exceed forestry and agricultural Best Management Practices and Streamside Management Zone standards for stream health**. *For links to each state's BMPs, visit www.forestrybmp.net.*

- **When possible, exclude or limit livestock access to stream, spring and seepage habitats**. *Livestock will trample microhabitats and waste products will cause eutrophication, oxygen depletion, and amphibian larval death.*

Mike Torocco

Maintaining buffers of forest cover may protect springheads and their small, cold-water pools in which Spring and Two-lined Salamanders breed. Awareness of and protection for these small habitats will help minimize losses of Northeast biodiversity.

Joe Mitchell

Mountain streams in the Appalachian and Blue Ridge Mountains support a diverse streamside salamander assemblage, including Dusky Salamanders, Seal Salamanders, Northern Red Salamanders, and Northern Spring Salamanders. Streams require forest canopy cover to maintain cool water temperatures.

- **Minimize or eliminate agricultural, industrial, and residential contaminants, nutrients, sediments, and silt in watersheds containing springs and headwater streams.** *Control runoff and production of these various forms of pollution.*

- **Minimize or control motorized vehicle (including ATV) access to stream channels.** *Such activities will disrupt and destroy sensitive microhabitats and cause pollution.*

- **When using fertilizers and pesticides, be sure to follow label directions and adequately buffer streams, springs, and seepages.** *The directions on the labels are government mandated and have been tested for safety. Use the minimum amount necessary to achieve the management objective. Ensure there is an adequate buffer to prevent runoff. Do not empty or clean containers in streams or other wetlands.*

Joe Mitchell

Seal Salamanders may reach large population sizes in Appalachian and Blue Ridge Mountain streams. They are often referred as "spring lizards" by local fishermen.

- **Minimize use of riprap for shoreline stabilization.** *Borders of large rocks can impede turtle movements between aquatic habitats and upland nesting sites.*

- **Restrict and/or closely regulate collection and use of salamanders as bait.** *(see "Spring Lizards" information box*).

- **Evaluate beaver populations and their effects in the target area and control their numbers if necessary. Protect springs and seepages.** *Beaver alteration of streams will cause loss of the seepage habitats and the stream environment within which a specialized suite of species live. Creation of beaver ponds will kill sensitive species but make the area attractive to generalists.*

- **Minimize the number of road crossings over streams.** *The more crossings, the greater the chances of pollution and direct alteration of small streams, springs, and seepages.*

"SPRING LIZARDS"

Harvest of stream salamanders (known locally in the southern Appalachians as spring lizards) for bait may lead to declines in populations. Some states in the Northeast permit fishermen to collect Northern Dusky Salamanders, and some prohibit collections for bait. Other less common species, however, are virtually indistinguishable from common "duskies" and are therefore incidentally taken as bait, even by the well-intentioned. Release of unused bait salamanders into a system other than where they were collected can harm the native species.

—Mark Bailey

IDEAL: Refuges, Sanctuaries, and Preserves
When benefiting amphibians and reptiles is a PRIMARY objective, as with nature preserves, wildlife refuges, and private lands whose owners wish to optimize herpetofaunal diversity and abundance:

- **Avoid clearing or replacing natural vegetation along stream edges**. *Maintenance of canopy vegetation in stream riparian zones will help keep water temperatures cool and amphibian diversity high.*

- **Maintain stream floodplains in natural vegetation and avoid alteration.** *Natural vegetation in floodplains will slow flood rates, increase the nutrient content of floodplains, and replenish small pools. Complexity of habitats in such zones ensures that amphibians and reptiles will use these areas extensively.*

Phillip deMaynadier

Some of the salamanders associated with these streams may use forest habitats beyond the riparian zone.

- **Provide upland forested buffer habitat along the stream's riparian zone**. *Buffers should be as wide as possible. A minimum of two tree heights (100-150 meters) is important for water quality, organic inputs, and riparian habitat for stream amphibians*.

- **Leave snags, other woody debris, and rocks in streams to provide microhabitat**. *All these structures provide refugia for amphibians and reptiles. Juvenile and larval amphibians use these structures extensively to avoid predation by adults.*

- **Retain natural stream channel undulations, backwater areas, and floodplains**. *Do not channelize streams. Such alteration of stream courses removes habitat diversity that is important to amphibians and reptiles and the food web on which they rely.*

USGS Patuxent Wildlife Research Center, Northeast ARMI team

Eggs of Two-lined Salamanders are deposited under leaf litter and rocks along small streams. Pollution of these aquatic systems will harm eggs and larvae of these amphibians.

USGS Patuxent Wildlife Research Center, Northeast ARMI team

The Northern Red Salamander inhabits small streams, seeps, and springs. Brightly colored, they are rarely seen except by observant naturalists who look for them under rocks and logs along the edges of seeps and springs.

Joe Mitchell

Long-tailed Salamanders occur in small streams. Their larvae require clean water and are easily eliminated by siltation and pollutants, such as salts and oils from road run-off.

USGS Patuxent Wildlife Research Center, Northeast ARMI team

Northern Dusky Salamanders live in the edges of small mucky streams and seepages. Females deposit their eggs in depressions under cover and remain with them until they hatch. Like other streamside salamanders, they have no lungs and depend entirely on well-oxygenated water for respiration through skin adsorption.

- **Avoid storing chemicals, salt, manure, and other possible contaminants near streams.** *Control placement of such chemicals to prevent leakage and inadvertent input into streams.*

- **Do not alter spring flows and do not disturb the associated seepage areas**. *These small habitats are critical to several species of salamanders. Alteration of any kind will cause population decline and potential extirpation.*

- **Remove exotic vegetation**. *Non-native vegetation tends to overtake small streams and seepages, rendering them uninhabitable by the amphibians that need intact systems.*

- **Restrict activities upstream that could introduce contaminants downstream (e.g., water treatment plants, mining).** *Think at the landscape level. Remember that whatever is introduced upstream will likely make its way all the way downstream. Contaminants can affect a large area.*

- **Meet or exceed forestry and agricultural Best Management Practices and Streamside Management Zones standards for stream health**. *Meeting stream BMPs and SMZ standards is a good first step in providing habitat for amphibians and reptiles. For links to each state's BMPs, visit www.forestrybmp.net. In some cases, SMZs are adequate to protect aquatic-related amphibians and reptiles; however, in other cases, these practices may need to be modified, especially for species that migrate or disperse in and out of adjacent upland habitats.*

This is the Small Streams, Springs, and Seepages module of the PARC publication, HMG-3. ISBN 0-9667402-3-8. Please visit www.parcplace.org for further information, copies of the complete document, or a web-based version of these guidelines.

Kurt Buhlmann

RIVERS

Rivers are the major drainage arteries for watersheds in the Northeast. Although some are shallow with rocky bottoms, most have relatively large, deep channels and are steep-sided. Large volumes of water pass through these permanent ecosystems, sometimes at high flow rates, and temperature and turbidity fluctuate according to season, rain events and release schedules of major dams. As with fish, dams limit movement of amphibians and reptiles up- and downstream, especially species such as Hellbenders and Mudpuppies that are fully aquatic during all life stages. Amphibians and reptiles that inhabit such dynamic systems are usually able to tolerate extremes in water flow, whereas others find rivers to be barriers to dispersal.

Most rivers in the Northeast contain freshwater throughout most of their courses. Those near the Atlantic Coast, however, experience dramatic fluctuations in water depth twice daily. The daily fluctuation in the Hudson River, for example, is 3-4 feet up to 150 miles from the coast! Concentrations of salt water in tidal zones also vary depending on how much fresh water is being passed through the watershed. In lower portions of these rivers, salinities are higher in late

Mike Torocco

The Holtwood Dam on the Susquehanna River demonstrates the barrier effect to movements of riverine fish, amphibians, and reptiles. Exchange of genes above and below the dam is hindered or cut off completely. Some riverine herps (i.e., Hellbenders, Northern Map Turtles) do not thrive in the lake-like conditions upstream.

Linh Phu

Wood turtles mate in streams immediately following winter hibernation. In late spring they emerge from the streams to forage and nest in adjacent woodlands and fields.

Kurt Buhlmann

The natural rocky falls on the New River in West Virginia provide underwater structure and microhabitat for Hellbenders and Mudpuppies, as well as basking sites for River Cooters.

summer and fall than in winter and spring when rainfall amounts are usually greater.

Floodplains of rivers and large streams are used by many species of herps, some on a periodic basis given flood events. Floodplains are integral parts of riverine ecosystems and managers should take into account their role in conservation and management programs on their lands.

Threats to amphibians and reptiles in river systems include mortality from boat propellers, pollution, introduced predatory fish, and direct mortality from fishermen who kill unwanted catch, such as Hellbenders. Sedimentation is a major problem for many species because of its smothering effects on amphibian eggs, larvae and benthic prey (e.g., mussels) and their hiding places. Channelization for increased navigation by large ships and flood control measures all affect river-adapted amphibians and reptiles. Although land owners and managers may have little control over such activities, these aspects of large river management decisions may influence what can or cannot be done on adjacent property.

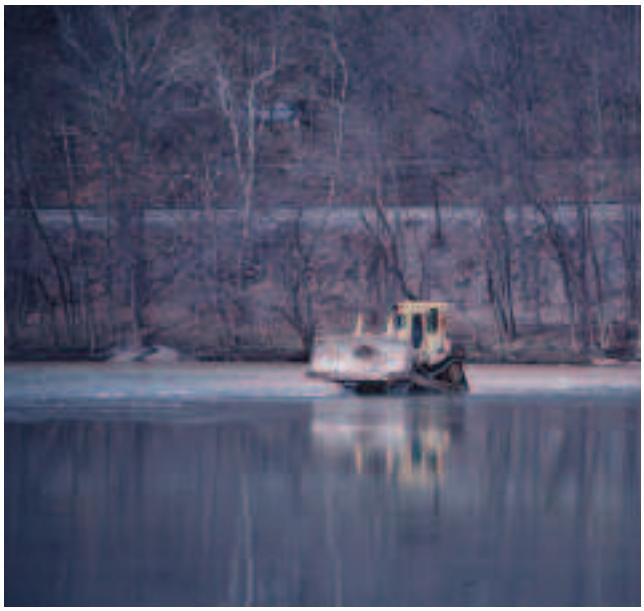
Rivers make up some of our most imperiled and degraded ecosystems. Although threats to riverine herps include pollution, excessive flow rates, and siltation, conservation efforts focus primarily on drinking water, recreation, and flood control. Reductions in high-intensity land-use within floodplains, such as agriculture and development, would limit the economic impact resulting from naturally occurring floods, help improve recreation opportunities, and improve drinking water quality while simultaneously enhancing habitat suitability for herpetofauna and other riverine wildlife.

CHARACTERISTIC SPECIES

Hellbender, Mudpuppy, Common Map Turtle, Musk Turtle, River Cooter, Snapping Turtle, Spiny Softshell Turtle, Wood Turtle, Northern Water Snake

MANAGEMENT GUIDELINES

MAXIMIZING COMPATIBILITY: Timberlands, Hunt Clubs, Farmlands, Recreation Lands, and other Integrated Land-uses
When benefiting amphibians and reptiles is secondary to other management objectives:



Kurt Buhlmann

Operating heavy machinery in rivers can be destructive to the bottom-dwelling fauna, notably freshwater mussels and hellbenders. It is illegal in some states.

Robin Jung-Brown

Northern Water Snakes occupy rivers in the Northeast where they feed on frogs and small fish. They often bask on logs and branches that overhang the banks. They are not "water moccasins," and they are not venomous. The true venomous Cottonmouth occurs no farther north than southeastern Virginia.

Kurt Weiskotten

Slow-moving rivers usually support emergent vegetation along shallow margins and offer habitat to many species of amphibians and reptiles. Bullfrogs, Green Frogs, Red-spotted Newts, and several species of turtle will occur here.

Kurt Buhlmann

Downed timber and undercut banks provide hibernation sites for Wood Turtles along a northern New Jersey river.

- **Meet or exceed forestry and agricultural Best Management Practices and Streamside Management Zones.** *If your situation is not covered by these guidelines, consider contacting PARC, NRCS, your state forestry commission, or your state Natural Heritage agency to determine what riparian zone management practice will best benefit your local amphibians and reptiles.*

- **When using fertilizers and pesticides, be sure to follow label directions and adequately buffer rivers.** *The directions on the labels are government mandated and have been tested for safety. Use the minimum amount necessary to achieve management objectives. Ensure there is an adequate buffer to prevent runoff.*

- **Minimize activities that alter flow or temperature regimes.** Discharges from dams should be scheduled to coincide with natural flooding cycles and to maintain base flow rates during drought periods; natural seasonal flow and temperature regimes should be maintained.

- **Minimize or exclude industrial, agricultural, and residential runoff.** *Waters from these sources carry pollutants that can harm aquatic life, including amphibians and reptiles.*

- **Limit or avoid livestock watering activities in rivers and develop alternative watering sites.** *Livestock will trample eggs in turtle nesting sites and their waste products may cause eutrophication, oxygen depletion, and amphibian larval death.*

- **Stabilize impaired riverbanks to allow wildlife access corridors to floodplains and upland nesting sites.** *Steep, undercut, and blocked banks prevent animals from using river resources by blocking their access.*

- **Restrict public access to nesting sites and other sensitive habitats.** *Turtle nesting sites along river banks and in riparian zones can be adversely impacted by excessive recreational activities.*

- **Keep snag removal activities to the minimum necessary for boat traffic**. *Components of a river's flow regime, woody and rocky structure provide important shelter, basking, and other microhabitat.*

- **Avoid introducing non-native game fish and other exotic species**. *Propagation and stocking projects should focus on the restoration of native fishes, mollusks, and invertebrates.*

- **Limit harvest and indiscriminant killing of amphibian and reptile species and/or enforce existing regulations more strictly**. *Shooting basking turtles and snakes for sport remains a persistent problem throughout parts of the Northeast as does killing of Hellbenders by fishermen who mistakenly fear they are venomous or impact sport fish populations. These practices may be contributing to the decline of some species.*

Joe Mitchell

The Hellbender, the largest salamander in river systems in the Northeast, is sometimes caught on fishermen's baited hooks and often killed. Hellbenders require clean and clear-flowing rivers, with gravel substrates and large rocks under which they hide. They are known to live as long as 30 years. Hellbenders are harmless and eat crayfish.

- **Provide conservation-related educational materials to boaters, fishermen, and other recreational visitors.** *These users would likely aid in amphibian and reptile conservation if they knew the problems and potential solutions. Most would welcome useful educational materials.*

- **Roads should be routed to avoid floodplains and nesting areas**. *Road mortality of amphibians and reptiles is usually highest in these areas.*

- **Dispose of uncontaminated dredge spoil to areas that would benefit nesting turtles.** *Although dredging degrades habitat quality for some species, spoil piles that are high in sand content can serve as important turtle nesting habitat if deposited above the high-water mark along the shore or as created islands. NOTE: Professional input from local herpetologists might be needed as new sandy beaches can also attract egg predators and, in some cases, elevate nest loss.*

- **Avoid filling in wetlands connected to rivers and river floodplains**. A*mphibians and reptiles use such habitats extensively.*

For detailed, site-specific guidelines regarding restoration of stream banks and associated aquatic habitats, check with your local NRCS office (county directory available at www.nrcs.usda.gov).

IDEAL: Refuges, Sanctuaries, and Preserves
When benefiting amphibians and reptiles is a PRIMARY objective, as with nature preserves, wildlife refuges, and private lands whose owners wish to optimize herpetofaunal diversity and abundance:

- **Avoid clearing vegetation along river banks or replacing natural vegetation with non-native species.** *Vegetation cover along river banks provides habitat for many species of amphibians and reptiles. Vegetation cover will minimize thermal variation and excessive bank erosion.*

- **Restore upland buffer habitats along the river's riparian zone.** *A width of several hundred feet is recommended.*

- **Allow natural movement of sand and gravel: retain sand and gravel bar-related processes by avoiding in-stream mineral extraction, vehicular traffic, and other disruptions to riverbeds.** *Sand bars and other open habitats in and along rivers provide basking sites and, most importantly, nesting*

Kurt Buhlmann

Spiny Softshell Turtles inhabit clear rivers with sand bottoms in the western portion of the Northeast, as well as Lake Champlain and the lower parts of the Ottawa River. Softshell turtles are susceptible to river pollution.

Mike Torocco

Forested riparian margins along rivers provide shade and cover, as well as help to maintain appropriate water temperatures.

Kurt Buhlmann

Large hydroelectric dams, such as Bluestone Dam on the New River, West Virginia, can alter river environments and affect fauna by increasing natural summer low flows and decreasing winter high flows. Temperatures downstream are colder than normal and the water has less oxygen due to the release of water from the bottom of the upstream reservoir.

Wayne Van Devender

Northern Map Turtles inhabit a number of northeastern rivers, including the Susquehanna, Delaware, and St. Lawrence. Map turtles feed on mussels and snails, thus their persistence is tied to water quality and the survival of endangered mollusks.

sites for turtles. Allowing natural formation of such places will also enhance natural ecological processes in the river and benefit many other species.

- **Avoid alteration of river undulations and backwater areas.** *Do not channelize rivers and large streams. Channelization destroys many microhabitats used by amphibians and reptiles in water and along the banks.*

- **Allow the natural buildup and movement of woody debris, banks, and rocky structures.** *Do not remove snags and rocks. These structures are used as basking sites by snakes and turtles.*

- **Exclude point source and non-point source pollution.** *Seek ways to minimize or eliminate such sources of pollution.*

- **Follow label instructions for use of agricultural chemicals and proper disposal of empty containers**. *Do NOT rinse canisters in river or stream water.*

- **Limit or avoid the use of rip-rap, bulkheads, or other structural modifications that could trap or impede movements of amphibians and reptiles.** *Unnatural objects around the shoreline inhibit use of these areas and interfere with movements into and out of the water. Rip-rap can trap animals and cause them to die inhumane deaths.*

This is the Rivers module of the PARC publication, HMG-3. ISBN 0-9667402-3-8. Please visit www.parcplace.org for further information, copies of the complete document, or a web-based version of these guidelines.

Kurt Buhlmann

ESTUARINE AND COASTAL

Estuarine and coastal ecosystems are truly dynamic environments. Salt in these waters challenges the physiology of amphibians and reptiles because these vertebrates are adapted to fresh water. Wave action, tidal surges, cyclical turnover of salt and fresh water, wind, sand, storms, changing temperatures, and the many predators in these habitats challenge life in these places. Estuarine systems include open bays, tidal rivers, and salt marshes characterized by salinities that vary monthly, seasonally, and even daily when storms occur. Several species of amphibians and reptiles inhabit estuaries because they are able to tolerate salt or brackish water permanently or periodically. Coastal zones include beaches, sand dunes, and maritime forests. A higher diversity of amphibians and reptiles live in these habitats. True marine habitat on the other hand supports relatively few reptiles, and nearly all of those are sea turtles. These large reptiles routinely occur in large estuaries in the Northeast such as Chesapeake and Delaware bays and Long Island Sound. The bays are critical nursery grounds for juvenile sea turtles. The Diamond-backed Terrapin is the only true estuarine reptile in the United States and occurs in estuaries from Cape Cod southward.

Matt Aresco

Tidal estuarine wetlands along the North American coast are highly productive ecosystems. They are often polluted from agricultural and urban activities. Diamond-backed Terrapins occur in these marsh systems.

Keith Johnson

The Diamond-backed Terrapin is the only truly estuarine reptile in the Northeast. Their populations are declining from loss of habitat, drowning in recreational crab pots, road mortality during nesting excursions, and commercial exploitation.

Joe Mitchell

Maritime forests occur on secondary dunes and support a diversity of reptiles such as Black Racers and Six-lined Racerunners that are adapted to living in this hot and dry environment.

Several species of amphibians and numerous reptiles occur on barrier islands and along oceanic shorelines of the Northeast. Management of these animals in estuarine and coastal zones should include considerations of their populations in these waters but also on the land areas adjacent to them. Barrier islands are bordered on the bay side by brackish marshes and intertidal swales and on the ocean side by sandy shorelines and dunes. Barrier islands and mainland shorelines receive periodic over-wash that may inundate freshwater ponds or pools. The dynamic nature of these habitats can seriously affect the amphibian and reptile populations that use them.

Beaches and dunes on barrier systems are critical nesting habitats for sea turtles, all of which are protected. The northernmost-known nesting sites are in Virginia. Estuaries, barrier islands, and most dune areas are also used extensively by Diamond-backed Terrapins. This species is experiencing major declines. Pollution has killed turtles and destroyed nesting beaches in many areas. Such habitats for turtles and their nests are important targets for active management and protection. Causeways across salt marshes are also important habitats because Diamond-backed Terrapins nest on them extensively. Unfortunately, vehicular traffic causes high mortality rates of females seeking nesting sites. Management and conservation projects offer challenging opportunities to land managers, biologists, and landowners.

Another challenge is to minimize the loss of individual sea turtles and Diamond-backed Terrapins from nets, trawls, and commercial and recreational crab pots. Although there are laws and regulations that should help this problem, the reality is that these turtles are still declining in the Northeast.

CHARACTERISTIC SPECIES

Estuaries — Diamond-backed Terrapin, Kemp's Ridley Sea Turtle, Loggerhead Sea Turtle; **Coastal Zones** — Fowler's Toad, Green Treefrog, Southern Leopard Frog, Eastern Mud Turtle, Snapping Turtle, Northern Water Snake

MANAGEMENT GUIDELINES

MAXIMIZING COMPATIBILITY: Timberlands, Hunt Clubs, Farmlands, Recreation Lands, and other Integrated Land-uses
When benefiting amphibians and reptiles is secondary to other management objectives:

- **When feasible, planned activities to avoid nesting periods (May-July) and hatching periods (August-September) of turtles**. *If the specific area needs management, then do so only before or after the nesting and hatchling emergence season.*

- **When possible, maintain existing adjacent coastal wetlands that act as buffers for estuarine systems.** *Limit the amount of land and brackish habitats lost to housing development and its infrastructure in these systems.*

- **Where practical, remove sources of garbage and food that may attract predators.** Subsidized predators (e.g., raccoons, skunks) kill many species and can completely eliminate all the eggs laid by a turtle population.

- **Limit pedestrian and motorized traffic on beach-**

Kurt Weiskotten

The coastal zone along the northeastern coast of Maine is rocky and dotted with numerous islands. The Maritime Garter Snake is the only reptile that occurs in this habitat.

Kurt Buhlmann

A Leatherback Sea Turtle washed up on a Virginia barrier island. Plastic bags are mistaken for jellyfish and ingested by Leatherback Sea Turtles, leading to intestinal blockage and mortality.

Harriet Forrester

A juvenile Diamond-backed Terrapin hides in salt marsh grasses to avoid the many predators that can easily eat this small turtle.

es and adjacent shorelines, including boats, jet skis, dune buggies, and ATVs.

- **Seek to incorporate herpetofauna habitat needs into development plans.** *Allow for naturally vegetated shorelines and dunes. Where possible, provide forested or marsh dispersal corridors between creek channels.*

- **Identify road-crossing areas of Diamond-backed Terrapins**. *Install signs to alert drivers to turtles on the road. Reduce speed limits during the nesting season. Consider temporary road closings if possible.*

- **Install signs around turtle nesting areas to discourage human activity during turtle nesting season.** *Educational signage may help prevent nest site destruction.*

- **Use oversized culverts to maintain natural saltwater flow patterns.** *These culverts may also allow Diamond-backed Terrapins to move freely and safely where roads or other manmade structures are present.*

- **Use innovative, non-toxic techniques for mosquito control where possible.** Excessive use of insecticides can disrupt food chains by reducing the abundance of important invertebrate and small vertebrate prey. Many biologically based controls for mosquitoes are environmentally sensitive and species-specific. Consult a licensed pesticide specialist before using any insecticide.

- **If fencing is needed to restore damaged dunes, use only in areas where it will not interfere with Diamond-backed Terrapins and sea turtles.** *Provide*

Kurt Buhlmann

Human manipulation of marshes, whether fresh or salt, will cause changes in their ecology. In Virginia Beach, the use of bulkheads lead to salt water intrusion into a freshwater swale wetland with mortality of the bald cypress trees.

Kurt Buhlmann

Forgotten crab pots kill Diamondback Terrapins by drowning them. This pot contains the shell of a female terrapin scoured by crabs, as well as a live male terrapin. "Ghost traps" abandoned or lost by commercial or recreational crab trappers continue to kill untold numbers of terrapins. Educational outreach may minimize the problem, as would the use of turtle excluders that prevent all but the smallest terrapins from entering the traps, with no impact on crab catch.

gaps of sufficient size in beach armament/ seawalls to accommodate nesting terrapin and sea turtles.

- **Remove, reduce, or modify lighting that affect known turtle nesting areas.** *Unnatural lighting inhibits adult nesting behavior and causes hatchlings to crawl toward lights. Hatchlings use cues from the sea and sky interface for direction; artificial lights interfere with this process. Avoid installing lighting on beaches or avoid use during nesting (May – July) and hatching (August – September) seasons.*

- **Encourage use of turtle-friendly fisheries equipment and excluder devices in crab traps.** *The unintentional take of marine turtles and Diamondbacked Terrapins is a significant source of unnatural mortality.*

IDEAL: Refuges, Sanctuaries, and Preserves
When benefiting amphibians and reptiles is a PRIMARY objective, as with nature preserves, wildlife refuges, and private lands whose owners wish to optimize herpetofaunal diversity and abundance:

- **Maintain or restore natural vegetation, especially where beach and dune stabilization is an issue. Exclude or remove exotic plant species.** *Many*

Stephanie Szerlag

Female Diamondback Terrapins on nesting forays are killed on causeways that span the salt marshes. Additive mortality from automobiles leads to population declines of these long-lived animals.

Dave Botherton

Coastal dunes and swales are home to several species of snakes and lizards. Dunes also protect the coastline from storms and erosion.

reptiles and amphibians are specifically adapted to survive in native vegetative communities.

- **Maintain natural shoreline and dune integrity and restore them where possible.** *Maintain or restore natural tidal and wave action. Pilings, sea walls, and other manmade disruptions to tidal process may alter flow regimes, thereby degrading habitat suitability*.

- **Minimize or eliminate point source and non-point source pollution.** *Pollution of all sorts threatens or destroys microhabitats used by amphibians and reptiles. Actions to prevent pollution may require collaboration with neighbors and others in the area.*

- **Remove sources of garbage and food that may attract predators.** *Subsidized predators kill many species and can completely eliminate all the eggs laid by a turtle population.*

- **Protect adjacent complementary habitats, like dunes, swales, and maritime forests, to allow for seasonal movement of species.** *Reptiles and amphibians in these systems move considerable distances. Allowing movements between habitat types aids in population survival and genetic diversity.*

- **Maintain or restore natural hydrological cycles, including storm over-wash and formation of sand bars on beaches and barrier islands, by removing jetties, pilings, and revetments that alter natural sand flow.** *Maintenance of large-scale natural processes will enhance the habitats used by estuarine and coastal zone amphibians and reptiles.*

- **Exclude or remove non-native invasive plants in marshes and on dunes.** *Non-native plants are not likely to be as effective in dune stabilization and may unsuitably alter natural microhabitat structure for nesting turtles. Non-native invasive plants may choke out native species.*

- **Prevent ATV use on beaches and dunes used for nesting by Diamond-backed Terrapins and sea turtles.** *Killing and noise-related disruptions of natural behaviors are unfortunate side effects of recreational access. ATVs and other motorized vehicles compact soil, increase erosion, provide corridors for invasive plant species along trails, elevate vehicle-related mortality rates, and cause noise-related disruptions of faunal activities.*

- **Minimize barriers to movements of females nesting on beaches, as well as emerging hatchlings when they hatch.** *Physical barriers could prevent*

Kurt Buhlmann

Salt marsh habitat at low tide. Diamondback Terrapins must be able to move between tidal creeks and salt marsh flats. Bulkheads and riprap prevent such movements.

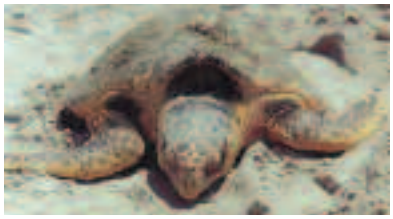
Kurt Buhlmann

Each May and June, female Diamondback Terrapins are killed in large numbers as they search for nesting sites above the high tide line. Many terrapins are drawn to the edges of causeways that span salt marshes and connect the mainland with barrier islands. Rescuing large numbers of terrapins from roadways has become an annual event in some states. The real management challenge is to provide safe nesting areas while keeping terrapins from accessing the causeways.

female sea turtles and Diamond-backed Terrapins from reaching nest sites and hatchlings from reaching the sea.

- **Use non-toxic techniques for mosquito control if possible.** *Use innovative techniques for mosquito control. Avoid ditching, introduction of exotic fish, and excessive use of chemicals. Excessive use of insecticides can disrupt food chains by reducing the abundance of important invertebrate and small vertebrate prey. Many biologically based controls for mosquitoes are environmentally sensitive and species-specific. Consult a licensed pesticide specialist before using any insecticide.*

- **Remove or modify lighting that affects known turtle nesting areas.** *Unnatural lighting inhibits nesting behavior and causes hatchlings to crawl toward lights.*



Cindy Driscoll

The Loggerhead Sea Turtle is an annual visitor to northeastern coastal areas. The Chesapeake Bay is the largest nursery for juveniles of this species along the Atlantic coast; many also spend summers in the waters around Long Island, NY. Their presence is linked to the health of bay shellfisheries.

- **Limit shoreline development where possible.** *Development destroys or fragments habitat, increases pollution, elevates vehicle- and other human-related mortality, cause noise-related disruptions to wildlife activities, and can contribute to pollution.*

- **Specific actions for Diamond-backed Terrapins:**

  - *Identify intensively-used nesting areas and design strategies that reduce female nesting mortality and nest predation.*

  - *Post signs for motorists that identify areas where terrapins cross roads while searching for nesting sites. Reduce roadway speed limits during the nesting season, May-mid-July.*

  - *Provide educational materials that illustrate the drowning potential to terrapins in abandoned and infrequently-checked crab pots.*

This is the Estuarine and Coastal module of the PARC publication, HMG-3. ISBN 0-9667402-3-8. Please visit www.parcplace.org for further information, copies of the complete document, or a web-based version of these guidelines.

Don Cameron

HARDWOOD FORESTS

Much of the Northeast was covered with hardwood forests of various species compositions, depending on elevation, aspect, and location, before European colonization and wide-scale clearing. Major forest types included oak-chestnut-hickory, elm-ash-cottonwood, and maple-beech-birch. In some areas, aspen was mixed with birch. Pine or hemlock was interspersed among the oaks in many locations. Hardwood forests still remain in much of the Northeast but introduced diseases and pests, such as the chestnut blight, Dutch elm disease, and hemlock wooly adelgid, have altered species compositions in many areas.

Hardwood forest trees are deciduous and have extensive root systems. They help to create a three-dimensional forest floor structure of leaves, organically rich soil, and subterranean passageways that supports a diversity of predators and prey, including amphibians and reptiles. Decomposing logs and limbs (downed woody debris and leaves) provide critical microhabitats for many species. Herbaceous vegetation, shrubs, and understory trees add structure to the forest above ground. The soils tend to be relatively moist compared to pine forests that develop on coarser, sandy soils. Energy flow through amphibians and rep-

Don Cameron

Hardwood forest canopy usually allows sunlight to filter down to the forest floor. The mosaic of sunlit patches helps to generate the rich herbaceous cover that supports populations of woodland salamanders.

Phillip deMaynadier

Hardwood forests at the northern latitudes of the Northeast contain more birch, beech, elm, sugar maple, and ash than forests farther south. However, they function in much the same way and have some of the same species of amphibians and reptiles.

Kurt Weiskotten

Eastern hardwood forests are dynamic systems with full to partial canopies, gaps from tree falls, an understory of herbaceous plants, layers of leaves in various stages of decomposition, and rich soil. Slimy and Red-backed salamanders, Ring-necked and Worm Snakes, and Box Turtles are naturally abundant in these rich habitats.

Linh Phu

Much of the Appalachian Mountains are covered with hardwood forests composed of mixed oaks, hickories, and tulip poplar. Historically, American chestnut dominated these forests. Large tracts of this region, especially in the southern Appalachians are owned and managed by the U.S. Forest Service.

tiles in northeastern hardwood forests is substantial. The biomass (energy in animal tissues per square meter) of a single Red-backed Salamander population in New Hampshire was twice that of all the birds during peak breeding season and about equal to that of all the small mammals in the area. Other terrestrial salamander species can also reach similar high densities in some areas (e.g., Appalachians). Thus, amphibians and many reptiles that act as predators and prey are important players in energy dynamics in mesic upland forests.

The diversity of amphibians and reptiles found in any hardwood forest depends on many factors, including forest structure, canopy openness or closure, and the history of the landscape. Slope and aspect influence temperature and moisture; elevation and latitude also determine which species are present. Forest structure and canopy openness varies across the landscape due to tree density, gaps in the forest created by tree blow-downs, and amount of edge habitat. How humans used the land historically affects which species occur there. Severely degraded soils from centuries of intensive agriculture will support fewer species than soils in areas that have largely remained forested. Generally, most amphibians tend to rely on cool, moist habitats to maintain their critical skin moisture, whereas most reptiles need more sunlight and higher temperatures. Thus, a mosaic of microhabitats in a mesic hardwood forest will support a higher diversity of herps than a forest with uniform environmental conditions.

Amphibians and reptiles are affected by forest patch size, its isolation from other patches, the amount of edge around the patch, water systems in the patch and

distance from water sources, tree density, and canopy cover. Fragmentation of forests across the landscape creates a patchwork of habitats of various sizes and degrees of isolation. Herp populations in northeastern forests contend with the many problems associated with small population size, isolation, and susceptibility to disease and catastrophic environmental events. Acid precipitation impacts herps on the forest floor and in aquatic systems associated with mesic hardwood forests. Fewer salamanders have been found in areas of forests with low pH soils, for example.

CHARACTERISTIC SPECIES
Red-backed Salamander, Blue-spotted Salamander, Northern Slimy Salamander, Spotted Salamander, Wood Frog, American Toad, Five-lined Skink, Eastern Worm Snake, Eastern Ratsnake, Ring-necked Snake, Eastern Box Turtle, Milk Snake, Timber Rattlesnake, Copperhead

MANAGEMENT GUIDELINES

MAXIMIZING COMPATIBILITY: Timberlands, Hunt Clubs, Farmlands, Recreation Lands, and other Integrated Land-uses
When benefiting amphibians and reptiles is secondary to other management objectives:

- **On sites where options exist, favor site preparation techniques that minimize soil disturbance.**
- **When possible, harvest during drier periods or periods with snow cover, and use low-pressure tires.** *Harvesting during dry periods minimizes rutting and disturbance to soil structure.*
- **Leave stumps, some logs, dead standing snags, and other coarse woody debris following timber harvests.** *Many amphibians and reptiles require woody debris and stump holes for shelter, nesting, and foraging.*
- **Meet or exceed existing Best Management Practices for sediment and erosion control.**
- **When timber is harvested, consider harvesting techniques such as group selection, single-tree selection, or small clearcuts.** *Seek to minimize the impacts of the harvest prescription on the forest floor.*

USGS Patuxent Wildlife Research Center, Northeast ARMI team

The Red-backed Salamander can reach very high densities in northeastern hardwood forests. The biomass (combined weight of all individuals) in some sites can be more than all the mammals combined and equal to all the birds combined.

Will Brown

Red-backed Salamanders occur in two primary color phases, one with the red stripe (red-backed phase) and one without the stripe (lead-backed phase). These woodland salamanders are major predators of invertebrates and are themselves prey for snakes, birds, and some mammals.

- **Limit construction of new logging roads and staging areas; return the area to natural contours and conditions when they are no longer needed.** *Minimize the footprint of your operation in the harvested area.*
- **When using fertilizers and pesticides, be sure to follow label directions and adequately buffer rivers.** *The directions on the labels are government mandated and have been tested for safety. Use the minimum amount necessary to achieve management objectives. Ensure there is an adequate buffer to prevent runoff.*

OAK DECLINE: AN ECONOMIC AND ECOLOGICAL THREAT.
Oaks are valuable to humans as a timber source and to wildlife as a food source. In some parts of the Northeast, xeric oak and pine-oak ecosystems are declining significantly due to a variety of factors such as pathogens, parasites, and fire suppression. In addition to having economic consequences, the loss of oaks in particular has serious implications for many wildlife species, including amphibians and reptiles. Acorns are a fundamental element in the forest floor food chain, providing forage for many wildlife species, including squirrels, rats and mice (snake prey). In many cases, the restoration of natural fire frequency, intensity, and seasonality may be all that is needed to reduce less-desirable timber species (sweetgum, red maple, etc.) and increase higher-quality oaks.

USGS Patuxent Wildlife Research Center, Northeast ARMI team

Eastern Box Turtles are especially prevalent in hardwood forests of the Northeast. They eat worms, fruits, and mushrooms. Isolated populations in small forest fragments eventually die out due to road mortality and low reproductive success. Because Box Turtles live so long, sightings of individual turtles often continue after the population is functionally extinct.

Joe Mitchell

The Peaks of Otter Salamander is an example of a hardwood forest salamander that has a very small range. It occurs only in a small section of the Blue Ridge Mountains in Virginia, and is likely a glacial relict. Loss of the hardwood forests on that mountain could endanger the species.

IDEAL: Refuges, Sanctuaries, and Preserves
When benefiting amphibians and reptiles is a PRIMARY objective, as with nature preserves, wildlife refuges, and private lands whose owners wish to optimize herpetofaunal diversity and abundance:

- **Maintain or restore native forest cover**. *Protect stands of older trees, especially old-growth stands, from harvest. Maintain a diversity of forest age classes, densities, and structures either within the same stand or among adjacent stands. While many mesic hardwood-related amphibians and reptiles need mature forest stands, others require a variety of structure and composition regimes.*

- **Maintain or restore downed woody debris on the forest floor.** *Allow limbs and snags to stay in place and decompose naturally. Salamanders and their prey, notably invertebrates, use such microhabitats extensively.*

- **Avoid fragmenting large blocks of forests with roads, field crops, developments, and other barriers between them.** *Habitat fragmentation creates small population sizes that are subject to a host of problems, especially if individuals cannot migrate between them. Some species will not cross open spaces, and those that try are subject to exposure, desiccation, and predation.*

- **Give special consideration to unique habitat features within the forest, such as ephemeral wetlands, springs, seepages, and rock outcrops**. *These microhabitats are special places for many species of amphibians and reptiles. They act as critical areas; without them these species will not be present.*

- **When timber is harvested, consider harvesting techniques such as group selection, single-tree selection, or small clearcuts.** *Where shade-dependent species or mature forest obligates are a concern, consider leaving patches of large trees. Forested habitat that can serve as refugia for forest-dwelling animals from which they can more easily disperse and repopulate harvested areas as they mature. Where early successional obligate species are a concern, clearcuts may be preferred. Where both late- and early successional species are present, a patchwork of harvest practices may be appropriate.*

Kurt Buhlmann

Invasive plant species can change the structure of hardwood forest understories. Barberry has established itself in thick patches along this trail in the Delaware Water Gap National Recreation Area. The effects of this spiny plant on amphibians and reptiles are unknown, but walking through the forest is certainly now less pleasant for humans.

Will Brown

Eastern Rat Snakes are common inhabitants of hardwood forests in the Northeast, although there are becoming increasingly rare at the northern end of their range. They help to regulate rodent communities and will prey on bird eggs and fledglings.

- **Manage deer populations so that forests will maintain understory structure crucial to amphibians and reptiles.** *Too many deer can have negative impacts on the herbaceous and shrub layers in hardwood forests. Salamanders climb onto this vegetation to forage on insects on wet nights.*

- **Ensure that the forest floor structure is maintained in as natural a state as possible.** *Leave logs, snags, leaves, and other woody debris on site; replace as needed.*

- **Minimize or eliminate barriers to dispersal across the landscape between forest fragments; leave or add windbreaks and hedgerows.** *Most species risk exposure to predation and desiccation if they try to cross open spaces.*

- **To the extent possible, mimic natural disturbance patterns, such as wind-throws and fire, when conducting forest management activities.** *Such actions provide natural openings in the canopy and alter the forest structure, thus making these small places attractive to species that could not survive in a closed canopy forest.*

- **Avoid locating trails through core habitat, seasonal wetlands, and intact old-growth forests**. *Trampling of the leaf litter, downed woody debris, and other microhabitat features on the forest floor can impact salamander populations. Public access to wetlands via trails increases the chances for pollution and collection of amphibians and reptiles.*

- **Carefully monitor the use of insecticides for control of gypsy moth and other invasive insects.** *Non-targeted insects, specifically moths, are often affected, impacting the prey base of amphibians and reptiles.*

THE VALUE OF FOREST OPENINGS

Box Turtles and many other reptiles need nesting areas where soils are well drained and where sunlight reaches the ground. Old borrow pits, quarries, and other man-made openings may actually be of considerable importance to nesting reptiles. Before reclaiming such sites, determine first if natural openings are available. When the only available sun-exposed ground is along roadsides and highways, road mortality may occur as females seek nesting sites.

Forest openings or tree-fall gaps caused by wind, called gaps, provide sunlit patches to lizards and snakes that need basking sites. Such gaps are integral parts of a dynamic hardwood forest. Ultimately, decomposing logs will provide habitat for terrestrial salamanders. Fallen trees and snags are essential microhabitat and should not be removed.

This is the Hardwood Forests module of the PARC publication, HMG-3. ISBN 0-9667402-3-8. Please visit www.parcplace.org for further information, copies of the complete document, or a web-based version of these guidelines.

Al Breisch

SPRUCE AND FIR FORESTS

The primary forest type in northern New England, notably Maine and northern New York, is comprised of red spruce and balsam fir. This forest dominates the poorly-drained and acidic soils of glacial origin in the Northern Appalachian-Boreal Forest ecoregion. Cold temperatures and soil conditions allowed this forest to remain relatively intact until recently. In areas with relatively fertile soils, deciduous trees such as yellow and paper birch, red maple, American beech, northern red oak, and sugar maple are interspersed with spruce and fir. At the highest elevations, this forest gives way to alpine vegetation.

In the southern portion of the Northeast, spruce and fir forests are limited to the highest peaks in the Southern Blue Ridge ecosystem. Canopy trees are often misshapen by high winds. In some cases, canopy trees may be sparse or entirely absent and replaced by heath or grassy balds. Spruce and fir forests are susceptible to insect outbreaks such as the native spruce budworm and the introduced balsam woolly adelgid.

Spruce and fir forests in the Appalachians support a high diversity of forest-dwelling salamanders in the

Don Cameron

Mature spruce and fir forests often contain swamps with cinnamon ferns and sphagnum. These forest floor habitats support a variety of cool-adapted amphibians and reptiles.

Phillip deMaynadier

Throughout the Northeast's higher latitudes and elevations, softwood forests, such as this red spruce-balsam fir type, may dominate the landscape providing habitat for northern species such as the Red-backed Salamander, Blue-spotted Salamander, Wood Frog including dorsally-striped northern forms), Red-spotted Newt, Maritime Garter Snake, and Northern Ring-necked Snake.

family Plethodontidae (See Appendix A), several of which are endemic (found no where else) to high elevation mountaintops. Amphibians in these habitats use cover objects (e.g., rocks, logs) on the forest floor for foraging, refugia and hibernacula. Some salamanders can reach high densities in the moss and duff layers. The few reptiles in these forests, such as Eastern Garter Snakes and Milk Snakes, need gaps in the canopy and exposure to sun. They are usually associated with rocky areas in this habitat.

Tom Pauley

The moist forest floor in red spruce forests in the mountains of West Virginia support a rich terrestrial salamander fauna due to the presence of mosses, ferns, and abundant ground cover.

CHARACTERISTIC SPECIES

Spotted Salamander, Four-toed Salamander, Red-backed Salamander, American Toad, Spring Peeper, Wood Frog, Eastern Garter Snake, Milk Snake, Red-bellied Snake

MANAGEMENT GUIDELINES

MAXIMIZING COMPATIBILITY: Timberlands, Hunt Clubs, Farmlands, Recreation Lands, and other Integrated Land-uses
When benefiting amphibians and reptiles is secondary to other management objectives:

- **Maintain connectivity of suitable habitats to facilitate dispersal and migration of reptiles and amphibians between forest stands**. *In some cases, retaining corridors may be an appropriate way to link suitable habitat. Stands that are separated from other forested stands by unfavorable habitat may limit the movement of amphibians and reptiles. Select locations for roads, fields, and openings carefully to avoid fragmenting forests. When establishing wildlife food plots, stay within the footprint of previous disturbances to avoid additional impacts.*

- **Allow dead, fallen trees and woody debris to remain and decompose naturally on the ground.** *These microhabitats are essential to forest floor amphibians and reptiles.*

- **Limit pedestrian and motorized vehicle access, including ATVs**. *Limiting human access will reduce the chances that amphibians and reptiles will be killed on roads and trails, their habitat trampled, and animals removed for the illegal trade in animals.*

- **Stabilize roadbeds and trails if erosion is a problem.** *Erosion of road and trail beds causes siltation in streams.*

- **Regulate the collection of mosses for personal use and commercial sale.** *Excessive moss harvest has the potential to damage salamander populations and their habitats.*

- **Manage deer populations so that forests will maintain understory structure crucial to amphibians and reptiles.** *Too many deer can have negative impacts on the herbaceous and shrub layers in hardwood forests. Salamanders use the moss and duff layer extensively, thus, removal of such cover could eliminate local populations.*

- **Where appropriate, maintain some forest canopy cover in its natural, unmanaged state.** *Canopy cover helps maintain cool temperatures and moist environments on the forest floor for salamanders, Wood frogs, and small snakes such as Red-bellied Snakes.*

- **Minimize soil disturbance (e.g., tire ruts, soil compaction) when using heavy equipment.** *Use low-pressure tires and limit equipment use to drier seasons or when the ground is frozen. Heavy equipment can disturb and compact soil, increase erosion and sediment, disrupt vegetative succession, and provide distribution corridors for exotic plants. Although some amphibian species may be able to breed successfully in tire ruts on low-traffic roads, the detrimental effects of excessive soil compaction and disturbances may outweigh the benefits.*

- **Leave large cull trees or patches of trees on harvested sites whenever practical**. *These patches may sustain pockets of intact forest floor cover and habitat for shade-dependent species until the surrounding harvest area achieves later succession stages.*

- **Minimize fragmentation of large tracts of forest**. *Fragmentation creates small populations with all the problems of inbreeding and susceptibility to disease and predation.*

Joe Mitchell

Red-backed Salamanders are likely the most abundant amphibian species in spruce and fir forests.

Will Brown

Ribbon Snakes are becoming rare species in the spruce and fir forests of the Northeast. They require grassy wetlands embedded in the spruce and fir forest type.

Joe Mitchell

Northern Ring-necked Snakes are predators of Red-backed Salamanders in spruce and fir forests. They inhabit the moist forest floor and may be affected by timbering activities that change the substrate temperature and moisture.

Steve Roble

The Blue-spotted Salamanders is a Northeast and upper Midwest species that breeds in wooded vernal pools. The species has a limited distribution in New Jersey.

Kurt Buhlmann

Relict high elevation spruce and fir forests in the Appalachian Mountains of Virginia and West Virginia are dying from air pollution. Management of these forests and their herp inhabitants presents challenges at a scale that most landowners will seldom face.

IDEAL: Refuges, Sanctuaries, and Preserves
When benefiting amphibians and reptiles is a PRIMARY objective, as with nature preserves, wildlife refuges, and private lands whose owners wish to optimize herpetofaunal diversity and abundance:

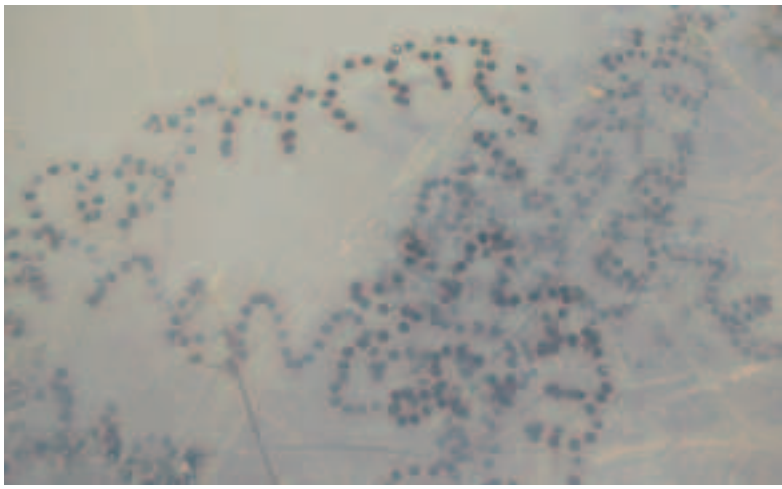
- **Avoid fragmenting large blocks of forests with roads, field crops, suburban developments, and other barriers.** *Habitat fragmentation isolates small populations in small patches that are subject to a host of problems, especially if individuals cannot migrate between them. Some species will not cross open spaces, and those that try risk predation and desiccation.*

- **Exclude motorized vehicles, including ATVs.** *Off-road drivers do not always stay on the trails provided. Trampling of amphibians and reptiles on the forest floor and trails is a threat from these vehicles. The mossy forest floor is particularly vulnerable to motorized vehicles and pedestrian traffic.*

- **Maintain and restore native forest cover where possible**. *Protect stands of older trees, especially old-growth stands, from harvest. Allow younger stands to reach maturity.*

- **Maintain or restore downed woody debris on the forest floor.** *Allow limbs and snags to stay in place and decompose naturally. Salamanders and their prey use such microhabitats extensively.*

- **Protect unique habitat features within the forest, such as ephemeral wetlands, springs, seepages, and rock outcrops**. *These microhabitats are important for breeding sites, foraging areas and hibernacula. Without them several species of amphibians and reptiles will not be present.*



Joe Mitchell

American Toads, like all toads, lay long strings of black eggs in shallow water. They are widespread in northeastern North America.

- **Prevent loss of moss and herbaceous ground cover by controlling deer populations and human access.** *Too many deer and loss of moss cover due to commercial harvest may alter the habitat enough to impact salamanders.*

- **Identify threats from acid precipitation.** *Acid precipitation impacts spruce and fir forests, streams, and the amphibians that occur in them. Seek ways to minimize or ameliorate the effects of the additional acidity.*

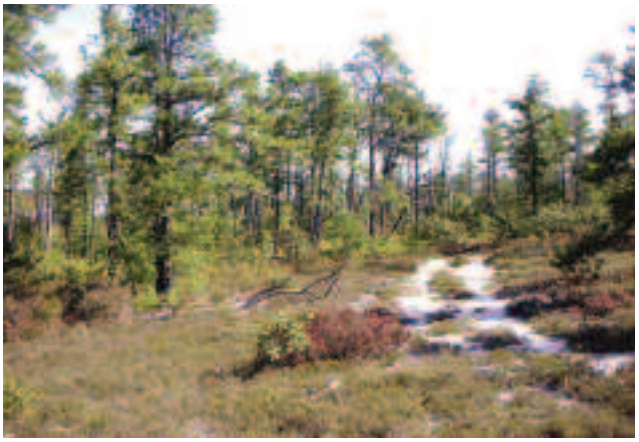
This is the Spruce and Fir Forests module of the PARC publication, HMG-3. ISBN 0-9667402-3-8. Please visit www.parcplace.org for further information, copies of the complete document, or a web-based version of these guidelines.

Kurt Buhlmann

XERIC UPLAND AND PINE FORESTS

Parts of the Northeast have xeric (low moisture), well-drained soils that do not support deciduous, broad-leaved trees. Such areas support a variety of pine forests. Examples are the pitch pine barrens in New York, the Pine Barrens in southern New Jersey, and the Virginia pine forests on south-facing slopes in the Blue Ridge and Appalachian mountains. In the Northeast, loblolly pine forests also occur on former agricultural fields in the Piedmont of Maryland and Virginia. Many pine forests have associated oak trees (e.g., scrub oak) but these tend to be sub-dominant. Naturally occurring pine forests are relatively open with an herbaceous ground cover and shrub layer. Recurring fire is an important component of natural pine forests that retards hardwood growth and maintains the more tolerant pine species. Where possible, fire should be a part of the manager's toolbox in this habitat.

Amphibians and reptiles use the forest floor extensively in pine-dominated habitats. Systems of decaying roots and stumps, as well as mammal tunnels, serve as hiding places and hibernacula. Moisture conditions affect activity patterns, with much of the amphibian activity correlated with periods of rainfall. Toads will stay underground for months until the surface is wet.



Mike Torocco

The Pine Barrens in southern New Jersey represents a unique ecosystem that supports amphibians and reptiles do not occur farther north. Encroaching urban development will make prescribed burns increasingly difficult and may cause this region to ultimately become the "Oak Barrens."

Reptiles are somewhat less limited by moisture. Embedded wetlands within some pine habitats support uncommon amphibians, such as Pine Barrens Treefrogs and Tiger Salamanders.

Joe Mitchell

Pine forests in the Northeast are targets of timber harvesting and management, as well as places slated for housing subdivisions. Management often results in mixed aged stands, as well as rutted roads. Some amphibians breed in these road rut pools.

Scott Smith

Many pine forests in the Northeast occur on mountains, or on the Coastal Plain, such as this one at Mount Misery in southern New Jersey. Low intensity prescribed fires would maintain the sparse understory and enhance this habitat for xeric-adapted amphibians and reptiles.

Joe Mitchell

Eastern Hog-nosed Snakes forage exclusively for toads in dry sandy and sand-loam soils in pine forests. Non-venomous Hognose Snakes will often roll over on their backs and play dead; they do not bite.

Joe Mitchell

Fowler's Toads occur in pine forests and other habitats with sandy soils. They require small pools of water for breeding and tadpole development.

CHARACTERISTIC SPECIES

Tiger Salamander, American Toad, Fowler's Toad, Pine Barrens Treefrog, Northern Fence Lizard, Black Racer, Copperhead, Hog-nosed Snake, Northern Pine Snake, Scarlet Snake, Timber Rattlesnake

MANAGEMENT GUIDELINES

MAXIMIZING COMPATIBILITY: Timberlands, Hunt Clubs, Farmlands, Recreation Lands, and other Integrated Land-uses
When benefiting amphibians and reptiles is secondary to other management objectives:

- **Maintain connectivity of suitable habitats to facilitate dispersal and migration of reptiles and amphibians between larger forest stands.** *In some cases, retaining corridors may be an appropriate way to link suitable habitat. Stands that are separated from other forested stands by unfavorable habitat may limit the movement of amphibians and reptiles. Locate roads, fields, and other openings carefully to avoid fragmenting forests. When establishing wildlife food plots, stay within the footprint of previous disturbances to avoid additional impacts.*

- **On sites where options exist, favor site preparation techniques that minimize soil disturbance.**

- **When timber is harvested, consider harvesting techniques such as group selection, single-tree selection, or small clearcuts.** *Where shade-dependent species or mature forest obligates are a*

Joe Mitchell

The Eastern Fence Lizard requires open canopies and lots of sunlight, as do most other lizards. They thrive in sparse-canopy pine stands.

Don Cameron

Most pine stands are tolerant of fire. Serotinous cones of some pine species open only after being burned. Fire maintained pine forests, often have sparse canopies with low herbaceous groundcover.

Mike Dorcas

Northern Pine Snakes are large and beautiful snakes of the New Jersey Pine Barrens. Pine Snakes have large home ranges. Habitat fragmentation, roads and automobile traffic are jeopardizing this species. Conservation strategies must include a landscape-level perspective and multiple land parcels, as most single private land holdings are not of sufficient size to maintain viable populations of this snake.

concern, consider leaving patches of large trees. Where both late- and early successional species are present, consider a patchwork of medium-sized clearcuts and similar-sized forested stands.

- **Consider maintaining or creating canopy gaps in managed pine forests.** *Such gaps in the canopy allow species that need sunlight to thrive in pine forests.*

- **Retain downed woody debris on the forest floor between fire cycles.** *Amphibians and reptiles use such debris extensively for shelter and foraging.*

IDEAL: Refuges, Sanctuaries, and Preserves
When benefiting amphibians and reptiles is a PRIMARY objective, as with nature preserves, wildlife refuges, and private lands whose owners wish to optimize herpetofaunal diversity and abundance:

- **Where feasible, restore natural fire frequency, intensity, and seasonality.** *Without fire, hardwoods often dominate pine forest ecosystems. Thick forest canopies shade out herbaceous groundcover, which is often the critical first link in the food chain.*

- **Consider prescribed burns to manage pine forests.** *Fire was likely an integral part of the history of many areas in the Northeast. Consult with a prescribed fire expert and a regional herpetologist to determine the correct management for your area.*

- **Avoid fragmenting large blocks of forests with roads, field crops, developments, and other barriers between them.** *Habitat fragmentation creates small population sizes that are subject to a host of problems, especially if individuals cannot migrate between them. Some amphibians and reptiles will not move across large open spaces, and those that try risk predation and desiccation.*

John Jensen

The Pine Barrens Treefrog has a restricted range in the Northeast, being known from the Pine Barrens of New Jersey. These treefrogs live in pine and hardwood forests and breed in acidic seasonal wetlands, as well as abandoned cranberry bogs.

Joe Mitchell

Eastern Hog-nosed Snakes provide great examples of how snakes can eat large prey. American Toads fill up with air as a defensive measure. Enlarged teeth in the snake's upper jaw puncture the toad, let the air out, and allow it to swallow the toad whole.

Joe Mitchell

Black Racers are xeric-adapted snakes that forage in the open grass and herbaceous ground cover in managed pine forests.

Joe Mitchell

The Eastern Hog-nosed Snake is the only species in the Northeast that plays dead after bluffing with head and neck expanded, to hopefully, avoid predation. Of course, all good dead snakes have to be on their backs, as this snake will quickly turn over on its back if you put it on its belly.

- **Protect unique habitat features embedded within the forest, such as ephemeral wetlands, springs, seepages, and rock outcrops**. *These microhabitats are special places for many species of amphibians and reptiles. They act as critical areas; without them these species will not be present.*

- **Leave logs, snags, and other woody debris on site; replace as needed.** *Amphibians and reptiles use such microhabitat features for shelter and foraging.*

- **Avoid removing stumps when landscaping or restoring habitat for amphibians and reptiles.** *Where possible, retain stumps as refuges for the area's amphibians and reptiles; they provide deep underground shelters as they decay.*

- **Work with knowledgeable state and regional herpetologists to minimize impact on native species through judicious use of timber prescriptions.** *Creative forest management will help maintain a diverse regional herpetofauna.*

This is the Xeric Upland and Pine Forests module of the PARC publication, HMG-3. ISBN 0-9667402-3-8. Please visit www.parcplace.org for further information, copies of the complete document, or a web-based version of these guidelines.

Mike Marchaud

GRASSLANDS AND OLD FIELDS

Grass-dominated habitats have increased in the Northeast due to extensive forest clearing and agriculture. Abandoned fields and reclaimed surface mines are quickly colonized by annual and perennial grasses that produce extensive ground cover. Small mammals use this microhabitat extensively and thus attract several species of predatory snakes. There is no canopy, thus high temperatures in warm months limit the occurrence of amphibians. Frogs and some salamanders may be present when there are associated microhabitats such as rock cover, downed woody debris from adjacent forests, ephemeral pools, and streams. When farmlands are in proximity to rivers and streams, Wood Turtles and Box Turtles may use them in spring and summer by for foraging on berries and earthworms. Patches of grasslands within extensive forest cover, at high elevations, and at northern latitudes offer open canopy areas where reptiles can achieve temperatures necessary for maintenance and embryonic development.

Natural grasslands in the Northeast include areas with mountain-top balds and pine barrens. Fire plays an important role in maintaining these natural systems. Fire frequency regulates the number and density of

Harriet Forrester

Grasslands in the Northeast are most often the historic result of land clearing for farming and grazing, and they vary in size and configuration. Abandoned agricultural fields often succeed back to forest, but may also be managed for herbaceous diversity, with benefits to certain birds, butterflies, and other insects that require open areas.

Kurt Buhlmann

A mountaintop bald in the George Washington National Forest is home to Eastern Garter Snakes, Milk Snakes, and Smooth Green Snakes. Debate continues as to how these mountaintop grasslands originated and remain open—perhaps by frequent lightning strikes, or perhaps grazing.

Joe Mitchell

Eastern Garter Snakes are common inhabitants of grasslands at all elevations. They are predators of salamanders, frogs, and earthworms. Their longitudinal stripes make them difficult to detect in the grasses.

pine and other fire-tolerant trees in these areas. Natural grasslands are generally rare in the Northeast. Farming and grazing for the past 300 years or so, perhaps earlier by bison, maintained most of the grasslands in the Northeast. Some grassland areas on northeastern farms support embedded wet meadows where the endangered Bog Turtle may occur.

CHARACTERISTIC SPECIES

American Toad, Northern Leopard Frog, Pickerel Frog, Eastern Box Turtle, Wood Turtle, Black Racer, Eastern Garter Snake, Eastern Milk Snake, Smooth Green Snake

MANAGEMENT GUIDELINES

MAXIMIZING COMPATIBILITY: Timberlands, Hunt Clubs, Farmlands, Recreation Lands, and other Integrated Land-uses
When benefiting amphibians and reptiles is secondary to other management objectives:

Gerald Schaffer

Smooth Green Snakes can be frequently encountered under large flat rocks within open grassy mountaintop balds.

- **Where mowing and haying are goals**:
  - *mow when reptiles and amphibians are least active (preferably prior to emergence from hibernation, e.g., November - February).*
  - *mow at high blade settings (8 inches or greater).*
  - *do first cutting after turtle nesting season is over (generally safe after mid-July).*

- **Rotate livestock frequently to prevent over-grazing.** *Over-grazing eliminates grass cover used by amphibians, reptiles, and other wildlife, and it increases erosion on slopes.*

- **Limit pedestrian and motorized vehicle traffic, including dirt bikes and ATVs except on established trails and roads.** *Excessive use of grasslands by humans and their vehicles can trample microhabitats used by amphibians and reptiles and increases erosion.*

IDEAL: Refuges, Sanctuaries, and Preserves
When benefiting amphibians and reptiles is a PRIMARY objective, as with nature preserves, wildlife refuges, and private lands whose owners wish to optimize herpetofaunal diversity and abundance:

- **Maintain the open nature of the habitat; promote a spatially-variable or sparse tree canopy cover appropriate for the area.** *Canopy provided by older*

Kurt Buhlmann

Patches of grassland habitat occur as a result of past rock quarry operations in the Northeast. The pile of rock remaining in the open habitat receives substantial sunlight and may attract Eastern Garter, Milk, Hog-nosed, and Copperhead snakes, as well as Fence Lizards. Such embedded microhabitat features provide basking and hibernation sites for reptiles.

trees may be desirable in a grassland community because it provides a variable microclimate and structures used by some species of reptiles, such as snakes and lizards.

- **Promote diverse, native grasses and forbs, and when necessary remove exotic plant species, woody encroachment, and woody succession.** *Many species require the physical structure (clumping) provided by native vegetation such as warm season grasses. Introduced vegetation does not form clumps but create mats, thus preventing use of the area by some amphibians and reptiles.*

- **If possible limit or prohibit off-road vehicle access.** *Trampling of grasslands will likely kill individual animals and destroy essential microhabitats.*

- **Maintain or restore connectivity between similar habitats and between complementary but dissimilar habitats.** *Amphibians and reptiles will move great distances between habitats. Natural corridors*

Kurt Buhlmann

A strip mine in West Virginia may provide habitat for grassland species if the reclamation follows best management practices.

Steve Roble

Northern Leopard Frogs spend substantial amounts of time away from wetlands and forage in grassland habitats. Indeed, Northern Leopard Frogs are often called "grass frogs" due to their frequent use of grasslands.

provide routes that minimize mortality due to predation and desiccation.

- **Restore natural fire frequency, intensity, and seasonality where appropriate.** *Fire-maintained grasslands, especially those with native plants, will regenerate quickly and form a diverse habitat favored by many species.*

- **Maintain or restore natural hydrological cycles in wet grasslands.** *Many types of grasslands have imbedded seepages and small, perennial streams. Avoid altering these hydrological features.*

PASTURE AND HAYFIELD TIPS

When sown with native grasses, pastures and hayfields can closely mimic natural prairie habitats and may provide important habitats for grassland-adapted amphibians and reptiles and other wildlife. If mowed, start in the center and use a back-and-forth approach to avoid concentrating fleeing animals where they may be killed or stranded. Elevating the mowing deck height to 8 or even 12 inches will reduce mortality and will leave important cover. This will help prevent killing Box Turtles and Wood Turtles that are common users of grassland habitats. Visit the NRCS website for information about planting old fields with native grasses.

This is the Grasslands and Old Fields module of the PARC publication, HMG-3. ISBN 0-9667402-3-8. Please visit www.parcplace.org for further information, copies of the complete document, or a web-based version of these guidelines.

Joe Mitchell

Management and maintenance of the Big Meadows grassland in Shenandoah National Park, Virginia, is accomplished by periodic prescribed burns. Growing season burns stimulate grasses to flower and produce seed, and return nutrients to the soil. Smooth Green Snakes, Milk Snakes, and Eastern Garter Snakes occur here.

Gerald Schaffer

Hatchling Black Racers, like baby Eastern Ratsnakes, look nothing like their parents. These snakes become entirely black with age. The blotch pattern helps with camouflage.

Tom Pauley

ROCK OUTCROPS AND TALUS

Exposed rock outcrops and talus slopes are relatively small habitats embedded within larger ecosystems such as hardwood forests. Most in the Northeast are usually located in mountainous or hilly areas in the Allegheny Plateau, Central Appalachian Forest, and Southern Blue Ridge ecoregions. They are dry, sparsely vegetated, with little soil and sparse canopy, and have an abundance of hiding places among the rocks and crevices. Gradients between open sun, shade, and moisture regimes are often abrupt. Grassy areas, cliffs, talus, quarries, rock slides, and ledges are examples of this habitat type. Reptiles are more characteristic of these habitats than amphibians. Several snakes, notably Timber Rattlesnakes and Copperheads, use such habitats for basking sites, birthing rookeries, and winter hibernacula, especially on south-facing slopes. Except for some species like the Northern Fence Lizard, reptile use of this habitat type is usually seasonal. Several species of amphibians such as the Cow Knob and Shenandoah salamanders occupy talus slopes and rocky seepages on north-facing slopes in the Central Appalachian Forest ecoregion. Occupancy by these herps tends to be year-round.

Mike Torocco

Rock outcrops represent ancient den sites for several species of snakes, notably the Timber Rattlesnake. Deep crevices and fissures allow these snakes to escape freezing winter temperatures. Several states now protect these important sites.

Mike Torocco

Talus slopes with fields of rocks and small boulders provide shelter and basking places for snakes and lizards. Snakes may overwinter in talus slopes if loose rock layers are deep and thus afford places to escape cold winter temperatures.

Rock outcrops, ledges, talus, and rocky glades are subject to a variety of threats, including human use from various forms of recreation. Some areas known for their numbers of snakes attract some people who seek to eliminate them. Fire is usually a natural form of maintenance but exclusion of fire causes overgrowth of vegetation, including canopy that destroys the thermal characteristics of these habitats.

CHARACTERISTIC SPECIES

Pickerel Frog, Cheat Mountain Salamander, Green Salamander, Shenandoah Salamander, Cow Knob Salamander, Five-lined Skink, Northern Fence Lizard, Black Racer, Copperhead, Eastern Milk Snake, Smooth Earth Snake, Timber Rattlesnake

MANAGEMENT GUIDELINES

MAXIMIZING COMPATIBILITY: Timberlands, Hunt Clubs, Farmlands, Recreation Lands, and other Integrated Land-uses
When benefiting amphibians and reptiles is secondary to other management objectives:

- **Manage rock climbing and other recreational activities to areas well away from biologically significant areas.** *Climbers should be aware of protected species.*

- **Limit motorized vehicles, including dirt bikes and ATVs, to areas well away from biologically significant sites, such as rattlesnake dens.** *Such management actions will minimize destruction and alteration of these sensitive sites.*

Robin Jung-Brown

Rock outcrops may be sunlit or completely shaded. The amount of sunlight reaching the rocks will determine whether outcrops are inhabited primarily by salamanders (shaded and moist) or snakes and lizards (sunny and dry). Therefore, altering the surrounding forest canopy will affect the composition of the rock outcrop herpetofauna.

Joe Mitchell

Copperheads also use rock outcrops as den sites in the Northeast. They occasionally overwinter with Timber Rattlesnakes and Eastern Rat Snakes.

- **Implement Best Management Practices (BMPs) in order to minimize erosion and soil disturbances uphill from talus and scree slopes.** *Excessive sediment from uphill can wash down, filling cracks and crevices that amphibians and reptiles need for microhabitat.*

- **Restore direct sunlight to outcrops that have**

been invaded by native or non-native plants that shade the area. *Some outcrops are susceptible to forest shading from the edges and below as trees grow.*

- **Limit hard rock mining in the vicinity of overwintering or birthing sites used by snakes.** *Mining can severely impact or eliminate snake populations in these areas.*

IDEAL: Refuges, Sanctuaries, and Preserves
When benefiting amphibians and reptiles is a PRIMARY objective, as with nature preserves, wildlife refuges, and private lands whose owners wish to optimize herpetofaunal diversity and abundance

John Jensen

Green Salamanders are inhabitants of sandstone and limestone rock outcrops in Virginia, West Virginia, Maryland, and Pennsylvania. Horizontal, deep cracks on partially-shaded, moist rock faces are preferred. Extensive timber harvest operations around these sites may increase temperatures and reduce moisture, prevent inter-population movements, and presumably cause extirpation of local populations. Recolonization, if possible, is likely a slow process.

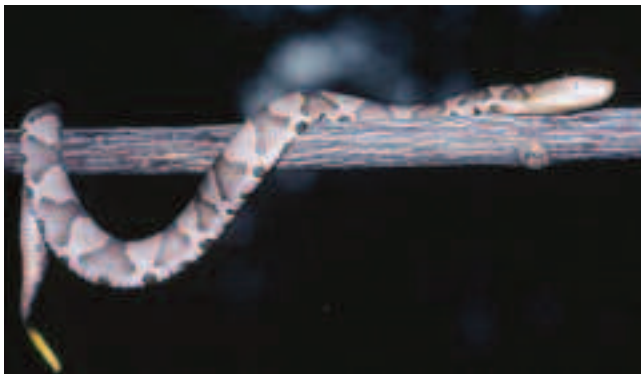
- **Exclude ATV access especially in the vicinity of sensitive habitat elements used for nesting, breeding, or denning areas.** *ATV and other vehicular traffic can compact soil, increase erosion and sediment, provide corridors for invasive plant species along trails and kill animals, especially snakes.*

- **Use adequate buffers and other Best Management Practices to protect biologically significant sites from logging, grazing, development, and other erosion-generating activities that may occur uphill.** *Sensitive sites below such activities will receive sediment or pollution that flows downhill.*

- **Monitor the long-term condition of reptile den sites and significant salamander locations.** *These snakes are imprinted to hibernate at a single location—if the hibernaculum is degraded or destroyed, they may not be able to find a suitable replacement. Because of limited mobility and a low tolerance for unfavorable habitats, most rock-dwelling salamanders are unable to move elsewhere if their habitat is lost.*

- **Minimize publicity of sensitive and unique areas to prevent poaching or indiscriminate killing.** *Hibernating snakes and dense colonies of salamanders are extremely vulnerable to collecting or killing because they are concentrated in small areas.*

- **Protect habitats adjacent to outcrops and talus areas to allow dispersal of amphibians and reptiles to foraging areas and other sites.** *Hibernating reptiles and rock-dwelling salamanders usually spend only a part of their annual cycles in talus and outcroppings. Reptiles often disperse to adjacent habitats to forage during warmer months. Some salamanders may breed in nearby springs, seeps, and headwaters. Both the rocky uplands and the adjacent, complementary habitats must be present for these species to survive. Ensure that land-uses do not render seasonal migration and natural dispersal patterns difficult.*



Joe Mitchell

Newborn and juvenile Copperheads possess a bright yellow tail tip that they use for luring insects, lizards, and other small prey as they sit camouflaged on the forest floor.

- **Where feasible, maintain and restore natural fire frequency, intensity, and seasonality, especially at landscape scales in surrounding, complementary habitats.** *Fire is especially important for reptiles that hibernate in sunny, south-facing rock exposures. Woody encroachment and excessive shade may render basking impossible. (See insert: "A Long Winter's Nap")*

- **Exclude or remove exotic plant species.** *Encroachment of non-native plants could alter the site's microclimate and physical structure needed by amphibians and reptiles.*

- **Route hiking trails around outcrops and talus zones, and reroute existing trails to avoid them.** *Avoidance and out-of-sight means out-of-mind policies will help maintain such sensitive sites.*

A LONG WINTER'S NAP

Like all amphibians and reptiles, snakes are "cold-blooded" and their body temperatures are dictated by their surroundings. As temperatures become increasingly cold, snakes are too sluggish to hunt or feed and may freeze to death if they stay on the surface. Therefore, they hibernate to conserve energy and avoid freezing. In order to successfully hibernate, snakes must use an underground location that is deep enough to escape freezing temperatures and has a south-facing aspect to allow them to warm quickly when basking.

Timber Rattlesnakes bask among the rocks to regulate their body temperatures. Rattlesnake hibernation den sites are used for repeatedly for many years. Juvenile snakes use scent-trailing to follow adults back to these dens each autumn. Since many rattlesnakes may congregate at a single den, the loss or disturbance of the site may endanger the local population. Complete canopy closure decreases the value of these sites but can be managed through monitoring and planned removal of some vegetation. Robin Jung-Brown

To survive long winters, snakes must "fatten up" prior to hibernation in the fall and feed as soon as possible after emergence in the spring Since temperatures are often marginal during these times, snakes must bask in direct sunlight (preferably on heat-absorbing surfaces such as rocks or fire-blackened ground) in order to build up enough energy to forage. Woody encroachment and excessive shading around hibernation sites may render basking difficult or impossible. As the habitat surrounding a hibernation den degrades, fewer and fewer snakes are able to survive the winter.

Why not simply move to another den? Snakes are usually imprinted on a single hibernation site and are incapable of finding a suitable replacement. In colder climates, generations upon generations of snakes from the same colony may gather at the same hibernaculum. These annual migrations repeat for decades or even centuries, as long as the site remains favorable. If the den is destroyed by development or degraded by fire suppression, the entire colony may be lost.

— Mark Bailey and Jeff Holmes

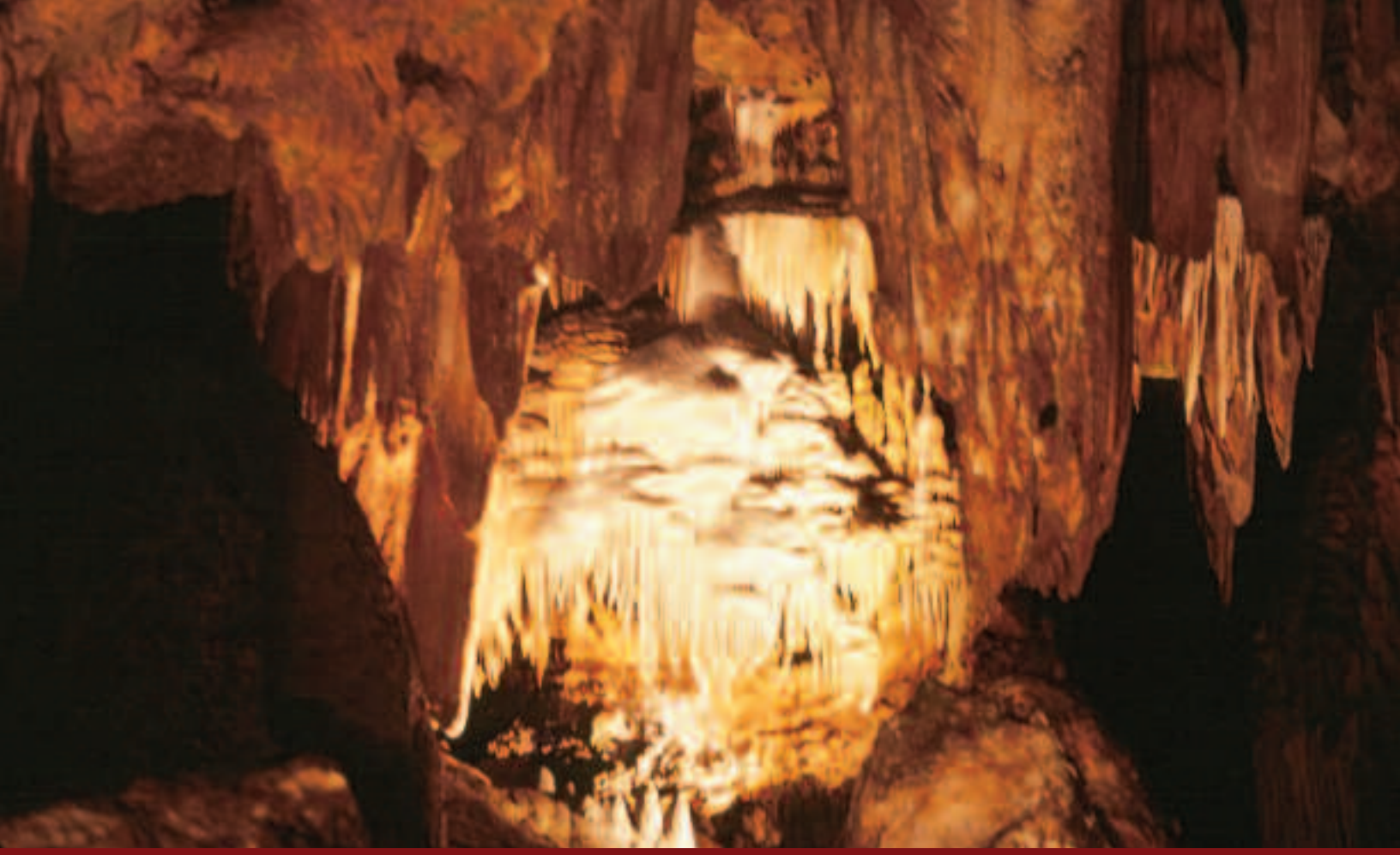
Kurt Buhlmann

Talus slopes in some parts of the Appalachian and Blue Ridge Mountains support unique and endemic salamanders, like the endangered Shenandoah Salamander in Shenandoah National Park.

Joe Mitchell

Eastern Ratsnakes often overwinter with Copperheads and Timber Rattlesnakes in northeastern dens. Large Black Racers, however, are known to kill and eat them.

This is the Rock Outcrops and Talus module of the PARC publication, HMG-3. ISBN 0-9667402-3-8. Please visit www.parcplace.org for further information, copies of the complete document, or a web-based version of these guidelines.



Kurt Buhlmann

CAVES AND KARST SYSTEMS

Despite the fact that they are made of limestone rocks, caves and karst habitats are fragile systems. They are specialized habitats that have unique air flow patterns, high humidity levels, and other microhabitat characteristics that remain stable over centuries. They are sensitive to surface activities that result in pollution. Human recreational use can easily disrupt the stable environmental balance and physical structure of these habitats, and thus harm the often-unique animal inhabitants in the process. Reputable caving and spelunking organizations are good stewards of the caves they visit. Caves and karst systems occur in the Northeast primarily in the Cumberlands and Southern Ridge and Valley, Southern Blue Ridge, and Central Appalachian Forest ecoregions. Some are well known and operated commercially (e.g., Luray Caverns in Virginia and Howe's Cavern in New York) and others are well-kept secrets. Land managers and private landowners protect many caves themselves. Abandoned mineshafts can function much like caves and be used by some species of herps. Although the caves and karst systems module has been placed in the terrestrial habitat section of this Guide, the occurrence of many salamanders in caves is dependent on cave streams and pools.

Mike Torocco

Although large, spectacular caves are generally restricted to Virginia and West Virginia within the Northeast region, smaller caves can be found in most ecoregions that contain limestone rock layers (e.g., Central Appalachian Forest, Cumberlands and Southern Ridge and Valley, High Allegheny Plateau ecoregions).

Mike Torocco

Caves that contain unique biological or historical significance have sometimes been gated to protect those resources. Caves are still extremely vulnerable to surface runoff from poor agriculture or timber harvest practices. There are opportunities to work with cave conservation organizations to protect cave resources.

Kurt Buhlmann

Pickerel Frogs are often found in cave entrances, especially those with streams. They are not true cave inhabitants and are only visitors, thus they are considered trogloxenes.

The animals that are truly adapted to cave environments are unique and extremely sensitive to disturbance. Some salamanders are especially suited for the dark reaches of caves and karst systems. One such species in the Northeast, the West Virginia Spring Salamander, is known from only one stream in one cave; it is troglobitic and endemic to that cave. Cave and Long-tailed Salamanders are well-known cave inhabitants, although they also use adjacent mesic hardwood forests. The twilight zone of caves is used by several species of reptiles and frogs and less specialized salamanders. A few reptiles may use caves and karst systems for winter hibernacula.

CHARACTERISTIC SPECIES

Long-tailed Salamander, Cave Salamander, Green Salamander, West Virginia Spring Salamander, Pickerel Frog, Eastern Ratsnake, Eastern Garter Snake.

MANAGEMENT GUIDELINES

MAXIMIZING COMPATIBILITY: Timberlands, Hunt Clubs, Farmlands, Recreation Lands, and other Integrated Land-uses
When benefiting amphibians and reptiles is secondary to other management objectives:

- **Where cave access is permitted, limit human activity to times outside of seasonal fauna activity.** *Consider guided tours over open access. Work with a management partner (caving grotto) or develop a permitting system to foster user accountability.*
- **Protect subterranean systems from sediment from timber harvest, agriculture, residential development, and other land-use activities in surrounding habitats.** *Sediment and runoff from activities on the surface outside caves can destroy sensitive microhabitats used by cave amphibians.*
- **Meet or exceed Best Management Practices.** *Cave amphibians and endemic invertebrates are extremely sensitive to changes in the quality of their habitat.*
- **Establish natural buffer zones around sinkholes in order to maintain the quantity and quality of water entering the karst aquifer.** *Treat these sensitive habitats like vernal pools.*

IDEAL: Refuges, Sanctuaries, and Preserves
When benefiting amphibians and reptiles is a PRIMARY objective, as with nature preserves, wildlife refuges, and private lands whose owners wish to optimize herpetofaunal diversity and abundance:

- **Each cave is unique, an irreplaceable creation that should be protected from damage.** *Erect gates where necessary to prevent illegal entry. Gate design should not alter airflow, temperatures, or humidity, or interfere with passage of fauna such as bats. Gate designs are available through Bat Conservation International (http://www.batcon.org/news 2/mines/batsmines_38-45.pdf).*
- **Maintain natural airflow patterns and prevent sediment from entering the cave.** *Altering cave entrances will change airflow, temperatures, and humidity. Cave organisms are sensitive to rapid changes in their cave ecosystem.*

Kurt Buhlmann

Small caves may be overlooked as insignificant, but in fact they may harbor populations of endemic invertebrates that are thus found nowhere else in the world.

- **Maintain forest buffers around all cave entrances.** *Forests help prevent sedimentation from entering cave entrances. However, organic particles generated by forest ecosystem processes do serve as a food sources for cave organisms.*

- **Prevent point and non-point source pollution from entering caves.** *Learn all the points of entry of your caves and protect them from input of polluted water.*

- **Prohibit dumping of commercial, industrial, and residential waste into caves, including trash and organic debris**. *Input of petroleum products, septic waste, and other contaminants can kill sensitive cave animals.*

- **Maintain natural hydrological patterns throughout the recharge areas of the caves on your property.** *Maintenance of natural water flow patterns will help keep pollution from entering cave recharge points*.

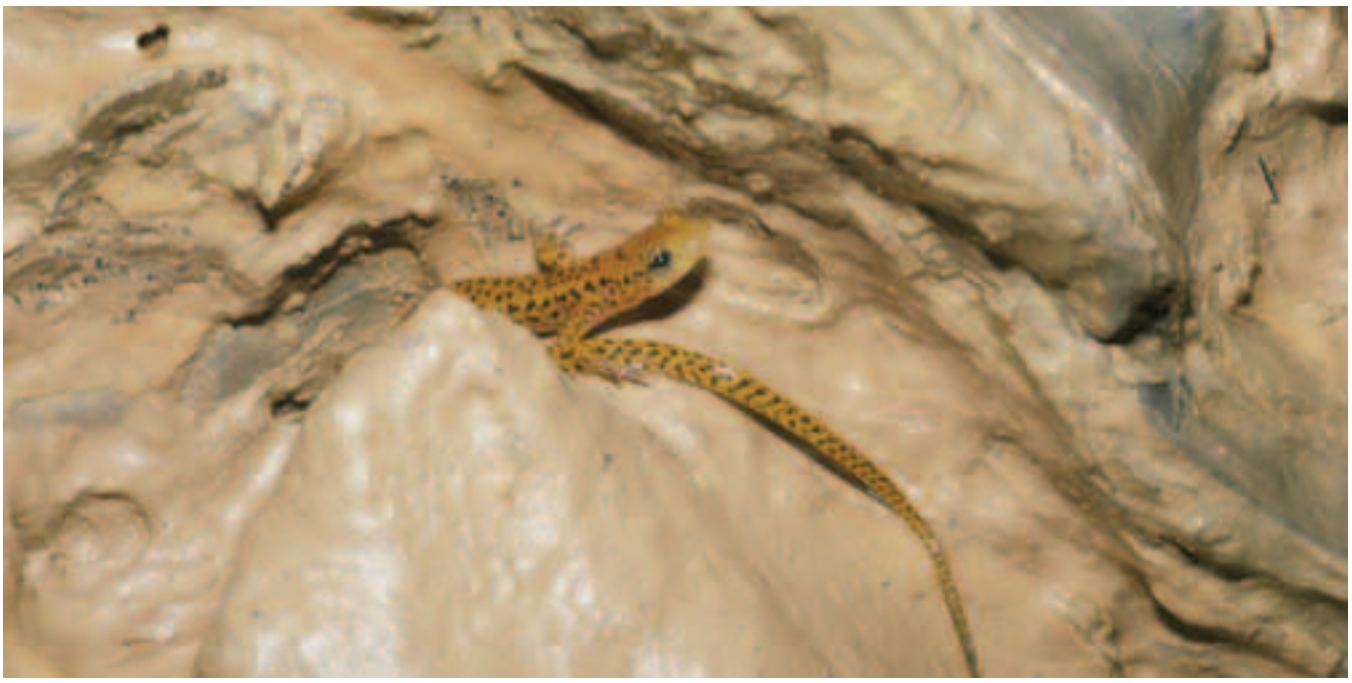
- **Restrict human use of caves of least sensitivity.** *If privately owned, consider partnering with a caving grotto to oversee visitation management. If government owned, consider a permitting system.*

- **Keep livestock out of cave openings and sinkholes.**

- **Remove trash and debris dumped into caves and sinkholes.**

For additional information on cave conservation, visit the websites of the
Virginia Cave Board:
www.dcr.virginia.gov/dnh/vcbsinkholes.htm
National Speleological Society: www.caves.org
American Cave Conservation Association:
www.cavern.org/acca/accahome.html
Southeastern Cave Conservancy: www.scci.org

This is the Caves and Karst Systems module of the PARC publication, HMG-3. ISBN 0-9667402-3-8. Please visit www.parcplace.org for further information, copies of the complete document, or a web-based version of these guidelines.



Kurt Buhlmann

The Long-tailed Salamander is considered a cave troglophile because they can exist and reproduce within a cave (as long as there is a cave stream present), although they are not obligated to remain there. In fact, most cave-dwelling populations of Long-tailed Salamanders regularly forage in hardwood forests that surround many caves.

Mike Marchand

AGRICULTURAL LANDS

Some 22% or more of the landscape in the Northeast is used for agricultural purposes, although the amount of land varies among states. Agricultural landscapes are actually mosaics of cultivated crops, pastures, orchards, hedgerows, farm ponds, swales, ditches, out buildings, barns, rock walls, and abandoned fields. With some thought to the naturally occurring habitat that existed before conversion, agricultural lands can provide significant and critical habitat for amphibians and reptiles. Croplands, pastures, and orchards can support some of the amphibians and reptiles that occurred there under natural conditions. Embedded wetlands, vegetated stream banks, wooded slopes adjacent to fields, remnant prairie patches, glades and barrens, and other non-cultivated areas (even fencerows and irrigation ditches) may serve as important patches of "natural" habitats in which amphibians and reptiles can survive in agricultural landscapes. Amphibians and reptiles will use agricultural lands to forage or to migrate to other natural habitats. For this reason, it is important to maintain corridors of suitable habitat connecting natural areas within agricultural lands.

Kurt Weiskotten

Monoculture crops do not afford much habitat for amphibians and reptiles, however, associated imbedded habitats such as farm ponds, hedgerows, and woodlots create a mosaic of habitats in which a number of common amphibians and reptiles maintain populations.

Kurt Buhlmann

Wood Turtles are frequently found in agricultural landscapes in the Northeast. They require a matrix of streams for winter hibernation and breeding, as well as fields, meadows and woodlands for summer foraging on berries and earthworms.

Kurt Weiskotten

Many agricultural areas in the Northeast are embedded in highly forested landscapes. This mosaic of habitats benefits many species of amphibians and reptiles, especially when water bodies are present.

CHARACTERISTIC SPECIES

Eastern Spadefoot, American Toad, American Bullfrog, Eastern Box Turtle, Painted Turtle, Snapping Turtle, Wood Turtle, Five-lined Skink, Black Racer, Eastern Ratsnake, Eastern Garter Snake, Northern Water Snake

MANAGEMENT GUIDELINES

MAXIMIZING COMPATIBILITY: Timberlands, Hunt Clubs, Farmlands, Recreation Lands, and other Integrated Land-uses
When benefiting amphibians and reptiles is secondary to other management objectives:

- **Protect and buffer natural areas in agricultural landscape.** *These are the areas where most amphibians and reptiles are found in agricultural landscapes.*

- **If necessary, develop naturally vegetated corridors between habitat fragments.** *Core habitats, refugia, and migration and dispersal corridors are essential to amphibian and reptile survival in agricultural zones.*

- **Consider restoring natural hydrological cycles to drained wetlands.** *Natural flood cycles and seasonal water retention may enhance breeding amphibian populations.*

- **When possible, avoid mowing wetlands, shorelines, and ditches from mid-spring through mid-fall. When mowing fields, raise deck height to at**

Mike Marchand

Wood Turtles frequently use agricultural fields for foraging and shelter during spring and summer but are risk being killed by mowers. Setting blade heights to 8 inches or higher would have avoided this accident.

Joe Mitchell

Cattle have mixed benefits for amphibians and reptiles. Trampling of wetland vegetation can alter these habitats, but grazing can keep such places free of hardwood encroachment. Low levels of cattle grazing are beneficial to endangered Bog Turtle habitats.

least 8 inches. *Raising the mowing deck height to 8 or even 12 inches will reduce mortality of Wood Turtles and other species.*

- **Rotate livestock frequently in order to retain groundcover vegetation as habitat for amphibians and reptiles.** *Hoof prints can disturb and compact soil, thus increasing erosion and runoff.*

- **Limit livestock grazing in wetlands.** *Where feasible, pump water to troughs away from wetlands. Livestock trample native wetland plants, altering habitats for amphibians and reptiles. Excessive concentrations of nutrients (manure) in aquatic systems can cause unnatural algal blooms, alter dissolved oxygen and CO_2 levels, and affect aquatic amphibians and reptiles, especially tadpoles and salamander larvae. Livestock can be used to control invasive species in wet meadows and fens.*

- **Follow fertilizer, herbicide, and insecticide label directions very carefully; use the minimum amounts needed to achieve management objectives precisely where needed.**

- **Encourage conservation tillage in agricultural lands if they are located near forested areas containing isolated, seasonal wetlands.** *Conservation tillage will minimize mortality of ground-dwelling amphibians and reptiles that are often killed by disking.*

- **Use native species wood chip berms, hay bales, and staggered siltation fencing for erosion control in areas surrounding wetlands and their terrestrial buffers**. *Be creative in preventing pollution of the waters on your property. These materials can allow passage of animals from breeding sites to upland refugia.*

IDEAL: Refuges, Sanctuaries, and Preserves
When benefiting amphibians and reptiles is a PRIMARY objective, as with nature preserves, wildlife refuges, and private lands whose owners wish to optimize herpetofaunal diversity and abundance:

- **Add buffers several hundred feet in width along wetlands and streams**. *Amphibians and reptiles use much of the adjacent habitats around wetlands, streams, and rivers. Vegetated buffers limit fertilizer and pesticide input from agricultural areas, as well as providing cover for these animals.*

- **Develop corridors with hedgerows between habitat fragments**. *Amphibians and reptiles will move along such habitats as they disperse to other areas.*

USGS Patuxent Wildlife Research Center, Northeast ARMI team

American Toads are often found in agricultural landscapes. They breed successfully in farm ponds and can move long distances from water. They hibernate underground in soft or sandy soil.

USGS Patuxent Wildlife Research Center, Northeast ARMI team

Toads breed and lay long strings of black eggs in very shallow water. American and Fowler's Toads can use mud puddles and road rut puddles in agricultural areas.

Steve Roble

American Toad tadpoles are black and usually congregate together. They have to reach metamorphosis quickly before the pool dries up. This can take as little as three weeks. The metamorphs then disperse widely.

Kurt Buhlmann

Overgrazing by cattle can lead to erosion of soil and minimize the value of wet meadows and rivulets to amphibians and reptiles.

- **Avoid mowing or plowing around shorelines of permanent and seasonal wetlands.** *Maintaining shoreline cover will benefit wildlife that use these wetlands. This management activity will reduce mortality to many species inhabiting wetland shorelines and the areas around them.*

- **Avoid precision land leveling where possible.** *Such practices eliminate shallow depressional wetlands that are primary breeding habitats for several species of amphibians. Some species are in decline because of this practice.*

- **Prevent livestock access to streams and wetlands**. *Use fences or other means to keep livestock out of water bodies and consequently polluting them*.

- **Avoid storing silage, manure, salt, and other possible contaminants near wetlands**. *Minimize contamination of water bodies from these sources.*

- **Avoid using chemicals where possible.** *Recent studies have demonstrated that even low concentrations of some chemicals may cause harm to amphibians*.

- **Restore and protect existing wetlands and wetland complexes.** *Restoration of such habitats used extensively by amphibians and reptiles will go a long way to ensuring their continued presence on your property.*

- **Reduce erosion from livestock and tillage.** *Use conservation tillage and minimize overgrazing. See recommendations by the Alliance for the Chesapeake Bay (*http://www.alliancechesbay.org/project.cfm?vid=85)

- **Learn effective nutrient management (timing, amounts, mechanics of spreading).** *Consider using crop rotation and burning to add nutrients to the soil rather than chemicals.*

USGS Patuxent Wildlife Research Center, Northeast ARMI team

Upland Chorus Frogs will persist in agricultural settings provided that woodlots and hedgerows are present and pools contain water for at least three weeks.

Kurt Buhlmann

The Eastern Milk Snake is unfortunately mistaken for the venomous Copperhead and killed when encountered by humans. Milk Snakes got their name because they eat mice around barns and early settlers thought they sucked milk from cows. They are beneficial in agricultural landscapes.

- **Be careful with or avoid using plastic mesh netting for reducing deer and bird impact on commercial plants and fruit trees.** *Snakes and other wildlife become entangled in the mesh and often die inhumanely from overheating or struggling. They can be removed safely by clipping the mesh away and releasing the animal.*

- **Do not kill snakes in and around barns and other structures.** *These predators eat mice and other rodents and thus serve a valuable function to farmers.*

This is the Agricultural Lands module of the PARC publication, HMG-3. ISBN 0-9667402-3-8. Please visit www.parcplace.org for further information, copies of the complete document, or a web-based version of these guidelines.

Joe Mitchell

URBAN AND RESIDENTIAL SYSTEMS

A mosaic of landscapes ranging from completely unsuitable for amphibians and reptiles to those that support populations of tolerant species characterizes urban and residential areas. Yet, patches of habitat suitable for some species persist. Patches of habitat in urban areas include parks, woodlots, backyard habitats and ponds, wetlands of varying quality, streams with narrow wooded buffer zones, golf courses, and plant nurseries. Some species persist for many years in these habitats, and these habitat patches offer opportunities for enhancement, restoration, and creation that would greatly benefit some amphibians and reptiles. The urban landscape comprises over five million hectares in the Northeast.

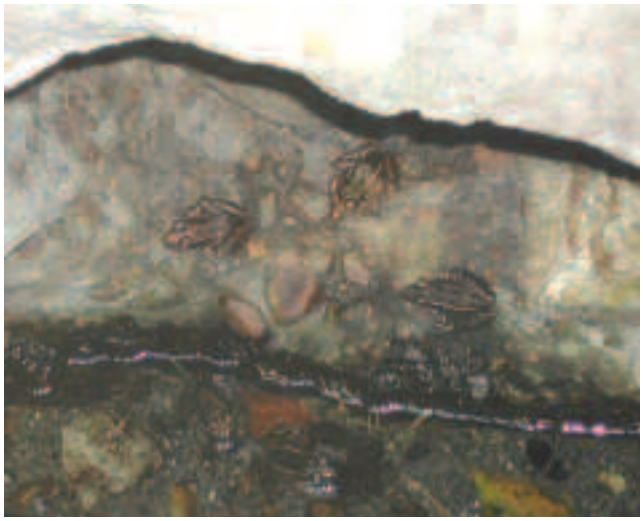
Dispersal between habitat patches is difficult for amphibians and reptiles because of several forms of barriers such as storm drains, curbs, fences, buildings, channelized streams, and hot asphalt. Dogs, cats, crows, blue jays, raccoons, opossums and other subsidized predators usually thrive in urban systems. Urban and suburban areas containing suitable habitats whether in patches or along stream and river corridors offer many opportunities for education and study on how well some species adapt and why some do not.

Joe Mitchell

This new development has many barriers to amphibians and reptiles and little natural habitat. Only the woodlot to the right may support small species, such as Southern Leopard Frogs, Red-backed Salamanders, Worm Snakes. Large urban parks may continue to support Box Turtle populations.

Mike Marchand

Open drainage grates in urban areas are traps to small animals, including amphibians and reptiles. The curb is a barrier to the movements of salamanders and turtles.



Joe Mitchell

These Southern Leopard Frogs are trapped in a culvert beneath a grate in Delaware.

Mike Marchand

Cape Cod curbing along roadsides would allow amphibians and reptiles, especially turtles, to crawl over it rather than be blocked by the vertical walls provided by standard curbing.

Mike Marchand

Manicured yards are understandably the norm for northeastern home sites. Yet, such lawns are inhospitable to amphibians, reptiles, and most other fauna due to the close cropping, herbicide applications, and lack of cover. Consider adding natural structure to your yard, where possible.

CHARACTERISTIC SPECIES

Two-lined Salamander, Spring Peeper, American Toad, Fowler's Toad, American Bullfrog, Gray Treefrog, Northern Green Frog, Common Snapping Turtle, Eastern Garter Snake, Northern Brown Snake

MANAGEMENT GUIDELINES

MAXIMIZING COMPATIBILITY: Timberlands, Hunt Clubs, Farmlands, Recreation Lands, and other Integrated Land-uses
When benefiting amphibians and reptiles is secondary to other management objectives:

- **Include existing natural areas in the design and planning of new neighborhoods.** *Retention of natural areas will greatly enhance the capacity of neighborhoods and other urban developments to support amphibians, reptiles, and other native animals.*

- **Identify and protect existing special habitat features such as streams, wetlands, rock walls, and rock outcroppings.** *A survey of such habitats available to amphibians and reptiles is a good first step in protecting these sensitive areas.*

- **Consider protection of wetlands, stream corridors, and representative terrestrial habitats during the planning process before development**

Kurt Buhlmann

Golf course ponds may contain freshwater turtle populations. Painted, Red-bellied, Snapping, and Musk Turtles lived in this golf course pond in Newport News, Virginia. However, the pond was adjacent to a large permanent reservoir that allowed for immigration and subsequent recolonization when the pond was periodically drained to retrieve golf balls, and then re-filled.

Kurt Buhlmann

The same golf course pond in Newport News, Virginia after draining in early autumn. Turtles were able to move successfully to the adjacent reservoir. If the pond had been drained in winter, mortality from exposure would have been severe.

Joe Mitchell

American Toads often disperse widely from breeding pools in residential areas and may show up in one's backyard. Their carnivorous habits are helpful for control of insects.

Wendy Robertson

Free-ranging house and feral cats are notorious for killing wildlife, including snakes. Cats in a suburban residential area found this Eastern Garter Snake.

permits are issued. *Doing so in an early phase of planning will ensure that these sensitive habitats are not overlooked.*

- **Protect and maintain riparian and wetland areas, including the maintenance of pre-development hydrological regimes (depth, duration, and frequency of flooding) of streams and wetlands.** *Many species that would otherwise be lost to development may be able to persist if natural hydrological cycles and associated vegetation buffers are protected or restored.*

- **Install a garden pool.** *If you build it, frogs will find it. Don't stock it with fish or non-native animals, however.*

- **Landscape with native species. Prevent the introduction and spread of exotic plants.** *Many reptiles and amphibians are specifically adapted to survive in native vegetative communities. Highly adaptable, rapidly reproducing invasive plants can sometimes out-compete, displace, and ultimately extirpate more specialized native plant species.*

- **Spay and neuter cats and dogs, and keep them indoors.** *Uncontrolled pets kill amphibians, reptiles, songbirds and other wildlife.*

- **Control subsidized predator populations**. *Raccoons, foxes, and other subsidized predators kill and eat many amphibians and reptiles, especially turtles and their eggs. Homeowners should limit access to food, garbage, and shelter for subsidized predators.*

- **Use the minimum amount of fertilizers, herbicides, and pesticides necessary to achieve man-**

Mike Marchand

Small ponds in urban zones receive excessive nutrients from fertilizer applications on lawns and golf courses. The result is a eutrophic system with algal blooms, concentration of pollutants, and a reduced capacity to support amphibians.

agement objectives, especially on golf courses.

- **Identify or create breeding habitats with associated upland habitat and corridors to connect them. Include road crossings (culverts, ecopassages) where feasible. Use signs in the vicinity of known migration routes.** *Even when all complementary habitats are present, road mortality along migration routes can eliminate amphibian and reptile populations.*

- **Encourage developers to design their projects around natural areas to minimize habitat fragmentation, protect stream corridors, and maintain natural vegetation.** *Education of all persons concerned with urban development will greatly increase the chances that some natural areas will be set aside.*

- **Encourage and support public education about the functions and values of wildlife.** *Education can go a long way in affecting value systems and an appreciation for nature.*

- **Provide ground cover such as rocks and logs in patches of natural habitats.** *Such microhabitats will be attractive to some amphibians and reptiles.*

- **Do not introduce non-native species, such as fire ants and terrestrial flatworms, in landscape plants and other materials**. *Be careful what you bring home on potted plants and other landscape materials.*

- **Consider rerouting planned or existing roads around, instead of through, sensitive natural**

Joe Mitchell

Channelizing streams and lining them with rock and concrete is a common way to deal with wetlands in urban and residential areas in the Northeast. Unfortunately, it eliminates nearly all of the amphibian and reptile fauna.

Joe Mitchell

Streams in urban areas are often mismanaged. Note the steep eroded banks and exposed public waterworks pipe. These problems occur because large amounts of imperious surfaces, such as asphalt and concrete, greatly exacerabate water flow rates.

THE MOST ENVIRONMENTALLY-FRIENDLY PESTICIDE?

Anyone who owns a flowerbed knows that slugs can seriously damage ornamental foliage. Although there are numbers of pesticides on the market that target slugs, they often raise questions: How safe are they? Why do the slugs keep coming back?

Garter Snakes, Northern Brown Snakes, Red-bellied Snakes, and Box Turtles love to eat slugs (and other pests) and have adapted to urban life in many areas. Unlike most pesticides, snakes and turtles are guaranteed 100% environmentally safe and can find and eat source populations of slugs in places where chemicals can't (e.g., foundations, burrows, stone walls).

— Mark Bailey

Joe Mitchell

The Northern Brown Snake has been called the "City Snake" because it sometimes occurs in abundance in vacant wooded lots in urban areas. It feeds on slugs and earthworms, and is thus a valuable addition to a suburban garden.

areas. *Work with planners and Department of Transportation personnel to help minimize impacts on natural areas remaining in your area.*

- **Road curbing that allows small animals to climb out of the roadbed is preferred over steep, vertical curbing.** *Small animals, such as Box Turtles, cannot climb over vertical curbs that are commonplace in urban areas. Cape Cod curbing is preferred.*

IDEAL: Refuges, Sanctuaries, and Preserves
When benefiting amphibians and reptiles is a PRIMARY objective, as with nature preserves, wildlife refuges, and private lands whose owners wish to optimize herpetofaunal diversity and abundance:

- **Protect and buffer special natural areas, such as isolated wetlands, vernal pools, forested riverine floodplains.** *Seek ways to ensure that the natural functions of such places remain intact. Buffers around wetlands help control pollution input and provide additional habitat.*

USGS Patuxent Wildlife Research Center, Northeast ARMI team)

Snapping Turtles occupy rivers, streams, ponds, and lakes in urban and residential areas throughout the Northeast. They are susceptible to mosquitoes just like humans. We do not know if these turtles contract mosquito-bourn diseases.

- **Maintain and develop corridors between habitat fragments; eliminate vertical curbing along roadways.** *Movement of amphibians and reptiles across the landscape is a common activity of their lives*

- **Maintain historical water regimes in streams and rivers**. *Urban and residential systems usually alter these systems. Seek to restore them to historic natural conditions.*

- **Maintain vernal pools and other small wetlands in riparian zones and elsewhere.** *These small, ephemeral pools in riparian zones in urban areas may be the only place where several species of amphibians can breed. Salamander larvae will consume mosquito larvae in woodland pools.*

Steve Roble

Spring Peepers may be heard in springtime in residential areas if there are small bodies of water in which to breed and trees and shrubbery in which to hide and forage.

- **Avoid using non-native vegetation in landscaping, and encourage control of non-native species.** *Keep cats indoors, as they are well known to kill amphibians and reptiles, as well as birds.*

Joe Mitchell

Rough Green Snakes can persist in residential areas in overgrown woodlots and shrub thickets. Domestic house cats often kill these harmless, non-venomous, insectivorous snakes.

Joe Mitchell

People often mistakenly kill juvenile Eastern Rat Snakes, pictured here, because they think they are Copperheads. Rat snakes are occasionally found in woodlots in residential areas.

- **Assess the impact and consider control of subsidized native predators.** *Raccoon populations can become very dense in residential areas and are a major threat to amphibians and reptiles. Work with local animal control officers and game wardens to find ways to reduce subsidized predator populations.*

- **Use the minimum amount of fertilizers, herbicides, and pesticides necessary to achieve management objectives, especially on lawns**. *These chemicals are often applied to lawns and in other urban settings in excessive amounts that run off and pollute water systems in the area and downstream. Even low concentrations of some chemicals can harm amphibians.*

- **Create a compost pile in natural landscaping.** *These are good sites for Box Turtle nests and overwintering sites. Even some snakes may use them for egg deposition and hiding.*

- **Be careful with or avoid using plastic mesh netting to control deer and bird impact on horticultural and landscape plants.** Snakes and other wildlife become entangled in the mesh and often die inhumanely from overheating and struggling. They can be removed safely by clipping the mesh away and releasing the animal.

This is the Urban and Residential Systems module of the PARC publication, HMG-3. ISBN 0-9667402-3-8. Please visit www.parcplace.org for further information, copies of the complete document, or a web-based version of these guidelines.

APPENDIX A.
AMPHIBIANS AND REPTILES OF THE NORTHEAST

The Northeast supports at least 155 species of amphibians and reptiles: 31 frogs, 57 salamanders, 25 turtles, 9 lizards, and 33 snakes. The following table presents species occurrence information for each state and habitat covered in this book. We have used the most recent taxonomic information available, but some of the names used to describe species may change over time. Species occurrences by Habitat are provided, and each habitat is qualitatively assessed as P (preferred), S (suitable), or M (marginal).

Global and State ranks: We have used NatureServe's global (G) and state (S) ranks to provide a standardized measure of rarity of each species throughout its global range and by each State within which it occurs. This numeric system is not regulatory, and does not indicate federal or state protected status. Ranks may change as more information becomes available. Each species has a single G rank indicating the total number of occurrences throughout its range. An S rank is also assigned for each species' state occurrence (blank fields in the table below indicate the species does not occur in the state). The definitions provided below apply to both global and state ranks. Note that a species ranked G1 is at very high risk of extinction globally, whereas a species ranked S1 is at very high risk of extirpation within a particular state, and may be secure elsewhere in its range. NatureServe ranks several species with a range (e.g., 2-3, 3-4), but for space considerations, the lower number (i.e., higher conservation priority) is used in the following table.

1 = Critically Imperiled—At very high risk of extirpation due to extreme rarity (often 5 or fewer populations), very steep declines, or other factors.

2 = Imperiled—At high risk of extirpation due to very restricted range, very few populations (often 6-20), steep declines, or other factors.

3 = Vulnerable—At moderate risk of extirpation due to a restricted range, relatively few populations often 21-80), recent and widespread declines, or other factors.

4 = Apparently Secure—Uncommon but not rare; some cause for long-term concern due to declines or other factors.

5 = Secure—Common; widespread and abundant.

N = Not Ranked. For various reasons, a species' status is unknown and awaiting further scientific information.

U = Unknown

i = Introduced

H = Species was known historically, but its presence may not have been verified in the past 20-40 years.

X = Species regarded as Extirpated.

More information about the NatureServe ranking system may be found at: www.natureserve.org/explorer.

Federal Status: Endangered Species Act protection, according to U.S. Fish and Wildlife Service, as of January 2006. **E** = Endangered, **T** =Threatened. Information about Federally protected species can be found at: www.fws.gov/endangered.

State Protection Status: Each state has laws and/or regulations protecting certain amphibians and reptiles. These may appear on state lists as Special Concern, Endangered or Threatened. NatureServe state ranks for any species that has regulatory protection in that state are given in **boldface red**. Check with your state natural resource agency for most up-to-date information on legal status (see Appendix C).

One of the goals of PARC is to help keep common species common, as well as to restore species that have declined as a result of human activities. Therefore, providing information about species occurrences and their rarity, as well as current protected status, may be useful to land owners and land managers for evaluating the positive effects of their habitat management actions. These ranks and protected status listings were accurate as of January 2006.

Future actions by the PARC community may affect whether species become scarcer or more abundant. Thus, this table can also be used as a benchmark to measure our future success.

Species	Common Name	NATURESERVE GLOBAL RANKS	FEDERAL (USFWS) STATUS	CONNECTICUT	DELAWARE	DISTRICT OF COLUMBIA	MAINE	MARYLAND	MASSACHUSETTS	NEW HAMPSHIRE	NEW JERSEY	NEW YORK	PENNSYLVANIA	RHODE ISLAND	VERMONT	VIRGINIA	WEST VIRGINIA	SEASONAL ISOLATED WETLANDS	PERMANENT WETLANDS	WET MEADOWS, BOGS, & FENS	SMALL STREAMS, SPRINGS, SEEPS	RIVERS	ESTUARINE AND COASTAL	HARDWOOD FORESTS	SPRUCE AND FIR FORESTS	XERIC UPLAND & PINE FORESTS	GRASSLANDS AND OLD FIELDS	ROCK OUTCROPS AND TALUS	CAVES AND KARST	AGRICULTURAL LANDS	URBAN AND RESIDENTIAL SYSTEMS
AMPHIBIANS: Frogs and Toads																															
Acris crepitans	**Northern Cricket Frog**	5			5	3		5			N	1	2			4	2	S	P	S	S			S			M			S	
Acris gryllus	**Southern Cricket Frog**	5														4		P	P					S			M				
Bufo americanus	**American Toad**	5		5	5	5	5	5	5	5	5	5	5	5	5	5	5	P	P	S	M			P	P	P	P			S	S
Bufo fowleri	**Fowler's Toad**	5		4	5	5		5	5	3	4	4	3	3	1	5	5	P	P	S				P		P	S			M	M
Bufo quercicus	**Oak Toad**	5														1		P	P	S						P					
Bufo terrestris	**Southern Toad**	5														4		P	P	S				P		P					
Gastrophryne carolinensis	**Eastern Narrow-mouthed Toad**	5						1								4		P	P	S				P		P	S				
Hyla andersonii	**Pine Barrens Treefrog**	4									3								P	P						P	S				
Hyla chrysoscelis	**Cope's Gray Treefrog**	5			2	4		5			2					5	4	P	P					P	P	P	M			M	S
Hyla cinerea	**Green Treefrog**	5			3	H		5								4		P	P				S	P		P					S
Hyla femoralis	**Pine Woods Treefrog**	5														4		P	P							P					
Hyla gratiosa	**Barking Treefrog**	5			1			1			H					1		P						S		P					
Hyla squirella	**Squirrel Treefrog**	5														4		P	P				S			P					S
Hyla versicolor	**Gray Treefrog**	5		5	4	4	4	5	4	5	5	5	4	5	5	5	5	P	P					P	M	P	M			M	S
Pseudacris brachyphona	**Mountain Chorus Frog**	5						2					2			4	4	P	P	S				P	M	P	M			S	
Pseudacris brimleyi	**Brimley's Chorus Frog**	5														4		P	P												
Pseudacris crucifer	**Spring Peeper**	5		5	5	4	5	5	5	5	5	5	5	5	N	5	5	P	P	P		M		P	M	S	S			M	
Pseudacris feriarum	**Upland Chorus Frog**	5				N					N					N	2	P	P	S				P		P	S	M		M	
Pseudacris kalmi	**New Jersey Chorus Frog**	5						4			N		1			N		P	P	S				P		P	S	M		M	
Pseudacris nigrita	**Southern Chorus Frog**	5														2		P	P	S						S	S				
Pseudacris ocularis	**Little Grass Frog**	5														3		P	P	P			S			P					
Pseudacris triseriata	**Western Chorus Frog**	5										4	2		1				P	P				P							
Rana catesbeiana	**American Bullfrog**	5		5	5	4	5	5	5	5	5	5	5	5	5	5	5		P		S	S					M			S	M
Rana clamitans	**Green Frog**	5		5	5	5	5	5	5	5	N	5	5	5	5	5	5	M	P	S	P	P		M	M		S			S	M
Rana palustris	**Pickerel Frog**	5		5	5	5	5	5	5	5	5	5	5	5	4	5	5		P	S	P	S		S	M		S				
Rana pipiens	**Northern Leopard Frog**	5		2			3	4	4	3	i	5	3	2	4		2	S	P	P	P	M		S			P			M	
Rana septentrionalis	**Mink Frog**	5					4			3		5			4				P	S	P	M		S	M						
Rana sphenocephala	**Southern Leopard Frog**	5			5	2		4			5	1	1			4		P	P	S			S	S		P	S			S	S
Rana sylvatica	**Wood Frog**	5		4	4	2	5	5	5	5	5	5	5	5	5	5	5	P	S		M			P	S						
Rana virgatipes	**Carpenter Frog**	5			1			2			4					3		M	P	P											
Scaphiopus holbrookii	**Eastern Spadefoot**	5		1	4	H		4	2		N	2	1	1		4	1	P								P	P			S	M
AMPHIBIANS: Salamanders																															
Ambystoma barbouri	**Streamside Salamander**	4															1	P			P			P			S				
Ambystoma jeffersonianum	**Jefferson Salamander**	5		3		H		3	3	2	3	4	4		2	4	3	P	P		M			P		P	S				
Ambystoma laterale	**Blue-spotted Salamander**	5		1			4		3	4	1	4			3			P	M		M			P	S	P	M				

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Ambystoma mabeei	**Mabee's Salamander**	4														1		P						P		P				M	
Ambystoma maculatum	**Spotted Salamander**	5		5	2	4	5	5	4	5	3	5	5	4	5	5	5	P	S	M	M			P	S	S	S			M	
Ambystoma opacum	**Marbled Salamander**	5		4	3	3		5	2	1	3	3	3	2		5	5	P						P	S	M		M	M		
Ambystoma talpoideum	**Mole Salamander**	5														1		P	P					P		P					
Ambystoma texanum	**Small-mouthed Salamander**	5															1	P						P			S				
Ambystoma tigrinum	**Tiger Salamander**	5			1			2			N	1	X			1		P	S					P		P	S				
Amphiuma means	**Two-toed Amphiuma**	5														4		P	S		M										
Aneides aeneus	**Green Salamander**	3						2					1			3	3				P			P		P		P			
Cryptobranchus alleganiensis	**Hellbender**	3						1				2	3			2	2				P	P									
Desmognathus auriculatus	**Southern Dusky Salamander**	5														4					P			P		M		P			
Desmognathus fuscus	**Northern Dusky Salamander**	5		4	5	5	5	5	5	5	N	5	5	4	4	5	5		S	M	P	M		P	S						
Desmognathus marmoratus	**Shovel-nosed Salamander**	4														2					P			P		P					
Desmognathus monticola	**Seal Salamander**	5						5					4			5	5				P			P	S						
Desmognathus ochrophaeus	**Allegheny Mountain Dusky Salamander**	5						5			H	5	5			4	4				P			P	P						
Desmognathus orestes	**Blue Ridge Dusky Salamander**	4														3					P			P	S						
Desmognathus quadramaculatus	**Black-bellied Salamander**	5														4	3				P			M	S	P					
Desmognathus welteri	**Black Mountain Salamander**	4														3	2				P			M	S	P					
Desmognathus wrighti	**Pygmy Salamander**	3														2					P			P	S	P					
Eurycea bislineata	**Northern Two-lined Salamander**	5		5	5	5	5	5	5	5	5	5	5	5	5	5	5	M	M	S	P	S		P	S	M				M	M
Eurycea cirrigera	**Southern Two-lined Salamander**	5														5	5	M	S	S	P			P		P					
Eurycea guttolineata	**Three-lined Salamander**	5														4			S		P			P		P					
Eurycea longicauda	**Long-tailed Salamander**	5			1	N		5			N	2	5			5	5		S		P			P		P		M	P		
Eurycea lucifuga	**Cave Salamander**	5														4	3				S			P		M			P		
Eurycea wilderae	**Blue Ridge Two-lined Salamander**	5														2					P			P	S	S					
Gyrinophilus porphyriticus	**Spring Salamander**	5		2			3	4	3	4	N	5	5	1	4	5	5				P			P	P	M			P		
Gyrinophilus subterraneus	**West Virginia Spring Salamander**	1															1				M								P		
Hemidactylium scutatum	**Four-toed Salamander**	5		4	1	H	3	5	3	3	3	5	4	3	2	5	5	P	P	P	M			P	S	M					
Necturus maculosus	**Mudpuppy**	5		N			N	*1*	N	N		4	4	N	2	2	4		S		P	P									
Necturus punctatus	**Dwarf Waterdog**	4														2					P	P									
Notophthalmus viridescens	**Red-spotted Newt**	5		5	4	*3*	5	5	5	5	N	5	5	5	5	5	5	P	P	M	P	P		P	P	P	S	M		M	M
Plethodon chlorobryonis	**Atlantic Coast Slimy Salamander**	5														5								P		P					
Plethodon cinereus	**Eastern Red-backed Salamander**	5		5	5	*5*	5	5	5	5	5	5	5	5	5	5	5							P	S	S		M			M
Plethodon cylindraceus	**White-spotted Slimy Salamander**	5														5	4							P		M					M
Plethodon electromorphus	**Northern Ravine Salamander**	5											3				5							P		M					
Plethodon glutinosus	**Northern Slimy Salamander**	5		2		X		5		H	N	5	5			5	5							P	M	S					

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Plethodon hoffmani	**Valley and Ridge Salamander**	5						5					4			4	4							P		S					
Plethodon hubrichti	**Peaks of Otter Salamander**	2														2								P		P					
Plethodon kentucki	**Cumberland Plateau Salamander**	4														3	3							P		M					
Plethodon montanus	**Northern Gray-cheeked Salamander**	3														N															
Plethodon nettingi	**Cheat Mountain Salamander**	2	T														2							P	P						
Plethodon punctatus	**Cow Knob Salamander**	3														2	1							P	S	S					
Plethodon richmondi	**Southern Ravine Salamander**	5														4	4							P		M					
Plethodon shenandoah	**Shenandoah Salamander**	1	E													1								P		P		P			
Plethodon sherando	**Big Levels Salamander**	2														2								P		S					
Plethodon ventralis	**Southern Zigzag Salamander**	4														1								P		P					
Plethodon virginia	**Shenandoah Mountain Salamander**	2,3														2	2							P		M					
Plethodon wehrlei	**Wehrle's Salamander**	4						2				3	4			4	4							P	P	P		S			
Plethodon welleri	**Weller's Salamander**	3														2								P	S	P					
Plethodon yonahlossee	**Yonahlossee Salamander**	4														3								P		P					
Pseudotriton montanus	**Mud Salamander**	5			1	3		2			N		1			5	1	S	S	P	P			P		P					
Pseudotriton ruber	**Red Salamander**	5			3	3		5			N	3	5			5	3		P	P	P			P	M	M					
Siren Intermedia	**Lesser Siren**	5														2			P		P										
Siren lacertina	**Greater Siren**	5				H										3		P	S		S	M									
Stereochilus marginatus	**Many-lined Salamander**	5														3			P		P										
REPTILES: Turtles																															
Caretta caretta	**Loggerhead Sea Turtle**	3	T	N	N		N	1	1	N	N	1		N		1							P								
Chelonia mydas	**Green Sea Turtle**	3	T	N	N		N	1	1		N	1		N		N							P								
Dermochelys coriacea	**Leatherback Sea Turtle**	2	E	N	N		N	1	1	N	N	1		N		N							P								
Eretmochelys imbricata	**Hawksbill Sea Turtle**	3	E		N			N	1		N	X		N		N							P								
Lepidochelys kempii	**Kemp's Ridley Sea Turtle**	1	E	N	N		N	1	1	N	N	1		N		1							P								
Apalone mutica	**Smooth Softshell**	5											X				1					P									M
Apalone spinifera	**Spiny Softshell**	5						1			i	2	3		1	2	4		P		M	P									M
Chelydra serpentina	**Snapping Turtle**	5		5	5	5	5	5	5	5	5	5	5	5	5	5	5	S	P	S	P	P	M	M	M				S	M
Chrysemys picta	**Painted Turtle**	5		5	5	5	5	5	5	5	5	5	5	5	5	5	5	S	P	S	P	P	M	M	M				S	M
Clemmys guttata	**Spotted Turtle**	5		4	3	1	3	5	3	3	4	3	3	5	1	4	1	P	P	P	S			S	M				M	
Deirochelys reticularia	**Chicken Turtle**	5														1		P	P							S				
Emydoidea blandingii	**Blanding's Turtle**	4					2		2	3		2	1					P	P	S	S	P		P	M				S	
Glyptemys insculpta	**Wood Turtle**	4		3		H	4	4	3	3	3	3	3	2	3	2	2	S	S	M	P	P		P	S		P		S	
Glyptemys muhlenbergii	**Bog Turtle**	3	T	1	1	X		2	1		2	2	1			1				P	M			M						
Graptemys geographica	**Northern Map Turtle**	5						1			3	3	3		3	2	2					P								

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Graptemys pseudogeographica	**False Map Turtle**	5															1					P									
Kinosternon baurii	**Striped Mud Turtle**	5														4			P		P										
Kinosternon subrubrum	**Eastern Mud Turtle**	5			5	4		5			N	1	H			5		S	P	M	S	S				P					M
Malaclemys terrapin	**Diamond-backed Terrapin**	4		3	4	X		4	2		U	3		1		4							P								
Pseudemys concinna	**River Cooter**	5				X										4	2					P									
Pseudemys rubriventris	**Northern Red-bellied Turtle or Cooter**	5	E		5	4		5	1		4	i	2			4	2		P			P									
Sternotherus minor	**Loggerhead Musk Turtle**	5														4					M	P									
Sternotherus odoratus	**Stinkpot**	5		4	5	4	3	5	5	5	5	5	4	4	2	5	5	M	P		M	P									
Terrapene carolina	**Eastern Box Turtle**	5		4	5	3	1	5	3	N	5	3	4	4		4	5	S	M	S	S			P	M	P				S	M
Trachemys scripta	**Slider**	5			i	i		i	i		i	i	i	i		4	3	S	P			S								S	
REPTILES: Lizards																															
Cnemidophorus sexlineatus	**Six-lined Racerunner**	5				X		4								5	1									P	P	P			
Eumeces anthracinus	**Coal Skink**	5						U				2	3			2	2							P		P	P	P			
Eumeces fasciatus	**Common Five-lined Skink**	5		1	5	4		5	X		3	3	4		1	5	5							S		P	S	P			S
Eumeces inexpectatus	**Southeastern Five-lined Skink**	5						4								N										P	P				
Eumeces laticeps	**Broad-headed Skink**	5			H	1		4					1			5	2							S		P	P				M
Ophisaurus attenuatus	**Slender Glass Lizard**	5														4										P	P				
Ophisaurus ventralis	**Eastern Glass Lizard**	5														1				P			S			P	P				
Sceloporus undulatus	**Eastern Fence Lizard**	5			5	H		5			N	1	3			5	5							P		P	S	P			
Scincella lateralis	**Ground Skink**	5			1	N		5			4					5	3							S		P	P	P			
REPTILES: Snakes																															
Agkistrodon contortrix	**Copperhead**	5		3	1	1		5	1		N	3	4			5	5							P		P	P	P		P	S
Agkistrodon piscivorus	**Cottonmouth**	5														3		S	P		P	P									
Carphophis amoenus	**Eastern Worm Snake**	5		4	5	4		5	3		N	3	3	1		5	3							P		P	P				M
Cemophora coccinea	**Scarlet Snake**	5			H	H		3			N					4								P		P	P				
Clonophis kirtlandii	**Kirtland's Snake**	2											H						P						P		P				P
Coluber constrictor	**Eastern Racer**	5		5	5	4	2	5	5	3	5	4	5	5	1	5	5	S						P	M	P	P	S		M	
Crotalus horridus	**Timber / Canebrake Rattlesnake**	4		1		H	H	3	1	1	N	3	3	X	1	4	3							P	M	P	S	P		S	S
Diadophis punctatus	**Ring-necked Snake**	5		5	5	4	5	5	5	5	5	5	5	N	4	5	5			S				P	M	M	P	P			S
Elaphe alleghaniensis	**Eastern / Black Rat Snake**	5		4	5	N		5	1		N	4	5	2	2	5	5							P		P	P	P	S	S	S
Elaphe guttata	**Corn Snake**	5			1	X		4			N					4	1							P		P	P	P			
Farancia abacura	**Mud Snake**	5														4		S	P		S										
Farancia erytrogramma	**Rainbow Snake**	5						1								3		S	P		S										
Heterodon platirhinos	**Eastern Hog-nosed Snake**	5		3	4	H		5	4	3	5	3	3	2		5	3									P	P	S		M	
Lampropeltis calligaster	**Mole Kingsnake**	5				H		4								5								P		P	P			S	M

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Lampropeltis getula	**Eastern Kingsnake**	5			2	2		5			N		X			5	2		P	S	P			P		P	S				
Lampropeltis triangulum	**Eastern Milk Snake**	5		5	2	1	5	5	5	5	N	5	5	5	5	5	5							S	M	P	P	S		P	
Nerodia erythrogaster	**Plain-bellied Water Snake**	5			1			2								4		S	P		P	P		S		S					
Nerodia sipedon	**Northern Water Snake**	5		5	5	4	5	5	5	5	5	5	5	5	5	5	5	M	P	S	P	P	S				M			S	S
Nerodia taxispilota	**Brown Water Snake**	5														4			S		P	P									
Opheodrys aestivus	**Rough Green Snake**	5			2	4		5			5		1			5	3	S	P	S	S	S		P		S	S				
Opheodrys vernalis	**Smooth Green Snake**	5		3		X	5	5	5	3	3	4	3	5	4	3	5			S				S		S	P			M	
Pituophis melanoleucus	**Pine Snake**	4						H			N					1	H							P		P					
Regina rigida	**Glossy Crayfish Snake**	5														1			P		P										
Regina septemvittata	**Queen Snake**	5			1	1		5			H	1	3			5	4			M	P	S									
Sistrurus catenatus	**Massasauga**	3,4										1	N							P				S			S			S	
Storeria dekayi	**Northern Brown Snake**	5		5	3	4	3	5	5	5	5	5	5	4	4	5	4			S				P		S	P	S		M	M
Storeria occipitomaculata	**Red-bellied Snake**	5		4	1	H	5	5	5	5	N	5	5	2	5	5	5			S				P	M	S	P	S		M	M
Tantilla coronata	**Southeastern Crowned Snake**	5														2								P		P	S			M	
Thamnophis brachystoma	**Short-headed Garter Snake**	4										3	3							S				P			P				
Thamnophis sauritus	**Eastern Ribbon Snake**	5		3	2	4	3	5	5	5	5	4	3	3	2	5	2	P	P	P	S	S		P	M	M	S				
Thamnophis sirtalis	**Common Garter Snake**	5		5	5	5	5	5	5	5	5	5	5	5	5	5	5	S	S	S	S			P	S	P	P	S		S	S
Virginia striatula	**Rough Earth Snake**	5														4								P			P	S			S
Virginia valeriae	**Smooth Earth Snake**	5			1	4		2			U		2			1	2							P			P	S			

DISTRIBUTION CODES

N = Not Ranked or Not Applicable
i = Introduced
X = Extirpated
H = Historic
U = Unknown

HABITAT CODES

P = Primary
S = Suitable
M = Marginal

APPENDIX B: CONSERVATION OPTIONS

DECIDING ON CONSERVATION OPTIONS

There are many opportunities available to help you protect and improve natural resources on your property. Many include incentives such as annual rental payments, cost-share payments, tax relief, and technical assistance. Deciding which of them is right for you can be confusing. Some of the more popular options are presented here.

CONSERVATION RESERVE PROGRAM (CRP)

CRP protects erodible soils by removing them from agriculture. It also improves water quality adjacent to agricultural lands and can enhance wildlife habitats. CRP annual land rental payments are provided based on the dry land cash rental rate in your county. Cost-share payments are available for establishing conservation practices. Additional incentive payments (up to 20%) are available for high priority practices. Erodible soils are protected, meaning your soil stays on your property. Water quality is improved by reducing erosion. Wildlife habitats are enhanced. You are compensated for the land taken out of production and are provided funds for conservation practices. **Website**: www.nrcs.usda.gov/programs/crp

ENVIRONMENTAL QUALITY INCENTIVES PROGRAM (EQIP)

EQIP identifies resource conservation priorities and addresses concerns such as soil erosion, water quality, wildlife habitat, waste management, etc. Cost-share payments of up to 75% are available for implementing certain conservation practices. For some practices, incentive payments are available on a per-acre basis over a term of 1 to 3 years. Funding and technical assistance are provided to establish various conservation practices. **Website**: www.nrcs.usda.gov/programs/eqip

PARTNERS FOR FISH AND WILDLIFE

Partners for Fish and Wildlife restore and enhance unique ecosystems such as wetlands and improve wildlife and fish habitats. Priorities include migratory birds, threatened and endangered species, and imperiled natural communities, like wetlands for Bog Turtles. Cost-share payments (up to 100%) are available for habitat restoration and direct benefits to federally protected species. There is a maximum of $10,000 per landowner per year. Technical assistance is also offered. This is a good way to help fund conservation practices specific to your needs and those of the resource. **Website:** http://partners.fws.gov

WETLAND RESERVE PROGRAM (WRP)

WRP is a voluntary land-retirement program. The program is designed to improve water quality and enhance wildlife habitats by restoring wetlands that have been degraded due to agricultural practices. The program provides both technical and financial assistance. Payments are available based on the agricultural value of the land and the duration of the easement placed on the property. **Website:** www.nrcs.usda.gov/programs/wrp

WILDLIFE HABITAT INCENTIVES PROGRAM (WHIP)

WHIP is a land-management program. The primary focus is to create, enhance, and restore habitats for upland and wetland species, threatened and endangered species, fish, and other types of wildlife. Of particular concern are habitats for threatened species, neotropical songbirds, amphibians, and plant communities such as early succession habitats, upland and bottomland hardwoods, and habitats associated with isolated wetlands. Technical and cost-share assistance of up to 75% may be provided for conservation practices. **Website**: www.nrcs.usda.gov/programs/whip

CONSERVATION EASEMENTS

A Conservation Easement is a legal agreement between a landowner and a qualified conservation organization (land trust, government agency, or other organization) that contain restrictions you voluntarily place on your property. Easements are a flexible tool used to protect your property and to help you keep the land in your family. Since you help write the easement, you can choose which rights are restricted. Incentives include keeping the land in the family, maintaining traditional uses that are compatible with conservation, reduction in federal and state income and estate taxes, and potential property tax savings. Contact your state wildlife or forestry agency, or consult the Land Trust Alliance website (www.lta.org) for a list of land trusts in your area.

ALLIANCE FOR THE CHESAPEAKE BAY

There are many private groups that offer guidance for habitat management and restoration. The Alliance for the Chesapeake Bay is one that provides several free booklets and guidance for landscaping your property. BayScapes are low-input landscapes, requiring less mowing, less fertilizing, and less pesticide use. BayScapes help to protect the water quality in our streams, rivers, and the Chesapeake Bay. BayScapes are attractive, colorful landscapes with hundreds of

colorful and beneficial plants to choose from. Along with reducing pollution, BayScapes provide diverse habitats for amphibians, reptiles, songbirds, small mammals, butterflies, and other creatures. The Alliance for the Chesapeake Bay and the U.S. Fish and Wildlife Service have produced a series of free guides for homeowners, including: *BayScapes for Wildlife Habitat—A Homeowner's Guide*, *Conservation Landscaping—A BayScapes Homeowner's Guide*, *Creating Landscape Diversity—A Homeowner's Guide*, and *Using Beneficial Plants—A Homeowner's Guide.* **Website**: http://www.alliancechesbay.org/project.cfm?vid=85

BEST MANAGEMENT PRACTICES (BMPS) FOR FORESTRY AND AGRICULTURE

Best Management Practices promote voluntary compliance. If resource users implement BMPs successfully, there would be little need for mandatory programs. BMPs give you the ability to protect basic soil and water resources while allowing you to maintain healthy forests and/or agricultural production. For forestry BMPs, contact your state forestry agency. For agricultural BMPs, contact the NRCS office in your county.

CONSERVATION TILLAGE PROGRAMS

There are several websites one will find when searching this topic. Crop Residue Management (CRM) is an "umbrella" term encompassing several tillage systems including no-till, ridge-till, mulch-till, and reduced-till. Conservation buffers are associated with conservation tillage and part of an overall program to enhance environmental quality and habitat and wildlife management. Buffers are small areas or strips of land in permanent vegetation, designed to slow water runoff, provide shelter and stabilize riparian areas. Strategically placed buffer strips in the agricultural landscape can effectively mitigate the movement of sediment, nutrients, and pesticides within farm fields and from farm fields. Conservation buffers protect soil, improve air and water quality, enhance fish and wildlife habitat, and beautify the landscape. Search on this topic for programs and guides to serve your needs.

FOREST STEWARDSHIP PROGRAM (FSP)

FSP provides technical assistance, through state forestry agencies, to non-industrial private forest owners to encourage and enable active long-term forest management. Technical assistance is provided and you are furnished with a management plan. This program enables you to manage your land for multiple resource objectives, such as conservation, wildlife, timber, recreation, water quality enhancement, and aesthetics. **Website**: www.fs.fed.us/spf/coop/programs/loa/fsp.shtml

Mike Marchand

All frog populations exhibit deformities in very low frequencies (about 1%) such as this Green Frog with an extra forelimb. However, high frequencies of deformities indicate severe ecosystem, parasite, and perhaps disease problems. High incidences should be reported to the state wildlife departments.

APPENDIX C: RECOMMENDED READING AND ONLINE RESOURCES

SUGGESTED READING FOR MANAGERS

References below provide a starting point for land managers who wish to learn more about this subject. This is a small sample of the abundant literature available.

Biebighauser, T.R. 2003. A Guide to Creating Vernal Ponds. USDA Forest Service, Morehead, KY. Free copy: 606-784-6428

Buhlmann, K.A. and J.W. Gibbons. 2001. Terrestrial habitat use by aquatic turtles from a seasonally fluctuating wetland: implications for wetland conservation boundaries. Chelonian Conservation and Biology 4(1):115-127.

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Dodd, C.K., Jr. 1993. Strategies for snake conservation. Pp. 363-393 In: R.A. Seigel and J.T. Collins (eds.), Snakes: Ecology and Behavior. McGraw-Hill Book Co., New York.

Heyer, R.W., M.A. Donnelly, R.W. McDiarmid, L.C. Hayek, and M.S. Foster. 1994. Measuring and Monitoring Biological Diversity: Standard Methods for Amphibians. Smithsonian Institution Press, Washington, DC. 364 pp.

Hunter, M.L., Jr. (editor). 1999. Maintaining Biodiversity in Forest Ecosystems. Cambridge University Press, New York, NY. 698 pp.

Johnson, E.A., and M.W. Klemens (eds.). 2005. Nature in Fragments. Columbia University Press, New York, NY. 382 pp.

Kenney, L.P., and M.R. Burne. 2000. A Field Guide to the Animals of Vernal Pools. Massachusetts Div. Fisheries & Wildlife., Westborough, MA. (http://www.mass.gov/dfwele/dfw/nhesp/nhpubrare.htm#vernpubs)

Klemens, M.W. (ed.). 2000. Turtle Conservation. Smithsonian Institution Press, Washington, DC. 334 pp.

Pechmann, J.H.K., R.A. Estes, D.E. Scott, and J.W. Gibbons. 2001. Amphibian colonization and use of ponds created for trial mitigation of wetland loss. Wetlands 21:90-111.

Ripple, K.L. and E.W. Garbisch. 2000. POW! The planning of wetlands, An Educator's Guide. Environmental Concern, Inc., St. Michaels. MD. (www.wetland.org)

Schneider, R.L., M.E. Kransy, and S.J. Morreale. 2001. Hands-On Herpetology, Exploring Ecology and Conservation. National Science Teachers Association Press, Arlington, VA. 145 pp.

Semlitsch, R.D. (ed.). 2003. Amphibian Conservation. Smithsonian Institution Press, Washington, DC. 324 pp.

Semlitsch, R.D. and J. B. Jensen. 2001. Core habitats, not buffers. National Wetlands Newsletter 23(4):5-11. Environmental Law Institute, Washington, D.C. http://www.eli.org

Stebbins, R.C., and N.W. Cohen. 1995. A Natural History of Amphibians. Princeton University Press, Princeton, NJ. 316 pp.

AMPHIBIAN AND REPTILE IDENTIFICATION SOURCES

Titles below provide a sample of available literature on identification and natural history of amphibians and reptiles.

REGIONAL

Behler, J.L., and F.W. King. 1979. The Audubon Society Guide to North American Reptiles and Amphibians. Alfred A. Knopf, New York, NY. 719 pp.

Conant, R. and J.T. Collins. 1998. A Field Guide to Reptiles and Amphibians Eastern and Central North America. 3rd expanded edition. Houghton Mifflin Co., Boston, MA. 616 pp.

Dodd, C.K., Jr. 2001. North American Box Turtles. A Natural History. Univ. Oklahoma Press, Norman. 231 pp. [soft cover edition issued in 2002]

Ernst, C.H., and E.M. Ernst. 2003. Snakes of the United States and Canada. Smithsonian Institution Press, Washington, DC. 668 pp.

Ernst, C.H., J.E. Lovich, and R.W. Barbour. 1994. Turtles of the United States and Canada. Smithsonian Institution Press, Washington, DC. 578 pp.

Petranka, J.W. 1998. Salamanders of the United States and Canada. Smithsonian Institution Press, Washington, D.C. 587 pp.

Smith, H.M. 1946. Handbook of Lizards of the United States and Canada. Cornell University Press, Ithaca, NY. 557 pp.

Wright, A.H., and A.A. Wright. 1949. Handbook of Frogs and Toads of the United States and Canada. Cornell University Press, Ithaca, NY. 640 pp.

Joe Mitchell

Northern Fence Lizards that occur in dry habitats illustrate two characteristics commonly found in reptiles. The female on the left is larger and has a different pattern than the male on the right. The relationship is also reversed in many species with males being larger than females.

STATE

Connecticut

Klemens, M. 1993. Amphibians and Reptiles of Connecticut and Adjacent Regions. State Geological and Natural History Survey of Connecticut, Bulletin 112, Hartford, CT. 318 pp.

Delaware

White, J. and A. White. 2002. Amphibians and Reptiles of Delmarva. Tidewater Publishers, Centreville, MD. 248 pp.

Maine

Hunter, M.L., Jr., A.J.K. Calhoun, and M. McCollough. 1999. Maine Amphibians and Reptiles. University of Maine Press, Orono, ME. 252 pp.

Maryland and Washington D.C.

Harris, H.S., Jr. 1975. Distributional survey (Amphibia/Reptilia), Maryland and District of Columbia. Bulletin of the Maryland Herpetological Society 11:73-167.

Massachusetts

Lazell, J.D., Jr. 1974. Reptiles and amphibians in Massachusetts. Massachusetts Audubon Society, Lincoln, MA. 34 pp.

Lazell. J.D., Jr. 1976. This Broken Archipelago. Quadrangle, New York, NY. 260 pp.

New Hampshire

Taylor, J. 1993. The Amphibians and Reptiles of New Hampshire. New Hampshire Fish and Game Department, Concord, NH. 71 pp.

New Jersey

Schwartz, V., and D.M. Golden. 2002. A Field Guide to Reptiles and Amphibians of New Jersey. New Jersey Division of Fish and Wildlife, Trenton, NJ. 89 pp.

New York

Gibbs, J.P., A.R. Breisch, P.K. Ducey, G. Johnson, J.L. Behler and R.C. Bothner. In press. Amphibians and Reptiles of New York State: Identification, Natural History, and Conservation. Oxford University Press, New York, NY.

Metropolitan Conservation Alliance. 2002. Conservation Area Overlay: A Model Local Law. Technical Paper Series, No. 3, Bronx, NY. 46 pp.

New York State Amphibian and Reptile Atlas Project http://www.dec.state.ny.us/website/dfwmr/wildlife/herp/index.html

Pennsylvania

Hulse, A.C., C.J. McCoy, and E.J. Censky. 2001. Amphibians and Reptiles of Pennsylvania and the Northeast. Cornell University Press, Ithaca, NY. 419 pp.

Rhode Island

Raithel, C. in press. Amphibians of Rhode Island. Rhode Island Natural History Survey, Kingston, RI.

Vermont

Vermont Amphibian and Reptile Atlas. 2005. http://cat.middlebury.edu/herpatlas/

Virginia

Mitchell, J.C. 1994. The Reptiles of Virginia. Smithsonian Institution Press. Washington, DC. 352 pp.

Mitchell, J.C., and K.K. Reay. 1999. Atlas of Amphibians and Reptiles in Virginia. Spec. Publ. No. 1, VA Dept. of Game and Inland Fisheries, Richmond, VA. 122 pp.

Pinder, M.J., and J.C. Mitchell. 2002. A guide to the snakes of Virginia. Spec. Publ. No. 2, VA Dept. of Game and Inland Fisheries, Richmond, VA. 32 pp.

West Virginia

Green, N.B., and T.K. Pauley. 1987. Amphibians and Reptiles in West Virginia. University of Pittsburgh Press. Pittsburgh, PA. 240 pp.

ORGANIZATIONS

Massachusetts-based Vernal Pool Association.....www.vernalpool.com

Rhode Island Vernal Pool Website.....www.uri.edu/cels/nrs/paton

The Nature Conservancy (search by state).....http://nature.org/

The National Speleological Society .....www.caves.org

STATE AGENCY WEBSITES

Connecticut Department of Environmental Protection .....http://dep.state.ct.us/
Connecticut Wildlife Division .....http://dep.state.ct.us/burnatr/wildlife/wdhome.htm

Delaware Department of Environmental Resources and Environmental Control http://www.dnrec.state.de.us/dnrec2000/
Delaware Division of Fish and Wildlife.....http://www.dnrec.state.de.us/fw/wildregs.htm

District of Columbia Environmental Health Administration, Fisheries and Wildlife Division .....http://dchealth.dc.gov/doh/cwp/view,a,1374,q,584468,dohNav_GID,1810.asp

Maine Department of Environmental Protection .....www.maine.gov/dep/index.shtml

Maryland Department of Natural Resources .....http://www.dnr.state.md.us/

Massachusetts Department of Environmental Protection .....http://www.state.ma.us/dep/dephome.htm

New Hampshire Department of Environmental Services .....http://www.des.state.nh.us/
New Hampshire Fish and Game Department .....http://www.wildlife.state.nh.us/hunting.htm
http://www.wildlife.state.nh.us/Wildlife/Northeast_Hab_Mgt_Guide.htm

New Jersey Department of Environmental Protection .....http://www.state.nj.us/dep/
New Jersey Division of Fish and Wildlife .....http://www.state.nj.us/dep/fgw/njregs.htm

New York State Department of Environmental Conservation.....http://www.dec.state.ny.us/

Pennsylvania Department of Environmental Protection ..... http://www.dep.state.pa.us/
Pennsylvania Department of Conservation and Natural Resources .....http://www.dcnr.state.pa.us/
Pennsylvania Fish and Boat Commission.....http://www.fish.state.pa.us/mpag1.htm

Rhode Island Department of Environmental Management .....http://www.state.ri.us/dem/
Rhode Island Division of Fish and Wildlife .....http://www.state.ri.us/dem/programs/bnatres/fishwild/index.htm

Vermont Department of Environmental Conservation .....http://www.anr.state.vt.us/dec/dec.htm
Vermont Department of Fish and Wildlife .....http://www.anr.state.vt.us/fw/fwhome/

Virginia Department of Environmental Quality .....http://www.deq.state.va.us/
Virginia Department of Game and Inland Fisheries ..... http://www.dgif.state.va.us/wildlife/
Virginia Department of Conservation and Recreation .....http://www.dcr.virginia.gov/dnh/vcbsinkholes.htm
http://www.dcr.virginia.gov/dnh/vcbsurvival.htm

West Virginia Division of Environmental Protection .....http://www.dep.state.wv.us/

OTHER WEB SITES

U.S. Environmental Protection Agency ..... http://www.epa.gov/

Natural Resources Conservation Service .....http://www.nrcs.usda.gov/

U.S. Fish and Wildlife Service .....http://www.fws.gov/

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All reptiles lay shelled eggs or give live birth. Black Racers lay shelled eggs under logs and other surface objects and hatch in about 90 days. Hatchlings have a blotched pattern but change to uniform black during growth.

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A female Northern Water Snake flees after release using the sinusoidal locomotion typical of most snakes. Snakes cannot move overland faster than humans can run.

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